An Empirical Analysis of the Spanish Gas Price Structure

Abstract We can say without hesitation that in energy markets a throughout data analysis is crucial when designing sophisticated models that are able to capture most of the critical market drivers. In this study we will attempt to investigate into Spanish natural gas prices structure to improve understanding of the role they play in the determination of electricity prices and decide in the future about price modelling aspects. To further understand the potential for modelling, this study will focus on the nature and characteristics of the different gas price data available. The fact that the existing gas market in Spain does not incorporate enough liquidity of trade makes it even more critical to analyze in detail available gas price data information that in the end will provide relevant information to understand how electricity prices are affected by natural gas markets. In this sense representative Spanish gas prices are typically difficult to explore given the fact that there is not a transparent gas market yet and all the gas imported in the country is negotiated and purchased by private companies at confidential terms.

Keywords: Natural Gas, Gas Price, Oil Indexation, CCGT, Spark Spread.

1 Introduction

Probably the most visible link between gas and electricity prices is found when analyzing operations by gas-fired power generation plants (CCGTs). In this respect, for a CCGT the decision to generate electricity or not, will depend on the 'spark spread', i.e. the difference between the cost of gas generating an extra MWh of electricity and the revenue obtained from the sale of electricity at the System Marginal Price (SMP). As we said, the report aims primarily to provide a

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detailed analysis of the available gas price references to understand and quantify the essential features applying to the Spanish gas and electricity markets

2 Gas Pricing Fundamentals in Spain.

Perhaps the most crucial factor having a strong influence on the existing long term contract gas prices in Spain, is the fact that the majority of those gas contracts prices are determined by a formula referenced to oil and oil products evolution. Moreover long term contracts are confidential by nature and therefore a precise determination of wholesale gas prices is opaque. Not only are most contracts confidential, but contracts are often limited to two or three years in length, and have been struck at very different prices over time. As a result the 'average' gas price normally quoted as a reference is often significantly different from the current contracts available in the market.

Additionally to the long-term purchasing strategy, Spanish traders actively seek short term optimization opportunities which bring incoming gas of another nature, named spot LNG. This opportunistic gas supply is normally priced with reference to other benchmarks different from oil and oil products like National Balancing Point (NBP), Transfer and Title Facility (TTF) or even to the recently devised LNG spot indices.

Although a detailed analysis of Spanish natural gas price influencing factors is far from the scope of this report, we will analyse those gas price formation drivers through the resulting price structure. Furthermore this will help us to better understand which would be the best option to analyze potential for forecasting gas and electricity prices in the future.

The fact that gas coming into Spain is generally delivered through long-term agreements, this structure covering at least 94% of the total expected annual demand as of 2011 according to the Comisión Nacional de la Energía (CNE), creates a solid framework to assess the Spanish gas price contracting structure. Moreover a high proportion of these contracts use Brent oil and oil products as base price reference for buyers and sellers.

It has to be said that, establishing a reference for end-user gas prices is also difficult. In the first place, the liberalization process in the gas market has significantly widened up the range of gas suppliers in the country adding a certain variety of gas price formulas and price levels. Furthermore the traditional regulated, i.e. fixed price reference applicable to specific customers is today only a residual share of the total gas market, i.e. the Last Resort Tariff (LRT) scheme for small customers that sets a price benchmark only relative to the actual volumes sold in that segment, around 20% of total volumes sold. Nonetheless the Ministry´s procedures to establish a transparent LRT price formation scheme has helped substantially to determine fundamentals of imported price, as we will see.

3 Gas Price Data Available in Spain

In order to perform the analysis, we have examined the main information published ready available in Spain for wholesale gas prices, of which perhaps the most relevant today is that collected by the CNE, directly processed from imported gas price data by origin from Agencia Tributaria (AEAT) in www.AEAT.es, similar to the information that AEAT provides to all Spanish Cámaras de Comercio and that is available through the Comercio Exterior Data Base in http://aduanas.camaras.org/ web site. We will nominate this reference as CNE_AT gas price.

As the second gas price reference for Spanish import prices we will select the base price benchmark described in the Last Resort Tariff (LRT) calculation methodology developed by the Ministry of Industry in 2008 with the intention to reflect existing long term contract prices into Spain for LRT calculation purposes. The benefit of this price reference is that it gives in our view a very accurate representation of larger import volumes prices into Spain but also of expected oil-indexed average price trends in the future, at least for the next four or five years. In this sense we anticipate a significant alignment between the current cost of long-term supplies into Spain (as per the CNE_AT gas price) and the LRT base price.

It has to be said that additionally, the LRT Ministry´s calculation weights this long term base gas price with gas prices resulting from regular auctions and also with a percentage of NBP and Henry Hub (HH) prices. The introduction of external price benchmarks into the resulting price formula had initially the intention to take into account regular LNG spot purchases by traders at a liquid hub price. The actual weighting determined by the Ministry is in our opinion somehow misleading as it does not consider that liquid markets, like NBP and HH do also structurally fluctuate according to medium term supply/demand conditions. At this point in time and with the depressing effect of shale gas production significantly lowering HH index, we understand that a resulting weighted average of 80% LRT price and 20% NBP price to construct a final LRT proxy price is more realistic. This will be our second gas price reference.

Finally and in order to complete the picture we have also considered in the analysis the NBP price benchmark to reflect trends and seasonality of global LNG spot prices as a whole affecting Spanish traders price expectations under the current market conditions.

4 Distribution Function of Spanish natural gas prices.

4.1 Objective

The objective in this section will be to understand the statistical properties of typical long term gas price benchmarks in Spain to prepare for an ulterior analysis of effects into electricity prices formation. We start with an analysis of almost eight years history (01/01/2004-01/07/2012) with price details on a monthly basis by the different benchmarks, i.e. CNE_AT, LRT proxy and NBP to set up the picture of wholesale gas price formation in Spain.

The main objective of the analysis will be to conclude on the distribution patterns of the different gas price data as an essential starting point for building up gas price factors into stochastic models to determine electricity prices in the future. Modelling techniques, model testing and acceptance and finding the right parameters all depend in great extent on the choice of the relevant distribution. Although there is a vast amount work devoted to empirical analysis of the properties of gas price distributions in different markets, the Spanish gas market situation under the rules of oil-indexed contracts, make the analysis of price distributions a very challenging task.

Although the opening of the gas market in Spain is prior to 2004, we will consider that a relative more stable picture for trading activities is starting around 2003 and 2004. We will try in the first place to test the hypothesis that log-returns of these values are normally distributed. We will follow the traditional methodology in finance, in particular the Black–Scholes model, that considers changes in the logarithm of energy price indices are assumed normal (these variables behave like compound interest, not like simple interest, and so are multiplicative.

4.2 Statistical Properties of Spanish Natural Gas Prices

As discussed, we will start by analyzing the statistical properties of the data referred in previous sections that will allow us to examine the dynamics of the long term gas price series. At a later stage we will present a model taking into account previous observations in order to extract as much as possible significant characteristics of the data. We anticipate that general work done on modelling crude oil and their volatile will be essential for modelling identification and model selection.
In order to assure that there is not trend component and data are stationary to some extent, we will analyze dynamics of returns series rather than price series themselves. We will calculate for each of the price references log returns as a sequence of prices S1 as defined by the continuous compounding basis:

$$X_i = \ln(1 + R_t) = \ln\frac{P_{i+1}}{P_i}$$

Here $P_t$denotes the price of natural gas at time t. In this way we will smooth out existing trends, i.e., those arising from crude oil price evolution. Furthermore it will allow us to test the hypothesis that log-returns of these values are normally distributed in a more convenient form.

Figure 1 presents the history of the gas price benchmarks considered and Figure 2 returns of LRT Proxy and NBP from January 2004 until July 2012.

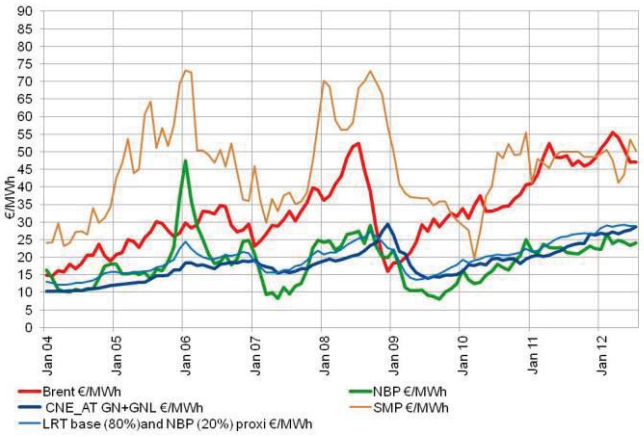


Fig. 1 Evolution of different gas price benchmarks and electricity prices since 2004

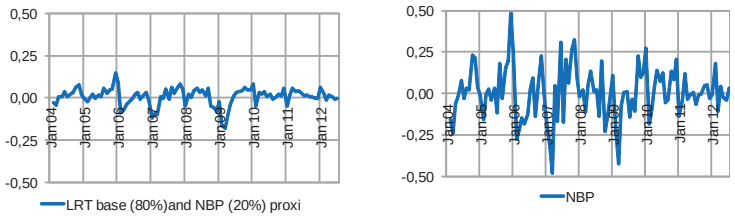
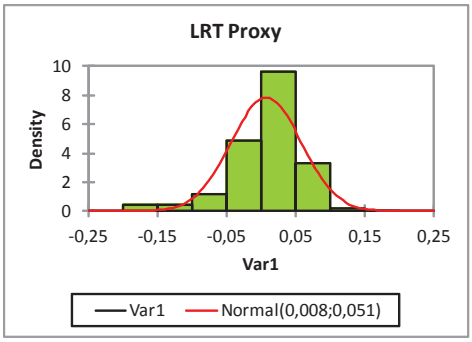


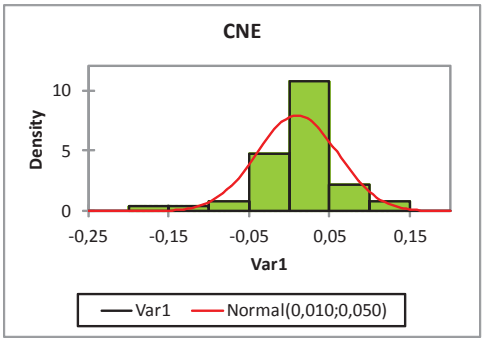
Fig. 2 Evolution of returns from LRT proxy and NBP since 2004

The behaviour of prices and returns in the case of the LRT proxy is unsteady and although volatility is low compared to that of NBP, there is some evidence of volatility clustering, i.e. periods of high volatility followed by periods of relatively low volatility, what seems to be in line with typical crude oil returns characteristics.

Figure 3 shows the resulting histogram of long term gas price benchmarks log-returns. In the tables attached we can see the statistical parameters determining each function characteristics.



Number Observations	101
Minimum	-0,180
Maximum	0,145
First Quartile	-0,007
Median	0,015
Third Quartile	0,037
Average	0,008
Variance (n-1)	0,003
Standard Deviation (n-1)	0,051
Skewness (Pearson)	-1,084
Kurtosis (Pearson)	2,321



Number Observations	101
Minimum	-0,189
Maximum	0,122
First Quartile	-0,007
Median	0,016
Third Quartile	0,031
Average	0,010
Variance (n-1)	0,003
Standard Deviation (n-1)	0,051
Skewness (Pearson)	-1,076
Kurtosis (Pearson)	3,486

Fig 3 Distribution functions of log-returns for LRT proxy and CNE data.

- *Kurtosis* is greater than 3 for CNE price and around 2.5 for LRT Proxy, thus density functions are characterized by the fatness of their tails comparing to the density of the Gaussian distribution N(0,1) As it can be seen higher kurtosis distribution have a sharper peak around the mean and longer, fatter tails, while a low kurtosis distribution has a more rounded peak and shorter, thinner tails. For Normal distributions excess kurtosis is cero. We can also say that this is an indication of infrequent extreme deviations, as opposed to frequent modestly sized deviations.
- *Coefficient of skewness* is negative for prices of CNE and LRT Proxy indicating that there is an asymmetry of the probability distribution, namely data are left skewed, i.e. left tail is longer and the mass of the distribution is concentrated on the right of the figure an indication that the market gives higher probability to decreases than to increases in prices.

4.3 Test of Normality

In order to have a clearer picture of the nature of current distribution functions of gas prices in Spain we will use a formal test of normality to provide the foundation to accept o reject the normality distribution of the various functions being analyzed. This material will be used to better assess hypothesis embedded into energy models.

To do this, we will be using the frequently used Jarque-Bera (JB) test as it is possibly the most powerful test when a large number of observations is given.
The JB test uses the following statistic:

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$$

Where S and K are skewness and kurtosis respectively, i.e. the third and fourth moments of the variance. For normal distributions S= 0 and K=3 and hence JB=0. If the JB statistic is sufficiently large, i.e. greater than 6 at 5% significance level, the null hypothesis is rejected.
The test interpretation is as follows:

- *H0***:** The variable distribution from which the sample was taken, follows a Normal distribution.
- *H1***:** The variable distribution from which the sample was taken, does not follow a Normal distribution.

As for both CNE_AT and LRT distributions the p value is higher than the one at significance level of alpha=0.05, then the null hypothesis H0 needs to be rejected and H1 accepted.

The results for CNE_AT, LRT proxy, NBP and SMP are shown below.

Table 1 Jarque-Bera test of normality.

LRT	
JB (Observed value)	42,446
JB (Critical value)	5,991
GDL	2
p-valor	< 0,0001
alfa	0,05

CNE	
JB (Observed value)	70,607
JB (Critical value)	5,991
GDL	2
p-valor	< 0,0001
alfa	0,05

NBP	
JB (Observed value)	3,157
JB (Critical value)	5,991
GDL	2
p-valor	0,206
alfa	0,05

SMP	
JB (Observed value)	0,514
JB (Critical value)	5,991
GDL	2
p-valor	0,773
alfa	0,05

In view of the results and as expected, we can conclude that both oil-indexed distributions, i.e. LRT proxy and CNE, cannot be regarded as Normal distribu-

tions. Interestingly, both the NBP gas price distribution and the SMP function can be accepted as following a Normal distribution reflecting a more variable pattern typical from true liberalized and liquid markets.

This reveals in our understanding that although the oil-gas price link is possibly the main determinant of electricity prices in Spain, its aggregated distribution function is far from normal and therefore assuming normality for further price modelling would be wrong. This is a result to be expected somehow as the process of oil-indexed gas price formation is determined by a rigid set of oil and oil products linked formulas with little room for 'gas market driven' price variations. It has to be noted that on the contrary, NBP prices do reflect much better the true fundamentals of a very liquid and deep gas market in which oil-indexed gas contracts do not have until now a significant effect on resulting hub prices. Unfortunately NBP price benchmark is not really a good proxy for the Spanish wholesale price.

From this analysis it is also interesting to point out that the rigid structure of oil-indexed gas contracts in Spain, as per analysis of LRT and CNE distributions, show that there seems to be very little impact of liquid hub prices into the formal Spanish gas price formation mechanisms. This result should be expected in a context of last years' low demand and structural oversupply conditions of Spanish traders.

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