Imperial College
Business School

Imperial means
Intelligent Business

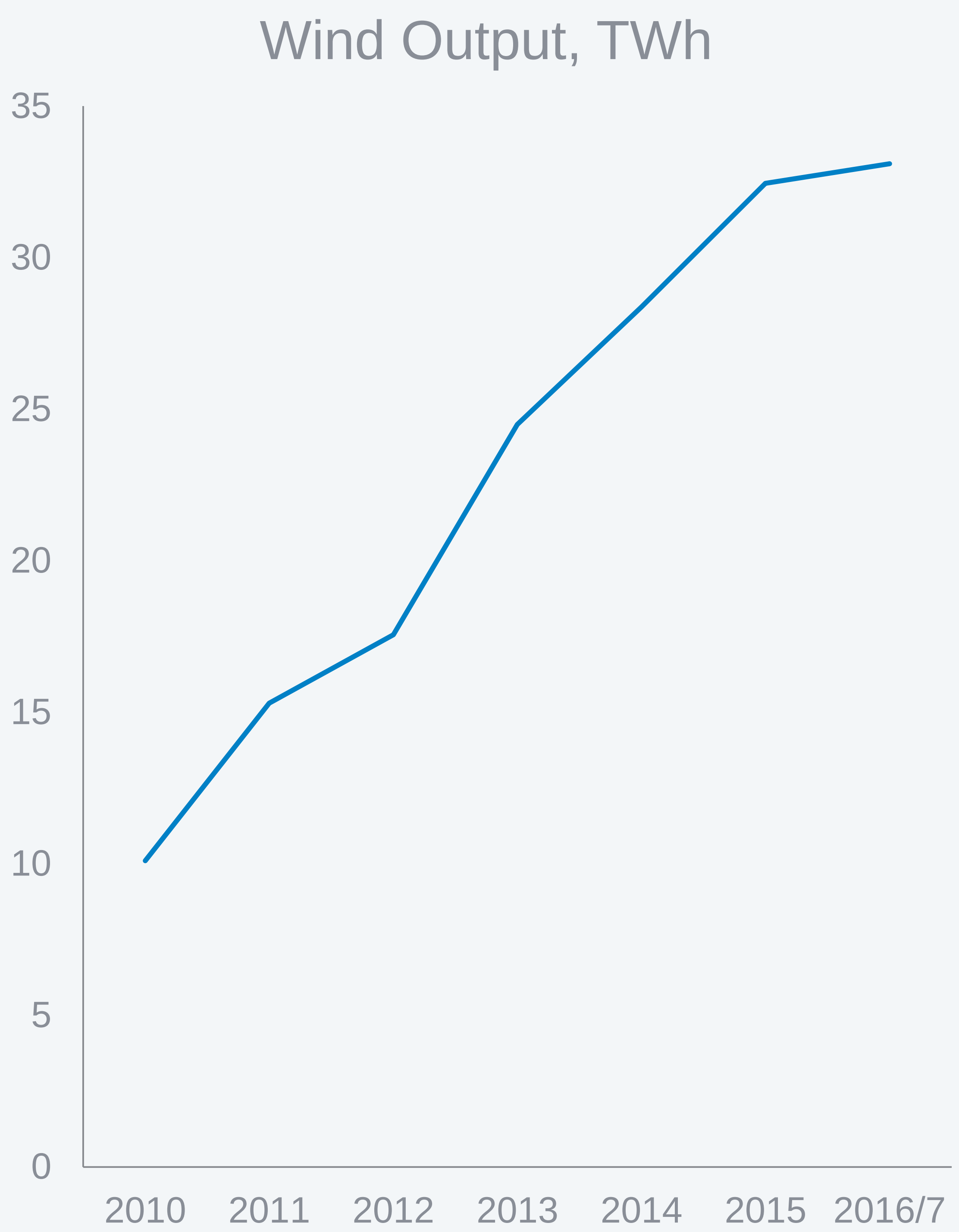
Electricity, Wind and Carbon

Professor Richard Green

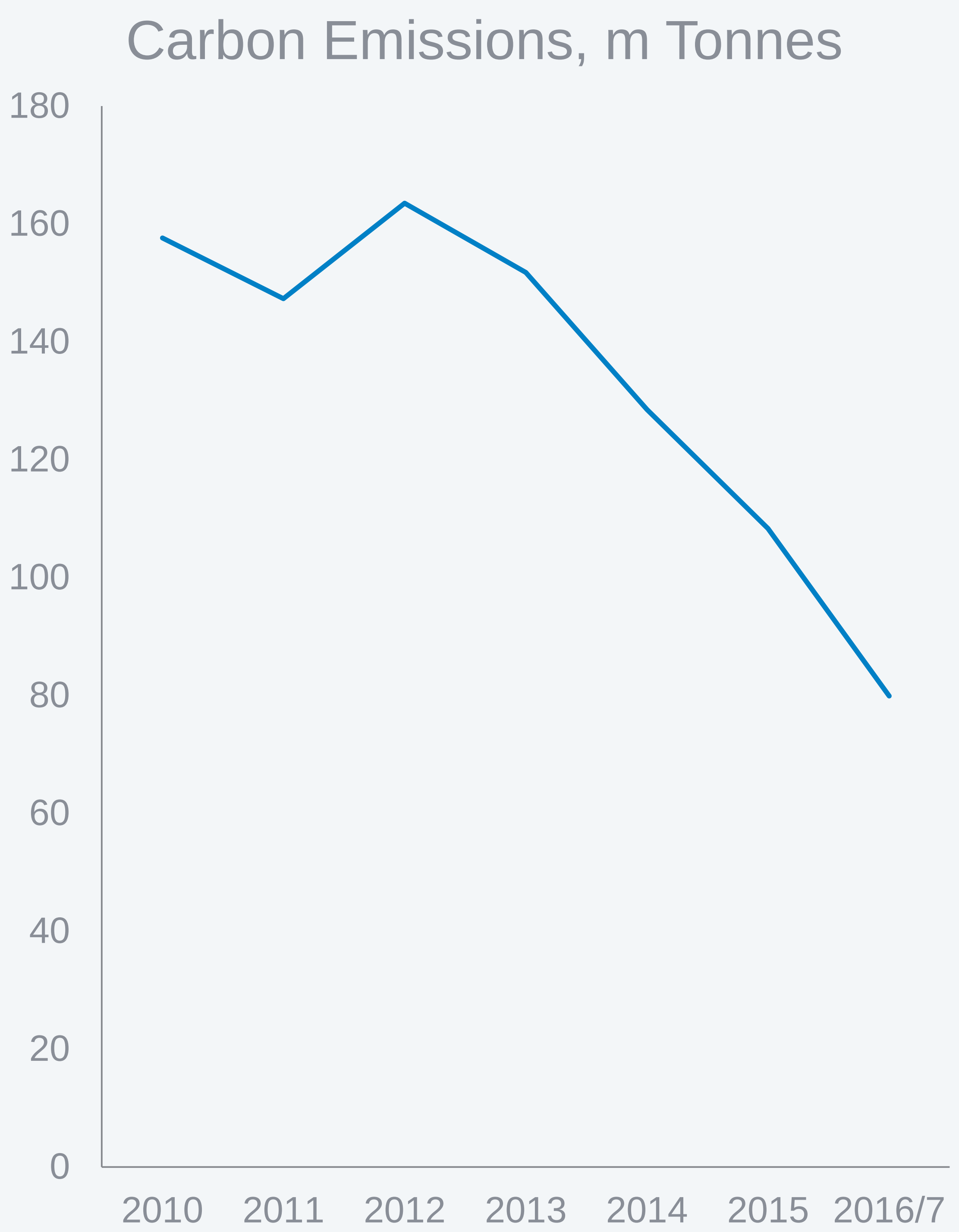
Supergen Wind Hub General Assembly, 27 April 2017

Two recent trends:

The Rise of Wind



The Reduction in CO_2 Emissions



Maximising the Carbon Impact of Wind Power

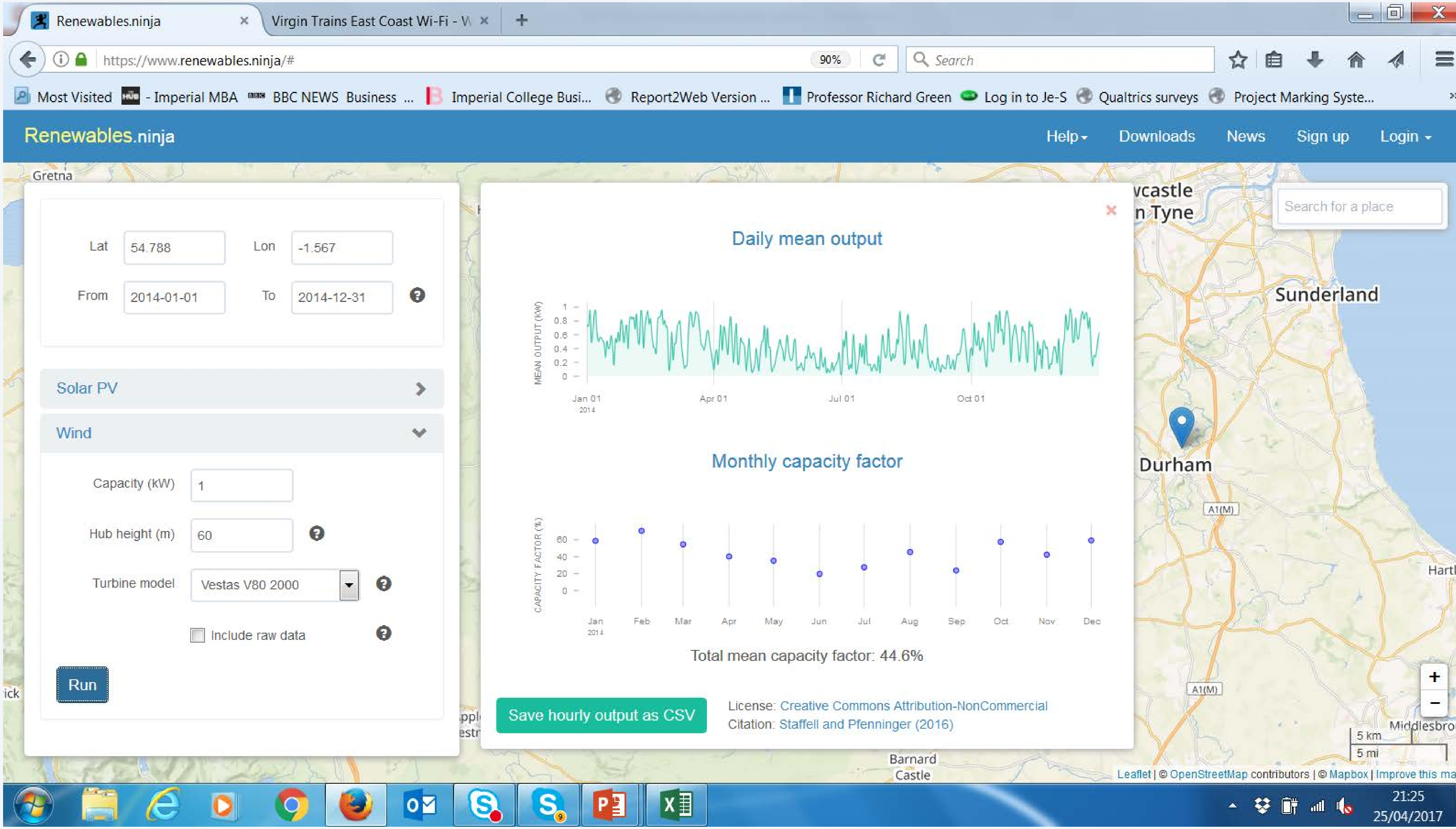
1) Improve wind output simulations based on reanalysis weather data

2) Estimate hourly emissions for the British power sector

3) Assess the impact of wind output, fuel prices, and wind forecast accuracy

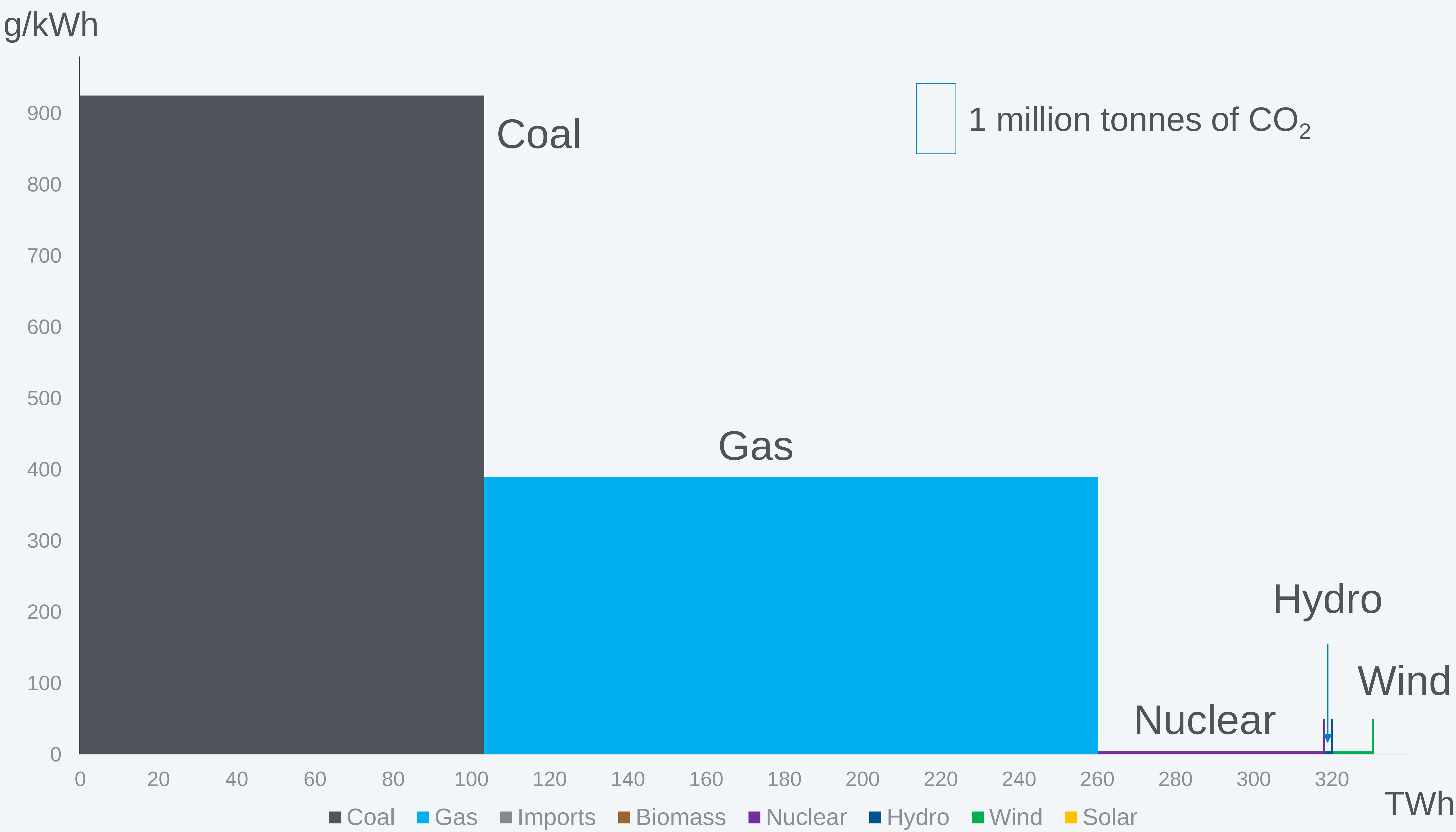
Wind simulations from Renewables.Ninja

Stefan Pfenninger and Iain Staffell



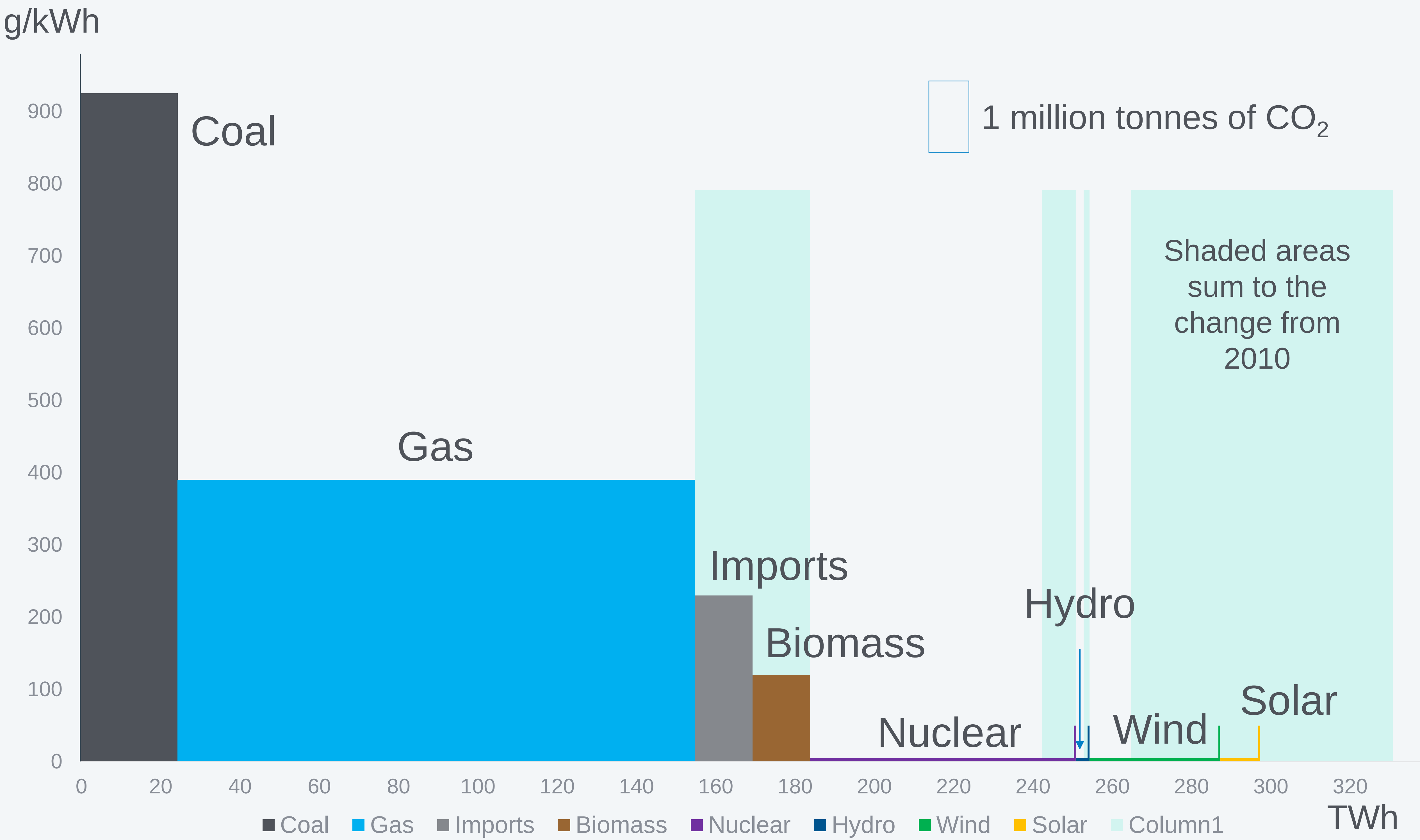
Where do the emissions come from?

Electricity Generated and CO_2 emissions in GB, 2010



Source: www.electricinsights.co.uk (Imperial College and Drax Power)

Electricity Generated and CO_2 emissions in GB, 2016/7



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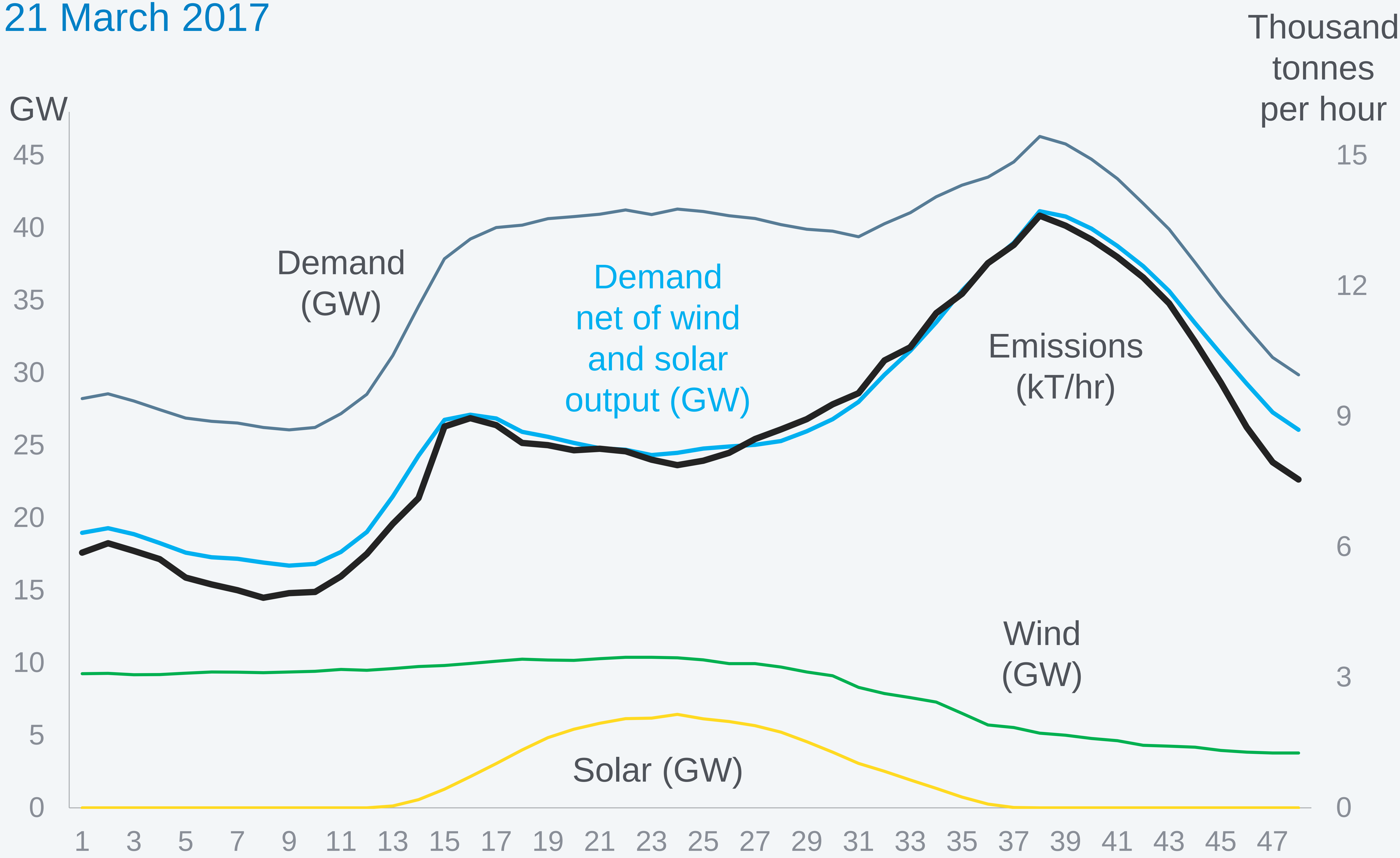
What’s behind the big picture?

Demand and Emissions of CO_2

21 March 2017



Demand and Emissions of CO_2

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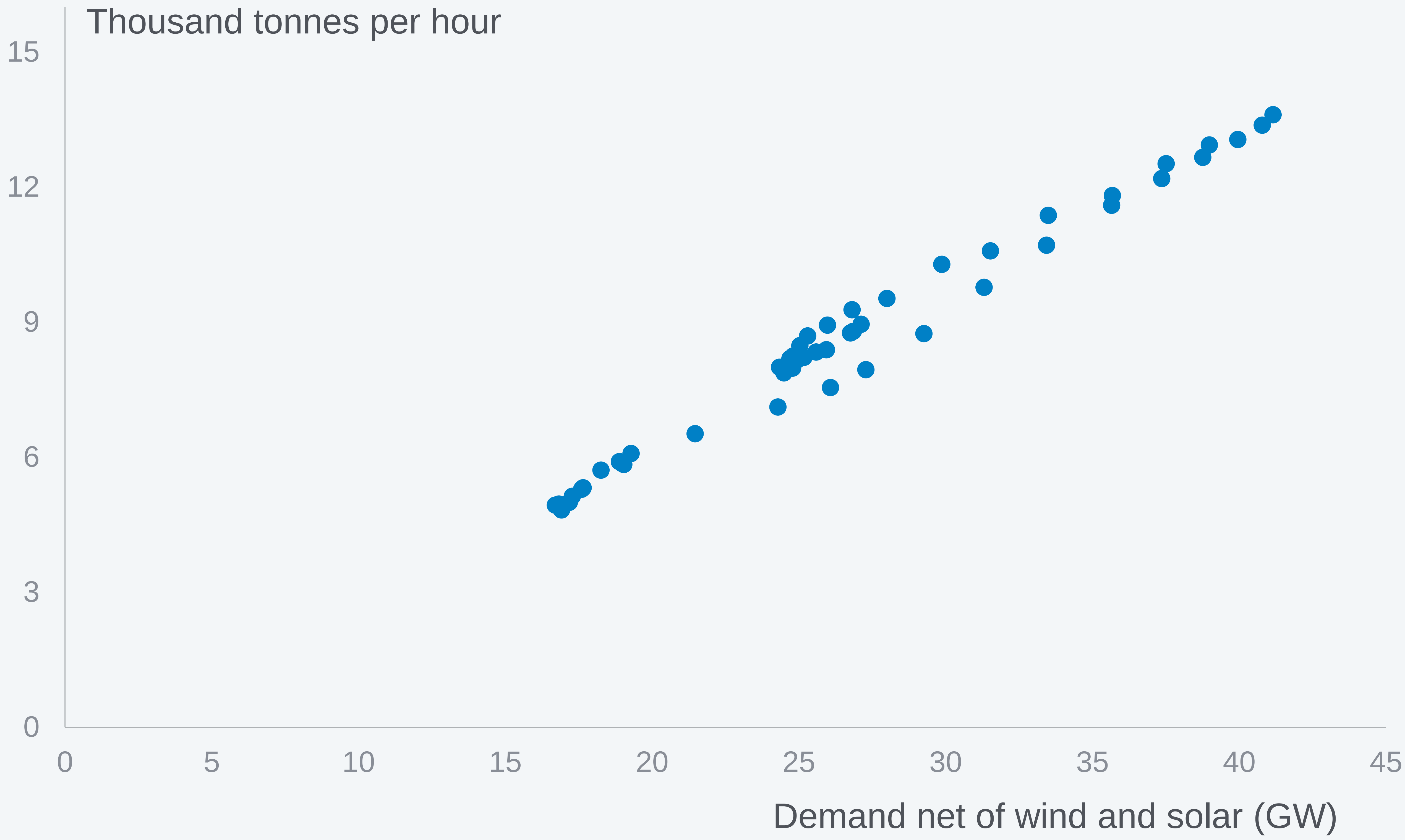
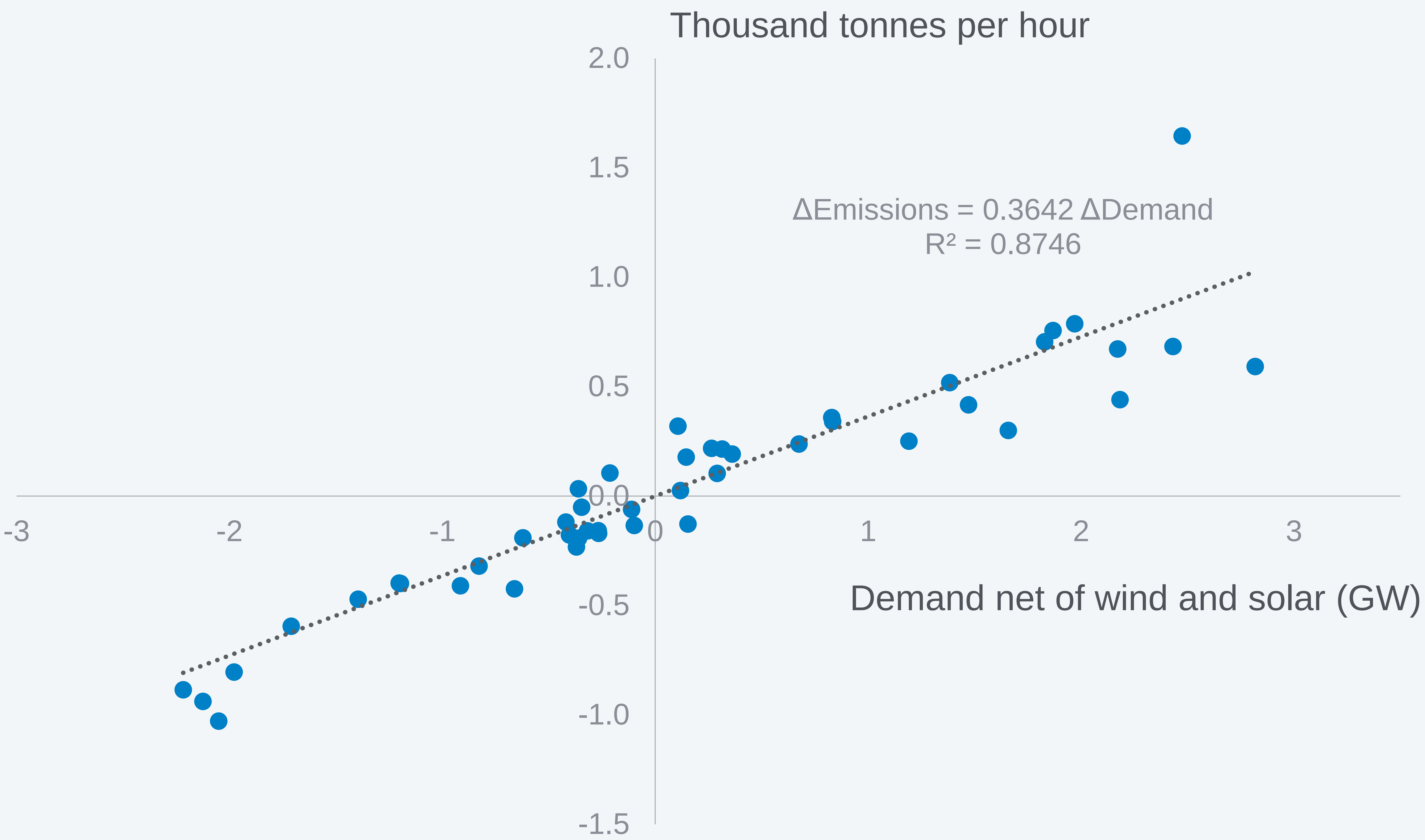


Changes in Demand and Emissions of CO_2

21 March 2017

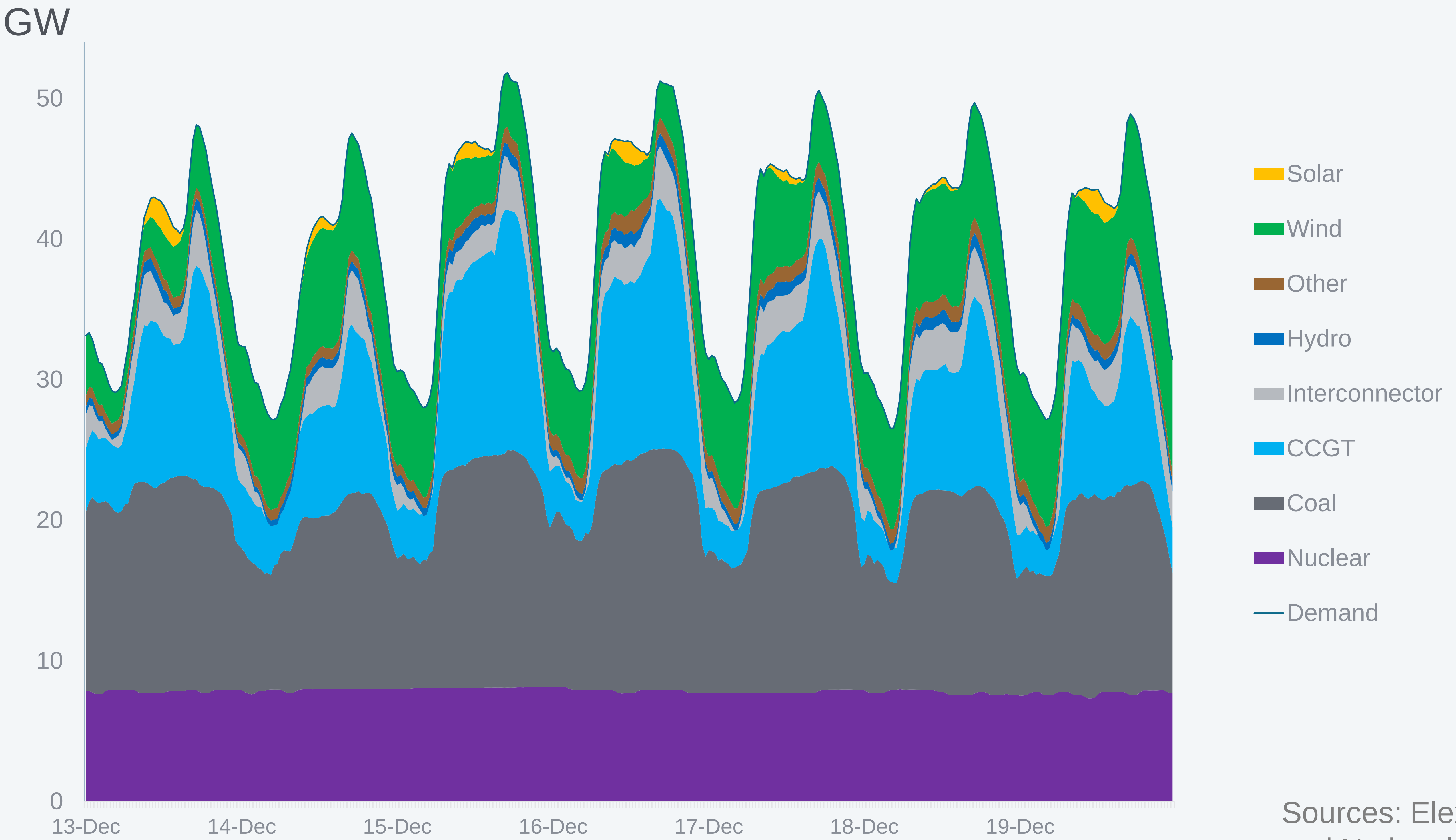


Preliminary answer?

- An extra MWh of demand raises emissions by 493 ± 1 kg
- An extra MWh of wind output cuts emissions by 462 ± 10 kg
- An extra MWh of solar output cuts emissions by 510 ± 8 kg

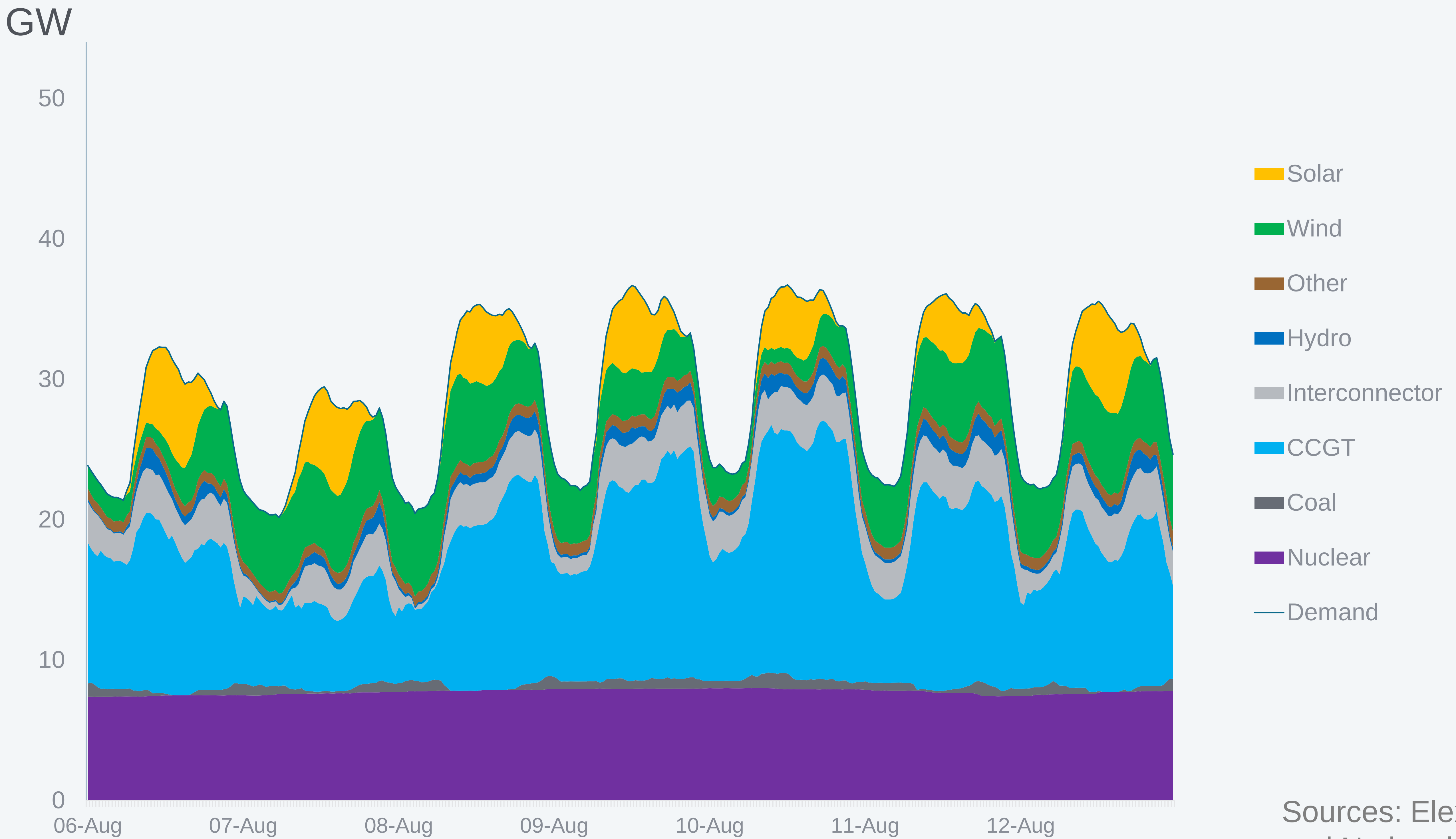
- Calculations of this kind have already been done by Hawkes AD, 2010, Estimating marginal CO_2 emissions rates for national electricity systems, *Energy Policy*, Vol: 38, Pages: 5977-5987
- These are averages of marginal emissions factors that are likely to change over time, and hence VERY preliminary

Generation in Great Britain,13-19 December 2014



Sources: Elexon and National Grid

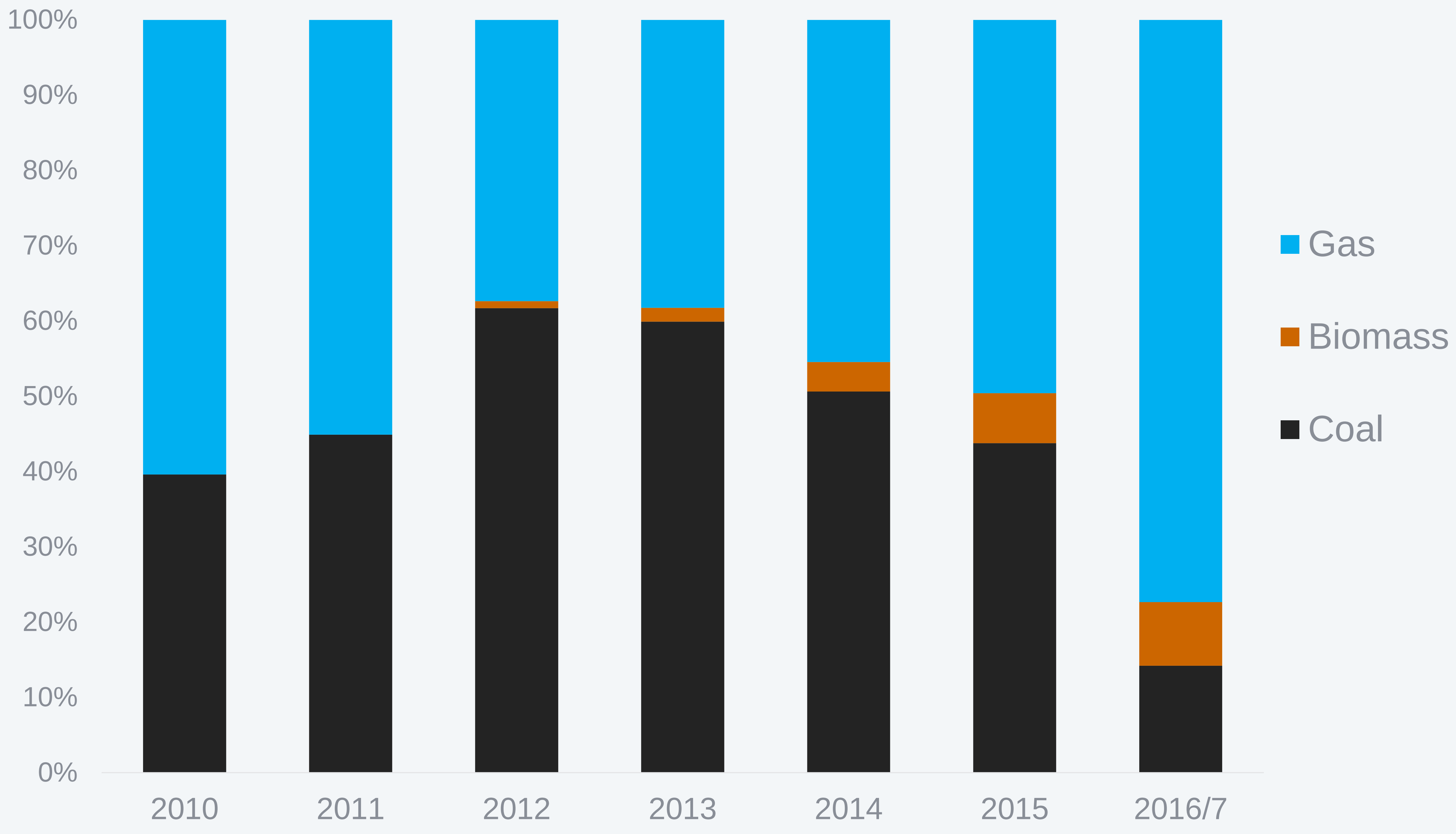
Generation in Great Britain, 6-12 August 2016



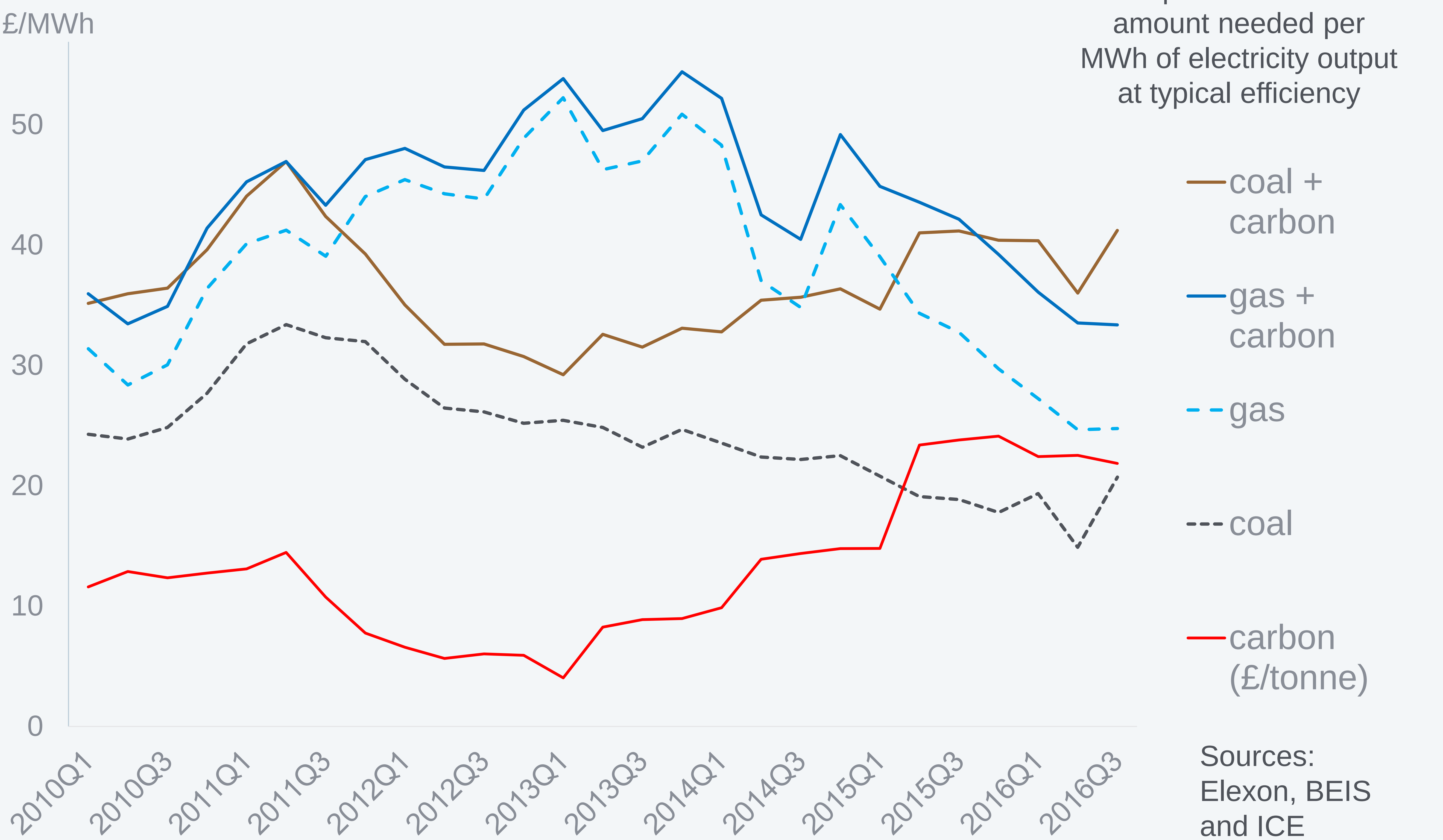
Sources: Elexon and National Grid

What caused the change?

Shares of Thermal Generation



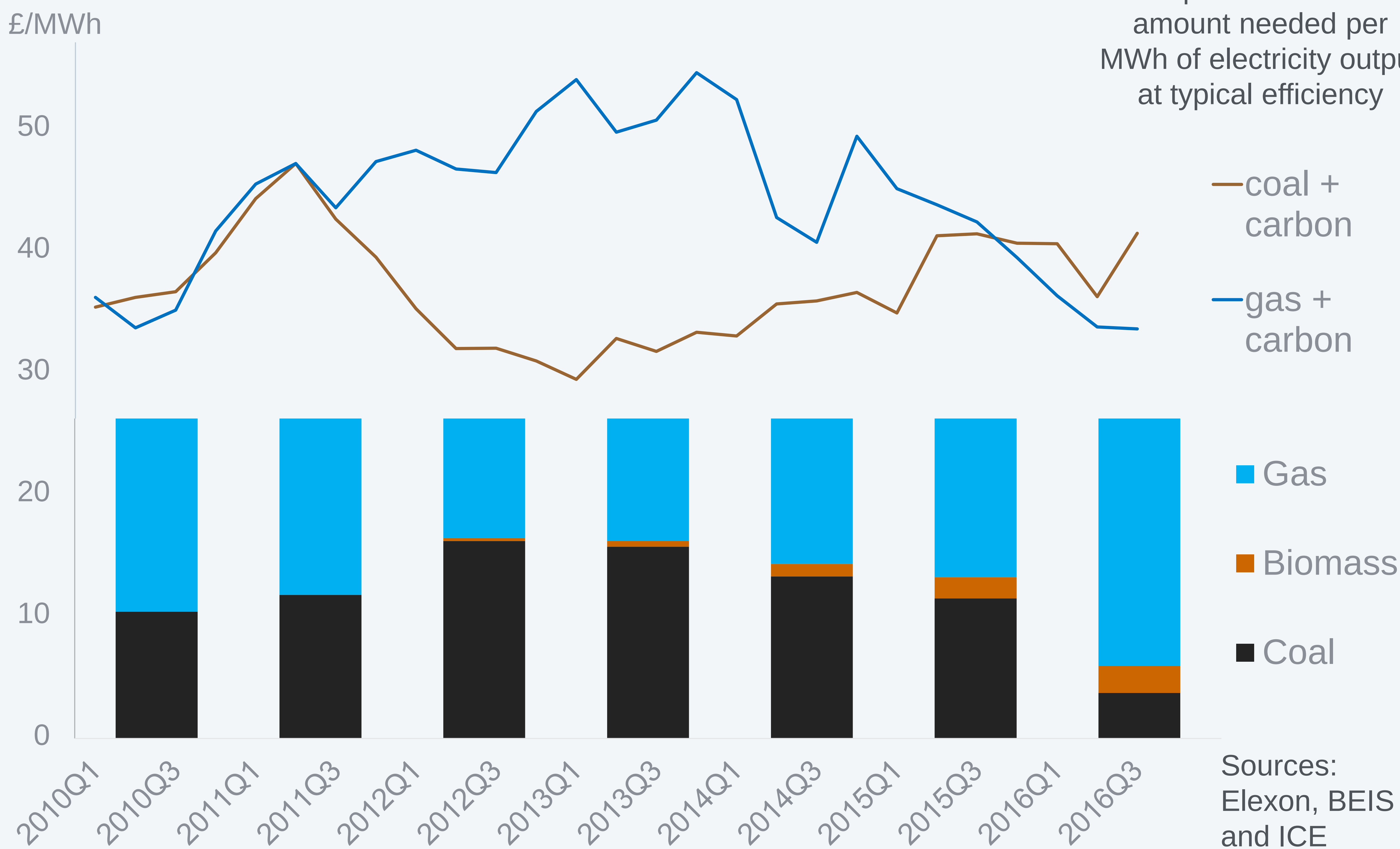
GB Fuel Prices



Fuel prices are for the amount needed per MWh of electricity output at typical efficiency

Sources: Elexon, BEIS and ICE

GB Fuel Prices



Fuel prices are for the amount needed per MWh of electricity output at typical efficiency

Sources: Elexon, BEIS and ICE

Preliminary answer?

When Coal is the marginal fuel (2009Q3 – 2011Q2, 2015Q4 – 2017Q1)

- An extra MWh of demand raises emissions by 521 ± 1 kg
- An extra MWh of wind output cuts emissions by 481 ± 15 kg
- An extra MWh of solar output cuts emissions by 526 ± 11 kg

When Gas is the marginal fuel (2009Q1 – Q2, 2011Q3 – 2015Q3)

- An extra MWh of demand raises emissions by 468 ± 1 kg
- An extra MWh of wind output cuts emissions by 454 ± 13 kg
- An extra MWh of solar output cuts emissions by 451 ± 12 kg

More detailed calculations have already been done by Thomson, R., Harrison, G. & Chick, J.(2017) Marginal Greenhouse Gas Emissions Displacement of Wind Power in Great Britain *Energy Policy*

We will be “digging deeper” into the causal factors

Maximising the Carbon Impact of Wind Power

1) Improve wind output simulations based on reanalysis weather data

2) Estimate hourly emissions for the British power sector

3) Assess the impact of wind output, fuel prices, and wind forecast accuracy

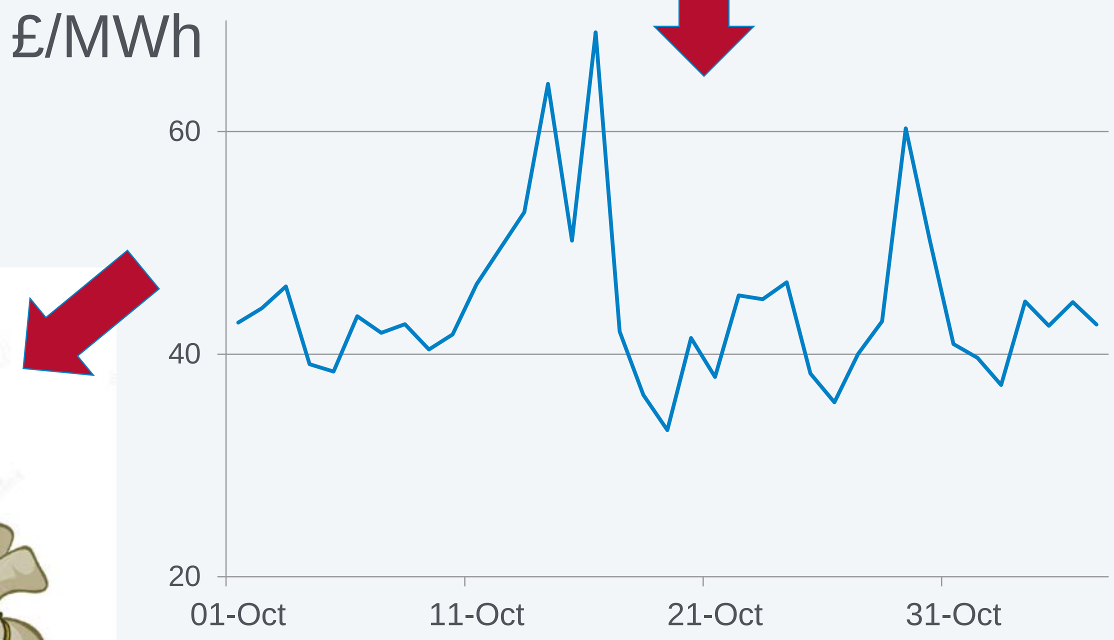
4) Model future investment and operating decisions changing with wind

The MOSSI model

Merit Order Stack with Step Investment

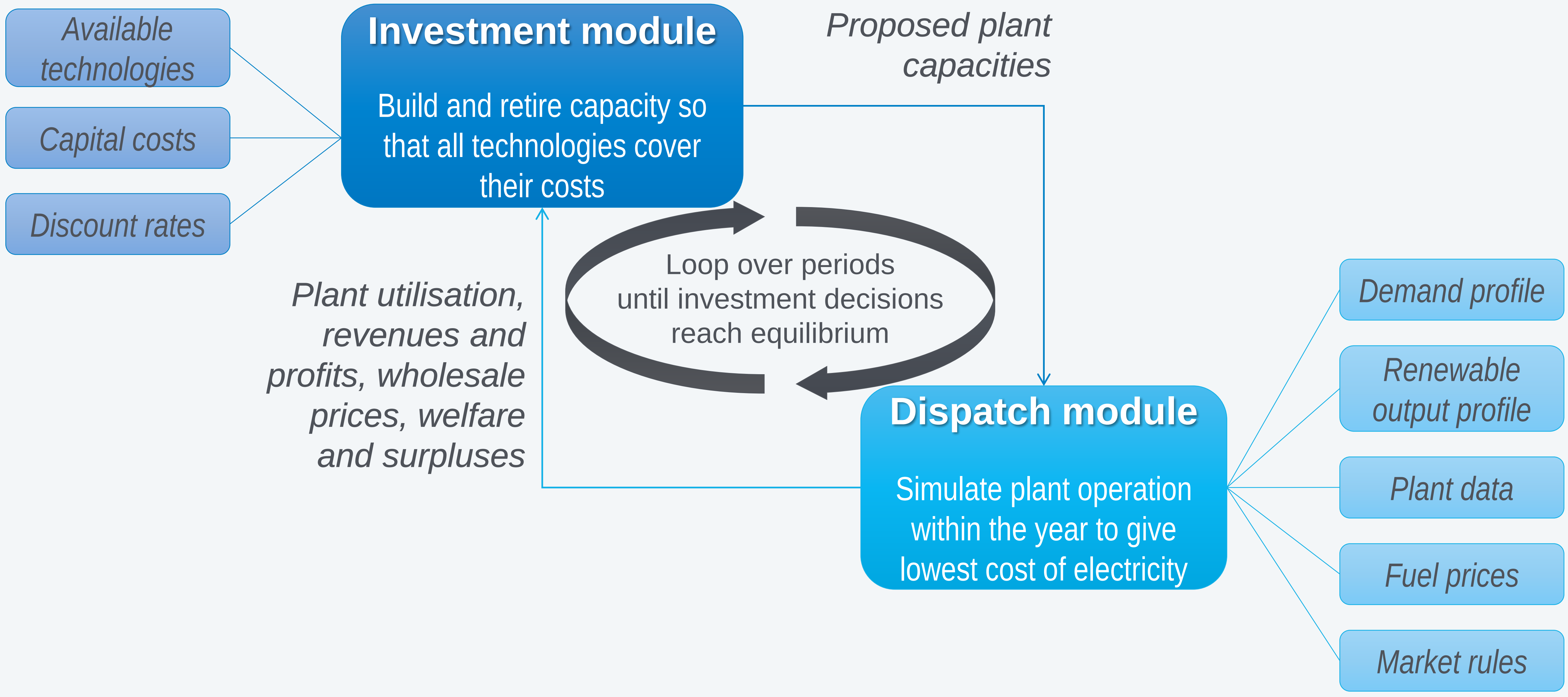




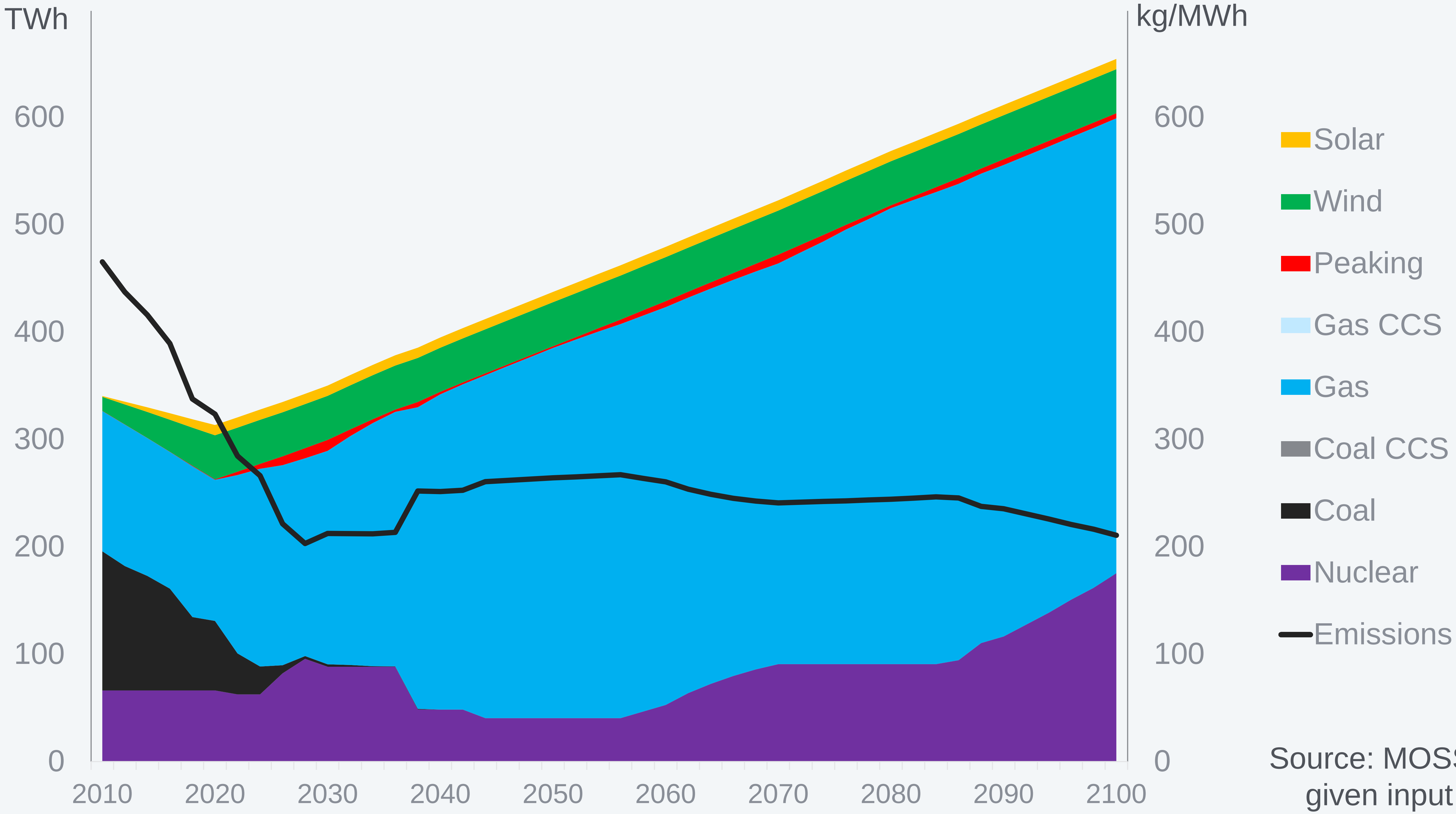
The MOSSI model

Merit Order Stack with Step Investment



Future Electricity Output

Renewables held at 2017 levels, £50 Carbon price in 2050

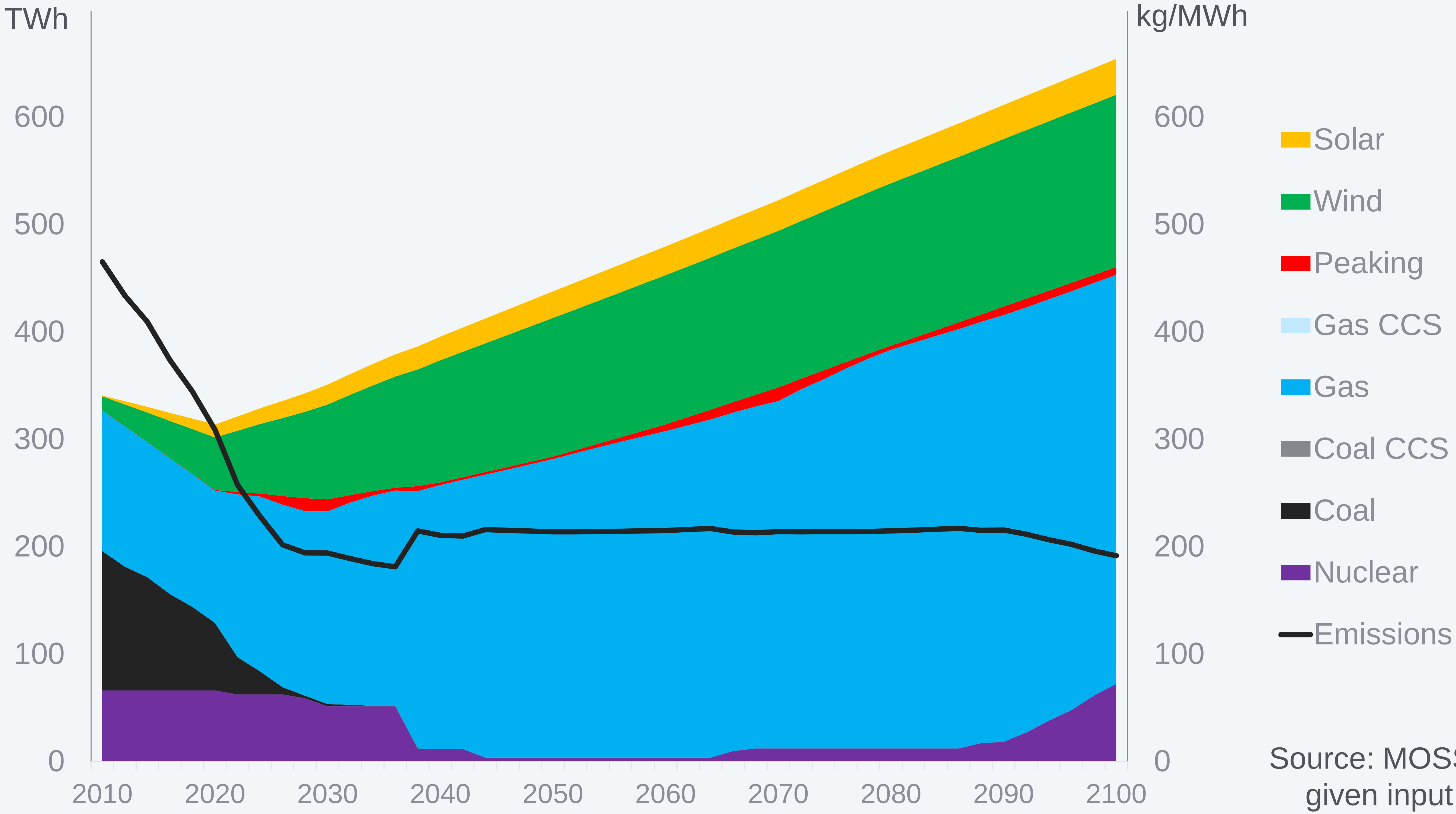


Source: MOSSI, given input assumptions

Electricity storage is not yet included at a significant scale

Future Electricity Output

Renewables continue to grow, £50 Carbon price in 2050



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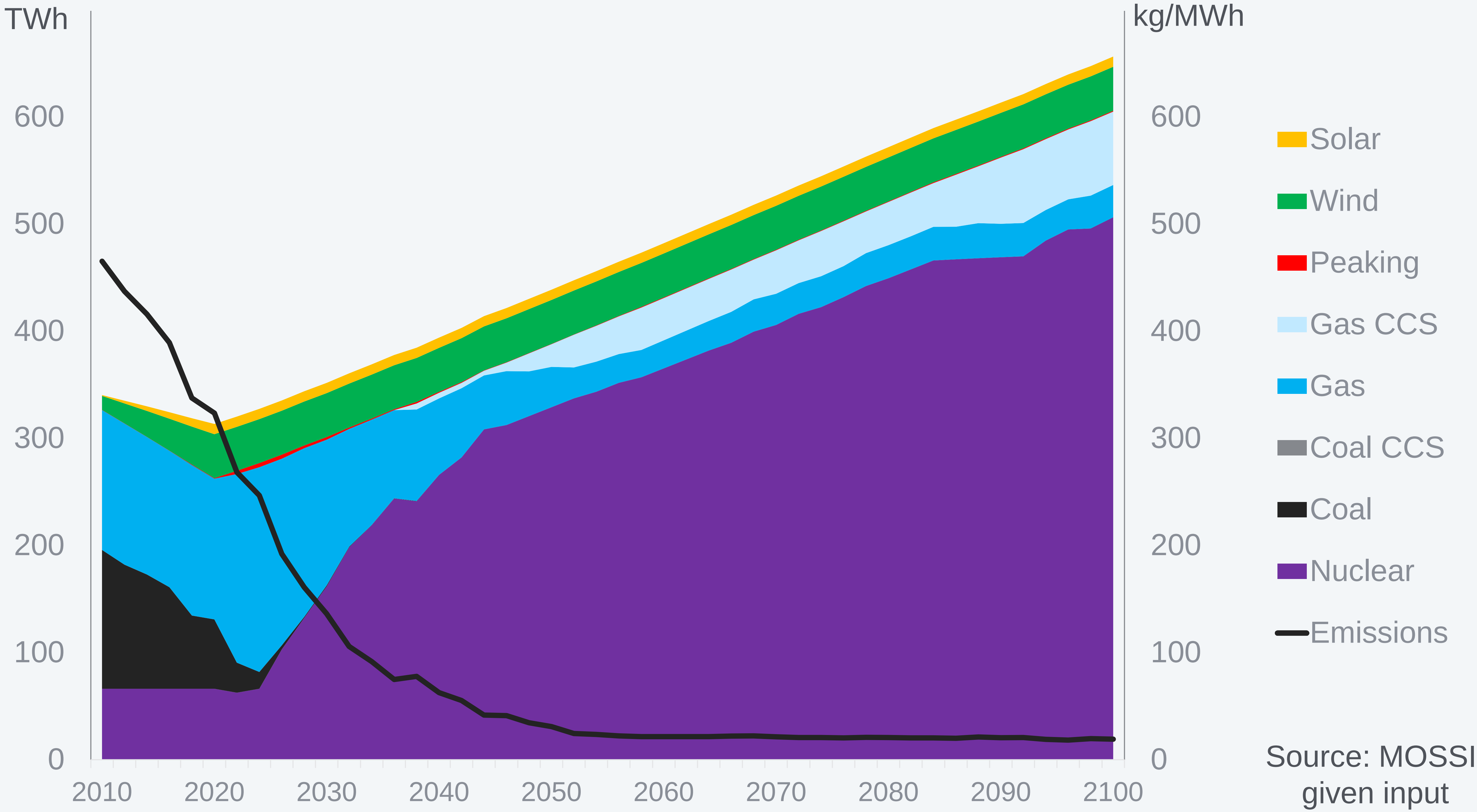
Future Electricity Output

Renewables held at 2017 levels, £250 Carbon price in 2050



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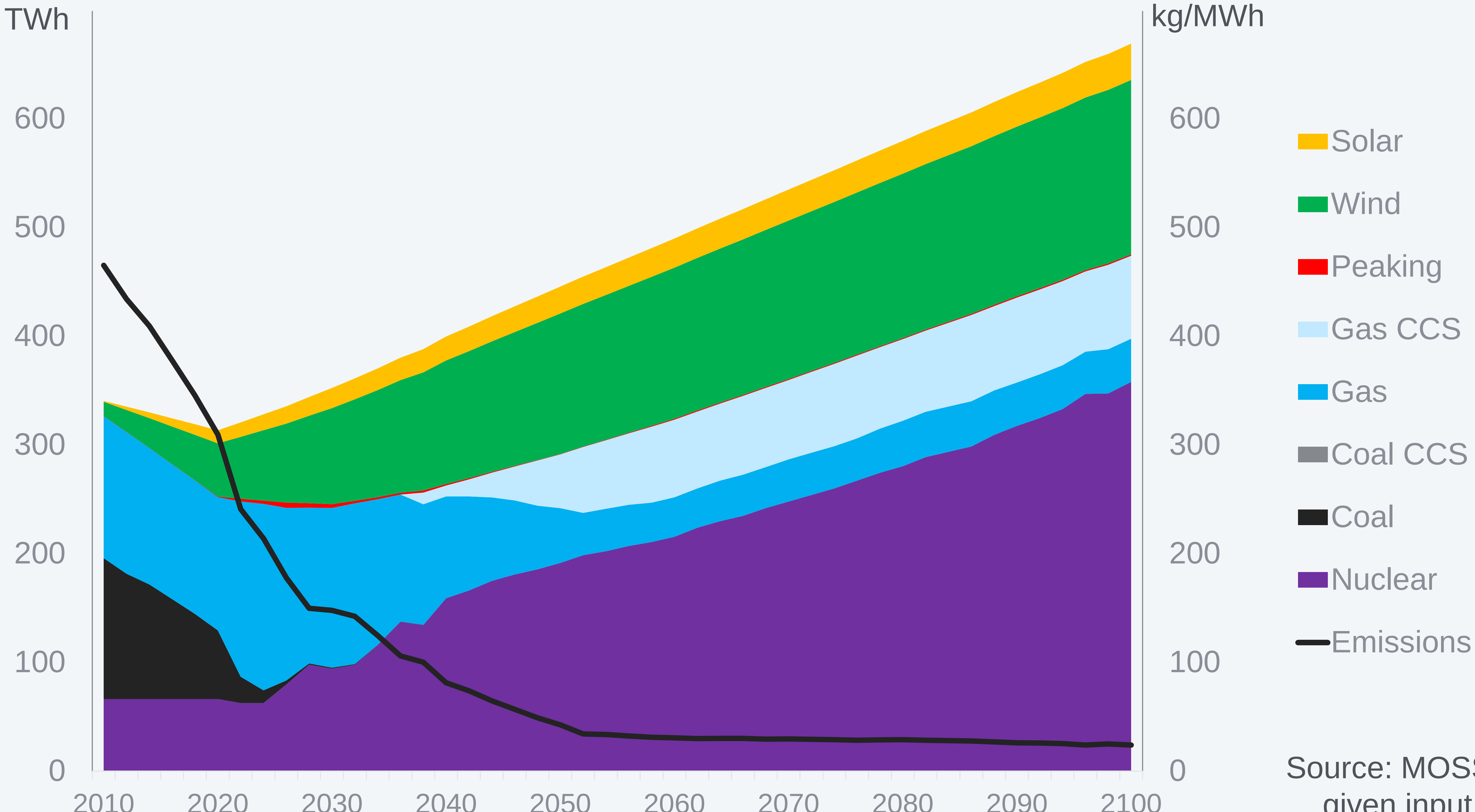

Source: MOSSI, given input assumptions

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Thank you