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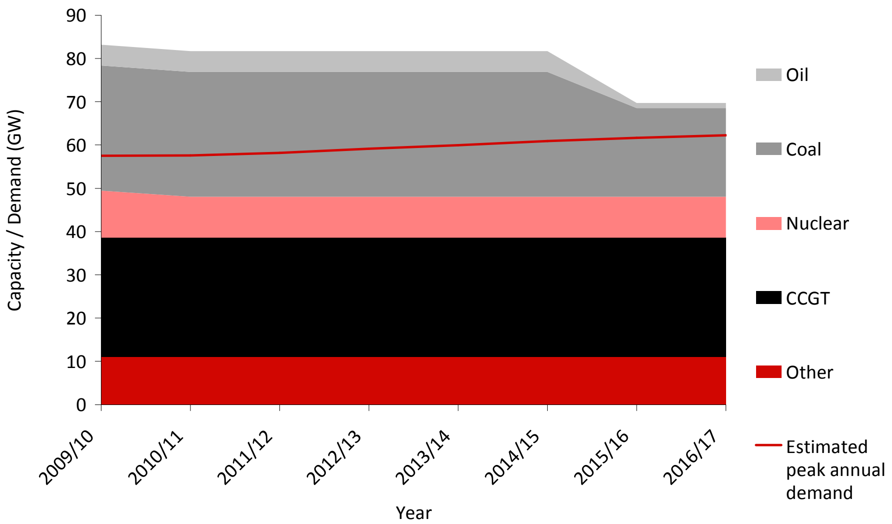
Carbon Price *Flaw*? The impact of the UK's CO_2 price support on the EU ETS

In March 2011 the UK Government began implementing a carbon "price floor" for domestic power generators, which will apply from April 2013. Since the policy will effectively create two different prices for CO_2 within the European Union Emissions Trading Scheme, it will have distortionary impacts on the European carbon market. Our analysis suggests that it will lead to additional emissions abatement in phase 3 by the UK power sector of between 26.6 $MtCO_2$ and 37.6 $MtCO_2$ to 2020. In the absence of more ambitious emissions targets for the EU ETS, this will lower the EUA price and reduce EUA auction revenues for other Member States. At stake is the question of how other countries will react to the UK's example, and the extent to which the EU can pursue a harmonised climate change policy.

Background: The UK Energy & Climate Policy Context

A need for large-scale new capacity investment: British peak electricity demand is forecast to continue rise steadily, by 1.14% per year, over the foreseeable future. Meanwhile, a large share of its existing non-intermittent generation capacity is expected to be retired in the next 5-12 years. As shown in Figure 1, 13 GW of mainly coal and oil generation, roughly 17% of all capacity, is currently expected to retire by 2016 and a similarly large share in the early 2020s. At a time of constrained credit for investments, the UK Government perceives a need to ensure that its domestic electricity market is sufficiently attractive to receive this investment (HM Treasury, 2010).

Figure 1 – Net installed capacity per primary fuel without new construction vs. peak demand forecast (winter season)



Without taking into account new generation capacity, the peak annual demand coverage (expected peak demand/installed capacity) would fall from 144% to 112% by mid-decade, which would significantly increase the probability of disruptions to supply. Note: CCGT – Combined cycle gas turbine.

Source: adapted from NETSSYS, National Grid, May 2010.

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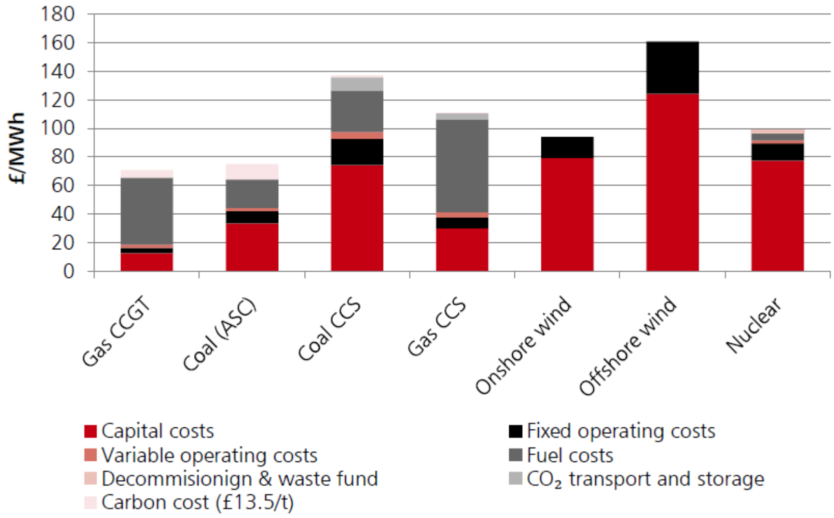
Ambitious domestic emissions goals, in line with the climate change science: The UK Government is unusual in Europe for having a domestic climate policy that reflects the policy ambition called for by the climate science and which is clearly defined over time. The UK Government has committed itself via domestic legislation to a GHG emissions target of 80% below 1990 levels by 2050[1]. To meet this objective, the Government's strategy has been to establish a plan aiming at a 37% reduction[2] by 2020, with 40% of electricity production coming from "low-carbon" sources, i.e. renewables, CCS and nuclear power. In 2010, such low-carbon generation accounted for only 20% of electricity production.

Moreover, the UK Treasury considers that the current level of carbon prices faced by UK fossil fuel generators under the European Union Emissions Trading Scheme are not yet high enough to stimulate this investment, see Figure 2. More importantly, it considers that the high degree of regulatory uncertainty surrounding the future level of the EU ETS emissions cap – and therefore the EU ETS carbon price – could lead investors in low carbon generation to delay their investments, or to have difficulty raising capital. The UK sees a risk of "locking-in" new carbon intensive capacity which would not be compatible with its emissions targets.[3]

Figure 2 - Comparison of costs of different generation technologies



Note: CCGT – Combined cycle gas turbine, ASC - Advanced super critical, CCS - Carbon capture and storage. Assumes 2009 project start & including CO_2 prices. This graphic does not include the effects of other existing policies, such as Renewable obligation certificates (ROC), CCS subsidies, or proposed policies, such for contracts for difference, etc.

Source: HM Treasury 2010

Fiscal consolidation: Implementing what is in effect an additional tax on the carbon emitted from fossil used for power production is consistent with the UK Treasury's stated goals of "greening the tax base" (HM Treasury, 2010). Furthermore, it will stabilise future fiscal revenues, as it will have a (delayed) countercyclical effect vis-à-vis EUA price variations.

News: How the "price floor" is supposed to work

As part of its response to the three priorities just mentioned, the UK Government will aim to ensure a specific minimum price on CO_2 emissions for domestic power generators. Thus, in its 2011 Budget, it adopted a target carbon price pathway, which it will use to determine the effective or "all-in" carbon price that UK power generators will pay each fiscal year from April 2013 out to March 2031.

To achieve the targeted all-in carbon price, the Government will require power generators using fossil fuels to pay a tax – called the 'Climate Change Levy (CCL) carbon price support rate' – which is based on the carbon content of primary fuels. This will be paid *in addition* to

[1] The UK Low Carbon Transition Plan (2009)

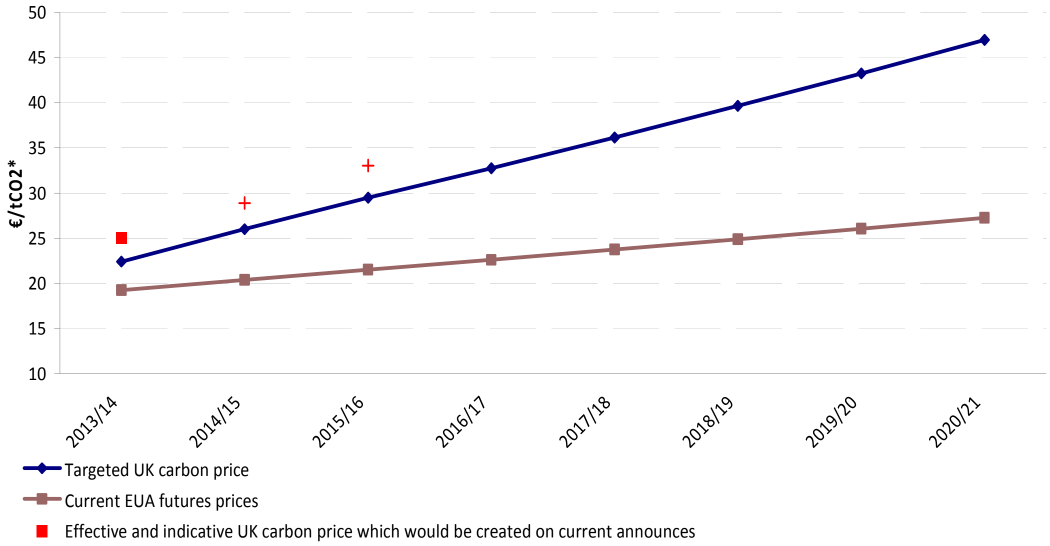
[2] These targets have recently been changed - the 2020 emissions reduction target raised from -34% to -37% and a 2027 target was set at -50% below 1990 levels.

[3] Climate Change Act (2008): http://www.legislation.gov.uk/ukpga/2008/27/pdfs/ukpga_20080027_en.pdf

the emissions allowance (EUA) price they pay under the EU ETS. The CCL support rates will be set to try to ensure that the sum of the EUA price plus the CCL rates per ton of CO_2 emissions is equal to the targeted all-in carbon price.

Thus, the UK Government will set the CCL support rates following pre-established rules. At the end of each fiscal year, it will set the annual CCL support rate for the year Y+2. This rate will be set equal to the difference between the targeted all-in carbon price in year Y+2 and the average EUA futures price for delivery in that same year as observed over the past 12 months. See Annex 1 for a table summarising the expected prices in Pounds Sterling.

Figure 3 - UK Targeted all-in carbon prices vs. EU ETS futures prices (in Euros)



*Results based on the UK Government's 2011 Budget announcement. Targeted price is calculated based on realised and anticipated RPI for 2009-2020 period. Current EUA futures price based on average ICE December EUA futures prices during April 2011. The GBP/EUR rate used is 1.17 = the average of the preceding 12 months at April 2011. *in nominal Euros*

Note that the UK carbon price floor is not a pure "price floor" in the true economic sense. The all-in carbon price can still be below the targeted price. Since the EUA price fluctuates, while the CCL support rates are fixed during the year, if the EUA price falls by X Euros, the all-in UK carbon price will also fall by the same amount. An example of this, but in the inverse direction, has been the unexpected rise in the EUA price following the German Nuclear shutdown decision in March 2011, an event not anticipated when the CCL support rates were set for 2013/14 one week beforehand. Hence, as shown in Figure 3, the currently expected all-in carbon price for 2013/14, given by the red square, is now 2 € above the targeted price for that year. Provided the UK Government does not change the target price trajectory, the CCL rates will correct to compensate for EUA price shocks, but with two years delay. Perhaps the biggest threat to the effectiveness of the price floor is whether investors will trust successive Governments not to change the targeted carbon price trajectory.

Analysis: Impacts on the EU ETS

Three types of economic impacts

1) Lower the EU ETS carbon price: The first impact of the "price-floor" we can expect is an increase in CO_2 abatement by the UK's power sector, which will in turn lower the EU ETS carbon price. Power plants facing a higher CO_2 price will have an incentive to undertake those abatement measures which are marginally more expensive per ton than the EUA price. However, despite additional abatement in the UK, the overall emissions cap for all EU ETS participant countries will remain unchanged; therefore the UK policy will have no impact on overall EU emissions. On the contrary, additional abatement in the UK will simply reduce demand for EUAs (coming from the UK power sector) by the same amount. This fall in demand will lower the equilibrium price of EUAs.

2) Reduce the economic efficiency of the EU ETS: It follows that the second impact of the UK's policy will be to reduce the economic efficiency of the EU ETS, at least in the short run.

This will happen because it will indirectly lead to the replacement of cheaper CO_2 abatement options being exploited by higher cost abatement options in the UK power sector.

3) Reduce EUA auction revenues for Member States: Finally, since EUA prices will fall to some extent, EU Member States' revenues from auctioning allowances in Phase III will fall in proportion.

Estimating the size of the economic impacts

Methodology

There are two main categories of abatement in the UK power sector which are expected to result from the "price floor" policy. The first is so-called "fuel-switching" between generation from coal-fired power plants to generation from gas-fired power plants. The second is the abatement if the intended boost to investment in new low-carbon capacity does eventuate, as well as retrofitting and other energy efficiency improvements. In our analysis, we have only focused on the short-term coal-to-gas switching effects and have ignored longer-term investment impacts. We also ignored electricity price effects which may reduce demand.

To estimate the additional UK abatement from fuel-switching under the higher CO_2 price from 2013, we began by estimating the impact of EUA price variations on overall electricity production from both coal and gas in the UK power market. We did this by estimating an econometric model which we adapted from McGuiness and Ellerman (2008) (see Annex 2). It yielded the following linear estimates of the relationship. All else equal, a 1 £ / tCO_2 rise in the EUA price (in 2009 prices), if sustained over the course of a year, is expected to lead to:

- + 1 032 GWh of annual production from gas plants.
- – 1 104 GWh of annual production from coal plants.

Next, we constructed two scenarios for the 'CCL carbon price support rate' level. The first supposes that the Government will apply the announced rate for 2013 and the currently "indicated" rates in the 2011 Budget for 2014 and 2015. The second scenario introduces an adjustment for 2014 and 2015 to fit the targeted carbon price, allowing for the fact that the UK Government will correct the future CCL rates for the recent jump in the EUA futures price. These two scenarios, summarised in Table 2, gave us what we think is a reasonable spread of possible values of the CCL rate pathway to 2015/16.

For each year from 2013 to 2015, we then multiplied our estimated change in production from gas and coal by the level of the CCL rates in the two scenarios to obtain the impact of the price floor in terms of increased (decreased) electricity production from gas (coal).

Results 1: Abatement in the UK

We assumed that each GWh switched from coal to gas saves 526.58 tCO_2. This figure was calculated based on DECC's "Electricity fuel used and generation" data. From this, we estimated the additional abatement in the UK resulting from the "price floor" to be at the levels shown in Table 1.

Table 1 - Estimated impact of the "price floor" on UK abatement from fuel-switch ($MtCO_2$)

Fiscal Year		2013/14	2014/15	2015/16	2013-2020
Scenario 1	(£/tCO_2)	4.94	7.28	9.86	
	Best estimate	**- 2.7**	**- 3.9**	**- 5.2**	**- 37.6**
Scenario 2	(£/tCO_2)	4.94	4.79	6.81	
	Best estimate	**- 2.7**	**- 2.3**	**- 3.6**	**- 26.6**

Note: For the years after 2015, we have assumed marginal annual abatement from fuel switching to remain the same as in 2015. This assumption reflects the fact at a certain point additional rises in the price of CO_2 in the UK above the EUA price should yield increasingly smaller increments in their effects on fuel switching due to capacity constraints. As reported in annex 2, we also estimated a quadratic form of the model which supported this assumption.

According to our estimates, 2.7 $MtCO_2$ will be reduced from additional production switch from coal-fired to gas-fired power plants in 2013, as a direct consequence of the price floor. This volume is expected to increase in 2014 and 2015 to 3.9 $MtCO_2$ and 5.2 $MtCO_2$ respectively in scenario 1, while the increase is more limited in scenario 2 (respectively 2.3 and 3.6 $MtCO_2$). This abatement represents between 1.5% and 3.5% of verified emissions coming from the UK power sector in 2009. For the overall EU ETS phase III period (2013-2020), the aggregate emissions reduction from fuel-switching as suggested by our scenarios should be in the range between 26.6 $MtCO_2$ and 37.6 $MtCO_2$.

Results 2: EUA price effects

To give an idea of the EUA price effect of adding between 26.6 and 37.6 million EUAs – corresponding to the estimated additional abatement in the UK – onto the market during Phase III, we used a simple "back of the envelope" calculation. Specifically, we compared the shock to demand for EUAs from the price floor to the recent demand shock coming from the Fukushima nuclear accident, which has resulted in the shutdown of Germany's 7 oldest nuclear reactors. The latter was, after all, a perfectly exogenous positive demand shock which could not have been anticipated by the market.

By comparing the average EUA spot price on BlueNext during the week before the German announcement to the average of the week after, we calculated an average price increase of 1.29 €. Assuming the 7 reactors stay closed, this event is estimated to have added 36 $MtCO_2$ per year to demand for EUAs over the next few years. Comparing this to our estimates of a reduction in demand by 26.6 and 37.6 $MtCO_2$ over Phase III from additional UK fuel-switching, and assuming constant returns to scale, we estimated a "ballpark" effect on the EUA price of between -0.13 to -0.18 €, corresponding to our two CCL rate scenarios[4].

Results 3: Member State auction revenue and economic welfare effects

These results lead us to consider the following impacts on Member States EUA auction revenues, which we calculate for 2013:

Table 2 – Estimated welfare impacts of the "price floor" for 2013

Estimated EUA price impact	Scenario 1: -13 cents	Scenario 2: -18 cents
UK Government	+ 830 M€	+ 823 M€
Other EU Governments	- 122 M€	- 166 M€
Net welfare impact	- 8.2 M€	- 8.3 M€

Note: Assumes 1 billion EUAs sold at auction in 2013 of which 100 million in the UK.

Not surprisingly, the UK Treasury is the big winner from the tax implementation, while the UK power sector loses roughly the same amount, minus the gains from cheaper EUA purchases. What is noteworthy here is the negative impact that will affect other EU ETS governments through EUA auction revenues. A fall in the EUA price will, of course, reduce auction revenues received by all EU ETS participant governments. In 2013, we estimate that roughly 900 million EUAs will be auctioned outside of the UK.

Based on just the fuel switching impact on the EUA price, it follows that over the 8 years of phase III (2013 -2020) the Europe-wide decrease in auction revenues outside the UK could reach between 976 M€ and 1,328 M€, or higher depending on the overall level of auctioning. The German Government would miss out on 190 M€ to 259 M€ of revenues, Poland would forego 127 to 173 M€, and Spain would miss out on 78 to 106 M€ over Phase III, assuming auctioning shares of 19.5%, 13% and 8% respectively[5]. These amounts would effectively be a transfer between governments and operators - mainly electricity producers - in the EU ETS, who will pay less at the auctions. Finally, the EU-wide efficiency loss is estimated at roughly 8 M€ euro for 2013. This represents the additional economic cost that comes from exchanging lower cost abatement options in Europe with higher cost fuel-switching in the UK.

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[4] This will in turn reduce the all-in carbon price by the same amount. This small "feedback effect" should therefore reduce the amount of abatement in the UK by a negligible amount compared with our estimates.

[5] The assumption is least certain for Poland, who may give a share of free EUAs to its power producers.

Other factors to consider

We can identify four main areas of uncertainty which might change the fuel-switching dynamics in the UK power market and which could possibly affect our results.

- Fuel switching to gas would, based on our estimates, increase natural gas consumption in the UK by between 1 and 2% and in the EU15 by 0.2 to 0.4% per year. This might have a small decreasing effect on fuel-switching via the UK natural gas price.
- A 1.5 GW interconnection between the British Isles' and the Netherlands' electricity markets to be opened in 2012 could see slightly more electricity imported to the UK in peak periods. By 2020 these interconnections could rise by up to 4 GW.
- The planned exit of around 13 GW of the UK's oldest coal and gas plants from 2016 may reduce fuel switching potential.
- The possibility of a large and positive future shock to the EUA price, e.g. due to a change in the EU ETS cap, could render the CCL rates less significant.

On balance, these developments might be expected to reduce fuel-switching resulting specifically from the CCL carbon price support rates.

On the other hand, our analysis is quite conservative in estimating UK abatement to the extent that we have ignored higher electricity price effects on power consumption and the possibility of investments in new capacity leading to additional abatement. The UK Government's consultants have estimated that, assuming it works as intended, the price floor would help replace 7 GW of gas- and coal-fired capacity with new low-carbon capacity (mainly nuclear) by 2030. This would lead to a cumulative abatement figure of roughly 261 $MtCO_2$ between 2013-2030, which would have a much stronger distorting impact on the EU ETS than what we anticipate.

What political consequences?

It is probably too early to predict the political consequences of the UK "price floor" policy. Nevertheless, we think that there may be broader political implications for the EU ETS that should not be overlooked.

1) What will be made of the UK's example? The UK is ahead of Europe in pursuing a domestic emissions reduction trajectory which is in line with current state of the climate science. It has made very clear that it supports the EU ETS but the current level of the EU ETS emissions cap (-20% below 1990 levels by 2020) is not sufficient to incite the necessary levels of low-carbon investments. Meanwhile, other countries besides the UK will face the joint challenges of ensuring reliable and affordable electricity, while also decarbonising it. In this context, the UK's example could be interpreted in different ways. It may be seen as an argument for why the EU ETS cap should be strengthened – ideally there would be a longer term trajectory set in line with the EU's 2050 emissions targets and embedded in EU legislation. This would lower the CCL rates and reduce the additional abatement effect of the UK policy. Potential losses in auction revenues, although seemingly small, could be an additional incentive for other MS to agree on a tighter cap, which would raise their auction revenues. On the other hand, the UK's approach could be interpreted as a precedent inciting other Member States to put in place similar domestic measures which distort or weaken the EU ETS carbon price signal.

2) Does a price floor really increase "certainty" for investors? The foregoing analysis raises the question of whether a carbon "price floor" policy actually does increase predictability for investors. As we have outlined above, the UK carbon price floor depends on two things. The first is that investors trust successive UK governments to stick to the targeted price path. The second is that, as explained above, the carbon price floor mechanism is based on the existence of a relatively stable and predictable EUA price, and not the other way around. However, if the carbon price floor incites other countries to introduce other measures which similarly undermine the EUA price, then the UK price floor may reduce the predictability of future carbon prices. Ultimately, the existence of a common European carbon market means that climate policy which aims to provide long-run investor predictability will be less efficient and effective if it is determined unilaterally.

To find out more…

- *HM Treasury (December 2010) Carbon price floor: support and certainty for low-carbon investment* http://www.hm-treasury.gov.uk/d/consult_carbon_price_support_condoc.pdf
- *HM Treasury (March 2011) Carbon price floor consultation : the Government response* http://www.hm-treasury.gov.uk/d/carbon_price_floor_consultation_govt_response.pdf
- *IEA (2010) IEA Statistics: Electricity information*
- *McGuiness and Ellerman (2008) "CO_2 Abatement in the UK power sector: Evidence from the EU ETS Trial Period" MIT CEEPR Working Paper* http://dspace.mit.edu/handle/1721.1/45654
- *UK Department of Energy and Climate Change electricity statistics* http://www.decc.gov.uk/en/content/cms/statistics/source/electricity/electricity.aspx
- *National Grid, (May 2010) National Electric Transmission System Seven Year Statement* http://www.nationalgrid.com/NR/rdonlyres/A2095E9F-A0B8-4FCB-8E66-6F698

Annex 1 - Targeted UK CO_2 price, EUA futures prices, CCL rates in £

Table 3 - Target & Effective UK carbon prices (in GBP at 2009 and current prices)

Fiscal Year	Targeted carbon price in £/tCO_2 (2009 prices)	Targeted carbon price in £/tCO_2 (nominal)*	EUA forward price in £/tCO_2** (nominal)	Announced CCL carbon price support rate in £/tCO_2 (nominal)	All-in carbon price for UK in £/tCO_2 (nominal)
2013-14	16.21	19.16	16.46	**4.94**	21.40
2014-15	18.21	22.22	17.43	**7.28***/4.79***	24.71***/22.22****
2015-16	20.21	25.19	18.37	**9.86***/6.81****	28.23***/25.19****
2016-17	22.21	28.00	19.32	?	?
2017-18	24.21	30.90	20.28	?	?
2018-19	26.21	33.89	21.27	?	?
2019-20	28.21	36.97	22.28	?	?
2020-21	30.21	40.14	23.29	?	?
2030-31	70.00	100.92	-	?	?

This is calculated with current assuming RPI (Retail Price Index) of 5% in 2013, 4% in 2014, 3% thereafter. **Average ICE December delivery EUA futures contract prices during April 2011. The GBP/EUR rate of 1.17 was the 12 month average of the past year to April 2011. ***Figures are based on the announced indicative rates in 2011 UK Budget. ** Figures readjusted to fit with the targeted carbon price.*

Annex 2 - Econometric Model of Fuel Switching in the UK

To estimate the impact of the CCL support rates on the UK power sector's emissions from fuel switching, we estimated a relatively simple econometric model of the historical impact of the price of CO_2 on electricity production levels from both coal and gas.

Data

For this we constructed a panel data matrix using monthly data on electricity production disaggregated by type of primary fuel, which is published by the Department of Energy and Climate Change. The production of electricity from gas and from coal as the primary fuel therefore represented i=1 & i=2 respectively in our panel data matrix. The timeframe of the observations extended over the period between April 2005 and February 2011. We obtained electricity consumption data from the same source. Data on fuel prices (gas and coal) came from NBP gas prices and coal (API 2) while data on the EUA spot price came from BlueNext.

Augmented Dickey Fuller tests indicated that our dependent variable was stationary after adjusting for seasonality of power demand. We therefore left the data in level form for our estimation, however we included one lag of the dependent variable, $Prod_{i,t}$ to clean up serial correlation.

Econometric model

We estimated the following linear model using these data, which was adapted from a similar specification used by McGuiness and Ellerman (2008):

$$Prod_{i,t} = \alpha + \beta_1 {*} Coal + \beta_2 {*} Demand_t + \beta_3 {*} Demand_t {*} Coal + \beta_4 {*} Fuel\ price\ ratio_t + \beta_5 {*} Fuel\ price\ ratio_t {*} Coal + \beta_6 {*} CO2price_t + \beta_7 {*} CO2price_t {*} Coal + \beta_8 {*} NukeRNW_t + \beta_9 {*} Price\ Crash_i + \beta_{10} {*} Prod_{i,t-1} + u_{i,t}$$

Where:

$Prod_{i,t}$	=	UK monthly electricity production from coal (i=1) and gas (i=2) in TWh
Coal	=	Dummy variable equal to 1 for production from coal and 0 for production from gas
$Demand_t$	=	UK monthly electricity consumption in TWh
$Fuel\ price\ ratio_t$	=	*Ratio of monthly average price of coal on average monthly price of gas converted in £/MWh*
$CO2price_t$	=	*Monthly average price of EUAs on BlueNext converted in £ at 2009 price levels and current (i.e. moving) exchange rates*
$NukeRNW_t$	=	*UK Monthly electricity production from nuclear and renewable energy in TWh*
Price Crash	=	*Dummy variable equal to 1 for the July 2008 – February 2009 period where the EUA price fell sharply*

α = Constant term

$u_{i,t}$ = Unobserved error term

*Demand$_t$ *Coal; CO2price$_t$*Coal; Fuel price ratio$_t$**Coal = Interaction terms

This specification allowed us to easily recalculate from the estimated coefficients the average historical impact of a rise of £X in the CO_2 price on respective production levels of electricity from gas and coal.

The inclusion of a dummy variable for electricity production from coal allowed us to take into account inherent differences in power production levels of coal and gas which may be due to time invariant differences in the economics of production from the two fuels in the UK, e.g. different production capacity, contract types and fuel availability. Moreover, it also enabled us to differentiate the effects of changes in the price of EUA and other variables on production from coal and gas by creating interaction terms with our explanatory variables, e.g. PriceCO2*Coal, Demand*Coal, etc. Finally the binary variable "Price Crash" allowed us to isolate the impact of the CO_2 price during its sharp drop following the 2008 crisis. As this period showed a strong increase in coal production relative to gas production, it could have led us to overestimate the impact of CO_2 price variations.

Results

The results confirm our hypothesis, namely that an increase of £1 / tCO_2 price of EUA (in 2009 prices) positively increases the aggregate monthly production from gas-fired plants (+0.086 TWh), and negatively that of coal-fired plants (0.086 – 0178 = -0092 TWh) (see table below, coefficients in bold).

Our CO_2 price parameter estimates were significant at the 99% level. Our results are the right sign and are logical to the extent that the fall in coal fired production in response to a rising CO_2 price is almost perfectly balanced by a corresponding increase in production from gas – suggesting that we have accurately estimated the fuel switching effect of CO_2 price rises. This confirms McGuiness-Ellerman (2008) findings which studied data from Phase 1 of the EU ETS are also robust for Phase 2.

Table 4 - Results of Fuel-Switching Regression

Variable Name	Coefficient	Standard Error	Significance
Constant	1.311	(1.771)	
Coal	-3.845	(2.207)	*
Demand	0.214	(0.04)	***
Demand * Coal	0.441	(0.061)	***
Fuel price ratio	6.655	(0.732)	***
Fuel price ratio*Coal	-13.326	(0.987)	***
CO2 Price	**0.086**	**(0.017)**	*******
CO2 Price * Coal	**-0.178**	**(0.025)**	*******
NukeRNW	-0.395	(0.094)	***
Price Crash	0.802	(0.315)	**
Prod(t-1)	0.174	(0.04)	***

,,*** mean respectively significant parameters at a 90%, 95% et 99% confidence level. Adjusted R-squared = 0.79; Number of observations = 140.*

Finally, since one of the key limitations of this model is that it, by construction, it assumes a linear relationship between the level of production from coal and gas and the CO_2 price and other control variables, we also estimated a robustness test where we added quadratic terms for the CO2Price and CO2Price*Coal variables. We found these to be significant at the 90% level. These results suggested the increasing (decreasing) relationship between the price of CO_2 and the level of production from gas (goal) starts to level out at roughly £21 in 2009 prices during the sample period. Since this is almost exactly the level of the proposed price floor target in 2009 prices in 2016/17, we therefore found that this result provided reasonable support for our simplifying assumption that we would assume a constant level of fuel-switch abatement from 2016 to 2020.