European power | coupling between Natural Gas and Electricity markets

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Introduction

With this paper we would like to analyse what we call “coupling” of the energy markets. It should be observed that the word “coupling” is not related to the country-to-country convergence of a given energy market, but rather the links of different markets (e.g. power, gas) over an identical geographical region.

One could ask what is the motivation behind such research. First and foremost, it is observed that – historically – phases of strong coupling have been followed by periods characterised by weak links. This is not a surprise, as the markets are very dynamic entities which respond, in a similar fashion, to dynamic drivers. Strongly coupled markets are more typically associated with clear and persistent fundamental drivers, whose forcing is capable of setting strong price trends. Conversely, periods characterised by loose markets are more likely to be dominated by noise (i.e. chaotic moves dictated by either weak fundamentals and / or by simple market rumours).

More recently, we witnessed one of the most interesting times for the continental energy markets, whereby power, natural gas and (to some extent) even thermal coal have been moving in phase with each other. In an attempt to investigate the causes of such a behaviour, we will extend our analysis backwards in time and consider other periods as well. We are not simply interested in identifying coupled markets phases, but also – if possible – to isolate which, among the different commodities, dictated the move.

Methodology

In order to do so, we will employ a cross-correlation technique, which can successfully highlight the causality between different time-series, such as market prices. This methodology simply calculates a
running correlation. For each time-step, in conjunction with the coincidental correlation (i.e. at lag-0), the lead / lag values are also derived. The resulting cross-correlation function is displayed as per Figure 1, which shows an example from the power-gas coupling (Germany Baseload front month vs. TTF front month).

The two curves refer to two different quarters in 2011. Let us focus first on the cyan curve. The coincidental correlation is always at lag-0. Negative lags indicate the electricity price is leading TTF. Conversely, positive lags indicate European gas is leading instead. In this particular example, the function’s maximum is at +1 day – this means that, for that particular quarter, electricity prices followed (on average) the European gas with a day lag.

The red curve exhibits a different shape. The peak is roughly around day-0, which means the two price moved in unison. This is a typical behaviour – it is in fact very likely the two markets will react with lags in the range of intra-day frequencies. How can one extrapolate their causality? This is done by looking at the memory of the cross-correlation function. In other words, the steepness of the descending branches are taken into account. In this example, it

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Figure 1. Source: EEX, EDX-ICE, Marex Spectron Research
is observed the red curve decreases more quickly on positive lags. This asymmetry is what we are after – if it is skewed towards negative lags (as in the example), then the electricity price is more likely to impose any given trend on TTF. If, conversely, the asymmetry leans towards positive lags, the opposite applies.

**Results | when TTF leads**

In the following sections, we analyse the markets coupling taking into account different years – we will see that the associated behaviour was very different and likely caused by the diverse balance of the underlying fundamentals. A final section will be dedicated to the overall analysis, which includes eight years of data (from 2009 till present).

**When TTF leads - 2010**

The cross-correlation [C-C] values of the four quarters in 2010 are illustrated in Figure 2. This was a year characterised by a relatively strong coupling (if we exclude Q3). Among all quarters, Q4 was the most peculiar – the C-C function exhibits the highest values for positive lags, while it drops on its left-hand side. This indicates TTF had the leading power during the end of 2010. This is also highlighted in the bottom panel of Figure 2, which shows the mean spread between negative and positive lags of the C-C function. Such a spread is then normalised against the coincidental correlation of that specific quarter. For example, the -33% bar in Q4 2010 indicates the asymmetry of the C-C function was (in absolute terms) a third
of its lag-0 correlation.

What happened in Q4 2010? The most important single factor, which affected not only gas, but the entire energy sector in Europe, was the cold weather. October and, in particular, December 2010, were very cold months. This clearly helped foster demand for heating. Moreover, storage levels ahead of the cold season were far short of being fully replenished. By the end of 2010 some of the storage sites were well below their long-term mean. This combination clearly made the gas price very sensitive to the S&D balance.

**When TTF leads - 2014**

Unlike in 2010, the coupling between the electricity and gas market was less volatile, with coincidental correlation values very much in line with each other throughout the different quarters (top panel in Figure 3). The spreads in the bottom panel of Figure 3 is what makes 2014 a unique year. All four quarters (more specifically, Q1 and Q4) were associated with negative values, which tells TTF led the electricity market for the entire year.

Readers are likely to recall that 2014 was characterised by the Ukrainian crisis, which had substantial impacts on all commodity markets in Europe. Geopolitical factors were crucial and heavily affected the fundamentals of the gas market (Russia cut off a significant portion of its gas exports towards Europe). This in turn dictated the trends of other European energy markets.
Results | When Electricity Leads

When electricity leads - 2009

Coincidental correlations greatly varied in 2009 – they went from 0.15 in Q2 to 0.54 in Q4. The associated spreads in the bottom panel of Figure 4 indicate that Q2 and Q4 held the largest asymmetries. Gas led electricity in Q2 (negative asymmetry), however the large spread (a 50% in absolute terms) is clearly inflated by the correspondent weak coupling. Conversely, the +35% spread observed in Q4 2009 was normalised against a much stronger market convergence (see the grey line in Figure 4, top panel).

Similar to 2010, cold weather outbreaks affected most European countries. However, unlike 2010, electricity prices imposed the price tendency. The main difference can probably be ascribed to the inventory levels, which were much higher than in 2010. Gas was therefore less sensitive to the demand surges. It should also be observed that both 2009 and 2010 were associated with unseasonably low westerly winds. This clearly exacerbates the bullish trend when a given cold snap is in place: the increase in demand is in fact accompanied by a significant tightness in renewable power generation – this is a “perfect scenario” for a bullish development and typically increases the sensitivity of the electricity price to the S&D balance.
When electricity leads - 2016

The C-C functions in 2016 (Figure 5) exhibited a standard shape – the peak for all quarters was always at day-0. In other words, the quarters exhibited correlations greater than 0.4. The associated spread (bottom panel of Figure 5) indicate that Q3 and Q4 were skewed towards negative lags, i.e. electricity was imposing the price trend.

Q3 and Q4 were dominated by the forced unplanned outages of the French nuclear reactors. The persistent cuts in electricity led to a prolonged undersupply phase. As the situation grew, unresolved, the forthcoming winter season and the associated fears of abrupt demand surges made the electricity prices fly. Gas followed. Interestingly, the winter season did not produce any significant cold outbreak until January 2017. The aforementioned price tendency was therefore mainly dictated by supply-related forcings.
Results | Overall Analysis

Seasonal dependence

With eight plus years of data in our hands, a more general analysis on the electricity / gas market coupling can be attempted. Figure 6 shows the average values of the C-C function as a function of the four different quarters. The results have been split by lag shifts – the coincidental correlation is in black, while the other lags are shown in different colours.

Unsurprisingly, the lag-0 correlation is the strongest, which confirms once again the two contracts tend to move in phase with each other. The warm quarters (i.e. Q2 & Q3) exhibit the weakest C-C values. Once again, this does not come as a surprise: the electricity-gas coupling is expected to be the strongest during the cold months, when demand is at its peak. The coloured lines (i.e. lead-lag domain) roughly follow the above seasonal dependence. However, there appears a clear asymmetry when comparing the solid vs. dashed lines. For example, the solid line is consistently above its dashed counterpart in Q1, regardless of the chosen lag. This simply means the C-C curve – during Q1 – is overall skewed towards its left-hand side, i.e. electricity leads gas.

In order to extend the above finding to all lags and quarters, we created Figure 7. There we show the spread between the solid and dashed lines of Figure 6, as a function of quarters (along the x-axis) and lags (the different bars). Such a spread has been subsequently normalised against the respective C-C value. A nice picture emerges, whereby all quarters but Q2 are

![Figure 6. Source: EEX, EDX-ICE, Marex Spectron Research](image)
associated with positive percentages. This means that, on average, electricity is likely to impose the price trend on gas for most of the year. Interestingly, the signal is consistent throughout all lags – only Q4 exhibits a significant volatility across different lags.

The above findings can be satisfactorily explained via an S&D analysis. The cold quarters (Q1 & Q4) are very sensitive to demand movements (i.e. cold snaps), but they also depend to a large extent on supply volatility (e.g. wind). Both factors play a major role in determining the electricity S&D balance and likely shape its price development. Unlike power, gas supply is not that dependent on the weather variability. Unless large unplanned outages occur (see for example page 5 which illustrated the 2014 case), the dominant factor remains the supply / demand balance dictated by the weather changes, which makes gas a “slave to power”. To some extent, this is also valid in summer (Q3), when electricity demand (and supply too) is very much sensitive to heat-waves events.

More generally, it is stressed that – among the two – electricity is the final product. This places it in a natural leading position as its sensitivity to prices is overall higher. Q2 is the only exception, whereby gas supply consistently plays the major role in setting price trends.
Conclusions

The results of this white paper shed some light on the European energy markets convergence. By employing a simple statistical technique, we extrapolated strong and weak coupling phases between the electricity and gas markets. Moreover, we have successfully isolated, for each of these phases, which of the two was imposing the price tendency.

Our analysis highlighted a few important points, which we summarise as follows:

1. When in phase, the two markets generally move in unison on a daily frequency (this is illustrated in Figure 6, which shows the coincidental correlation is always the strongest).

2. Despite what is shown in point (1), one can still be able to derive which of the two market is imposing the given bearish / bullish trend. This is calculated via the asymmetry of the C-C function, which, statistically speaking, is associated with the memory of the function itself.

3. According to our definition, positive asymmetries (or spreads) in the shape of the C-C curve are associated with electricity leading gas (and vice-versa). In our analysis, we found out that, apart from Q2, electricity always tends to lead gas. We speculate that this is down to two main reasons. Firstly, the high sensitivity this market holds on weather-driven fundamentals. This is even more valid in quarters when demand plays a dominant role in driving the S&D balance, i.e. Q4 / Q1 and, to some extent, even Q3. Secondly, and more generally, because electricity is the final product and as such it tends to take the lead over the underlying energy mix sources (e.g. gas).

4. Q2 is fundamentally different, not just because it depends to a greater extent on supply, but also because supply trends are not set primarily by weather factors. As Q2 is associated with the beginning of the restocking cycle, inventory-related approaches such as the convenience yield theory can explain more effectively the price movements. It is therefore obvious that in Q2 gas is more likely to impose the price trend on electricity.

5. The above findings must also be read in accordance with the specific seasonal signal. Both supply and demand can exhibit strong deviations from the “average behaviour” as they may be influenced by isolated yet strong drivers (such as the Ukrainian crisis in 2014, see page 5).
References


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The author of the paper, Giacomo Masato is Marex Spectron’s meteorologist. He joined the Group in July 2015 having previously worked as a research scientist focused on dynamical meteorology and the general circulation at the mid-latitudes. Giacomo holds a PhD in Meteorology obtained at the University of Reading, supervised by Sir Brian Hoskins.

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