Electricity and Natural Gas Pricing

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Keywords: electricity pricing, natural gas pricing, influencing factors

JEL: Q40, Q41
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1 Introduction

The rapid increase in electricity prices on the wholesale market since 2005 can largely be traced back to the introduction of the European Union Emissions Trading System (EU ETS) on CO₂ emissions, as well as to increased fuel prices.

On May 15, 2006 the EU Commission released emission figures for 21 member states, and revealed an allowance surplus of 44 million tons. Some member states had already released their figures at the end of April, which explains the dramatic decrease in CO₂ prices at the time. On April 25 at 9:00 am,¹ CO₂ traders could sell their allowances for 29.40 € per ton. Four working days later, an allowance authorizing one ton of CO₂ emissions was only worth 11.00 € by the end of trading. The futures price for a year’s supply of base electricity in 2007 subsequently sank by 18.47%. Regular stock traders would have described such a phenomenon as a crash, but for power traders, it’s just peanuts. A few reactions included comments by Peter Krembel from RWE Supply & Trading, who said, “The system still works,” and the World Bank’s Karan Capoor, who stated, “The market is just signaling its developments through price”. Nevertheless, the EU Commission encouraged other member states to temporarily withhold their relevant market data, so as not to further scare market players. Regardless of these differing standards, potential gains and losses of this magnitude should be carefully analyzed and quantified in order to minimize any potential portfolio losses.

This paper describes pricing mechanism and price influencing factors from the point of view of the German electricity and gas market, although most of the statements are valid in general.

¹9 am is the start of trading on the European Energy Exchange (EEX).
2 Pricing in Electricity and Gas Markets

In wholesale markets, electricity and natural gas are traded either bilaterally ("over the counter" = OTC) or centrally on an exchange (with a virtual point of delivery). OTC-contracts can be split into standardized products, which are traded through brokers or individually bargained contracts. The trading parties include not only market participants with an interest in satisfying their gas and electricity needs, but also intermediaries (banks and energy traders, for example) with a purely financial interest. Finally, a fundamental distinction needs to be drawn between the forward market, where the gap between trading and delivery can range from two days to several years, and the spot market, where gas and electricity can only be traded one or two days before delivery or on the day of delivery.

2.1 Pricing in Electricity Markets

The most important aspect in pricing electricity is the fact that electricity cannot be efficiently stored in large quantities. As a result, electricity must be constantly produced at the same rate as consumed to avoid a network collapse. In a competitive power market, all available power plants offer electricity at their individual variable costs. Hence, the market supply function corresponds to the so-called merit-order, in which power plants are arranged in ascending order of their variable costs, whereby efficient operation of the power plant fleet is guaranteed, and the total cost of power generation in any given demand situation can be minimized. In a uniform price auction, such as the one implemented at the European Energy Exchange (EEX), the market clearing price then always corresponds to the variable costs of the marginal power plant, i.e. the last power plant in the merit order needed to cover the most recent level of demand. All power plant operators who have produced electricity below this price will still receive this market price, independent of the actual variable costs
of the individual power plants. These margins are necessary to cover fixed costs and especially capital costs.

Besides the costs of fuel acquisition, the price of CO$_2$ allowances is considered to be one of the essential (calculatory) variable costs since 2005 because the allowances are consumed in the electricity production process and can no longer be sold on the CO$_2$ market.\textsuperscript{2} Renewable energy represents one exception to the merit order model, as it must always be used when it is available according to the Renewable Energy Law (Erneuerbare Energien Gesetz, EEG). Whenever renewable operators produce power, they earn a statutorily fixed feed-in-tariff. Furthermore, speculative supply and demand quantities as well as oligopolistic games can not be taken into account by the merit order model.

### 2.2 Pricing in Gas Markets

The most relevant pricing difference between natural gas and electricity lies in the ability to store natural gas, although such storage is expensive. One must also consider that, due to limited domestic availability, over 80% of the natural gas must be imported from abroad (particularly Russia, Norway and the Netherlands). This requires the construction of very expensive transport pipelines between the supply locations and the user locations. In the past, producers and importers signed long-term OTC gas delivery contracts with terms lasting up to 25 years, to secure these investments. In order to prevent individual participants from unfairly using any leeway in the contract to their advantage (hold-up problem), the quantitative risk was assigned to the importer in so-called Take-or-Pay contracts (ToP), where the importers were obliged to accept a certain minimum quantity of gas or at least to pay for it. In return, the producers bore the price risk, since the contracted gas supply

\textsuperscript{2}See also Janssen et al. (2007).
price did not depend on the variable cost of extraction but on the price of competitive fuels. Depending on how the gas will be used, these fuels usually are oil or coal (as a potential substitute for the heating market or for power generation, respectively).³

In order to secure investments in national infrastructure (long-distance supply grids, gas power plants, etc.) fed by transnational pipelines, importers have until now signed ToP contracts with national and regional gas companies as well as distribution companies. Thus, the price for end users is not established primarily by the supply and demand for natural gas on the wholesale market, but rather by the supply and demand of more flexibly transportable commodities - coal and oil.

The development of a liquid wholesale market in Germany has been progressing rather slowly, due to a barely working network access system and the predominant long-term gas delivery contracts. While at least a portion of gas is traded through short-term OTC contracts in the market sector for E.ON Ruhrgas Transport (EGT), trading in other virtual trading points is stuck in its infant stages of development. While the first reaction on the introduction of short-term trading in the market area of BEB⁴ in Juli 2007 was rather positive, the current trade volumes converge to zero. However, the EEX-trading opportunity in the EGT grid, introduced in October 2007, reveals a positive development. Nevertheless, due to basic principles of transportation arbitrage, the prices reported by the EEX hardly differ from those in more solvent, virtual trading hubs like the Title Transfer Facility System (TTF, Netherlands), Zeebrugge (Belgium) and National Balancing Point (NBP, United Kingdom), where the price of natural gas corresponds to offers received on the APX Group and ICE exchanges.

Despite the strong connections between gas and oil prices, there is a fundamental difference in how their prices are set. The greatest demand for oil stems from the

³For more information on Take-or-Pay contracts, see also Flakowski (2003).
⁴See http://www.beb.de/cms/.
transportation and petrochemical sectors, which are only subject to minor seasonal and stochastic fluctuations. As a result, short-term and medium-term price changes in the oil market are based primarily on supply-side factors, e.g. extreme weather, political instability, etc. In contrast, the cost structures in the extraction and transportation of natural gas hold the supply relatively constant, whereas the demand varies according to the seasons, since it is primarily used in the heating sector. Because natural gas is extremely expensive to store, price fluctuations cannot be smoothed here to the degree it is possible in the oil market.

2.3 Characteristics of Electricity and Gas Spot Prices

Two important characteristics of electricity and gas spot market pricing are a certain degree of non-constant volatility and a strong connection to the seasonal cycle. Mean reversion refers to the process by which prices return to a seasonal level (the mean reversion level) after fluctuations. Particularly large increases are labeled as jumps, or in extreme cases, as spikes. Spikes are abrupt or unanticipated price peaks that cross a certain threshold for a certain length of time. For electricity, the threshold value relative to seasonal levels is higher than for gas, and the time interval is shorter. This can be traced back to the difficulties of storing electricity and the fact that randomly occurring outages in generation and infrastructure capabilities have a more extreme effect on the price. However, electricity markets are often able to correct strained supply conditions within 24 hours (the time period between day-ahead auctions), whether through additional imports or through the activation of additional power sources.\(^6\)

\(^5\)Price volatility is generally understood as the range of fluctuation around its mean. In econometric applications, the concept of volatility is limited to the range of fluctuation in a seasonally adjusted time series.

\(^6\)For the characteristics of electricity prices see for instance Weron (2006). For gas price characteristics see Kaminski and Capital (2004).
Another important aspect of spot market prices, specifically pertaining to commodity with limited storage capabilities, is the installed price floor rate (usually 0 €/MWh). At certain times, negative electricity prices are more efficient in the sense of maximizing the surplus of consumers and producers, and can include important incentive signals for load-shifting. In order to account for that, the EEX - as the first exchange in Europe - has introduced negative electricity prices in September 2008. Thus, in times of a sudden low demand, producers may pay their customers for purchasing electricity in order to avoid the costly expense of shutting down plants.\(^7\)

The probability of negative gas prices is much lower due to the higher storage potential than in electricity markets. However, if storage facilities operate at full capacities, negative gas prices might occur temporarily, as seen during October 2006 in Great Britain. The reasons were a storage capacity utilization of 96 % due to unusually mild temperatures and an unexpected huge inflow of natural gas via an import pipeline from Norway, which had been tested during those days.\(^8\)

### 3 Factors Influencing Electricity Prices

#### 3.1 Spot Market Prices and Influencing Factors

On spot markets, electricity is bought and sold in the short term. While essentially any contract is negotiable “over the counter”, electricity is auctioned on the EEX’s day-ahead market at 12pm, for each individual hour of the next calendar day. Furthermore, regular block contracts can be traded continuously for the following day

\(^7\)Note that on OTC markets, electricity had been traded at negative prices even before the introduction of negative bids at the EEX. Similarly, electric power would be OTC-traded at prices above the EEX upper level ("price cap") of 3.000 /MWh, if supply and demand does not clear at that price on the EEX.

\(^8\)See for the incident in Great Britain energy risk, November 2006, p. 5.
Additionally, market participants can trade electricity on the so-called intra-day market, either OTC or via exchanges. The EEX introduced an intra-day market in September 2006. On that market, electricity for individual hours can be constantly traded starting at 3pm on the day preceding delivery and ending 75 minutes before delivery.

The trade volume on the day-ahead market in 2007 totaled 117 MWh on the EEX. That reflects an increase of 33% compared to the previous year and represents approximately 19% of the total power consumption. Because the majority of hourly day-ahead contracts is traded on exchanges, the Physical Electricity Index (Phelix) released by the EEX serves as the reference price of electricity in Germany. The Phelix Base is the average of all 24 hourly prices from the day-ahead auction, and the Phelix Peak is the average from 8am to 8pm.

The spot market supply stems primarily from surplus production, which cannot be sold long-term because of unpredictable stochastic influences. Similarly, users obtain remaining quantities of electricity from the spot market according to the amount of electricity not available in advance from the forward market because of long-term, unforeseeable load demands. Market participants also use the spot market to sell earlier-contracted excess quantities. On the other hand, electricity producers purchase electricity on the spot market when delivery obligations cannot be fulfilled through their own generating capacities, or when the spot market price lies below the variable costs of their own production.

The spot market price therefore is influenced by a completely different set of factors than the price on the forward market. Long-term developments and short-term fluctuations in the spot market price are determined largely by three groups of influencing factors, which will be explored below in more detail.

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9In the case of purely speculative supply bids, this excess quantity equals the total earlier-contracted quantity. Speculators could be banks without any physical interest, for example.
3.1.1 Fundamental Influences on Production Costs

Primary energy prices and CO₂ allowance prices, which mainly determine pricing on forward markets, merely establish the average level and long-term price trends for the spot market. For example, the extremely low average price of 31.75 €/MWh for electricity at the beginning of 2007 (two-month mean average of the Phelix Base in January and February) tends to be a consequence of the low gas price in the mild winter 2006/07, where gas only cost 12.21 €/MWh (APX Netherlands, Day-Ahead, TTF-H-Gas). When the gas price climbed to a two-month mean average of 22.87 €/MWh in November and December 2007, the average Phelix Base rose accordingly to 58.19 €/MWh (see Figure 1). For the trading period ending December 31, 2007, the drop in CO₂ allowance prices from 2.58 €/t CO₂ in January/February to 0.05 € per ton in November/December could only minimally counteract the gas-price-induced increase in electricity prices.

However, the substantial price jumps in spot market electricity prices cannot be explained by fuel and CO₂ price movements, but are a consequence of the inability to store electricity.

3.1.2 Predictable, Temporary Influences on Supply and Demand

In contrast to most other markets, where the traded product is storable, temporary changes in the conditions of production and demand for electricity on the spot market lead to significant price changes, even if they are perfectly expected. For example, the electricity demand, in contrast to the supply, depends greatly on the day of the week and the time of day. This results in a predictable pricing system based on a weekly and daily cycle, where prices are lower at night and on weekends and higher during the day and during the week.

Another factor influencing supply and demand is the seasonal cycle. For example
in the Californian power market, summer prices are often much higher than winter prices due to heavy reliance on air conditioning. In Germany, the decreased use of air conditioning in winter is in fact outweighed by the increased use of light and heating - approximately 14% of the total German power consumption is attributable to room and water heating.\textsuperscript{10} In addition, power plant fuels, particularly natural gas, are more expensive in the winter due to storage costs. Hence, power plants’ production costs increase seasonally. Both effects tend to lead to higher electricity prices in winter.

Since these developments follow a predictable pattern, the obligatory yearly inspections of nuclear power generating units can be anticipated and are distributed as evenly as possible during the low price period between April and September. As a consequence the power plants’ capacities are then fully made available in winter, and scarcity-based price spikes occur as rarely as possible. One side effect however is that this procedure leads to supply scarcities in summer, which counteracts an otherwise substantial seasonal price decrease. Despite the generally lower demand, this system thereby also increases the potential of price spikes in the summer. This became particularly clear in the middle of April 2007, when the power plants Philippsburg 1, Grafenrheinfeld and Brunsbüttel all went off-line for inspection at the same time. When additional, unforeseen production bottlenecks at the end of the month decreased the already scarce supply, April 24, 2007, saw the highest auction results since November 2006, when the average daily price for basic electricity rose to 67.91 €/MWh (see Figure 1).

3.1.3 Stochastic Influences

Besides predictable influences such as periodic inspections and seasonal, weekly and daily cycles, there are other short-term, unpredictable factors that play a deciding

\textsuperscript{10}Schulz et al. (2007).
role in pricing the cost of electricity in daily and hourly intervals. To a certain extent, historical data can establish trends and expectations for weather in certain seasons and even days, but the actual conditions, including temperature, precipitation and wind, can only be seen on the day. However, the accuracy of weather predictions converges to the actual weather situation as the time advances.

The greatest influence on the demand for electricity is the temperature. Very high and very low temperatures increase the demand for cooling and heating, respectively, and thereby alter the price accordingly. Heavy rainfalls increase the supply of affordable power from hydroelectric plants, whereas longer droughts can lead to insufficient levels of cooling water in German rivers and could prevent conventional power plants from functioning at full capacity. This occurred, for example, in the second week of June 2007 when the Phelix Base on June 12 jumped to 85.41 €/MWh.

In the last few years, wind intensity has begun to play an extremely important role in the price of electricity. The capacity of wind power plants has multiplied from barely 1000 MW in 1995 to 22,250 MW at the end of 2007 (German Wind Energy Institute). Because EEG prescriptions call for the prioritized utilization of wind energy regardless of the current spot market price, strong winds can lower the spot market price. On the other hand, in times of low or no wind, the more expensive, conventional power plants must increase production according to the merit order model, which leads to higher electricity prices. An unexpected technical failure in large power plant blocks represents another factor that can increase prices dramatically in the short term. Figure 1 represents a somewhat simplified rendition of the 2007 developments in the Phelix base and peak levels based on the factors explained above.
3.2 Forward Market Prices and Influencing Factors

Besides the electricity spot market, it is also important to consider the forward market, which is several times larger than the spot market.\textsuperscript{11} Participants in the forward market include hedgers on the one hand, who either physically produce or need electricity and wish to secure it from price risks, and speculators on the other hand, who try to gain speculative profits by taking on price risks.\textsuperscript{12} Forward market contracts can be interpreted as a form of insurance by hedgers, who are risk-averse, and for whom speculators act as insurers. In return, the speculators require a risk

\textsuperscript{11}The trade volume in forward markets exceeded the spot market volume by a factor of approximately 40. See also Commission (2007).

\textsuperscript{12}A third group of participants is made up of arbitragers, who take advantage of short-term instances of temporal and spatial price imbalances.
premium $\lambda$, where $\lambda$ represents the difference between the forward price and the mean of the expected spot prices during delivery. Its sign and value depend on the hedgers’ net position.

The simplest forward market contracts are non-contingent claims like OTC-traded forwards and exchange-traded futures. Sellers are obliged to deliver a certain quantity of electricity for a fixed price in a fixed future time span. Futures are standardized forward contracts, which are continuously traded on the market and are not typically geared towards a physical delivery.\(^\text{13}\) Furthermore, a series of conditional structured products, like swing and spread options, are traded primarily at the OTC level. In portfolios, swing options together with fixed load profiles yield so-called swing contracts (or flexible load profiles). A holder of a swing contract can stock up on external flexibility and thereby gain the right to deviate from the planned schedule without a change in price, i.e. he can draw on or sell a different quantity of electricity (upsangs and downswings) at certain times and for certain intervals. Finding a fair price for this kind of flexibility in an incomplete market is challenging, particularly in instances where these rights are licensed on an hourly basis.\(^\text{14}\) Fundamentally influential factors and quantitative evaluation methods need to be considered simultaneously in order to efficiently manage specific risks in power markets. In the following, we will concentrate on an analysis of the fundamental factors influencing futures prices.

In contrast to spot markets, where temporary influences affect supply and demand directly, the futures price $F$ at time $t$ for the delivery interval $[T_1, T_2]$ is determined

\(^{13}\)The equality of forward and futures is only valid for a non-randomized market interest rate. See also Geman (2005), pp. 42-44.

\(^{14}\)Power markets are incomplete because the underlying is non-tradable in the classical sense (because the possibility of short sales or storage are absent). In addition, price paths are non-continuous and jumps sizes are unpredictable. Subsequently, risks cannot be accurately quantified and secured. For more on the incompleteness of electricity markets, see also Fiorenzani (2006), pp. 88-90.
by three factors: the risk premium, the expected conditions of supply and demand in the delivery period, and the expected spot prices $S(T_1) ... S(T_2)$. The probability measure $Q$ already contains the risk premium and thereby reflects the market’s aggregate willingness for risk payments. While $Q$ can be determined implicitly by market prices for traded futures, the actual probability $P$ can not be calculated, since only one sample path of the random prices can be observed on the market. However, $P$ can be estimated with historical prices and the estimation error decreases with an increasing number of observations.

$$F(t, [T_1, T_2]) = \sum_{T=T_1}^{T_2} \mathbb{E}^P[S(T)|\mathcal{F}(t)] + \lambda(T, \mathcal{F}(t)) = \sum_{T=T_1}^{T_2} \mathbb{E}^Q[S(T)|\mathcal{F}(t)]$$

While the expected demand for electricity can essentially be calculated according to weather forecasts, business cycles, political conditions and user behavior, the expected supply depends primarily on future fuel and CO$_2$ costs, as well as on the anticipated available power plant production capacity. Expected price developments for storable fuels like coal, gas and oil can be derived from futures quotes (see below).

The EEX offers power futures lasting from one year to one month in the base period (12:00 am - 12:00 am) and in the peak period (8:00 am - 8:00 pm), as well as options on these futures. In the following, the effects of the most important price determining factors for the EEX annual power futures traded in 2007 for 2008 base and peak delivery are quantified based on two separate multivariate linear regressions. The daily rate of return for both power futures are regressed on the rates of return for gas and coal prices, as well as the CO$_2$ allowance price.$^{16}$

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$^{15}$Expectations are always based on the information $\mathcal{F}(t)$ available at time $t$. For a more detailed study of power futures, see also Benth and Koekebakker (2008). For an introduction to stochastic analysis and risk-neutral valuations, see also Shreve (2004).

$^{16}$In contrast to the use of the original time series, residuals in the return regressions are not auto-correlated. See also the Durbin-Watson test results.
Table 1: Multivariate Regression of EEX Phelix Futures 2008 (Base and Peak)

<table>
<thead>
<tr>
<th>Factors Influencing</th>
<th>Coefficients Base</th>
<th>Coefficients Peak</th>
<th>t-statistics Base</th>
<th>t-statistics Peak</th>
<th>R^2 / Durbin-Watson Base</th>
<th>R^2 / Durbin-Watson Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.0002</td>
<td>-0.0005</td>
<td>-0.6382</td>
<td>-1.2181</td>
<td>0.607/2.256</td>
<td>0.445/1.817</td>
</tr>
<tr>
<td>Gas Forward 2008 (TTF)</td>
<td>0.116</td>
<td>0.161</td>
<td>4.870</td>
<td>5.615</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal Futures 2008 (EEX)</td>
<td>0.185</td>
<td>0.168</td>
<td>5.780</td>
<td>4.353</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Futures 2008 (EEX)</td>
<td>0.193</td>
<td>0.130</td>
<td>12.569</td>
<td>7.053</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is worth noting that all three explicitly observed variables have a significant influence on the price of both base and peak power. For example, a 10% increase in the gas forward price is accompanied by an average increase in the base power futures price of 1.16%, while the price increase for peak power totals 1.61%. The inverse is true for coal prices, where a 10% increase has more of an effect on base electricity prices (1.85%) than on peak electricity prices (1.68%). Both effects can be explained by the fact that the price of coal is more frequently a factor in determining the price of electricity in off-peak hours than in peak hours, while the inverse holds true for gas. A change in the CO₂ allowance price has a significantly lower effect on peak electricity prices, since the dominant status of natural gas during peak hours decreases the need for allowances per kWh of generated power. In addition, the base electricity regression is characterized by a higher model performance (an R^2 value of 0.607 compared to the peak value of 0.445), due to the more significant influence by other factors not taken into consideration in this model on peak-load than on base-load electricity prices.
3.3 Outlook

The nuclear phaseout, the expansion of renewable energy,\textsuperscript{17} the design of the third emission trading period starting in 2013 as well as developments in fuel prices will determine the future of German wholesale electricity market prices. These variables could substantially alter the order of cost-efficiencies of various energy carriers, i.e. the merit order. The four central aspects named above are now examined briefly.

On the supply side, the nuclear phaseout significantly reduces the medium-term availability of CO$_2$-free power plants. On the one hand, the elimination of cost-effective nuclear power production will lead to an increase in average electricity prices. On the other hand, removing nuclear capacities, controlled by the four main German power producers, will increase competition, which tends to result in decreasing prices.\textsuperscript{18}

In order to achieve the political objective of lifting the share of renewable energy in electricity production up to 20\%, renewables will be further encouraged in the future. It is worth noting that with fixed feed-in tariffs for renewables and a parallel increase in the price for wholesale market electricity, it will be more attractive to market renewable energy just like all other forms of power production. Since reliable quantities can be offered neither on the preceding day nor up to 75 minutes before delivery, providers will have to insure the existing quantitative risk on the market.

The uncertain distribution for EUAs during the third emission trading period starting in 2013, will gain influence over the power market and its individual companies. These uncertainties could endanger investment projects, since investors prefer more stable, long-term conditions in their calculations.

The interdependence of CO$_2$ prices and fuel prices, which also affects electricity price

\textsuperscript{17}Above all, the marketing potential of renewable energy.

\textsuperscript{18}For more information on determining the intensity of competition in Germany, see also Mürgens (2006) or Janssen and Wobben (2009).
levels, must be considered. A rise in CO\textsubscript{2} prices results in rising electricity prices in the short term, but will increasingly shift the producers’ demand for coal to natural gas in the long term. As a result, fewer allowances will be necessary and CO\textsubscript{2} prices and thus electricity prices will decrease. This process will be strengthened, due to the introduction of CO\textsubscript{2} emissions pricing even in non-European countries. These interdependencies and increased efforts to either eliminate or store CO\textsubscript{2} will not lead to any meaningful structural changes in the merit order. We also conclude, that the climate-related political goals of the EU can be more effectively achieved by stimulating marketing strategies for renewable energies rather than through a complete fuel switch from coal to gas. Thus, hard coal power plants and combined cycle gas turbines (CCGT) will continue to coexist in the intermediate part of the merit order. As a result, gas power plants with their high level of flexibility will produce power mainly during peak demand hours. However, they will have an important role to play in the future. As insurers, they will adopt and aggregate quantitative and flexibility risks from technically and economically less flexible power plants as well as renewable energy providers.\footnote{In fact, due to their low flexibility and opportunity costs, they can offer operating reserve most efficiently.} Accordingly, they will be able to use earned insurance premia to recover their specific capacity costs. If expected earnings on this “capacity”-market are higher than expected earnings on the spot market, insurers will directly increase the security of supply.

4 Factors Influencing Gas Prices

4.1 Spot Market Prices and their Influencing Factors

Besides the development of oil prices, the main factors influencing short-term gas prices include the storage level, the short-term available transmission capacities and
weather conditions. 2007 was characterized on one hand by an oil price rally beginning in the middle of January 2007 and on the other hand by positive circumstances in the gas supply in spring.\textsuperscript{20}

Despite the dramatic reduction in production in Norwegian gas fields, the mild 2006-07 winter and the high storage levels exhibited bearish tendencies for gas prices. Between January 29 and 30, 2007, day-ahead quotes fell by 23.27\% on the Dutch TTF, and on February 15, 2007, they reached a temporary low point of 7.78 € per MWh. Because of the excellent supply infrastructure in Great Britain, the interconnector between Bacton, UK and Zeebrugge, Belgium intermittently fed gas through the so-called “forward flow” from the United Kingdom to Belgium. The new LNG harbor in Teesside, UK returned its first shipment ever back to the US because there was supposedly no market for the product in Europe at that time. Only increased demand in the power sector and the increasing oil prices contributed to the fact that gas prices never fell below the 7 € mark in spring 2007.

Following the May 1\textsuperscript{st} celebrations, German gas traders were confronted once again with rising prices, due to supply shortages in Great Britain. This resulted from maintenance and renovation issues, as well as an expansion in the second largest Norwegian gas field “Orman Lange”, which was initially scheduled to go online in fall 2007. The increase in price and volatility at the quarter change in the beginning of July can be explained by recurrent transportation disruptions in the CATS pipeline, which connects Great Britain to the North Sea gas producers. The increase was also partially due to the efforts of storage operators to thoroughly restock their gas supplies due to bullish information from the OTC forwards.

The unexpected crash in oil prices of approximately 12\% at the end of July tempered the gas price rally. Maintenance on the largest, well-stocked English gas storage

\textsuperscript{20}On January 18, the front month quotes for North Sea Brent crude oil briefly lay at a value of barely $51 per barrel. Drivers were also thrilled on the same day by gas station prices in Berlin of 1.159 € per liter for regular unleaded.
facility “Rough” and damage to several pipelines made it impossible to accept or re-route excess quantities. Consequently, gas prices on the TTF evened off at the rate of 14 €/MWh. The oil price rally,\textsuperscript{21} which finally began at the end of August, as well as temperature fluctuations, and above all inconsistent storage and production trends resulted in a tendency to price increases towards year-end and caused a highly volatile late fall.

### 4.2 Forward Market Prices and Influencing Factors

The majority of gas consumed in Germany is traded on the forward market. Besides OTC-forwards and take-or-pay contracts, which dominate the German market and are connected to oil and coal prices, gas futures are traded on the ICE in London, on the ENDEX in Amsterdam and on the EEX, with delivery to the British National Balancing Point (NBP), the Dutch Title Transfer Facility (TTF) and the German BEB and EGT market sectors. Contrary to electricity, simple arbitrage considera-

\textsuperscript{21}The front month contract for North Sea Brent crude oil climbed briefly from 68 € to 95 € per barrel.
tions show that the forward price is closely related to the short term (spot) price $S(t)$. Keeping in mind the cost of carry $u$, the interest rate $r$ as well as the constant availability (convenience yield) $y$, we get:\textsuperscript{22}

$$F(t, T) = S(t) \cdot e^{(r+u-y)(T-t)}$$

The information included in the price $S(t)$ for the short-term deliverable product primarily guides the futures prices in the form of the best available information at the moment, while this influence is negligible for electricity.

### 4.3 Correlation between Gas and Oil Prices

The relationship between wholesale market prices for oil and gas as discussed above is represented in Figure 3.

These figures are based on the front month futures traded on the ICE (virtually delivered to NBP), and on the North Sea Brent crude (virtually delivered to Sullom Voe, Scotland). It becomes clear that both prices only move parallel when the seasonal influences on gas demand are moderate and no extraordinary, supply-side interruptions arise. In the long-term trends of the last five years, these prices have developed similarly due to the possibility of mutual substitution and the related demand-induced dynamic. This last point becomes particularly clear when observing both prices from April 2007 to April 2008. But if the demand for gas increases because of an unexpected cold snap while reserves are low, then price spikes are bound to occur in the gas market - as in the power market. And this is exactly the constellation of events that occurred in the unusually cold winter of 2005-06. In the oil market, where storage is more cost-effective and only a small portion of the demanded quantities is consumed in the heating sector, these price movements do not occur.\textsuperscript{23}

\textsuperscript{22}See also Geman (2005), pp. 35-37.

\textsuperscript{23}For a detailed analysis of the relation between gas and oil prices, see Hartley et al. (2008).
Figure 3: Development of gas and oil prices since April 2003 (in €/MWh)*

* Source: https://www.theice.com/ and http://www.bafa.de/bafa/en/index.html. For a better comparability, oil prices have been converted from US-$/barrel to €/MWh. Thus, we detrended the oil price by US-Dollar-induced price movements such as the part of the oil price increase caused by the dollar decrease since early 2006. Similarly, the ICE-gas prices have been converted from UK-Pound/Therm to €/MWh.

Despite these various influencing factors in gas and oil pricing, the majority of the gas contracted in Germany is tied de facto to oil prices through the take-or-pay contracts described above. That can be illustrated through the tight correlation between the gas import prices at the German border, reported to the Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle), and the sliding average of oil prices over the preceding 7.5 months.\textsuperscript{24} This correlation

\textsuperscript{24}The gas prices released by the Federal Office for Economic and Export Affairs as a weighted, arithmetical monthly average have been interpolated based on cubic splines.
testifies to the dominance of take-or-pay contracts based on a connection between the gas purchase price and average oil price in a time frame ranging from three to six months and with time lags of one to three months. This also illustrates the temporary existing motivation for importers to limit the amount of gas purchased through take-or-pay contracts to the lowest level possible (for example, the first six months of 2007) and to acquire the rest of the gas from one of the more liquid trading points, which in the interest of producers must of course be contractually taken into account.

4.4 Outlook

In the future, the tendency for gas and oil prices to move parallel will continue to exist, if not even strengthen, due to the substitutability of the two products in heating and electricity markets. First of all, gas increasingly serves as an oil substitute in the transportation sector, and secondly, the amount of gas used in the heating market is approaching that of oil, due to a stiffer competition from alternative technologies in the heating market. For this reason, gas and oil price deviations will likely occur less often in the future. Additionally, the interdependency of the three continental markets in North America, Asia and Europe, which are today still quite distinct, will increase following a thorough expansion of the LNG (liquefied natural gas) infrastructure. Comparable to the oil market, significant price increases in one market in the future will lead to parallel price adjustments in intercontinental arbitrage trades.

In the short- and medium-term future, long-term take-or-pay contracts between gas producers and gas importers will still be signed in order to stabilize the development and transportation infrastructures. That holds, even if quantitative risks for importers increase due to more intense competition in the domestic market, and even if free network access lowers the specificity of investment projects and corre-
spondingly the threat of hold-ups for producers. Nevertheless, price clauses in these contracts will be linked not only to oil prices but also to the reference prices of liquid gas trading points in order to guarantee the absence of arbitrage. On the other hand, limitations on the contract duration set by the Federal Cartel Office will encourage more flexible, short-term contracts to replace long-term contracts between importers and distributors and tend to result in a more liquid spot market.

Network access based on a conversion from the contract-path model to the entry-exit model, as well as a decreased quantity of market sectors,²⁵ will increase the liquidity of the German Virtual Delivery Points (VDP). Besides this, if additional quantities of natural gas are released through the Gas Release Program, then the trade volume at the most liquid EGT trading point thus far could surpass the TTF volume in as little as two years. The dominance of OTC trading is anticipated in the long term to give way to EEX market trading, assuming spreads and transaction costs sink with increasing liquidity.

²⁵More precisely, the number of market sectors decrease from currently 14 to 8 from October 2008 onwards.
References


