Time-varying grid carbon intensity of the UK for the years 2009-2016

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For a growing number of businesses, assessment of carbon emissions has a significant influence on building and facilities investments. Evaluation of grid carbon intensity, typically measured in g CO_2 eq/kWh, is fundamental to footprint calculation. DEFRA provides annual carbon factors for companies to report their emissions, but the use of a single annual value introduces several key uncertainties into carbon assessment.

Research Approach

Historic (2009-2016) analysis of real grid carbon intensity data is presented below. This preliminary analysis is part of a wider study that aims to quantify uncertainty in carbon assessment arising from power grid carbon intensity estimation and assess the implications of this uncertainty. Grid carbon intensity has been calculated using Elexon generation data and equation (1) [1] .

$$CI = \frac{\sum_{n=1}^{N} c_n E_n}{\sum_{n=1}^{N_n} E_n} \quad (1)$$

where N is the total number of fuels, c_n is the carbon factor for different fuels and E_n is the generated energy corresponding to each fuel type n.

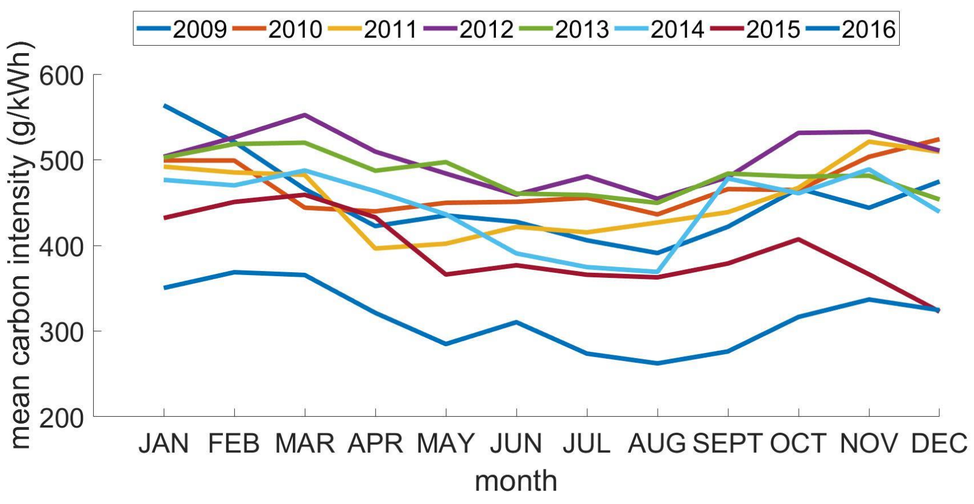

Figure 1: Monthly mean grid carbon intensity for years 2009-2016.

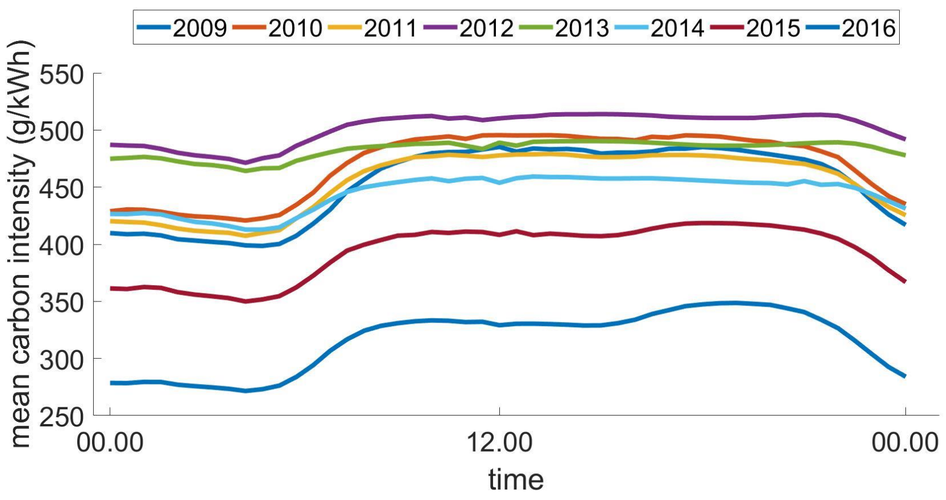

Figure 2: Daily mean grid carbon intensity for years 2009-2016.

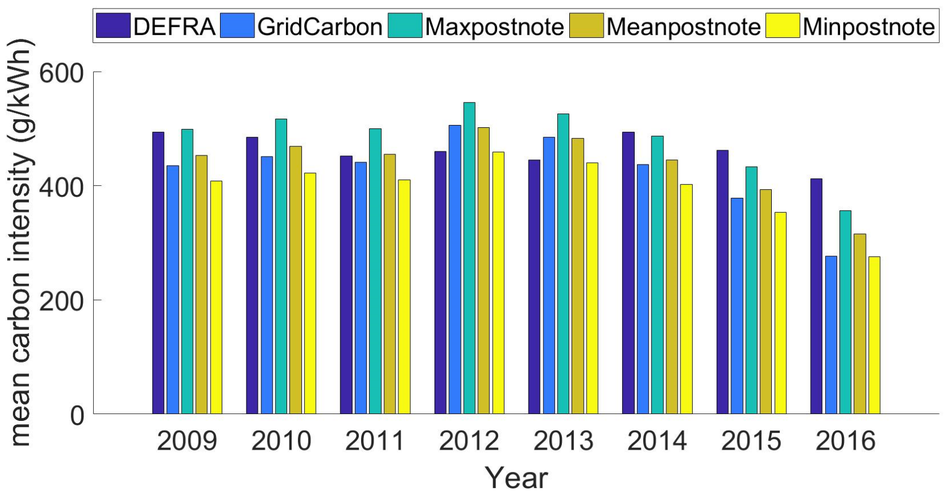

Figure 3: Annual mean carbon intensity calculated with different carbon factors (table 1) and DEFRA values for years 2009-2016.

The impact of different plant carbon factors on carbon intensity calculations

Plant type	GridCarbon	Literature (min)	Literature (mean)	Literature (max)
Coal	910	788	844	899
Nuclear	0	20	23	26
Oil	610	600	650	699
Wind	0	20	57	94
Hydro	0	2	8	13
CCGT	360	367	427	487
OCGT	480	466	526	586

Table 1: Carbon factors of different plant types in g CO2/Kwh (various sources).

Table 1 shows the range of the factors found in relevant bibliography alongside with the values used in the GridCarbon application [2]. The inconsistencies noticed in the carbon factors of the same plant system type are explained by the assumed age and efficiency of the plant and whether life cycle emissions were taken under consideration.

Early findings

Monthly mean carbon intensity values between 2009 and 2014 varied between 369 and 563 g/kWh with a mean value of 467 g/kWh **(figure 1)**. Daily mean carbon intensity follows a generic energy demand profile for all years **(figure 2)**. However, significant reductions can be seen in 2015 and 2016, by 17% and 37% respectively compared to the 2009-2014 mean value, which is in agreement with the DEFRA annual carbon factors for the same years [3]. This reduction can be explained by coal plant closures or conversion to biomass. 2016 was a record year for low coal generation and high renewable generation [4]; Average annual carbon intensity can vary by 100 g/kWh depending on the used set of carbon factors (**figure 3**).

Conclusions

Data analysis shows that carbon intensity varies not only monthly but also daily [1]. Therefore, calculations based on annual averages are likely to be inaccurate as specific daily and monthly operational schedules of plants will have a significant impact on actual annual emissions. The impact of different plant carbon factors on annual grid carbon intensity is significant so specific assumptions about age, efficiency and LCA must be carefully considered.

References

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4. DECC, Digest of UK energy statistics: Annual report, 2016.

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