Imperial College London

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Spotted: How varying fuel prices affected British electricity wholesale prices.

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Agenda

- Goals and motivation

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- UK energy market- background

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- Merit Order Effect

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- Results

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Motivation: We study the factors driving electricity prices to show why British prices rose by 22% from 2009 to 2017. So far no detailed studies with long-span have been performed for British market.

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In fact, the out-turn prices are highly dependent on energy demand and **other factors**.

Modelling electricity prices

- The main difference between electricity market and others - commodity is not storable. It gets more complicated: consider different types of generators in one pool- renewables are fairly cheap but not always available contrary to fossil fuels (expensive and not flexible but more reliable in general).

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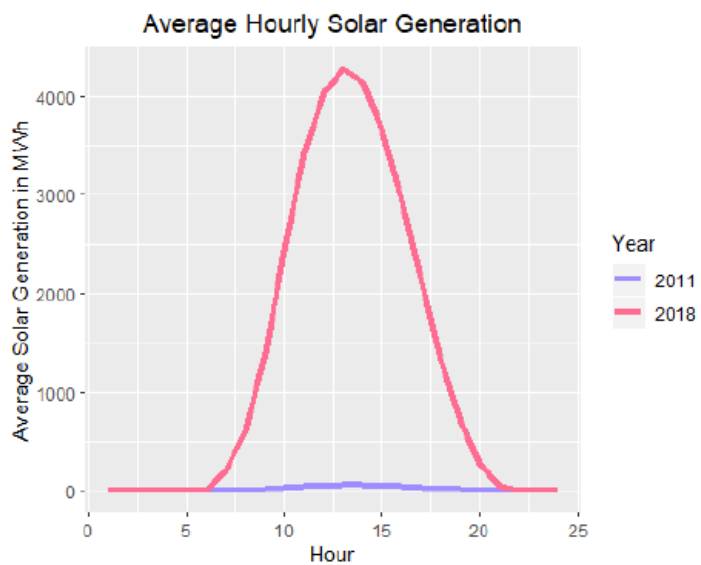

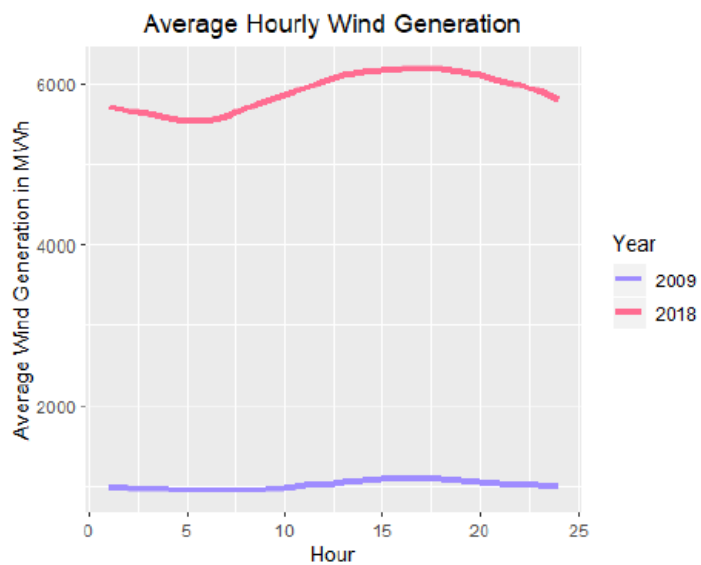

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All papers are based on direct fuel prices - mainly on gas and this approach, given the rapidly changing capacity mix may be subject to an upgrade.

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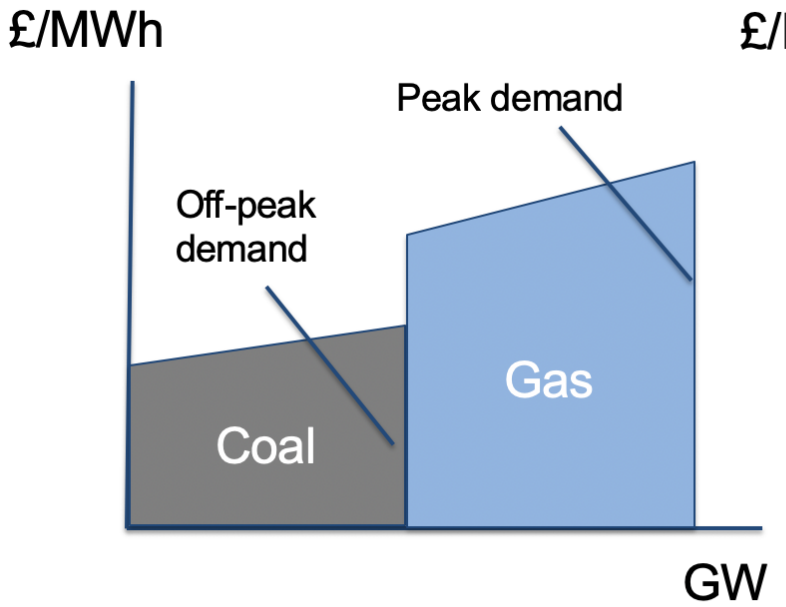
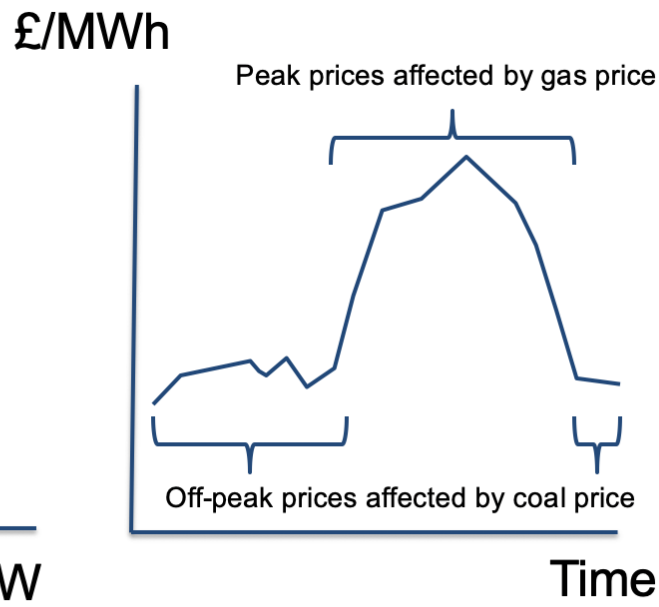
Merit order



The Merit Order



A day of spot prices

Higher cost stations are on the margin, producing less but setting the price in the spot market

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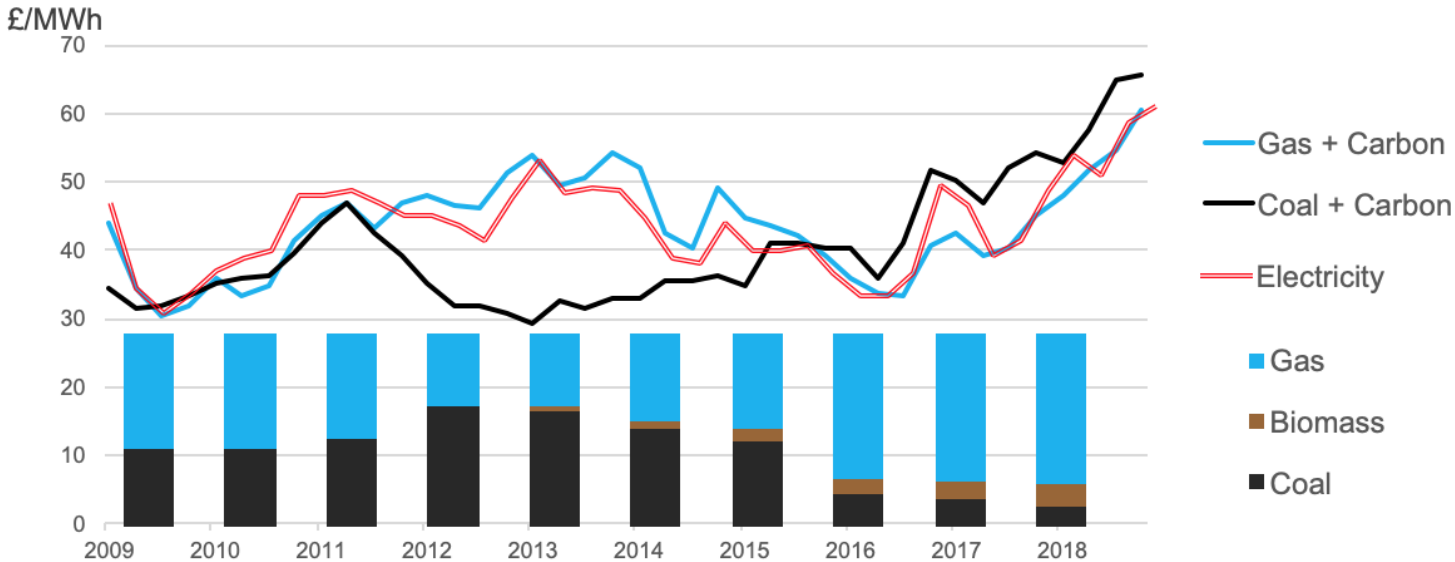
Fuel Prices incl. carbon price and share of thermal output



Data source: National grid & BEIS

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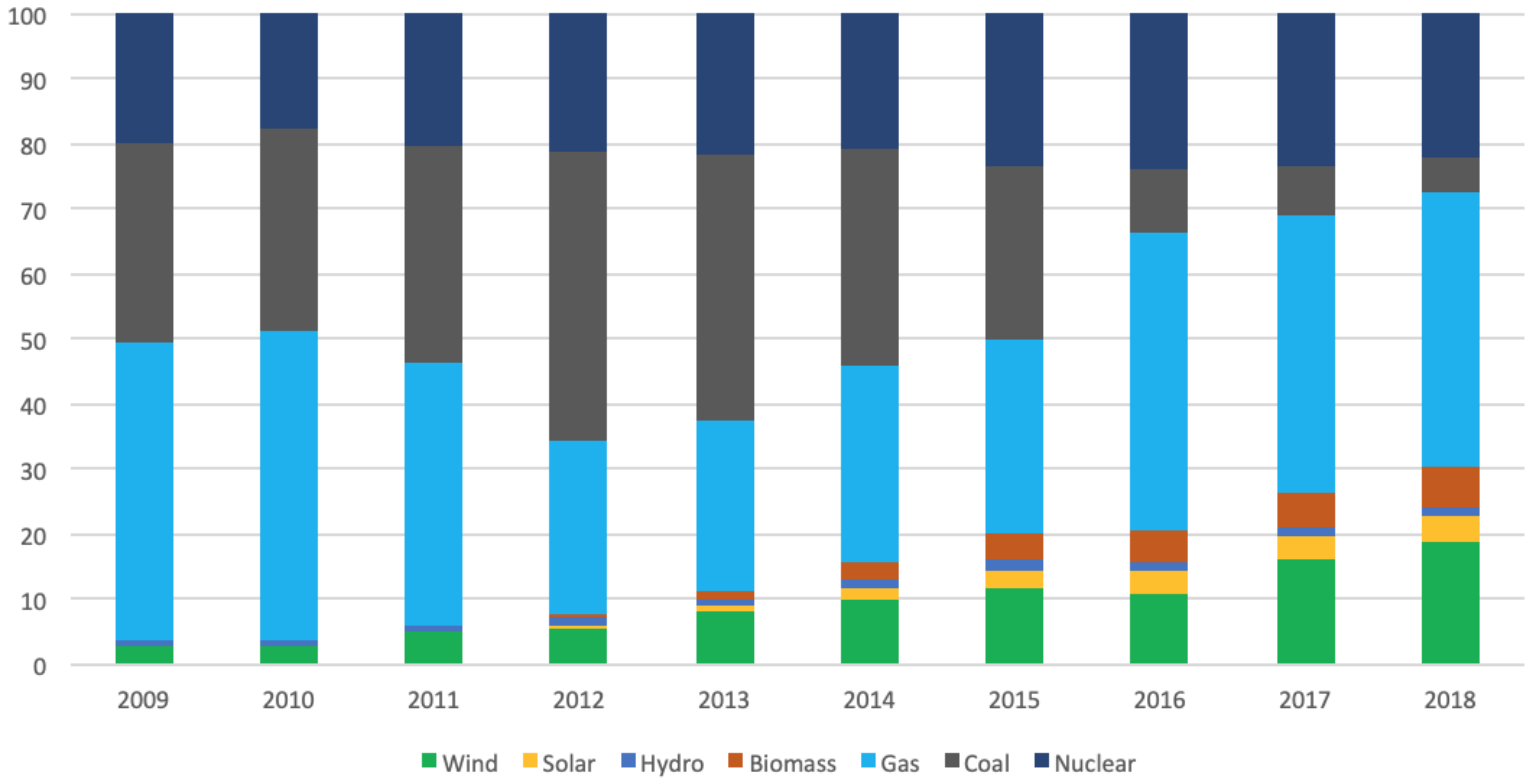
Output of different energy sources as a share of total yearly generation in %.



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Methodology

We capture this effect by constructing variables not for the variable costs of gas generation and of coal generation per se, but for whichever plant type is cheaper, and whichever is more expensive. Additionally, we introduce the nonlinear relationship between demand and electricity prices by using polynomials.

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Data:

- The focus is placed on the day-ahead market in UK encompassing half-hourly data from years 2009-2017.
- Sources include ENTSOE, BEIS, Ofgem, Bloomberg (for Gas price) and Investing.com (for Coal price).

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- Complex relationship of demand towards price.
- Firstly, to check if our assumptions of non-linearity is correct we run the model without interaction effects with demand to see clearly the relationship.
- Coefficients of demand squared and demand cubed are statistically significant.
- The positive sign for demand and negative sign for demand squared suggest a monotonic increasing function of price by demand until a turning point is reached and then it very slightly turns upward.

Price	£/MWh	Day-ahead electricity price
Demand	GW	Actual Total Load
Renewable Gen.	GW	Output of Hydro, Wind and Solar
Capacity	GW	Total generation capacity

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GasPrice	£/MWh	(Gas price + UKCarbon)/ thermal eff
CoalPrice	£/MWh	(Carbon price + UKCarbon)/ thermal eff + delivery cost
CheaperFuel	£/MWh	(The cheaper of Gas and Coal incl. fuel price + carbon cost) / thermal eff.
CostlierFuel	£/MWh	(The more expensive of Gas and Coal incl. fuel price + carbon cost)/ thermal eff.
Costlier Demand	GW	Net Demand which is not satisfied with the CheapFuel Capacity Formula: (Demand-Renewable Gen.-Nuclear Gen.)- 0.8*CheapCapacity. if <0 then set to 0
CheapCapacity	GW	Capacity of CheapFuel
PeakHours	binary	Dummy for peak hour=1, off-peak=0 Peak period: 8 am - 8 pm on weekdays

Note: 0.8 in Costlier Demand definition means that generators do not run at full capacity and based on previous research they usually use 80% of their overall capacity for optimal efficiency

Two approaches:

1.

$$P_t = \alpha_t + \beta \cdot Dem_t + \gamma \cdot Renewables_t + \gamma_1 \cdot PeakHours_t + \delta_1 \cdot GasPrice_t + \delta_2 \cdot CoalPrice_t + \boldsymbol{\Theta} \cdot \boldsymbol{V_t} + \epsilon_t \quad (1)$$

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2.

$$P_t = \alpha_t + \beta \cdot Dem_t + \beta_1 \cdot {Dem_t}^2 + \beta_2 \cdot {Dem_t}^3 + \gamma \cdot Renewables_t + \gamma_1 \cdot PeakHours_t + \delta_1 \cdot CheaperFuel_t + \delta_2 \cdot CostlierFuel_t + \delta_3 \cdot CostlierDemand_t + \boldsymbol{\Theta} \cdot \boldsymbol{V_t} + \epsilon_t \quad (2)$$

	Dependent variable:
	Price
DemandGW	−10.851*** (1.232)
I(DemandGW^2)	0.375*** (0.034)
I(DemandGW^3)	−0.004*** (0.0003)
Renewables	−1.056*** (0.012)
CheaperFuel	0.412 (0.363)
CostlierFuel	−4.390*** (0.324)
PeakHours	2.753*** (0.076)
CostlierDemand	0.954*** (0.067)
DemandGW:CheaperFuel	0.061** (0.031)
DemandGW:CostlierFuel	0.402*** (0.027)
CostlierFuel:CostlierDemand	−0.012*** (0.001)
I(DemandGW^2):CostlierFuel	−0.011*** (0.001)
I(DemandGW^2):CheaperFuel	−0.003*** (0.001)
I(DemandGW^3):CostlierFuel	0.0001*** (0.00001)
I(DemandGW^3):CheaperFuel	0.00004*** (0.00001)
Constant	101.175*** (14.477)
Observations	157,672

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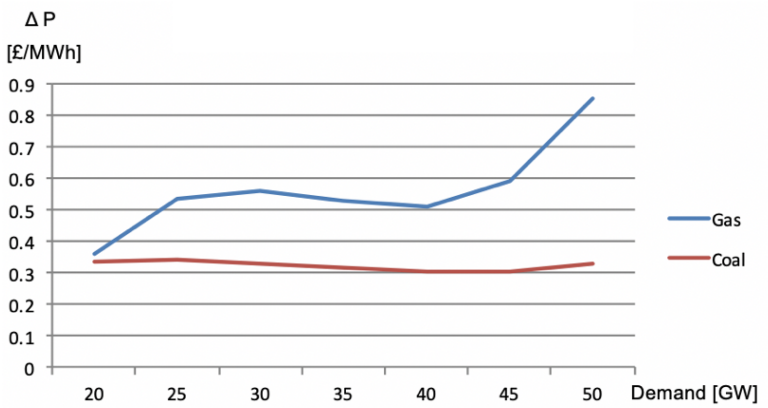
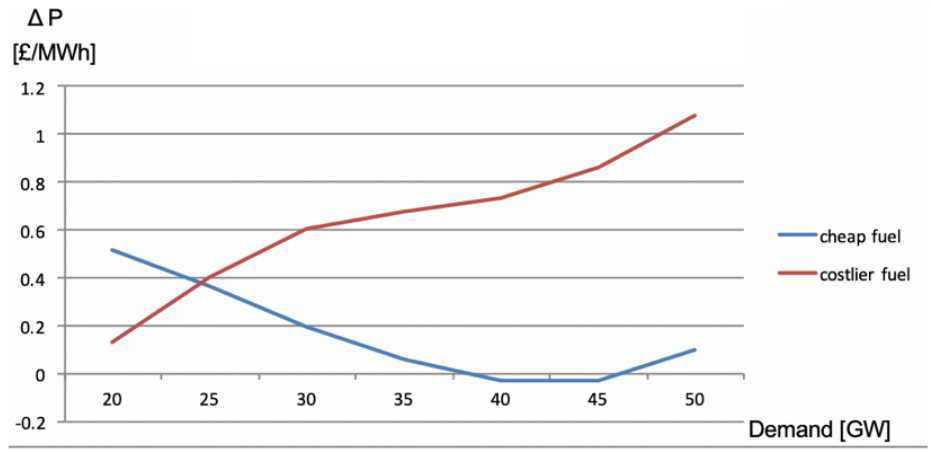
Results

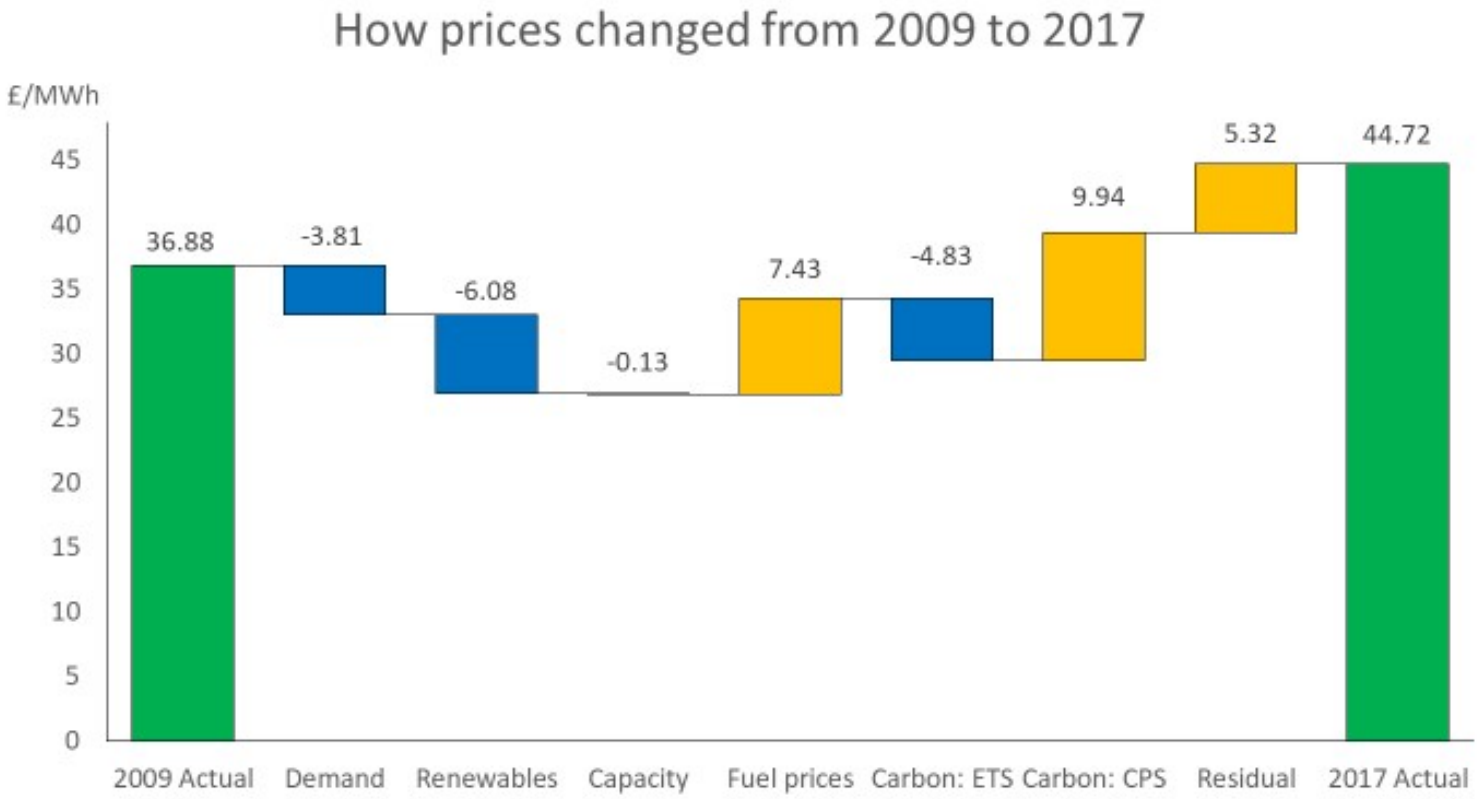
Marginal impact of fuels on power prices in polynomial model



Direct fuels approach



Switching fuels approach


How prices changed from 2009 to 2017
£/MWh
45
40
35
30
25
20
15
10
5
0
36.88
-3.81
-6.08
-0.13
7.43
-4.83
9.94
5.32
44.72
2009 Actual
Demand
Renewables
Capacity
Fuel prices
Carbon: ETS
Carbon: CPS
Residual
2017 Actual

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What-if analysis for year 2017

Level in 2009	Level in 2017	Real price in 2017	Counterfactual price in 2017
Demand			
37 GW	33.59 GW	44.72£/MWh	49.03£/MWh

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What-if analysis for year 2017

Level in 2009	Level in 2017	Real price in 2017	Counterfactual price in 2017
Demand			
37 GW	33.59 GW	44.72£/MWh	49.03£/MWh
Carbon			
11.8 £/tonne	23 £/tonne	44.72£/MWh	36.45£/MWh

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Fuels			
Gas:30£/MWh, Coal:21.6£/MWh	Gas:32£/MWh Coal:29 £/MWh	44.72£/MWh	40.83£/MWh*

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Gas:30£/MWh, Coal:21.6£/MWh	Gas:32£/MWh Coal:29 £/MWh	44.72£/MWh	40.83£/MWh*
Renewables			
1.4 GW	6.3 GW	44.72£/MWh	51.41£/MWh
*carbon level stays for 2017			

Conclusions

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2. Lower demand and increasing output of renewables contributed to the decrease in final electricity price by around 11 £/MWh
3. Carbon and fuel prices which increased in this period (particularly carbon price) triggered increase of electricity price by around 16£/MWh.

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