The Intraday Impacts of Wind Energy on Wholesale Electricity Markets in the UK

Xiaoyi Mu, Hanchen Xiao

Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP), University of Dundee

x.Mu@dundee.ac.uk

20 Sep 2023

Outline

1. Background
2. Motivation
3. Data and Methodology
4. Results
5. Conclusions

Motivation

A lot have been written on the average impact of wind energy on electricity prices (Csereklyei et al., 2019; Forrest & MacGill, 2013; Gil & Lin, 2013; Quint & Dahlke, 2019; Woo et al., 2011)

We focus on the intraday, half-hourly impact of wind energy on electricity prices and emission

→ Spot market prices differ by half-hour

→ Impact on the operation of conventional fossil-fuel fired powerplants

→ Emissions offset

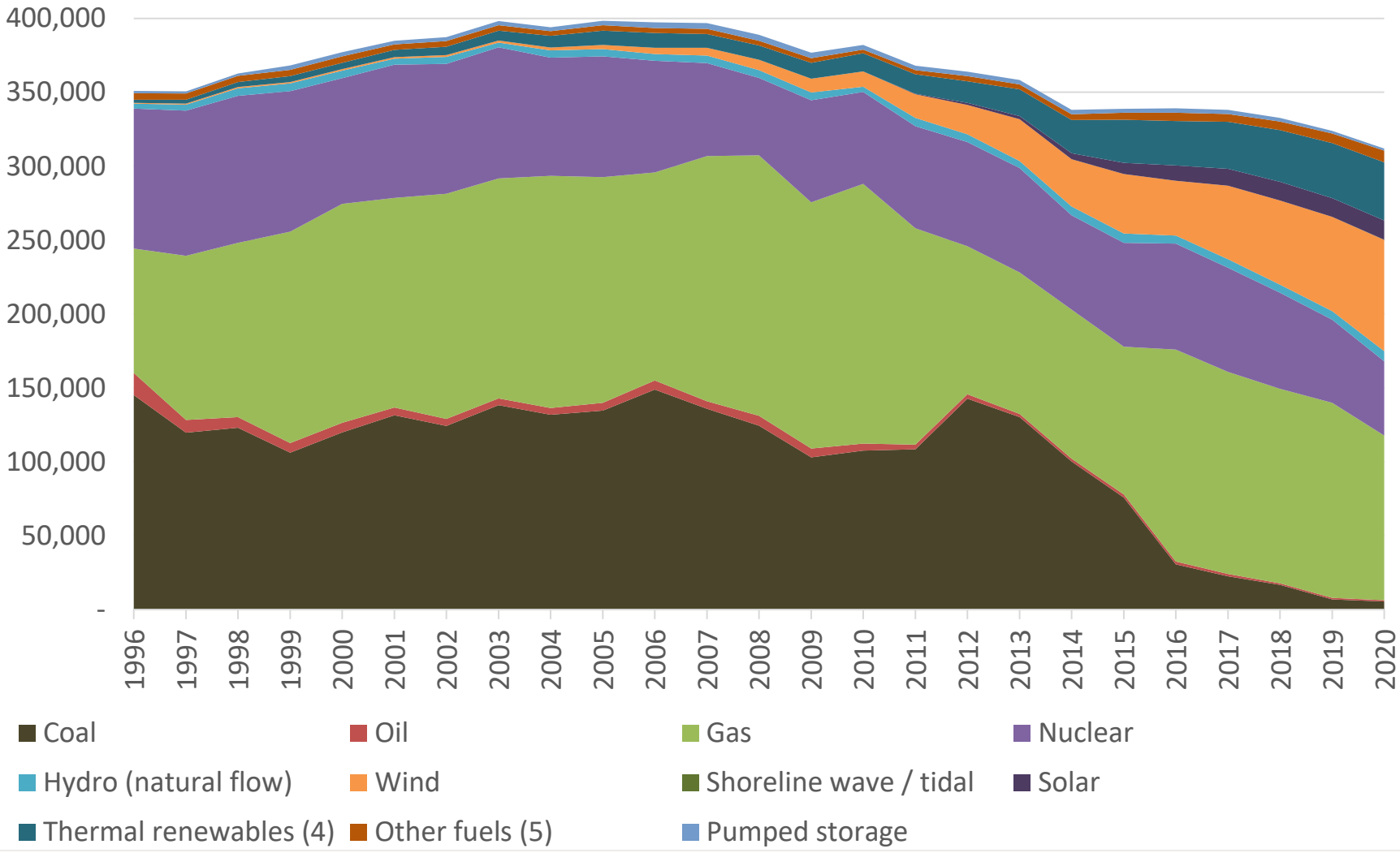
The paper close to us is Bushnell and Novan (2021)

Why UK? why wind?

→ Wind is potentially available for any hour of the day

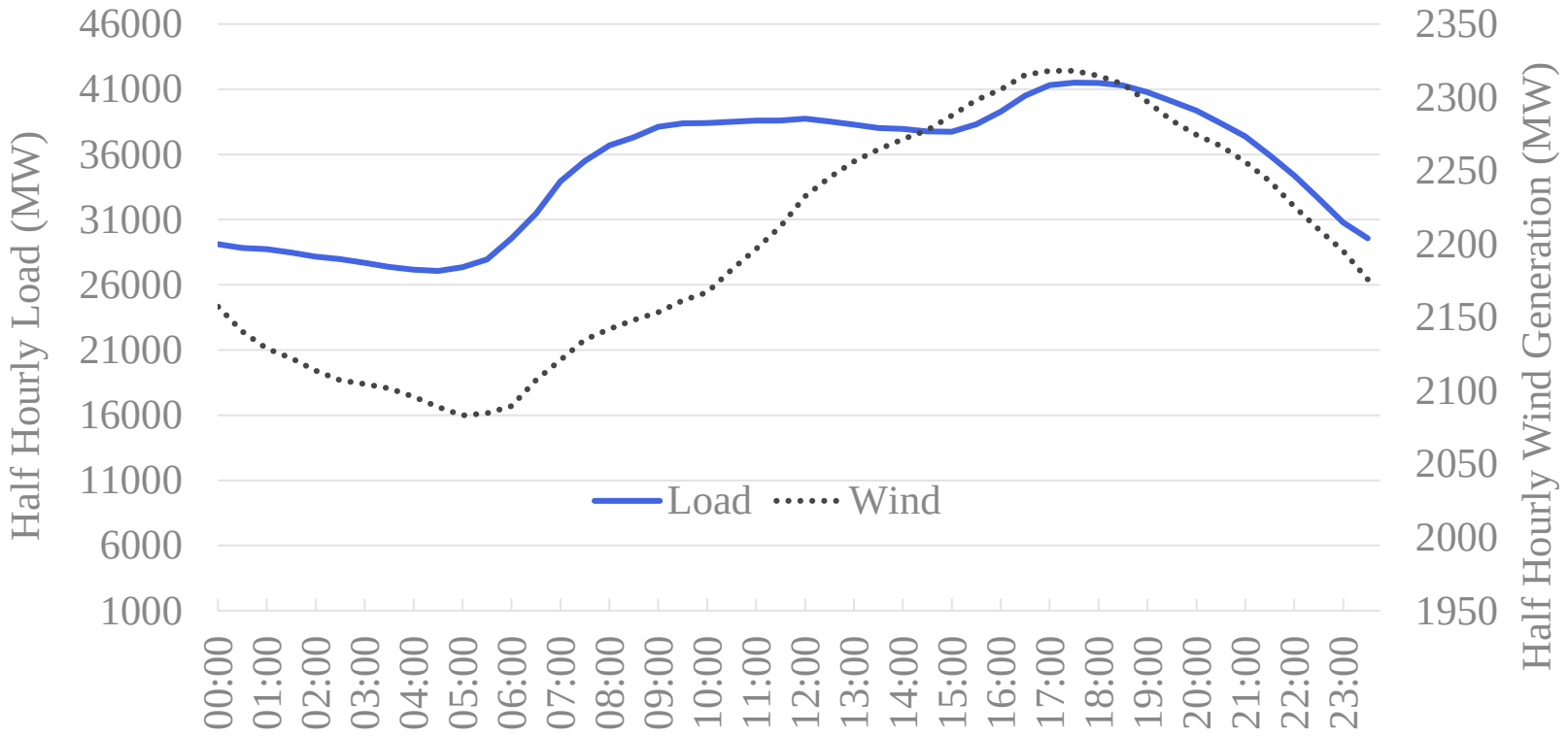
→ Wind accounts for >20% UK electricity generation

UK Electricity Generation by Source (GWh)

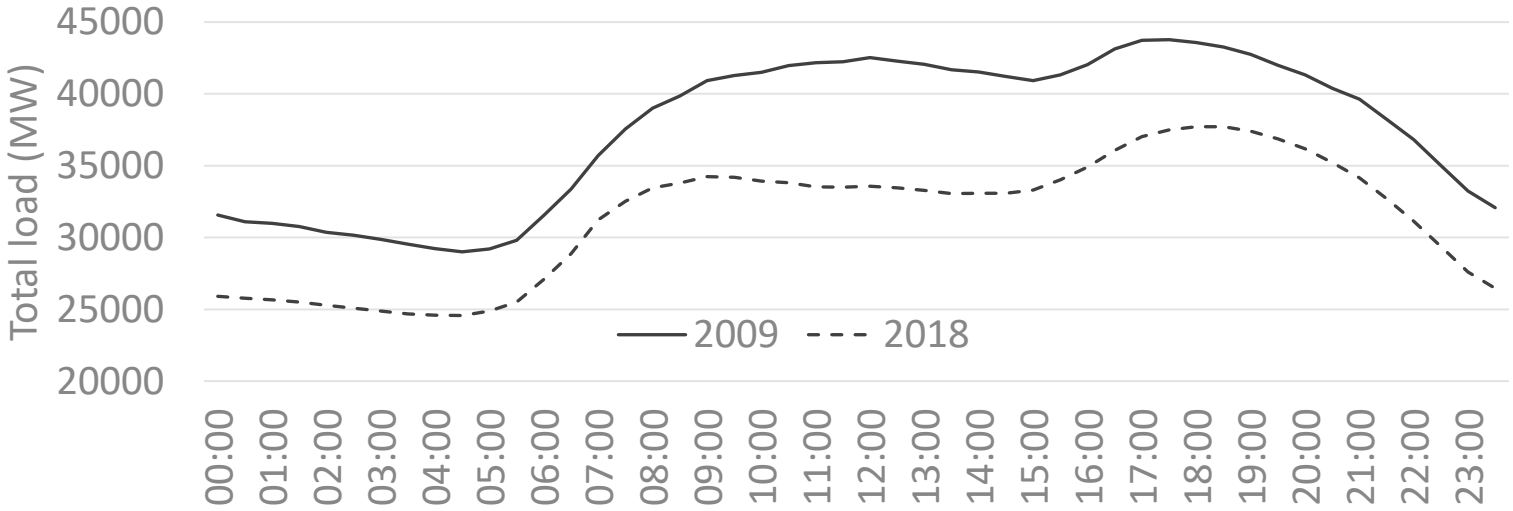


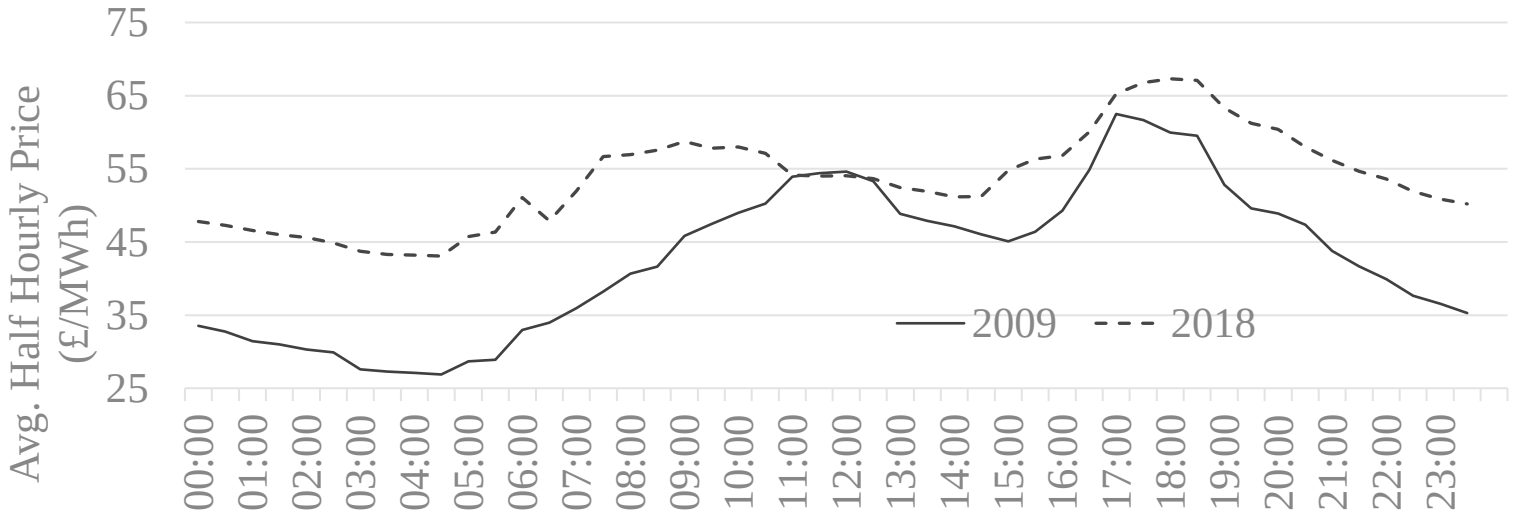
Source: Digest of UK Energy Statistics, 2021

Average Half Hourly GB Wind Generation and Total Load (2008-2019)

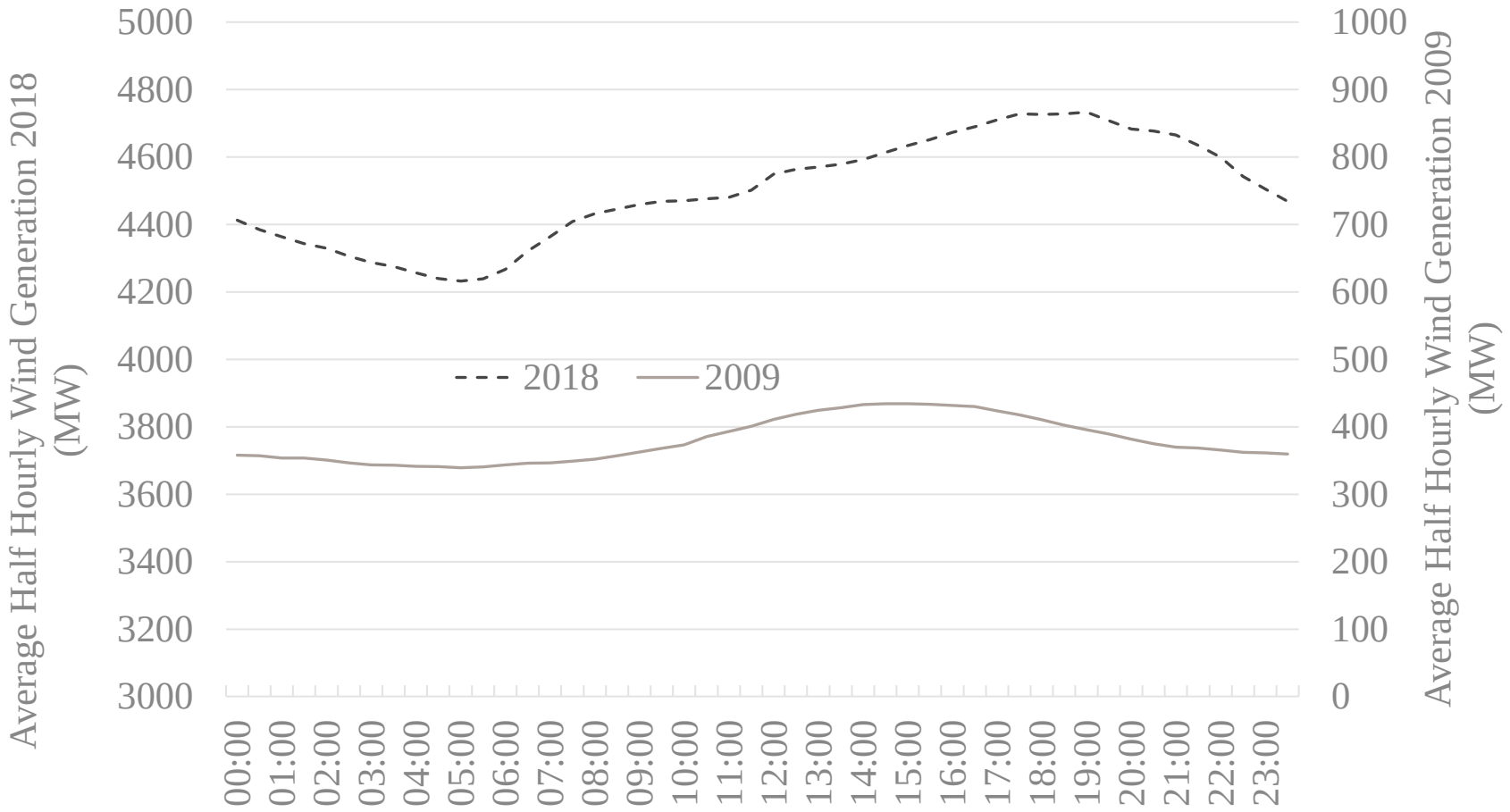


Data (Load and Wholesale Prices Comparison)

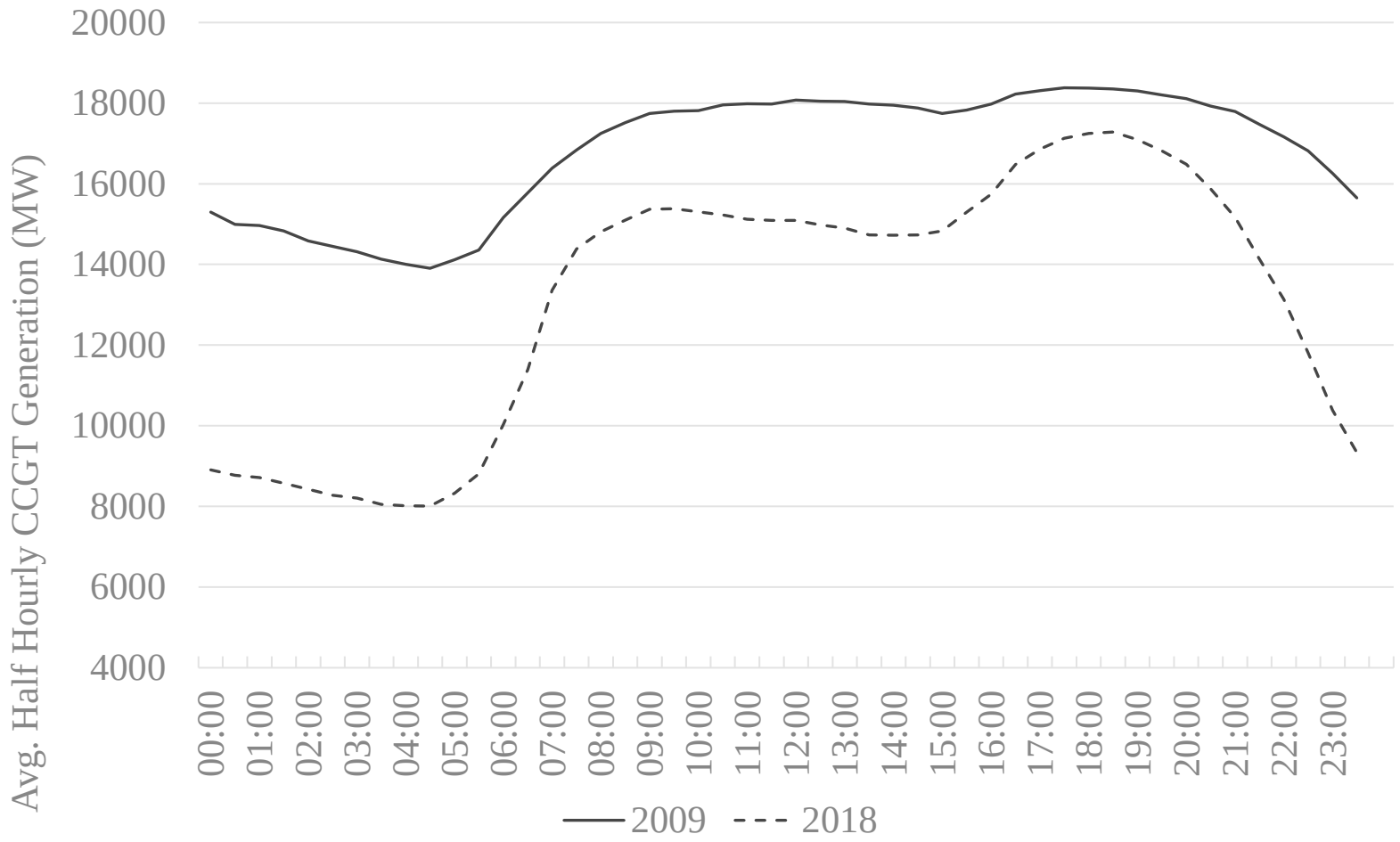




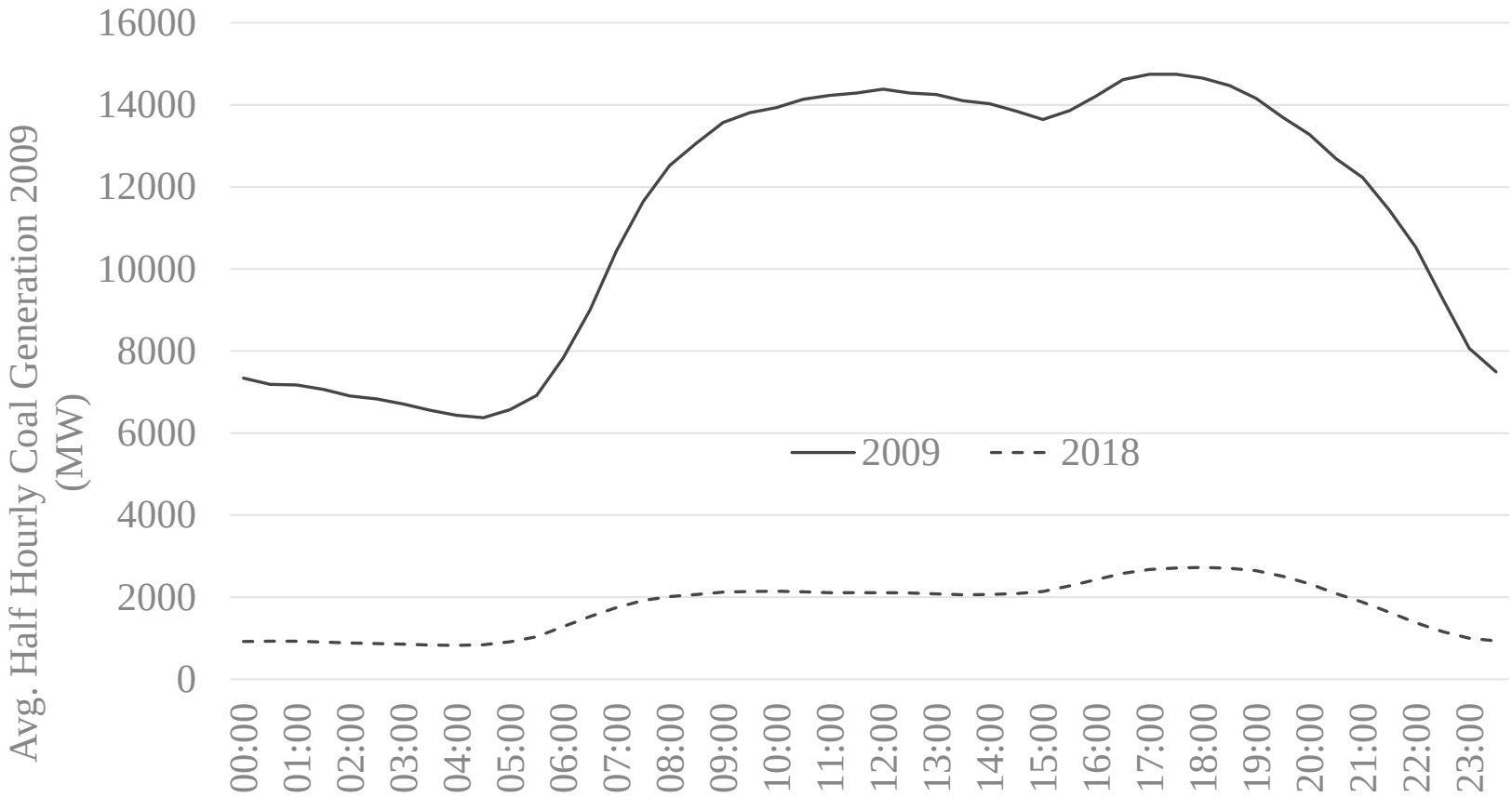
Wind Generation (2009 vs 2018)



CCGT (2009 vs 2018)



Coal (2009 vs 2018)



The empirical model

Half-hourly price with monthly dummies

$$P_{hf,d} = \alpha_{hf,m} + \beta_{hf}^{1} \cdot Wind_d + \beta_{hf}^{2} \cdot Load_{hf,d} + \beta_{hf}^{3} \cdot NBPI_d + \beta_{hf}^{4} \cdot Coalprice_d + \beta_{hf}^{5} \cdot CPF_d + \varepsilon_{hf,d}$$

Half-hourly price with month-and-yearly dummies

$$P_{hf,d} = \alpha_{hf,m,y} + \beta_{hf}^{1} \cdot Wind_d + \beta_{hf}^{2} \cdot Load_{hf,d} + \beta_{hf}^{3} \cdot NBPI_d + \beta_{hf}^{4} \cdot Coalprice_d + \beta_{hf}^{5} \cdot CPF_d + \varepsilon_{hf,d}$$

Non-wind generation

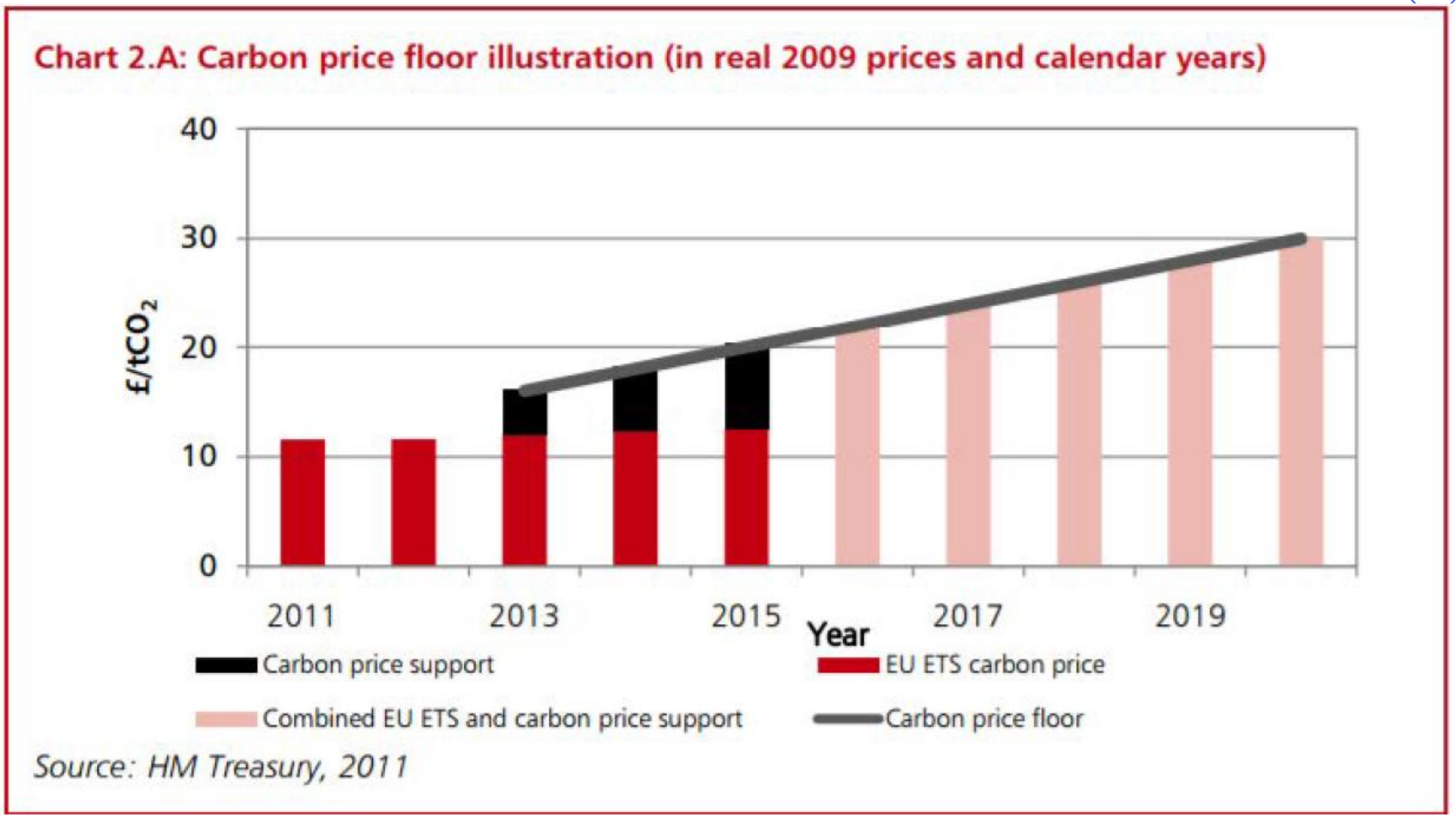
$$NWGen_{hf,d}^{i} = \alpha_{hf,m}^{i} + \beta_{hf}^{i,1} \cdot Wind_d + \beta_{hf}^{i,2} \cdot Load_{hf,d} + \beta_{hf}^{i,3} \cdot NBPI_d + \beta_{hf}^{i,4} \cdot Coalprice_d + \beta_{hf}^{i,5} \cdot CPF_d + \varepsilon_{hf,d}^{i}$$

Carbon Price Floor

The Carbon Price Floor (CPF) is a UK Government policy implemented to support the EU Emissions Trading System (EU ETS). The CPF was introduced on 1 April 2013 to underpin the price of carbon at a level that drives low carbon investment.

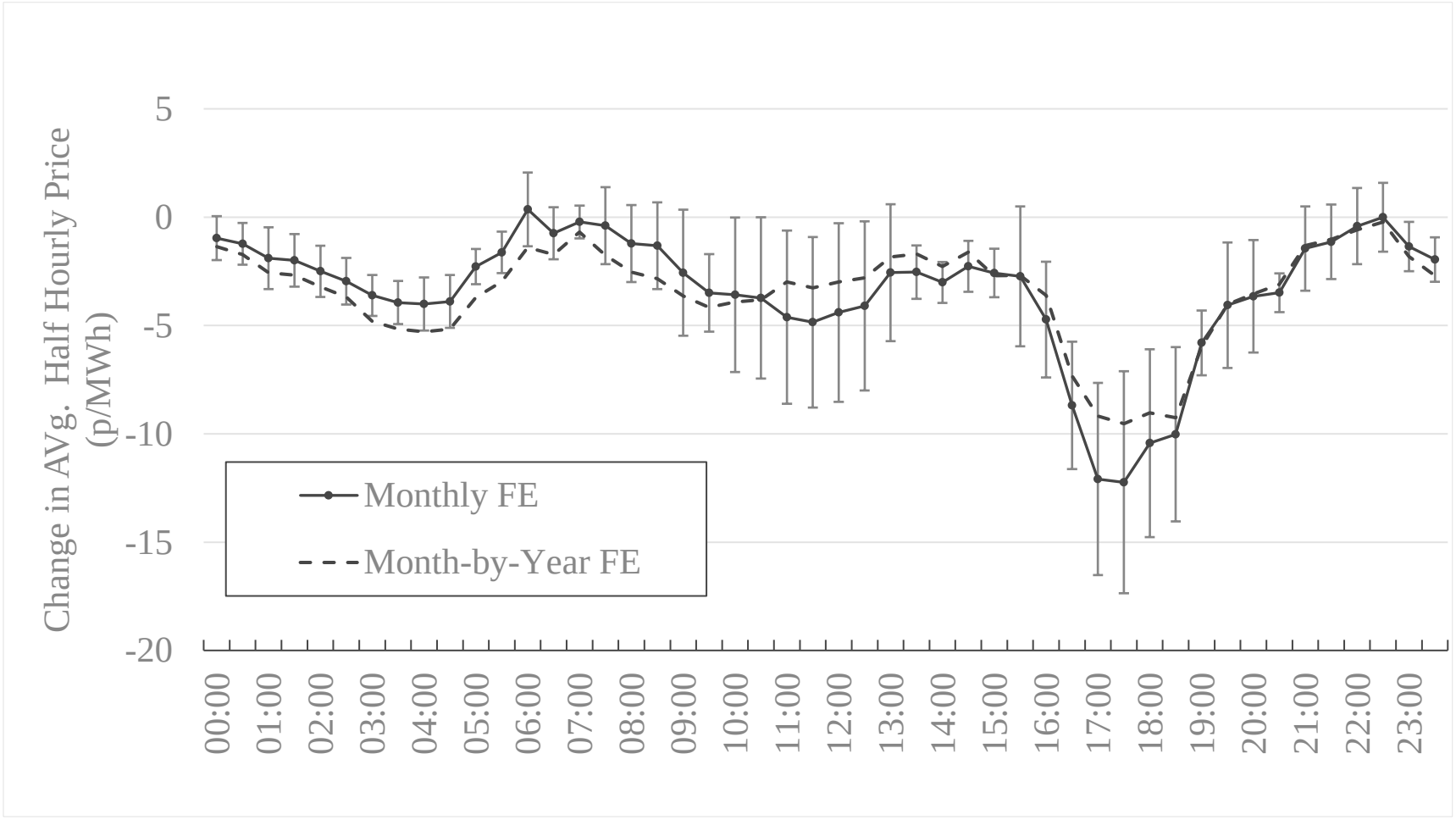
The CPF taxes fossil fuels used to generate electricity via **Carbon Price Support rates set under the Climate Change Levy.**

The price floor consists of two components which are paid for by energy generators in two different ways: (i) The EU ETS allowance price; and (ii) the Carbon Support Price (CPS), which tops up the EU ETS allowance prices, as projected by the Government, to the carbon floor price target.

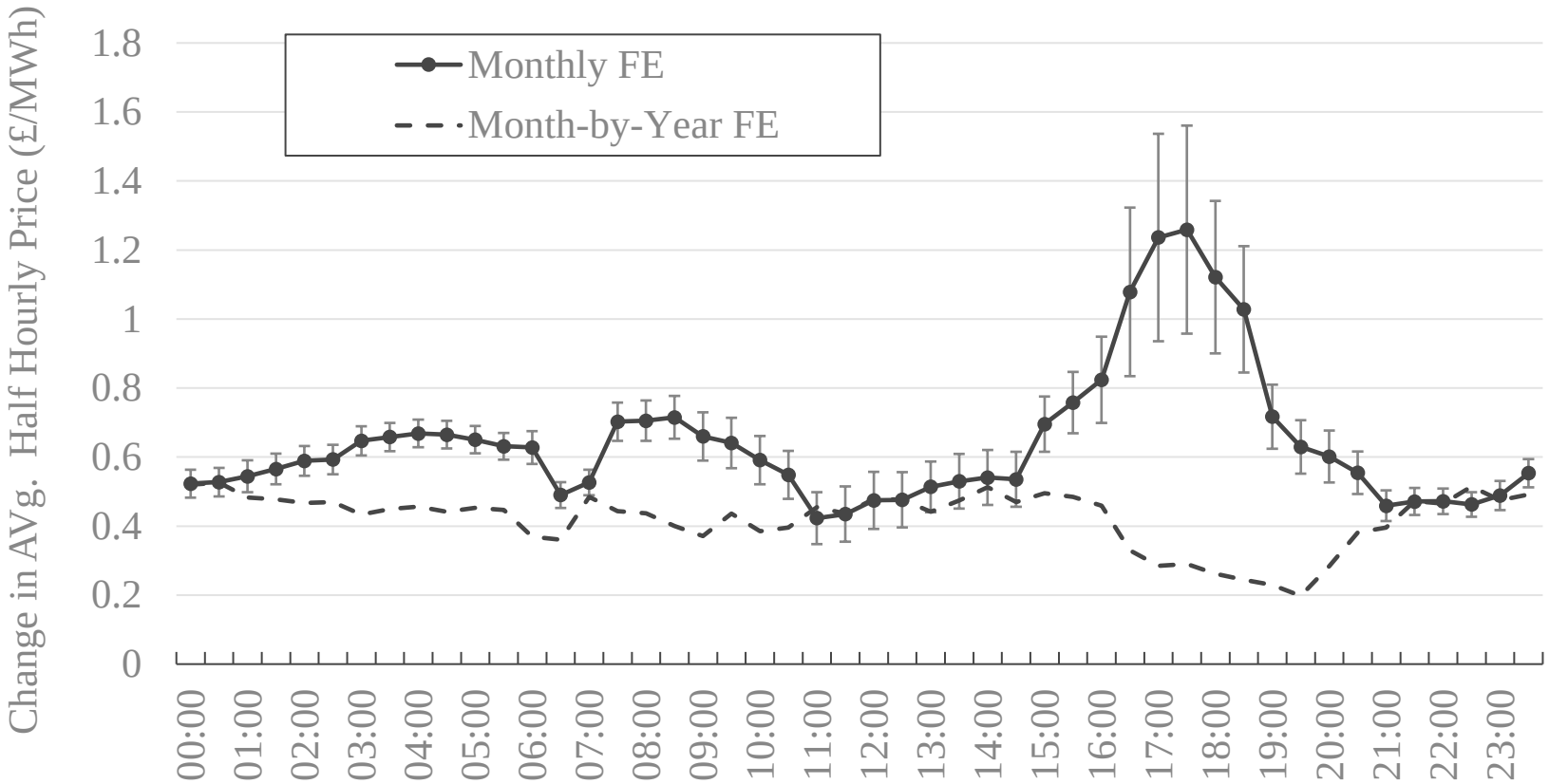


https://commonslibrary.parliament.uk/research-briefings/sn05927/

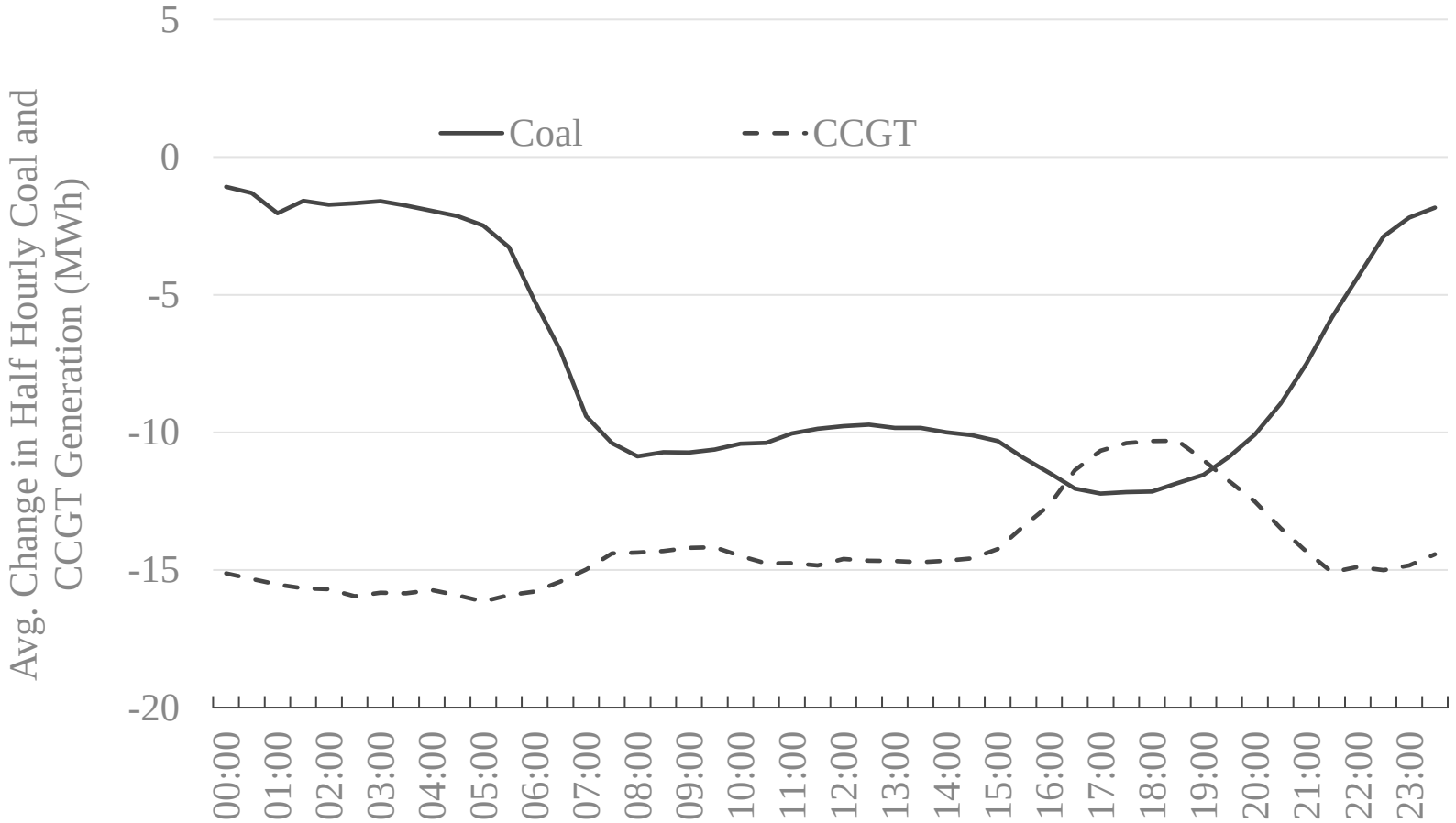
Change in Real Price (p/MWh) per GWh of Daily Aggregate Wind Generation

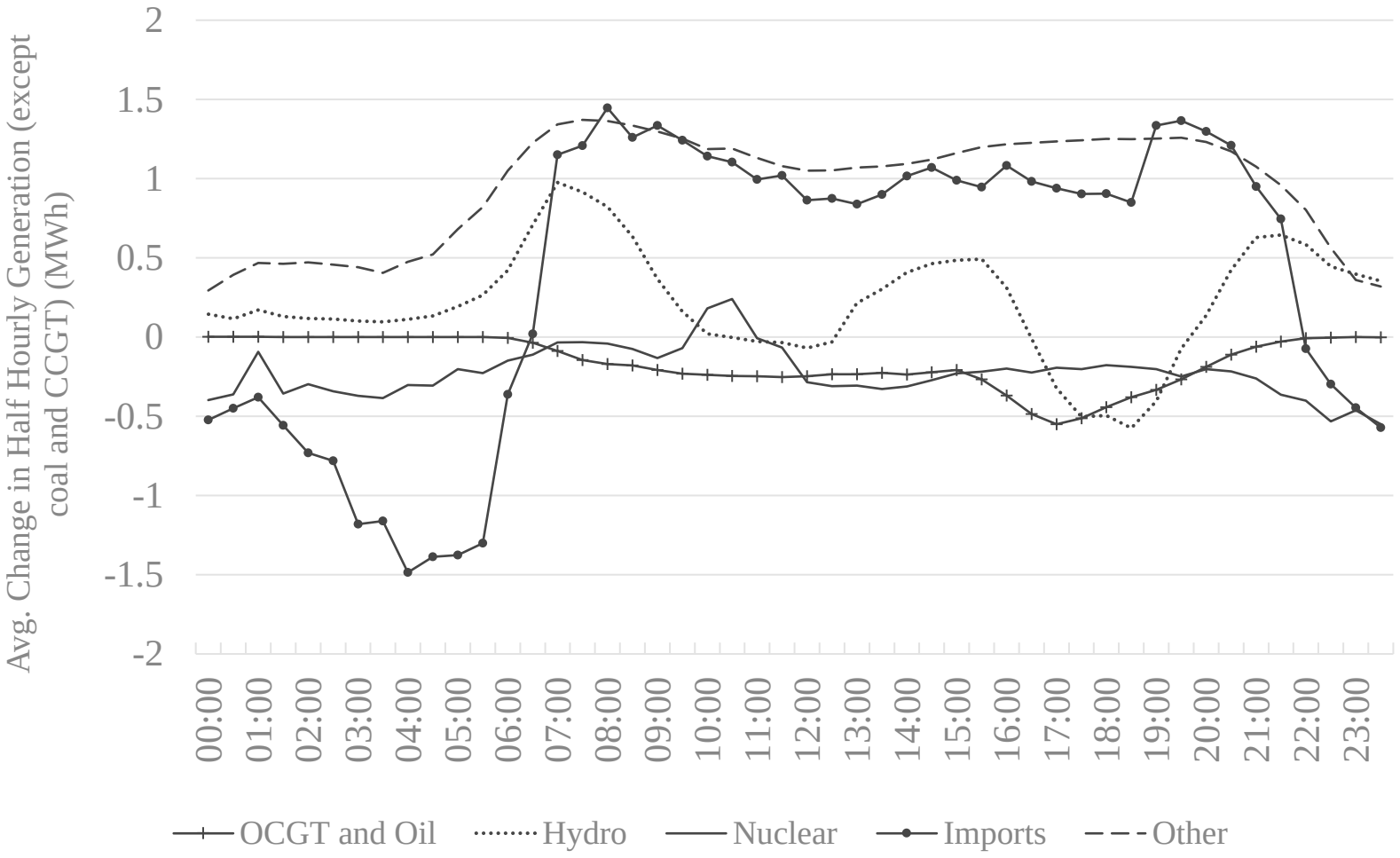


Change in Real Price per £/Metric Ton of CO2 (HAC 2sd 95% CI)

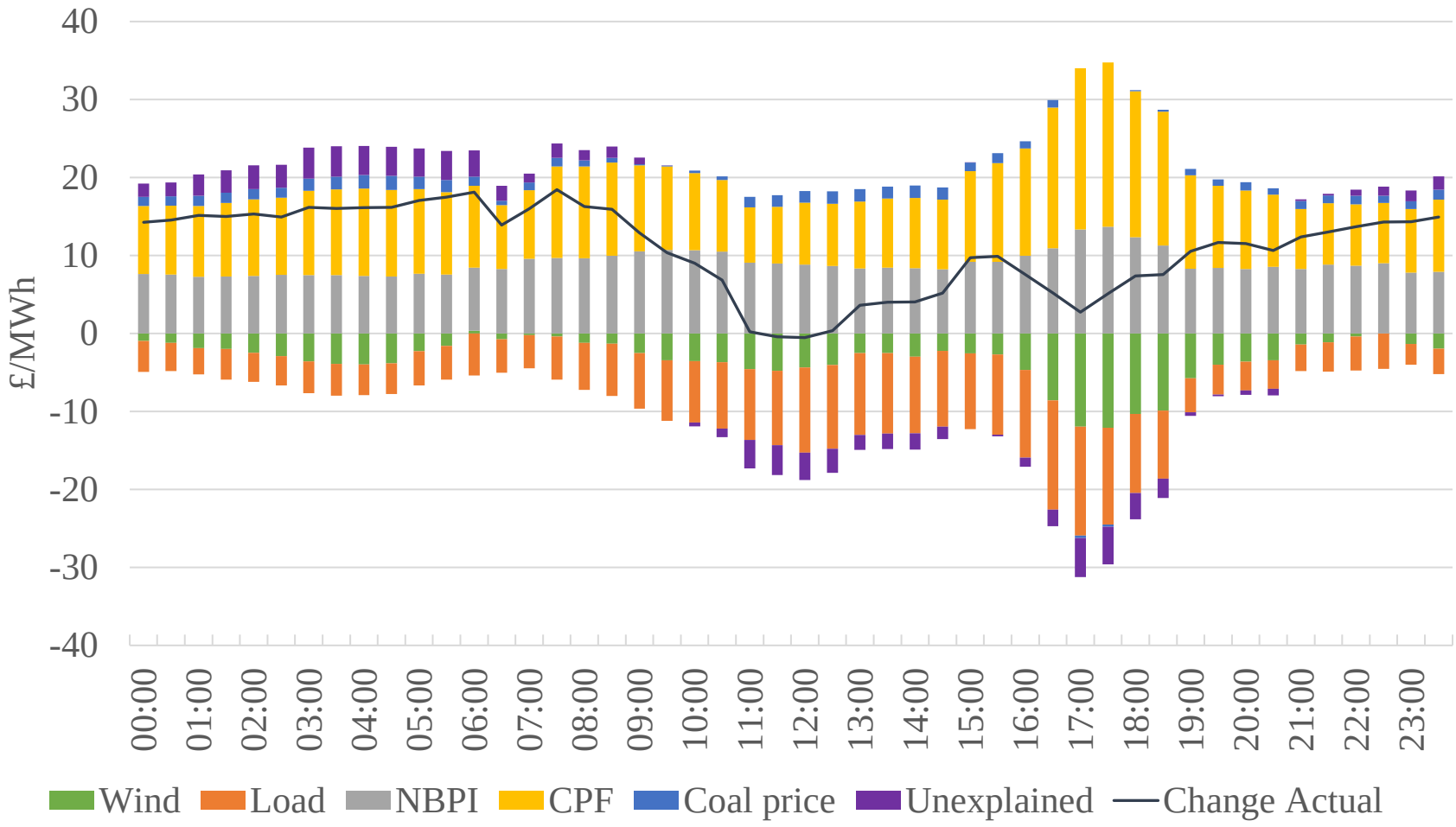


Change in the UK fossil generation per GWh of daily Wind

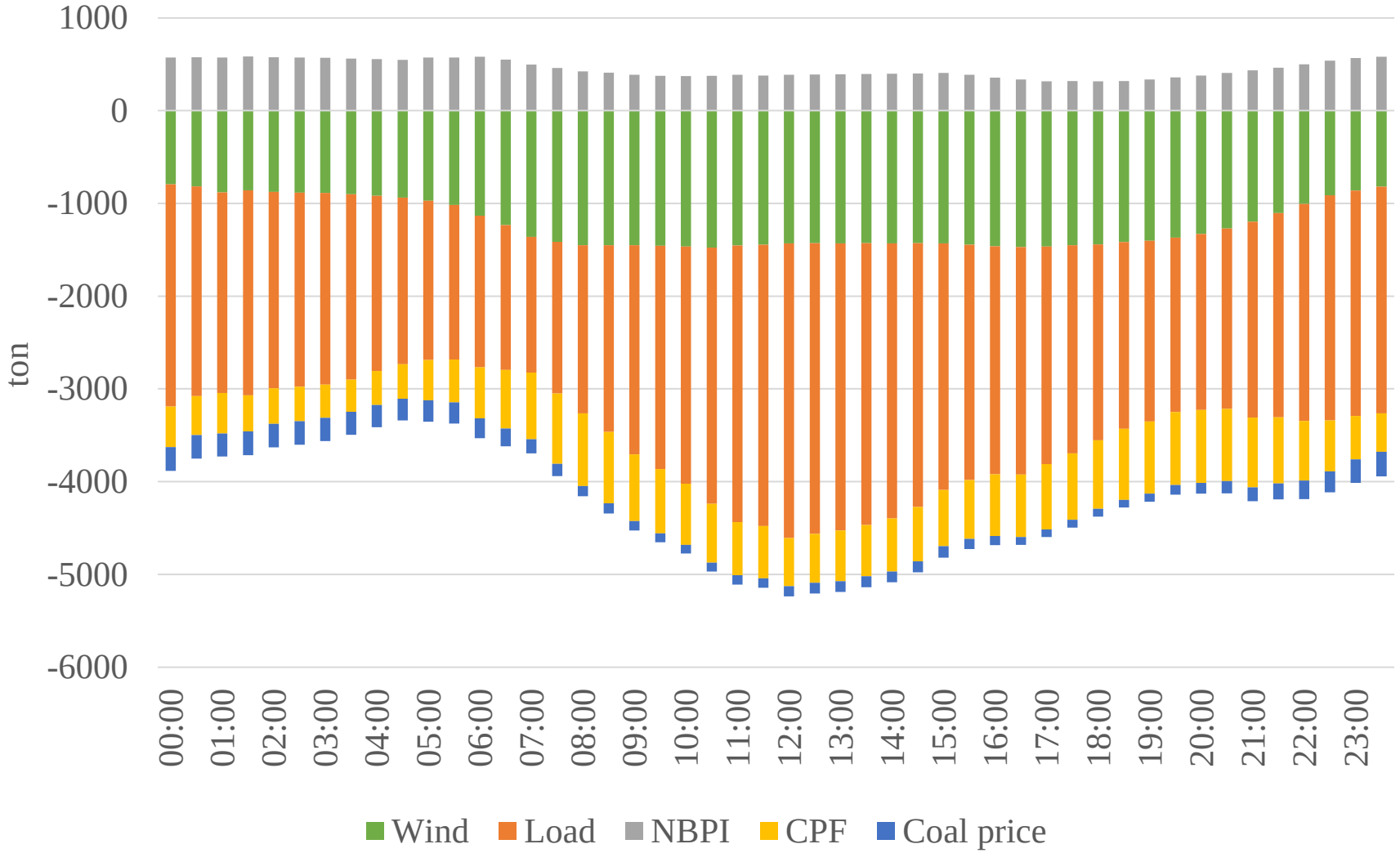



Avg. Change in Half Hourly Generation (except coal and CCGT) (MWh)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
OCGT and Oil
Hydro
Nuclear
Imports
Other

How has each of the factors impacted on the price?



Impacts on CO2 Reduction (contribution of independent variables between 2009 and 2018



Summary and conclusion

- Contributions:
  - Focus on the differential impact of wind on electricity prices, emissions and operation of other assets
  - Analyse the influence of different external factors
- The wind condition in UK is benevolent to load (positively correlated).
- The wind generation significantly lowers wholesale electricity prices in almost every hour, except morning ramping up and late evening ramping down hours.
- Load reduction and increased wind generation are the two most important factors lowering the price; while gas and carbon prices increase the electricity prices.
- Load reduction, carbon prices, and wind all contributed to the CO2 emission reduction.