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How will the price of carbon impact on power and gas prices?

Summary

• CO_2 is a true variable cost with direct impact on power prices

In a functioning wholesale power market, power prices depend on the 'variable' costs of the marginal technology. We see CO_2 as one of the 4 main costs/drivers of European power prices. CO_2-price changes tend to be immediately reflected in power prices, but due to hedging, fuel price increases are priced in more gradually.

• Quantification: c25% of current power price due to ETS

We estimate that for central European markets, every €1/t of CO_2 results in an additional €0.74/MWh on the power price. This relationship is muted though in monopolistic power markets. The full cost of CO_2 is reflected in the power price, thus free allocations affect only long term power prices and new entrant costs.

• Other impacts: Higher power price volatility and required reserve margins

In our view, EU ETS CO_2 prices are dependent on moves in coal and gas prices; pricing CO_2 into the power price amplifies such moves as well as adding exposure to the growing global emissions market. Rising CO_2 costs have encouraged the move towards clean but intermittent power (eg wind) and could mean increased volatility in the power price along with a need for a much wider reserve margin.

• Gas: Higher gas demand feeds back to higher power prices

We see CO_2 prices indirectly impacting gas prices by creating higher EU demand for gas as a clean alternative to coal. Sustained higher coal prices and rising gas costs could both encourage a higher CO_2-price outlook and upside to power prices.

Drivers of European power and gas prices

In a functioning wholesale power market, power prices are determined by the 'avoidable', or 'variable', costs for the marginal technology, which in Europe tends to be either coal or gas. Power generators are prepared to produce as long as the price allows some recovery of their fixed costs. What costs are considered as 'variable' depends on the time horizon being considered; in the short term (days or months) only fuel and carbon costs are variable; in the medium term (one year or more) you could include personnel, operational and maintenance costs; in the long term (over the investment cycle: 10-20 years) capital costs can also be considered as variable.

With this in mind we determine four main drivers of power prices: coal, gas (in turn largely driven by oil prices), CO_2 and in the long term, capital costs.

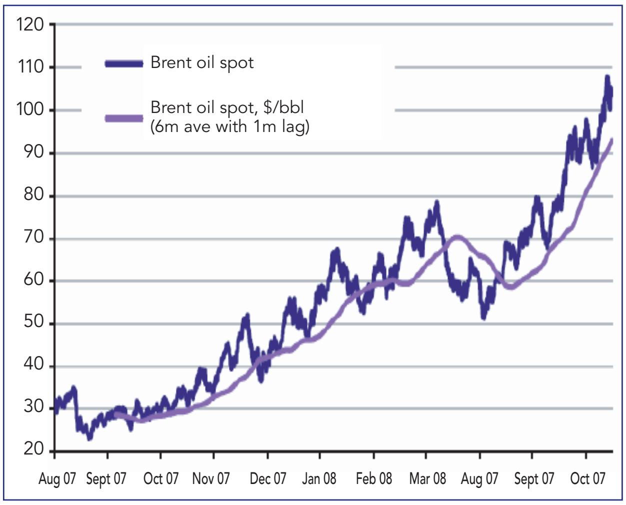
• Coal: Coal prices into Europe have doubled from \$70/t to \$140/t over the last year on the back of rapidly increasing coal demand in Asia, and in particular in China. We expect the higher coal costs to be sustained **(see Figure 1).**

Figure 1 – CIF ARA front month steam coal price (USD/t)

Source: Bloomberg (CIF = Cost insurance Freight, ARA = Amsterdam – Rotterdam – Antwerp)

• Gas: European gas prices are linked to oil **(See Figure 2)** but with a 3-6 month lag. We calculate that the current gas price (c.56p/th) corresponds to \$93/bbl oil and it thus looks likely that gas prices will go up in the near term.

Figure 2 – Brent spot oil and reference oil price used for gas border prices



Source: Bloomberg UBSe (The common formula used for Continental European border pricing is to use the rolling average of the last 6 months oil price with an additional one month lag.)

• **CO_2:** The power sector accounts for around 2/3 of the emissions covered by the EU ETS. We believe it makes sense that CO_2 prices should trade at a level indicative of their worth to the power sector. Thus we expect the CO_2 price to be set by the costs of emissions abatement via coal to gas fuel switching, which for a majority of power generators is the cheapest and most available method of reducing emissions.

The table below **(Figure 3)** shows our estimated fuel switching costs for different coal and gas prices. When reading the table it should be noted that:

• The prices in the table are prices delivered at plant. This means that for coal around $10-20/t should be added relative to the ARA-price in order to estimate the coal price. For gas, add a final transmission cost of 1-2p/th.

• We think that year-forward fuel prices are most relevant for Phase 2 and Q1/Q4 winter prices are most relevant for Phase 3 due to the much larger emissions reduction required in Phase 3.

– For Phase 2 we estimate that 40-50% of the fuel switching potential needs to be activated thus looking at an annual average should be relevant

– For Phase 3 fuel switching will also be required during the high demand winter season leading to higher required CO_2 prices

In the table we have light shaded the relevant area for Phase 2 and dark shaded the area we think is relevant for Phase 3.

• **Capital costs:** Costs for power generation equipment have increased by 30-50% over the last 3-4 years as a consequence of higher raw material costs (mainly quality steel) and fuller order books. We estimate construction costs of €700/kW for CCGT, €1500/kW for coal, €1300-1350/kW for wind and €2500/kW for nuclear.

Figure 3 – EU ETS CO_2 equilibrium prices (€/t)

coal price ($/t) \ gas price (p/th)	40	42.5	45	47.5	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75	77.5	80
40	41.8	45.4	49.0	52.5	56.1	59.7	63.3	66.9	70.5	74.1	77.7	81.2	84.8	88.4	92.0	95.6	99.2
45	39.4	43.0	46.6	50.1	53.7	57.3	60.9	64.5	68.1	71.7	75.3	78.9	82.4	86.0	89.6	93.2	96.8
50	37.0	40.6	44.2	47.8	51.3	54.9	58.5	62.1	65.7	69.3	72.9	76.5	80.1	83.6	87.2	90.8	94.4
55	34.6	38.2	41.8	45.4	48.9	52.5	56.1	59.7	63.3	66.9	70.5	74.1	77.7	81.2	84.8	88.4	92.0
60	32.2	35.8	39.4	43.0	46.6	50.1	53.7	57.3	60.9	64.5	68.1	71.7	75.3	78.9	82.4	86.0	89.6
65	29.8	33.4	37.0	40.6	44.2	47.8	51.3	54.9	58.5	62.1	65.7	69.3	72.9	76.5	80.1	83.6	87.2
70	27.4	31.0	34.6	38.2	41.8	45.4	48.9	52.5	56.1	59.7	63.3	66.9	70.5	74.1	77.7	81.2	84.8
75	25.0	28.6	32.2	35.8	39.4	43.0	46.6	50.1	53.7	57.3	60.9	64.5	68.1	71.7	75.3	78.9	82.4
80	22.6	26.2	29.8	33.4	37.0	40.6	44.2	47.8	51.3	54.9	58.5	62.1	65.7	69.3	72.9	76.5	80.1
85	20.2	23.8	27.4	31.0	34.6	38.2	41.8	45.4	48.9	52.5	56.1	59.7	63.3	66.9	70.5	74.1	77.7
90	17.8	21.4	25.0	28.6	32.2	35.8	39.4	43.0	46.6	50.1	53.7	57.3	60.9	64.5	68.1	71.7	75.3
95	15.4	19.0	22.6	26.2	29.8	33.4	37.0	40.6	44.2	47.7	51.3	54.9	58.5	62.1	65.7	69.3	72.9
100	13.1	16.6	20.2	23.8	27.4	31.0	34.6	38.2	41.8	45.4	48.9	52.5	56.1	59.7	63.3	66.9	70.5
105	10.7	14.3	17.8	21.4	25.0	28.6	32.2	35.8	39.4	43.0	46.6	50.1	53.7	57.3	60.9	64.5	68.1
110	8.3	11.9	15.4	19.0	22.6	26.2	29.8	33.4	37.0	40.6	44.2	47.7	51.3	54.9	58.5	62.1	65.7
115	5.9	9.5	13.1	16.6	20.2	23.8	27.4	31.0	34.6	38.2	41.8	45.4	48.9	52.5	56.1	59.7	63.3
120	3.5	7.1	10.7	14.3	17.8	21.4	25.0	28.6	32.2	35.8	39.4	43.0	46.6	50.1	53.7	57.3	60.9
125	1.1	4.7	8.3	11.9	15.4	19.0	22.6	26.2	29.8	33.4	37.0	40.6	44.2	47.7	51.3	54.9	58.5
130	-1.3	2.3	5.9	9.5	13.1	16.6	20.2	23.8	27.4	31.0	34.6	38.2	41.8	45.4	48.9	52.5	56.1
135	-3.7	-0.1	3.5	7.1	10.7	14.3	17.8	21.4	25.0	28.6	32.2	35.8	39.4	43.0	46.5	50.1	53.7
140	-6.1	-2.5	1.1	4.7	8.3	11.9	15.4	19.0	22.6	26.2	29.8	33.4	37.0	40.6	44.2	47.7	51.3
145	-8.5	-4.9	-1.3	2.3	5.9	9.5	13.1	16.6	20.2	23.8	27.4	31.0	34.6	38.2	41.8	45.4	48.9
150	-10.9	-7.3	-3.7	-0.1	3.5	7.1	10.7	14.2	17.8	21.4	25.0	28.6	32.2	35.8	39.4	43.0	46.5

Source: UBSe25

• **Also Supply/Demand balance:** Central Europe and the Nordic region have low and shrinking reserve margins; this situation encourages higher power prices and can create additional volatility and spiking in the power price.

Direct impact of CO_2 prices on the power price

Installations covered by the EU Emissions Trading Scheme must provide CO_2 permits for every tonne of CO_2 they emit. Power generators pass on the additional costs of these permits to consumers in the form of raised power prices. As such, and as an identified driver of the power price, CO_2 prices directly affect both spot and forward electricity prices.

The cost of CO_2 internalised in the power price depends per region on the fuel mix of that region. We estimate that as an average for central European markets, every €1 paid per tonne of CO_2 results in an additional €0.74/MWh on the power price. Our estimates for the Central European region are shown in **Figure 4** below.

Figure 4 – Emissions estimates for the Central European power market*

Time at margin	Time at margin	Emissions (kg/Mwh)	Marginal emission (kg/MWh)
Lignite	5%	1,200	60
Coal (low efficiency)	30%	950	285
Coal (higher efficiency)	25%	840	210
Gas (CCGT)	25%	375	94
Nuclear	5%	0	0
Oil/GT	10%	950	95
Gas	0%	550	0
Total	**100%**		**744**

Source: UBSe *Indicates France, Germany, Belgium, Austria, Switzerland and the Netherlands (Marginal emissions = time at margin x emissions kg/MWh)

Linking between CO_2 and power prices clear to see

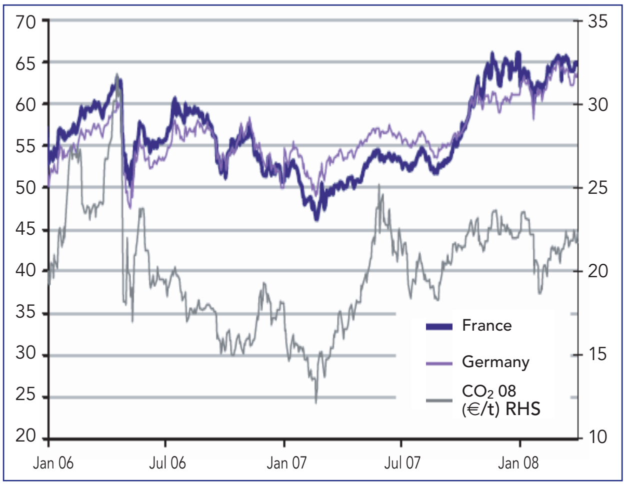
The impact of changes in CO_2 price on the power price is clear to see. **Figure 5** clearly shows the drop in CO_2 prices after the crash in Phase 1 allowance prices in 2006 and the resultant fall in power prices.

CO_2-price changes tend to be immediately reflected in power prices (a true variable cost) whereas power prices reflect more the actual procurement costs of fuel i.e. including the hedging impact. So in our view, the CO_2-price has already adjusted to the higher coal prices (having a negative impact on power price) whereas the positive impact from higher coal prices will come more gradually in the power price.

Limited impact in the case of a monopolistic power market

This relationship is true in open and competitive wholesale power markets, in markets that are subject to a monopoly or oligopoly power the relationship is likely to be distorted. A such, we believe that movements in the carbon price may have a more muted impact on Greek or Italian power prices but that they are already

Figure 5 – Baseload power, year forward (€/MWh) and 2008 CO_2 price (€/t)



Source: Bloomberg

reflected in other European electricity markets, which we deem to be largely efficient.

Free allocation of CO_2 permits only a consideration in the long term

The full cost of CO_2 per tonne of emissions is reflected in the power price and thus, the level of free allocations awarded to a power generator is irrelevant regarding short- to medium-term effects on the power price. Free allocations, or more importantly lack of them, are only really a consideration in the long term (10-15 years) in the sense that the additional costs of CO_2 affects new entrant costs and therefore the long term power price needed to stimulate investment. It is likely that these long term effects also assume that the new entrant will not be subject to the high penalty charges (€100/t in Phase 2) if they are not able to provide sufficient permits to cover their allocations.

CO_2 also increases power price volatility

CO_2 prices directly impact the power price; movements in the power price reflect moves in the CO_2 price as it is a true variable and easily measurable cost. We believe that CO_2 prices have an indirect impact on the gas price, which is difficult to quantify as the impact is largely resultant of the increased demand for gas caused by the existence of a significant CO_2 price. Moves in the gas price however can have a direct impact on both CO_2 prices and on power prices. In our view, not only does CO_2 directly impact the level of the power price but it also increases its volatility and risk.

Pricing CO_2 into power amplifies moves in coal and gas prices

We believe that CO_2 prices should be set at a level that at least reflects coal-to gas fuel switching cost equilibrium **(see Figure 3 on page 26).** Using this methodology the CO_2 price is dependent on the relative moves in coal and gas prices; pricing CO_2 into the power price therefore amplifies these moves, which also have their own direct impacts on the power price.

CO_2 prices indirectly enhance power price risk

The need for emissions reductions, encouraged by increasing costs of CO_2 emissions, has seen an increasing interest in the renewable and 'clean' power production technologies. A move towards power production that although clean, can be intermittent (for example wind power) could mean that we see increased volatility in the power price along with a need for a much wider reserve margin. The European CO_2 permit, the EUA, is part of a growing global emissions trading market. As such it is conceivable that European power prices, through CO_2 prices, could suffer additional risk through exposure to global emissions prices.

CO_2 abatement creates higher demand for gas

In contrast to its effects on the power price, the CO_2 price has little direct impact on the cost of gas. In our view, the CO_2 price will have most impact on the gas price through the additional demand for gas used in CCGT power plants that the EU ETS is likely to create.

In our recent note 'Half of coal generation shut by 2015' (22 February 2008) we estimate that in order to meet the Phase 3 EU ETS emissions limits around 430TWh of coal power will need to be replaced by gas **(See Figure 6).** We estimate that this will create a further 70bcm of gas demand, equivalent to the size of France's current demand. An increase in demand of this magnitude we believe is likely to put a significant amount of upwards pressure on the gas price.

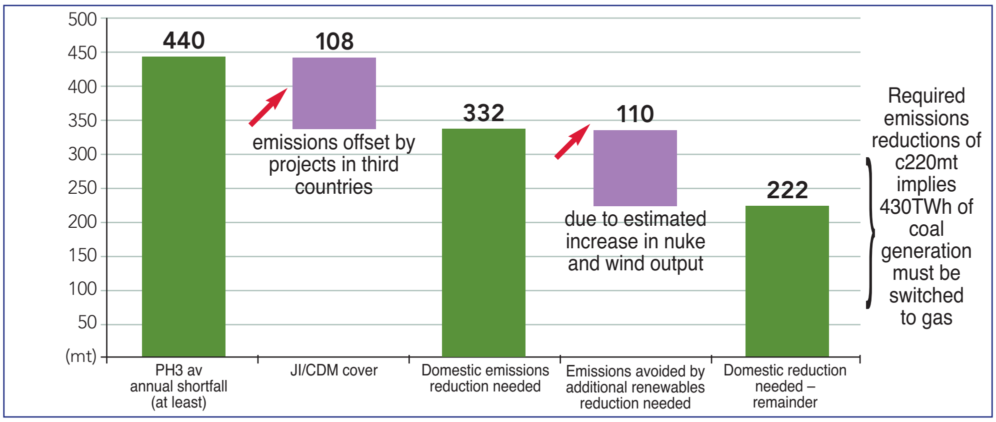
Higher gas prices likely to raise CO_2 prices

The current year forward Zeebrugge gas price is at c70p/th. With gas at this level, according to the fuel switching equilibrium table shown on page 26, even if coal prices remain high we could see a doubling of today's CO_2 price levels (c€22/t). Increases in the gas would mean further increases in the CO_2 price **(See Figure 7).**

Higher gas and CO_2 prices impact power prices

The coal supply squeeze in China and South Africa has already meant increased use of diesel and LNG.

Figure 6 – Output from coal generation must be reduced to meet emissions targets



Source: UBSe (Emissions avoided assumes 0.8t/MWh, Coal to gas switching assumes avoidance of 0.52t/MWh)

Figure 7 – Forward year gas prices imply a doubling of the current CO_2 price

Assuming gas unchanged at 70p/th (current year forward Zeebrugge price)	implied CO_2 price
with coal at $135/t (current forward month CIF ARA)	c.€40/t
with coal at $95/t (assumed in our power price model in 2010)	c.€55/t

Source: UBSe

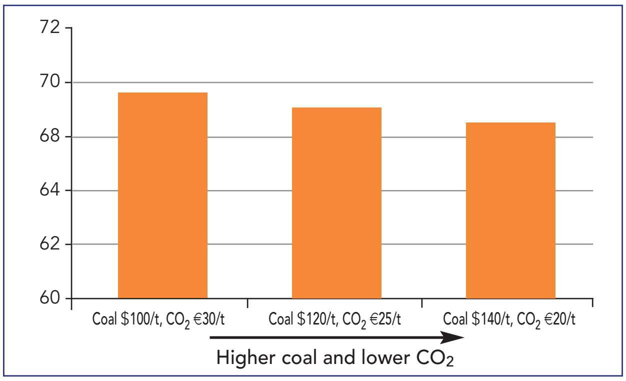
The oil and oil product markets are already tight and it is possible that the coal squeeze combined with the incremental demand created by the need to reduce emissions could have a significant price effect. Sustained higher coal prices and rising gas fuel costs could both encourage a higher CO_2-price outlook and create upside to power prices.

Gas rather than coal drives the power price

We do not believe that higher power prices will offset much of the increase in coal prices as, with carbon constraints, power prices are mainly driven by gas, whereas coal and carbon prices to a large extent (and assuming all else equal) offset each other, almost leaving power prices unchanged.

Figure 8 shows our 2009 Central European baseload power price forecasts, under three scenarios; our current assumptions ($100/t coal, €30/t CO_2) and two scenarios with higher coal and lower carbon prices. As shown in **Figure 8** we foresee almost unchanged power prices. ☐

Figure 8 – Central European power price forecast stable at €70/MWh



Source: UBSe (The chart is based on alterations to USB 2009 forecasts)