

**DEPARTMENT FOR BUSINESS**  
**ENTERPRISE & REGULATORY REFORM**

**INTRODUCTION TO PRICE  
AND PRICE SIGNALS IN THE  
GAS MARKET**

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## **Introduction to Price and Price Signals in the Gas Market**

### **SUMMARY**

*Theory indicates that the price of gas is determined when the demand for gas is just met by the supply. The supply curve is also the short-run marginal cost curve, therefore the price of gas is also equal to the cost of producing the last therm of gas required to meet demand. As demand increases and/or supply falls, prices start to rise and if prices become "too high", demand side response (DSR) will occur. High prices also send signals to suppliers and investors to increase supply to the market and (in the longer term) invest in new supply infrastructure. Where a market is operating effectively arbitrage takes place and gas will be delivered to where the price is the highest and prices will equalise between physically linked countries.*

*The retail price of gas is made up of the wholesale price, administration costs, transportation costs and the profit margin. In a competitive market, the wholesale price of gas is equal to the cost of the marginal therm and suppliers compete for business, e.g. by reducing administrative costs and only earning normal profits. This tends to keep prices below levels in less competitive markets.*

*Further, price transparency in a competitive market enables suppliers and investors to judge better when to increase supply and/or invest. If new investment occurs, supply will increase and prices will fall.*

### **1. INTRODUCTION**

Gas prices in a liberalised and liquid market are determined by the balance of supply and demand for gas. A fall in the level of supply or a rise in demand will result in an increase in the average price of gas. Supply in the short run could be tight for a number of reasons, for example: a problem at a pipeline; a country holding back supplies for possible future demand needs and not delivering it to where the price is highest; or a country's own reserves diminishing faster than anticipated. In the longer run, underinvestment in gas sources or import facilities could have a similar impact. Demand could rise as a result of a rise in the price of substitute fuels, colder weather or, in some countries such as the US, hot weather due to air conditioner usage. In the longer term, demand will be driven by changes in gross domestic product (GDP), population, the fuel mix of the electricity generating industry, and by investment in energy efficiency measures. Low gas prices towards the end of the last century drove investment in combined cycle gas turbine (CCGT) power generation. Today carbon emissions targets and air pollution limits are encouraging the use of gas to generate power and encouraging investment in more CCGTs, as well as investment in renewable technology.

This paper is split into three parts: the wholesale price of gas, the retail price of gas and the UK experience in practice. The section on the wholesale price of gas will look at factors of supply/demand that determine prices and how

greater interconnection with Europe is leading to an arbitration of prices. The retail price of gas will touch on competition and prices, while the UK experience focuses on what has happened to prices since the inauguration of the GB gas market.

## 2. THE WHOLESALE PRICE OF GAS

Whilst much gas is bought and sold under long term contracts, the UK's trading market plays a key part in price setting. UK's quoted gas prices are determined on the 'virtual' National Balancing Point (NBP) hub. Traders buy and sell gas on hubs, depending on the supply and demand needs of their customers, either on the spot market or forward/futures market. The spot market is where there is a settlement to deliver the gas to the respective parties in the next one or two business days. The forward/futures market on the other hand involves the payment of the gas today to be delivered at a future date.

The forward/futures contract price is determined by the expectations of what demand and supply will be in the future, along with a risk premium. On the spot market, prices are determined by the current balance of supply and demand, as explained below.

Figure1: Theoretical Example of UK Demand & Supply

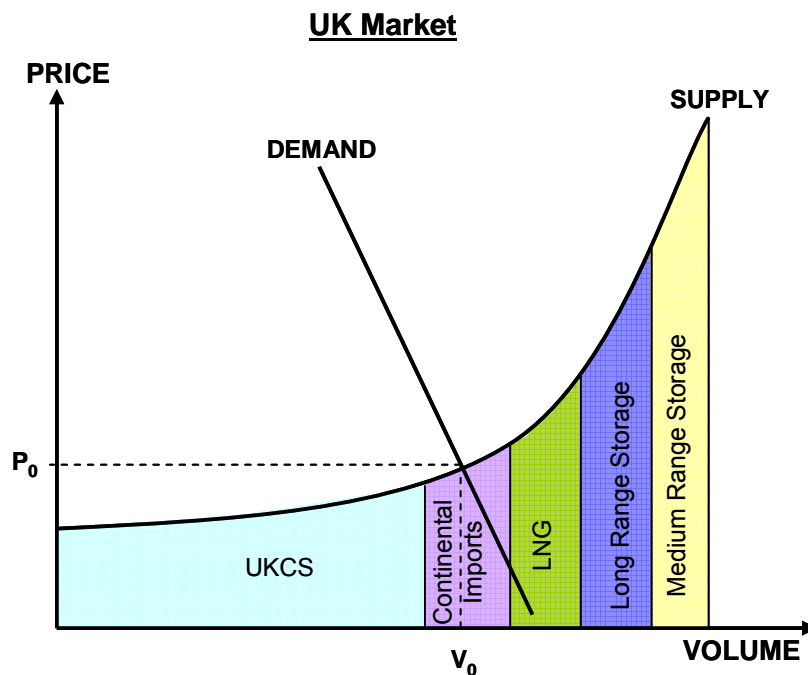


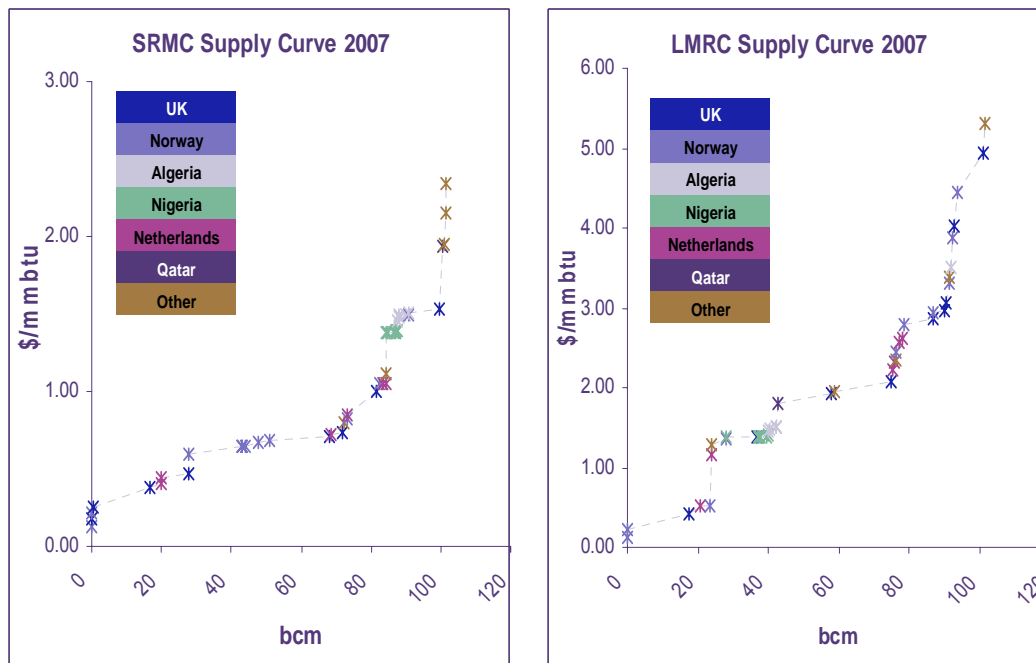
Figure 1 shows a theoretical example of how the price of gas is determined in the UK gas market. Continental Imports in the "UK Market" chart includes flows from Norway (Langeled, Vesterled etc), the Netherlands (BBL) and Belgium (IUK) and LNG includes the Isle of Grain and Teesside. The price of gas in the UK will be where DEMAND equals SUPPLY, shown by  $P_0$  on the

graph above, and at this price  $V_0$  will be supplied. In the short term the supply curve is steep because the cost of getting the next therm of gas from an existing source is higher (e.g. due to the cost/difficulty/risk of getting the field to produce more or the cost of getting labour to operate the rigs/ships/facilities for longer) – i.e. supply is inelastic. Factors that can shift the supply curve, such that more or less is supplied at each price level, include skill shortages that force up industry wages or outages of a source of gas etc.

The supply curve is the short-run marginal cost (SRMC) curve – i.e. the cost of producing one extra therm of gas. As supplies are offered to the market from various sources the cheapest ones are used first and hence the cost of obtaining gas from the next additional source is higher than the previous one. This is why as shown in figure 1 the supply curve rises. In the gas market, because resources are not inexhaustible, today's price and quantity supplied are also affected by expected future prices (i.e. the opportunity cost of supplying today is the higher price which would have been gained if the firm had sold the gas tomorrow instead) – this is particularly the case for the price of storage.

The long-run marginal cost (LMRC) is the cost at which an additional unit of gas will be supplied, provided that investment takes place. Factors that can shift the LMRC are the costs of finance, labour and raw materials needed for the investment. In the long run the supply curve will be less inelastic as completely new supplies can come on stream rather than existing sources operating harder.

Figure 2: SRMC & LMRC Supply Stacks



Source: Wood Mackenzie<sup>1</sup>

<sup>1</sup> European Gas and Power Service – UK Fundamentals

The chart above shows the 2007 SMRC and LMRC Supply stack for the UK. It is clear from the graph that the marginal cost of obtaining an additional therm of gas rises and becomes more inelastic as it moves from one country's source to another.

The above section gives the theoretical determination of prices. The next section explains how the various supply sources determine the price of gas for the UK and how prices influence where the supply will come from.

## **2.1 SUPPLY**

### ***United Kingdom Continental Shelf (UKCS)***

UKCS is the gas that is delivered to the GB network from the UK North Sea gas fields. Shippers buy the gas from the producers and then pay a transporter to deliver the gas. The price of the gas is determined by factors including the marginal cost of production, contract terms and the opportunity cost - the profits forgone by selling the gas tomorrow at a higher price than today.

### ***Continental Imports***

Continental imports are gas deliveries that come from Europe. Currently the UK receives European gas from Norway, the Netherlands and from the Interconnector (IUK) via Belgium. Under a fully functional single market gas should be delivered to the UK if the NBP price is higher than the Continental price. However, many EU gas markets are less open and flexible than that in the UK and this has resulted in some instances where gas has not been delivered to where the price is the highest.

### ***Storage***

Storage plays a crucial part in determining the price of gas. The price of storage can determine the spot price of gas where it is the marginal source of gas<sup>2</sup> (usually during the winter period). When demand, and hence prices are low, gas will be injected into storage. The withdrawal of gas on the other hand is not only dependent on the spot price, but is also affected by the forward price. This is because the owner of the stored gas can make a greater profit should he/she be able to get a higher price by selling his/her gas tomorrow rather than today. If this is the case, the fall in supply will feed back into the spot price of gas, driving it up relative to the forward price and therefore encouraging the release of stored gas.

### ***Liquefied Natural Gas (LNG)***

Where LNG becomes the price setting source of gas, this will also be affected by the European oil-linked price when it is able to arbitrage between the UK and the Continent (i.e. when there is capacity and access at the Continental import facilities). Also, the development of the LNG market should see a greater arbitrage between the UK and the US markets. We have already seen cargoes being diverted away from the UK and to the US this winter, as the average spot price of gas for winter 2006/07 was 37% higher in the US

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<sup>2</sup> I.e. where it is the highest price source of gas actually sold.

compared to the UK. In addition, Excelerate, which opened a new LNG terminal in Teesside in February 2007, only unloaded less than 10% of its cargo (less than 8mcm) and sent the rest to the US.

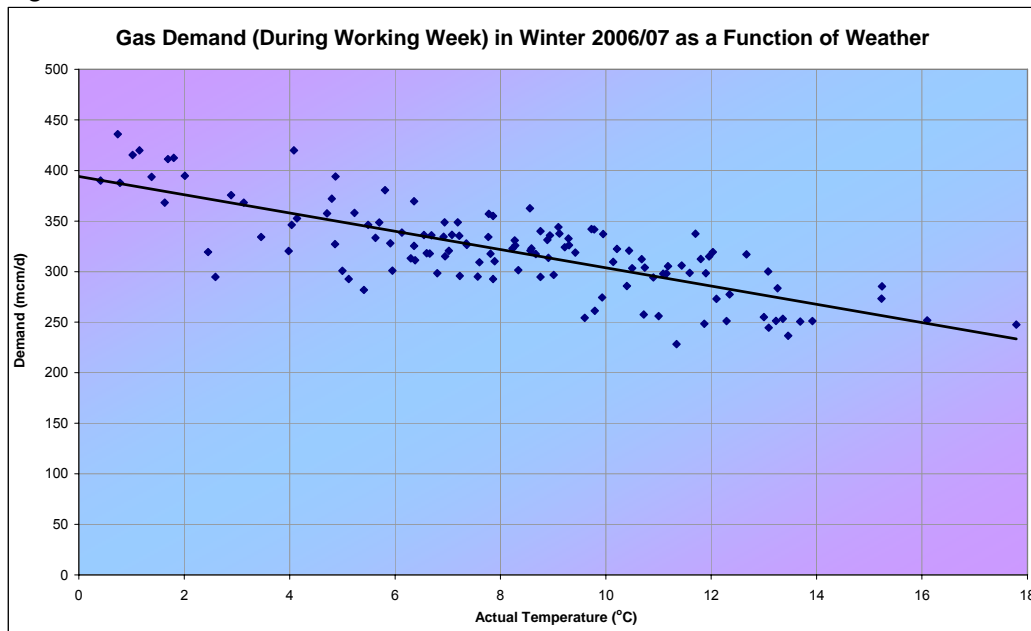
Supply alone cannot determine the price of gas, there has to be an equilibrium with the demand for gas. The next section discusses the impact prices have on demand and how it affects the price of gas, Demand Side Response (DSR) and investment.

## 2.2 DEMAND

The extent to which demand is influenced by price varies between users and over time. In the short term users can find it difficult to reduce demand because they might be unable to switch to substitute fuels or might not be set up to use less gas. In the long term demand is less inelastic as investments/changes can be made to use less gas and/or more alternative fuels.

Short term levels of demand in the UK are driven seasonally by domestic users whose winter demand can be half as much again as their summer demand.

Figure 3: Gas Demand as a Function of Weather



Source: National Grid, BERR

In the longer term demand is broadly expected to increase with increases in GDP, population and power generation using gas.

### ***Demand Side Response (DSR)***

DSR is when gas consumers voluntarily reduce or stop their consumption of gas because of the high price of gas. Most commonly high prices cause large industrial users plus gas fired power generators to voluntarily stop using, or

reduce their use of, gas: production might stop/fall, electricity might be generated by other fuels or generators might switch to back-up or distillate. DSR is undertaken more by industrial users and power generators than domestic users because they have a greater exposure to the spot price of gas.

A study for the then-Department of Trade and Industry (DTI) by Global Insight<sup>3</sup> found that if the price of gas was 100p/therm, theoretical demand reduction for industries would be 11mcm/d (111GWh/d) and if the price was 200p/therm the reduction would be 13mcm/d (133GWh/d).

Fuel switching is where it becomes more economical to switch to an alternative fuel because the price of the fuel that is originally being used is too expensive relative to other fuels. If the price of gas is too high, then in the longer term it might become more economical to build an alternate fuel power station, e.g. coal. Based on data published for the 2006 Energy Review, current wholesale prices and exchange rates, the (delivered) price of gas must be at least 42p/therm to make it more economical to build a coal plant, assuming a carbon price of €20/tCO<sub>2</sub>.

### ***Investment***

In order to evaluate a particular investment project, investors compare the expected costs of the project with the expected revenue stream. A number of factors are included in an investor's evaluation of any particular investment project. These factors help determine the type and timing of particular investment projects, and are:

- capital cost (in £m);
- access to finance;
- operating costs (p/th);
- asset life;
- earliest commissioning date;
- capacity (bcm or mcm/day);
- injection and withdrawal rates (mcm/day)—storage only;
- discount rate; and
- the expected revenues.

As mentioned above one of the key factors that investors consider when assessing whether to go ahead with a particular project or not is its expected revenue stream. This in turn depends on their future expectations of prices and the appropriate price differential.

Hence, current prices or future expectations of prices incentivise investment as firms will invest in: storage to take advantage of big summer-winter price differentials; in new import facilities to take advantage of high winter prices; and capacity which is “oversized” compared to winter demand or annual demand such that when prices are very high due to market tightness the

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<sup>3</sup> Estimation of Industrial Buyers' Potential Demand Response to Short Periods of High Gas and Electricity Prices. <http://www.berr.gov.uk/files/file28951.pdf>

owners can take advantage of the extra profits. Along with price volatility, high spot and forward prices send signals to investors.

When investments is forthcoming however it may have a dampening effect on prices and/or reduce price volatility as investment in gas supply infrastructure increases the available gas supplies, and improves the gas supply-demand balance. Hence, in a market where capacity does not exceed demand (a tight market) prices will be high, signalling the need for further investment in capacity, whereas when capacity largely outstrips demand, prices will tend to be lower, not making it profitable for any new investment to come on stream. A fuller explanation of investment dynamics and the price differentials necessary for different types of infrastructure can be found in a study carried out by Oxera<sup>4</sup> for the 2007 Energy White Paper.

One of the impacts of a softer market in the UK in the 1990s, when UK production was strong and prices low, was a signal to the market to invest in a direct pipeline link with the continent in order to export gas (small amounts of import capacity gave further flexibility to both markets). The following section focuses on the impact that this interconnection with the continent has had on prices.

### **2.3 PRICE ARBITRAGE**

The increasing dependence on Continental supplies and good pipeline links which enable gas to flow between markets has resulted in the price of gas between the UK and the Continental hubs arbitraging.

Cross-border gas trade is determined by relative market prices in the exporting and importing countries. Where there is a gas transportation link (and where capacity is physically and contractually unconstrained) between two countries, gas will be delivered to the country with the highest price. Supply falls in the other country and, if there is no change in demand, prices in that country will begin to rise. This will lead to arbitrage equalising prices between the countries (remaining differences being determined by differential transport costs) and supplies will settle - the appropriate volumes having flowed to where they are valued most. The result can be an efficient resource allocation, optimal investment where it is needed and efficient prices reflecting regional or even world supply and demand conditions.

Thus, the wholesale price of gas is virtually the same between the UK (NBP), Belgium (Zeebrugge) and the Netherlands (TTF) now that all three are well interlinked and when spare capacity allows such arbitrage. Where capacity is not available – e.g. where the pipeline is full due to cold weather or is off-line due to maintenance, or where contractual constraints bite, this arbitrage can break down and prices diverge.

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<sup>4</sup> Oxera (2007). An assessment of the potential measures to improve gas security of supply. <http://www.berr.gov.uk/files/file38980.pdf>

Figure 4: UK & Continental Gas Market

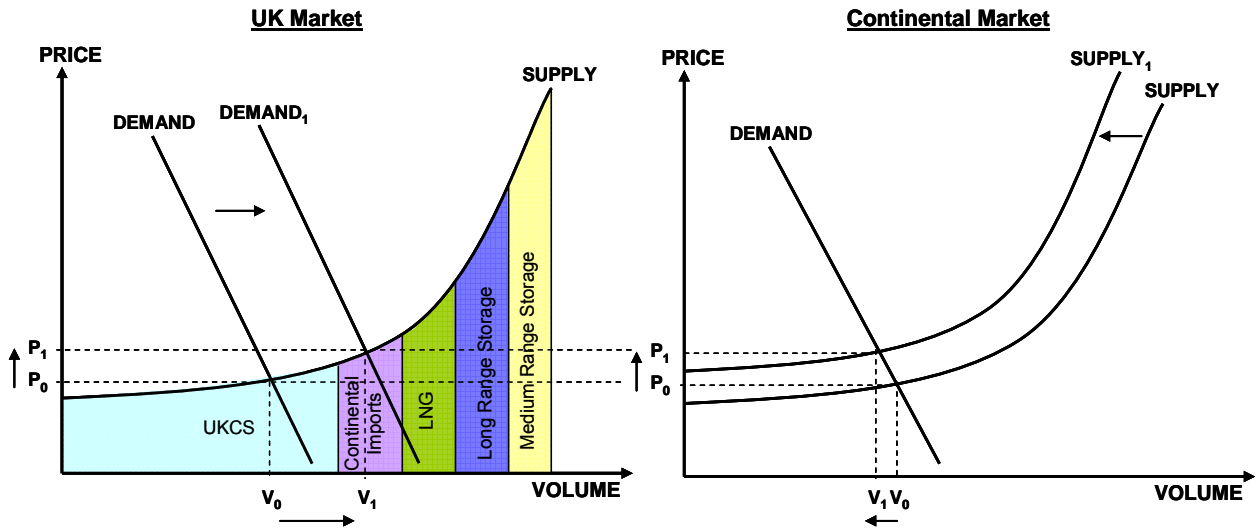
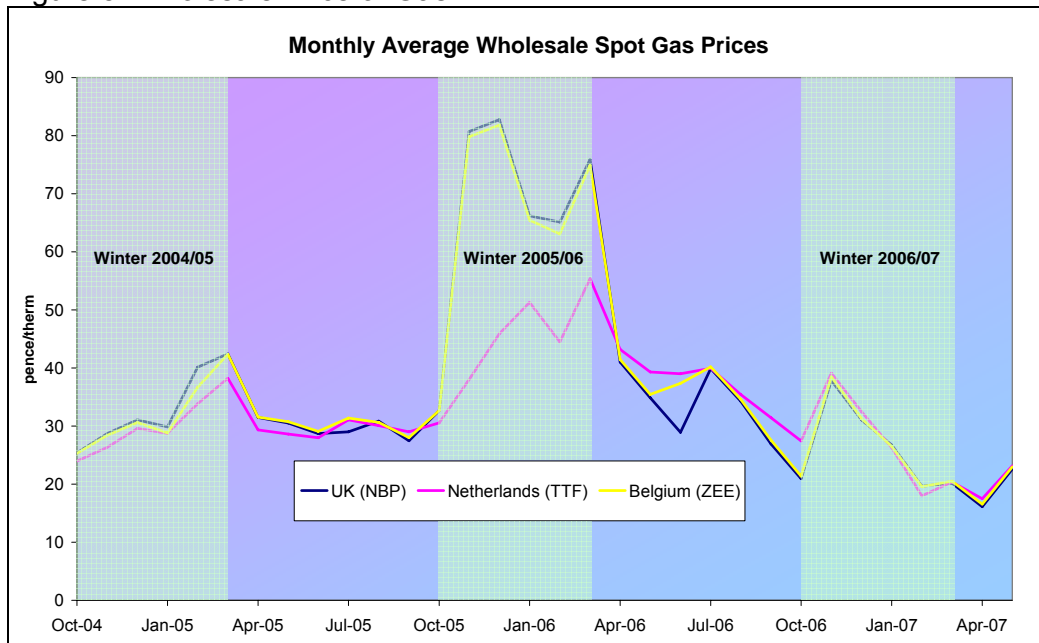


Figure 4 shows a theoretical demand and supply scenario in the UK and Continental gas market. The 'UK Market' graph shows that an increase in UK gas demand from DEMAND to DEMAND<sub>1</sub> will mean that supply will have to increase from V<sub>0</sub> to V<sub>1</sub> to meet demand. Due to the increase in demand, prices will rise from P<sub>0</sub> to P<sub>1</sub>, at the higher price more gas will be supplied and as a result continental gas will flow into the UK. The 'Continental Market' graph shows that as gas flows to the UK, supply on the continent falls from SUPPLY to SUPPLY<sub>1</sub> and prices rise from P<sub>0</sub> to P<sub>1</sub>. At the higher price demand falls on the continent from V<sub>0</sub> to V<sub>1</sub>. At the price of P<sub>1</sub> both markets have settled and prices between the UK and the Continent have arbitrated.

Figure 5: Wholesale Price of Gas



Source: Heren, BERR

The graph above shows that there has been arbitrage between the UK and Belgium prices due the direct link (IUK) between these two countries. Price differential between the UK and the Netherlands was large for most of winter 2005/06, due to a lack of interconnection/pipeline capacity between the two countries coupled with the UK's tight supply situation. However, prices converged in the winter of 2006 - 2007 as a result of the opening of the BBL pipeline (Balgzand, Netherlands → Bacton, UK) and further easing of capacity constraints.

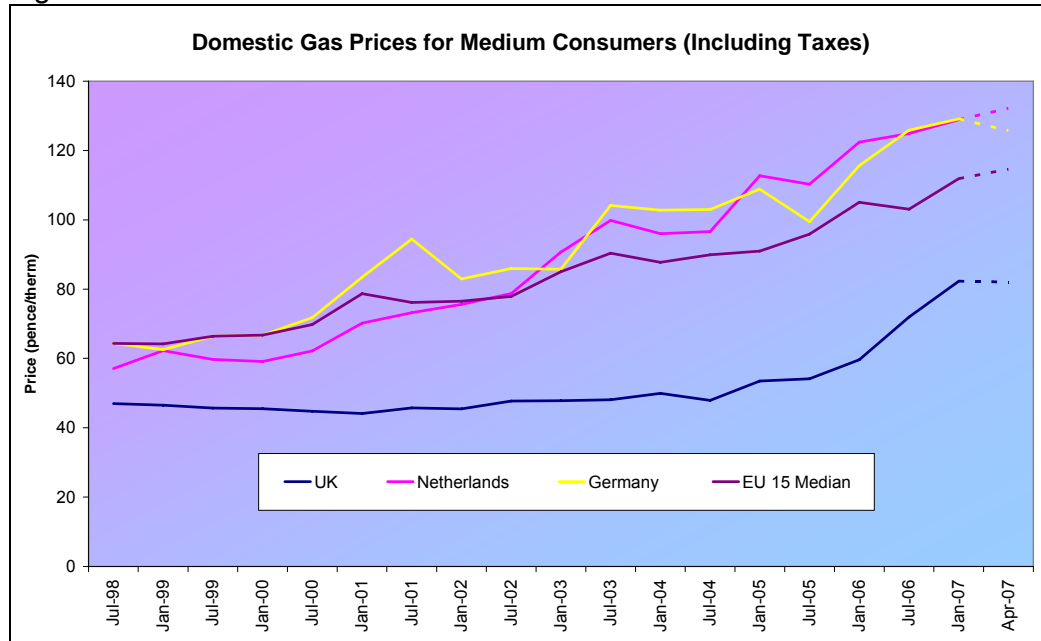
Continental prices tend to be linked to the oil price (the price of a typical contract might be 85% determined by oil or oil products) and because of the greater interconnection with the Continent, this also brings oil price linkage into long-term (e.g. greater than 6 months) UK prices.

The section above focused on the wholesale aspect of gas prices. The paper will now move onto the retail price of gas, as this is the price that the end user will pay.

### **3. THE RETAIL PRICE OF GAS**

The retail price of gas is made up of the wholesale prices, administration costs, transportation costs and the profit margin. The wholesale price is made up of the cost of contracted gas and both spot and forward gas and accounts for roughly 50% of the final retail price for domestic users and around 60% for industrial users.

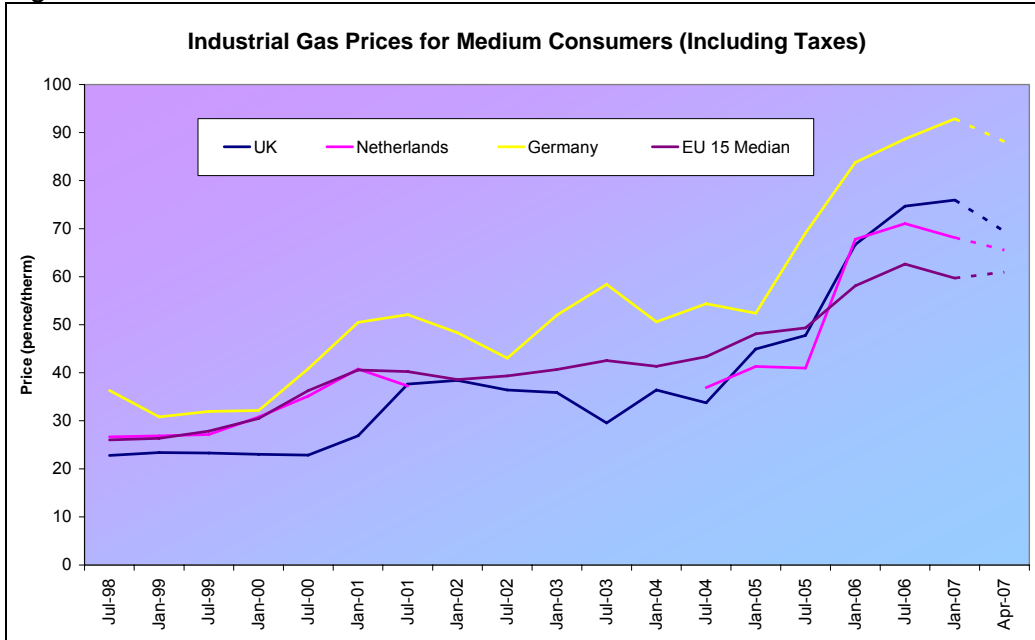
Figure 6: Domestic Price of Gas



Source: Eurostat, BERR

The graph above shows that including taxes, the price of gas for medium sized domestic consumers<sup>5</sup> is cheaper in the UK compared to the other major European nations as well as the EU15 median. The graph below shows industrial price comparisons where differentials are less.

Figure 7: Industrial Price of Gas



Source: Eurostat, BERR

Both graphs show that after the sharp price increases in the wholesale price of gas in Winter 2005/06, the retail price of gas also increased significantly, reminding us that in a functioning competitive market prices tend to show a close relationship to costs. Despite the falls in the wholesale price of gas this winter, prices have still to fall sharply, suggesting a time lag of around 6 to 9 months between the wholesale and retail price of gas. One of the reasons for this lag is because some of the gas now being sold to retail consumers would have been bought on the forward wholesale market, at last year's higher prices, so as to ensure security of supply.

The retail price of gas is directly affected by the level of competition in the market. The section below discusses the impact that competition can have on the retail price of gas.

### 3.1 COMPETITION AND PRICES

In a competitive market where there are many buyers and sellers, the price of gas will be equal to the marginal therm of gas. Therefore the market is said to be efficient with the "right" amount of gas being produced and consumed. Prices are kept equal to the cost of the marginal therm because any deviation

<sup>5</sup> Medium sized domestic consumers are those consuming between 23,260KWh and 34,889KWh per annum. Medium sized industrial consumers are those consuming between 11,630MWh and 116,299MWh.

away from this price will result in a loss of profit for the producer. An open market will encourage new entry and increase competition, and this is what we have seen in the UK.

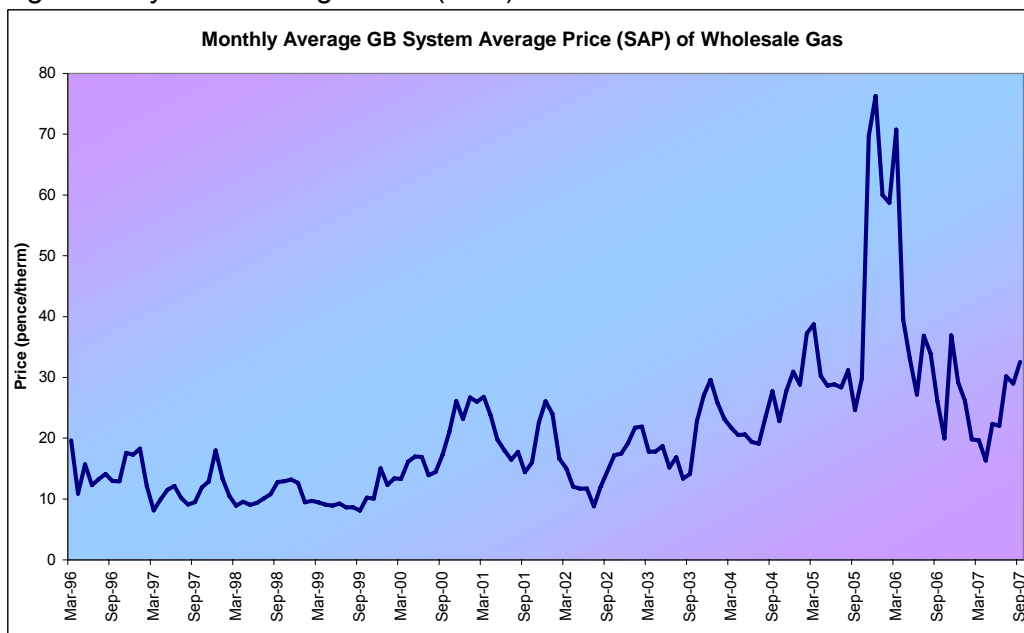
Many firms in the continental gas markets are either a monopoly or they operate in an oligopolistic industry. In addition, some of these firms are national champions and are fully or partly owned by the state. In the case of a monopoly firm, prices will be artificially higher as there is no incentive for the firm to lower its price because its profits would fall and it knows that the consumer cannot go elsewhere to get their gas. In an oligopolistic market, firms will not compete on price as their profits would fall in a price war. There is also the risk that firms in such a market structure may collude in order to make monopolistic profits.

The wholesale and retail prices of gas have been determined by those factors mentioned above ever since the market was created. The final section below discusses what has happened in the GB gas market, in particular the impact of high prices in the winter of 2005/06.

#### **4. THE UK EXPERIENCE IN PRACTICE**

The competitive UK gas market was inaugurated in 1996. Before then there was not a market based wholesale price of gas, as most trades were on a contractual basis between producers and British Gas.

Figure 8: System Average Price (SAP) of Wholesale Gas



Source: National Grid

The average wholesale price of gas in March 1996 was around 20p/therm, and remained between 8p/therm and 20p/therm up until October 2000. The price began to rise steadily after 2004.

The winter of 2005/06 was one of the tightest seen in the UK and, due to this, the wholesale price of gas reached record highs. Supplies were tight because of higher than anticipated demand as a result of a number of cold snaps, UKCS declining faster than anticipated, the UK not getting gas as had been expected via the UK-Belgium Interconnector and, late in the winter, the Rough storage facility being out of commission due to a fire there. The tight supply situation resulted in the price of gas becoming volatile. There are costs associated with price volatility, e.g. where users or suppliers are exposed to the spot price they might have to incur the costs of risk management and face cash-flow problems.

As a result of a fire at Rough, National Grid indicated that reductions in demand would be needed, if demand rose above 377mcm/d<sup>6</sup>. On 13<sup>th</sup> March 2006, demand breached this level and the first ever gas balancing alert (GBA) was issued. As a result of this, the system average price of gas increased by 63% in one day, from 109p/therm on the 12<sup>th</sup> to 178p/therm on the 13<sup>th</sup>.

The expectation of a tightening supply-demand balance and hence (in a competitive market) higher prices, encourages companies to build/expand supply capacity, and thus tap in on the high prices to reap the profits. New facilities were built to be ready for winter 2006/07. These facilities included two new importation pipelines, one from Norway (Langeled) and the other from the Netherlands (BBL), an expansion of the IUK Interconnector and a LNG terminal at Teesside. As a result the UK's import capacity increased by 140% from Winter 2005/06 to Winter 2006/07 and the average (monthly) price of gas in winter (2006/07) did not rise above 37p/therm. In fact, despite inflation, the average wholesale price of gas in March 2007 was exactly the same as the March 1996 average, therefore in real terms, the price of gas in March 2007 was cheaper than the March 1996 price.

In view of the continuing decline of gas production from the UKCS many firms are pursuing proposals to build gas storage facilities and to develop and expand LNG terminals.

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<sup>6</sup> Prior to Rough being out of commission, DSR would have been need if demand increased above 425mcm/d.