A Manifesto for a Low Carbon Electricity Supply

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Key Messages

- Great Britain generated 277g of Carbon Dioxide equivalent in the first six months of 2016 versus a target of 50-100g per kWh.
- A wholesale expansion of Nuclear, Biomass, Wind and Solar would achieve our carbon objective for electricity, with some Gas in the mix to meet demand in times of low wind and sun.
- The intermittency of wind and solar is not a barrier to their introduction
- Modest expansion of energy storage capacity is needed to meet our carbon objectives.
- But looming electrification of heating and transport presents further challenges for a low carbon energy supply.

Introduction

The UK has a legally binding objective to reduce carbon emissions from electricity. The Committee on Climate Change (an independent body which was set up to advice the UK Governments) says that our emissions from electricity must be between 50 and 100g of CO_2 equivalent[1] for kWh of electricity generated by 2030.

My website and social media feeds show in real time how electricity in Great Britain is being generated. It also estimates the carbon emissions in our electricity using factors from the Committee on Climate Change. In the first six months of 2016, it shows that our Carbon Emissions were 277 grams per kWh. Since we consumed 147 million kWh of electricity in that time, our emissions were of equivalent to 33,000 Tonnes of Carbon Dioxide.

The aim of my website is to report factual information on the electricity system. The purpose of this manifesto is to show that we can meet the carbon objectives for our present electricity demand by turning to low carbon sources. It is not necessarily a generation mix that I support.

To prove this manifesto is correct, you can follow a live simulation of it on my website: www.mygridgb.co.uk

[1] CO2 equivalent reflects that there are more gases than carbon dioxide which have a greenhouse effect. Methane is estimated by the US Environmental Protection Agency to have a warming potential of between 28 and 36 over 100 years (link).

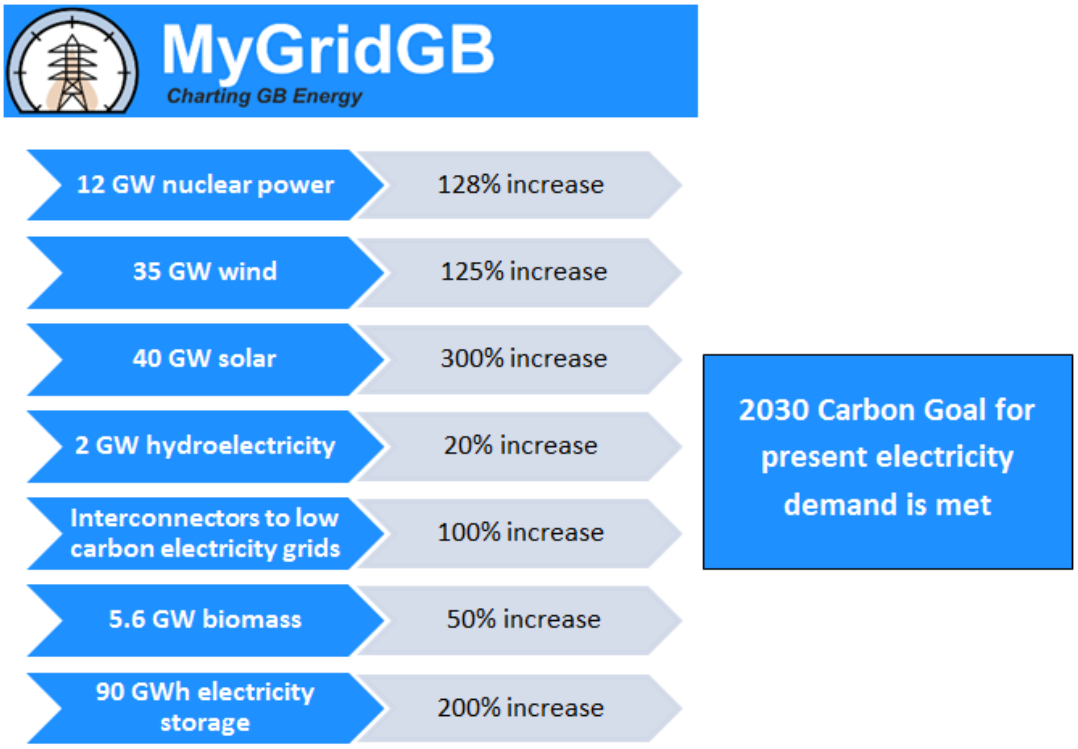
Manifesto

The manifesto shows that the following mix of electricity generation would allow us to meet our carbon target.

- Coal is completely removed from the mix as it is the most polluting form of fossil fuel for electricity.
- 15GW of Nuclear Power stations to provide baseload.
- 35GW of on-shore and off-shore wind generation, compared to 14 GW installed at present
- 40GW of solar generation compared to approximately 10GW installed at present. This would be deployed with energy storage on homes and on commercial and industrial roofs.
- A doubling of hydroelectric capacity
- A full biomass conversion of Drax Power Station or similar to expand biomass capacity by 280%.
- Double the capacity of interconnectors to import power from Europe when the wind and solar generation is low
- Sufficient gas generation to meet a shortfall when the above is insufficient to meet our needs.
- 90GWh of electrical energy storage, or three times the present installed capacity.

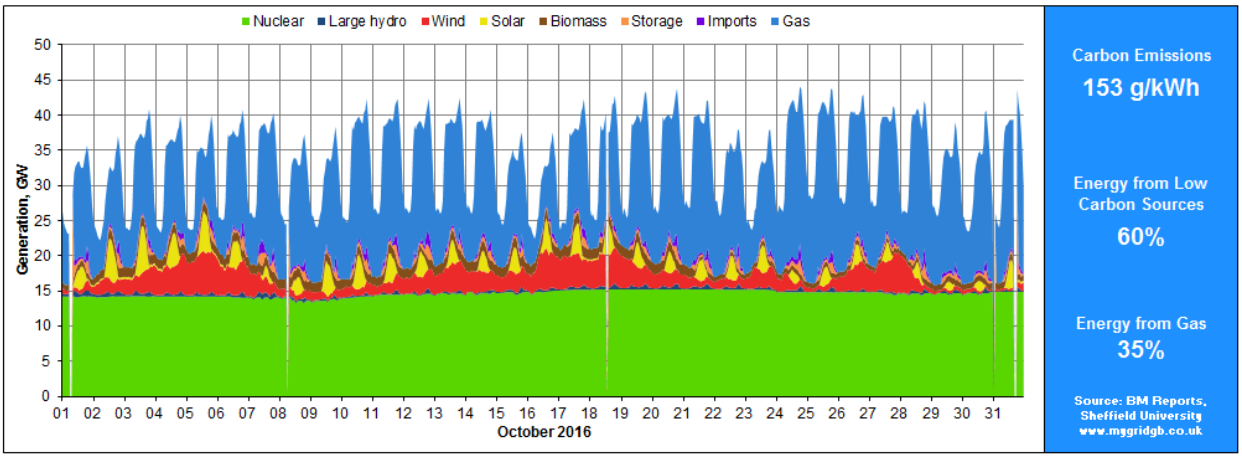
These figures are based on targets/objectives from various trade bodies and an internal assessment of the amount of Nuclear power and energy storage that is needed to meet the carbon target (i.e. what I did my PhD on).

Each of these is now modelled sequentially to determine if this could have met our demand between 1st June 2016 and 27th November 2016 and achieved low carbon electricity.



New Nuclear Power Stations and removal of coal

Replacing coal with gas and the addition of nuclear power reduces carbon emissions to 150g/kWh. However, since nuclear power cannot be readily switched on or off, its deployment must be restricted to 15GW unless demand can be smoothed or grows.

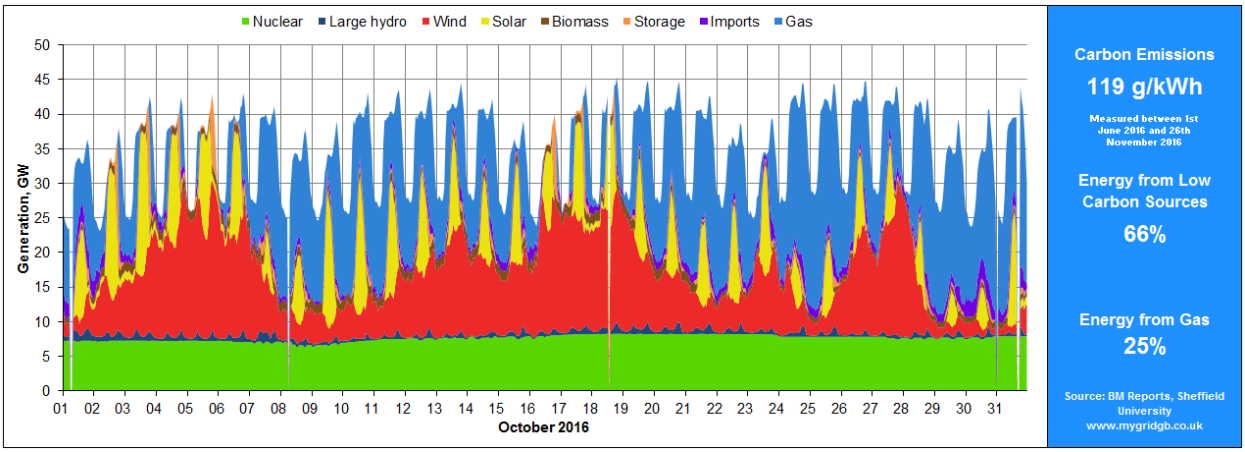


Wind, Solar and Hydro

Adding additional wind, solar and hydroelectricity has a big impact on reducing the carbon emissions. The UK has ~9GW of onshore wind, ~4GW of offshore wind, ~10GW of solar energy and ~1.7GW of hydroelectricity.

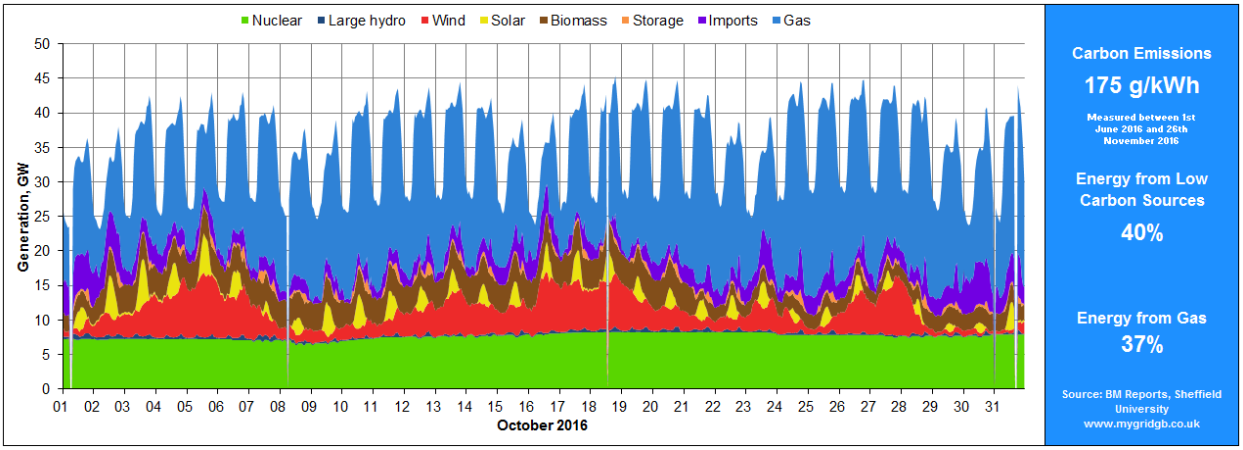
This manifesto calls for a 250% increase in energy generated by wind. The majority of this will come from offshore turbines where higher wind speeds mean you get more energy from an offshore than an onshore turbine. A fourfold increase in solar energy capacity would be mostly achieved through domestic and commercial and industrial solar installations as well as some solar farms. Hydroelectricity gains would be made through identifying new sites and improving the efficiency of existing sites.

Such an expansion of renewables has a bigger impact than Nuclear on carbon emissions and the energy from gas, but is insufficient to meet the carbon goal.



Biomass and Imports

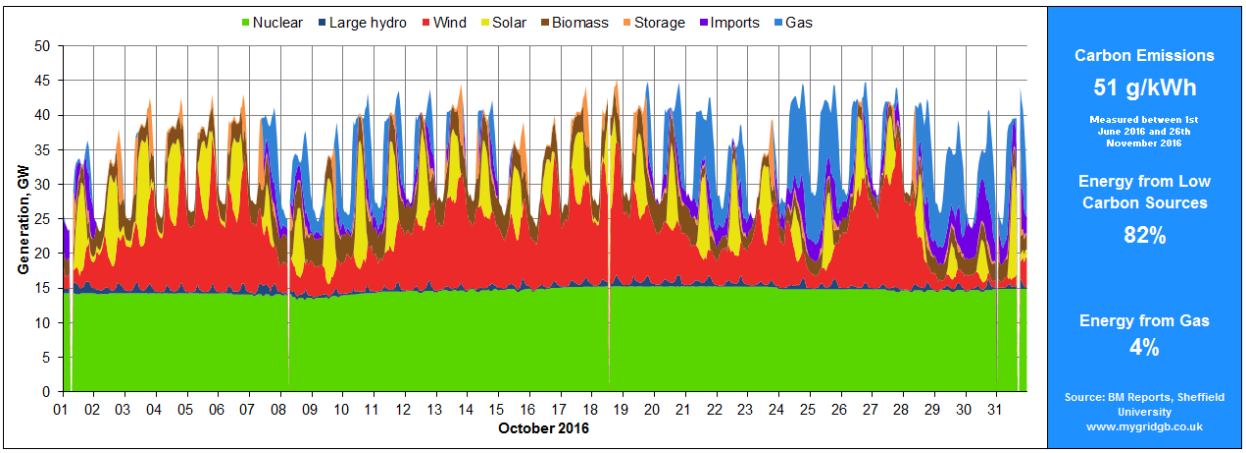
Although biomass is itself more carbon intensive than the carbon goal according to the Committee on Climate Change average figures, it can provide baseload power. Imports are low-carbon if these come from low-carbon sources abroad e.g. Norwegian hydroelectricity, German wind farms or French nuclear stations. This has a positive impact on carbon but is insufficient to reach the carbon objective.



All of the above

Integrating all of the above scenarios would be sufficient to reduce carbon emissions to the required level for the carbon objective. The existing 30GWh of energy storage assists the ability of energy to meet peak electricity demands

However, this is insufficient to beat the target and additional energy storage is needed to help make for reliable electricity supply.

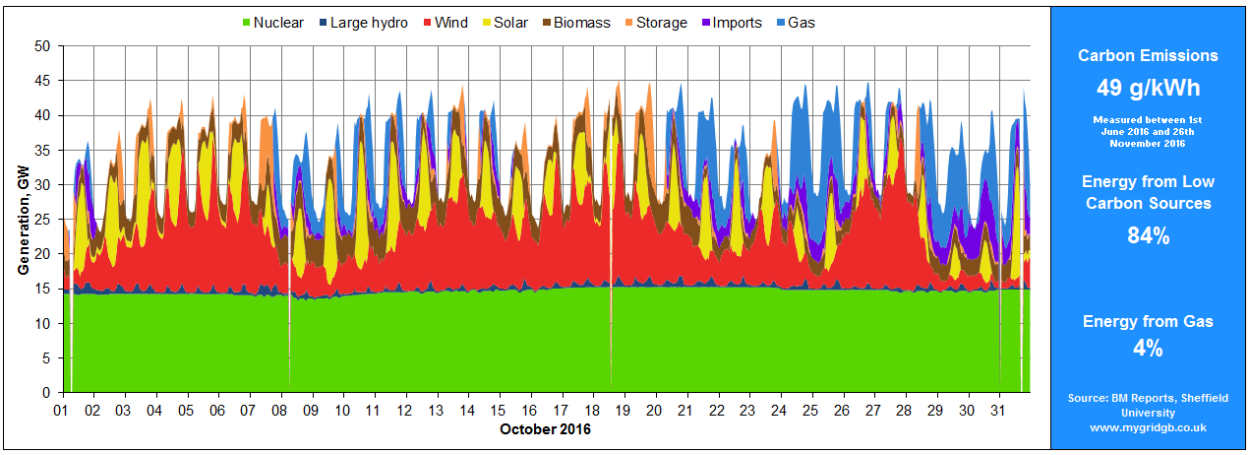


Storage

The above scenarios have utilised Britain's existing storage capacity, 30GWh.

If this were tripled to 60GW/90GWh, then a modest improvement in carbon can be made, but the system is able to cope with sudden swings in wind and solar generation thus a stable electricity supply can be made.

The manifesto achieves its low carbon objective.



What is next

I will address the following in future manifestos

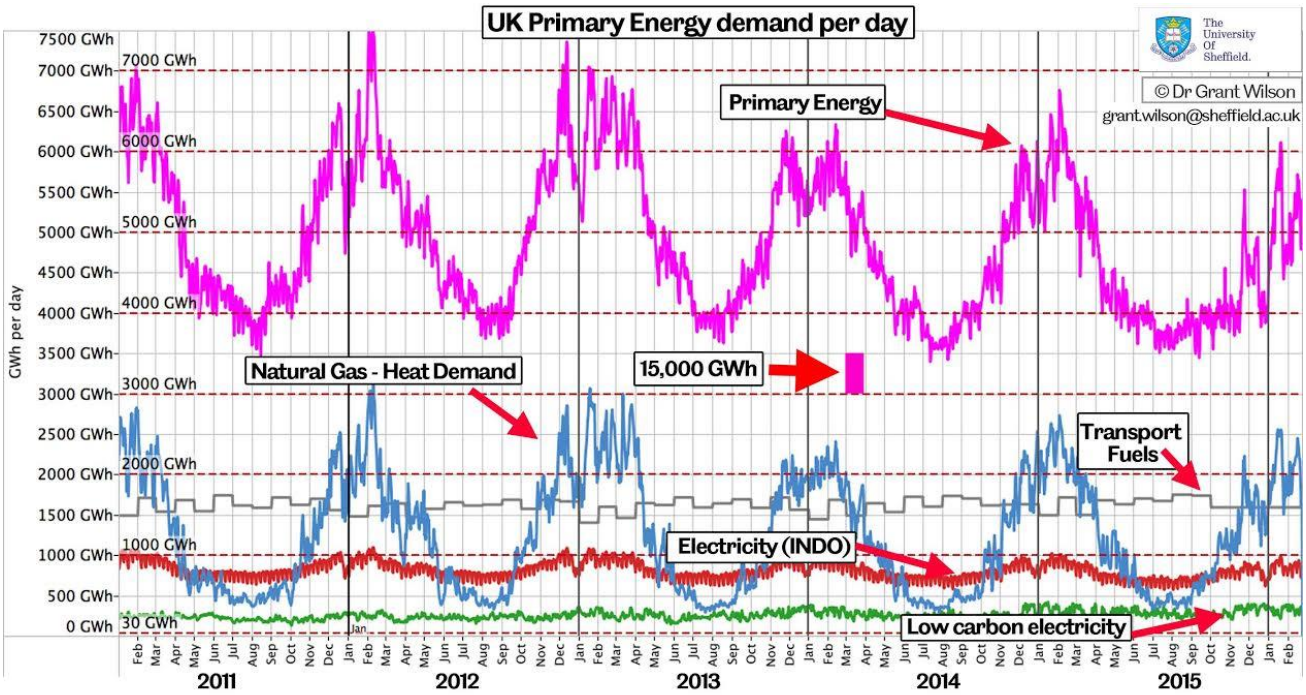
Costs

Cost data for electricity is difficult to ascertain. A 2012 report from DECC (the former UK Government Department for Energy and Climate Change) illustrates this well. In this, Nuclear was valued at £72.00/MWh, whilst a strike price of £92.50/MWh was agreed for the new Nuclear power station at Hinckley Point.

With reliable cost estimates, the lowest cost means of providing low-carbon energy can be calculated. My second manifesto ("A manifesto for low carbon and lower cost electricity") shall present this.

Heating and Electric Vehicles

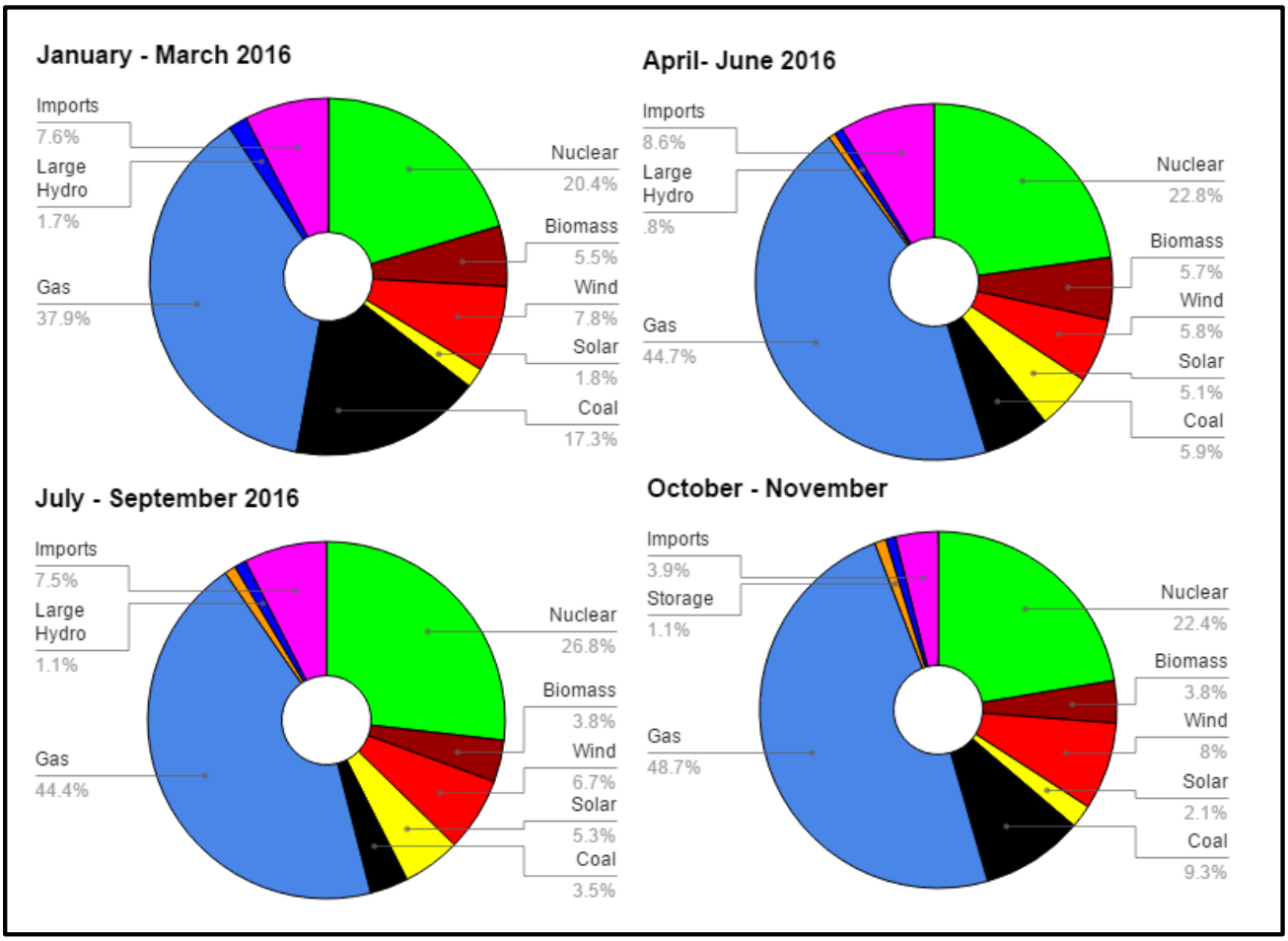
The UK uses a vast amount of energy in generating heat and for transportation (as the chart below from Dr Grant Wilson at Sheffield University shows). My third manifesto shall examine how we can generate sufficient low carbon energy to meet our transport and heating needs.


UK Primary Energy demand per day
The University Of Sheffield.
© Dr Grant Wilson
grant.wilson@sheffield.ac.uk
GWh per day
7500 GWh
7000 GWh
6500 GWh
6000 GWh
5500 GWh
5000 GWh
4500 GWh
4000 GWh
3500 GWh
3000 GWh
2500 GWh
2000 GWh
1500 GWh
1000 GWh
500 GWh
0 GWh
30 GWh
Primary Energy
Natural Gas - Heat Demand
15,000 GWh
Transport Fuels
Electricity (INDO)
Low carbon electricity
2011
2012
2013
2014
2015

Appendix

Electricity so far in 2016 (a short story)

In the first three months of 2016, coal provided nearly a third of our electricity. It has been in decline since then, replaced by gas. Wind and Solar have made a contribution. Nuclear and Biomass have formed a baseload. It is hard to discuss these figures as matter of fact without politicising them.



Greenhouse Gases in Electricity

The Intergovernmental Panel on Climate Change (IPCC) publish the estimated emissions of different types of electricity. Coal is the most carbon intensive form of electricity generation followed by coal and biomass. On average emissions, nuclear, wind, solar, storage and hydroelectricity have carbon emissions below the 2030 carbon target.

These numbers form the basis of my carbon emissions calculations.

Generation source	CO2 eq. Emissions g/kWh	Below 2030 target?
Nuclear	12	✓
Coal	820	✗
Gas	400	✗
Biomass	230	✗
Wind	12	✓
Solar	45	✓
Storage	24	✓
Large Hydro	24	✓

Backcasting

Backcasting is the process of modelling the electricity mix if different electricity power stations were built. It uses historical data on the generation from different power stations and the electrical demand of the country. It extrapolates the generation mix given different volumes of electricity in the system and matches that to demand.

My backcasting model operates as follows:

- Nuclear power stations are always on and are never switched off.
- Weather dependant generation (wind, hydro and solar) are scaled from the historical data sets
- Storage, biomass, imports and gas make up any shortfalls in generation to meet demand (in that priority order).
- If there is too much production of weather dependent generation, then it is stored and used to meet shortfalls at later dates.

This is a simple approach which allows me, in real time, to assess my manifesto.