GridCarbon: A smartphone app to calculate the carbon intensity of the GB electricity grid

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GridCarbon is a smartphone app, first released in December 2009, that calculates the carbon intensity of the GB electricity grid. This paper reports on the current version of the app, released in February 2019, that merges two online data sources to use actual and estimated wind and solar generation in the calculation of carbon intensity.

GridCarbon

GridCarbon was first released in December 2009 and uses instantaneous generation mix data from ELEXON, updated every five minutes, to calculate the carbon intensity of the GB electricity grid. Since its launch, renewable generation within the grid has grown steadily and now represents a significant proportion of electricity generation. Much of this generation is from wind and solar sources deployed within the distribution network and is unmetered. It is not included in the standard generation mix data. Thus, the current version of the app combines estimates of wind and solar data with the instantaneous generation mix data to provide an improved estimate of the carbon intensity of the electricity grid.

Carbon Intensity

GridCarbon makes use of three data sources: two available through the Elexon Insights Solution API[1] and one from Sheffield Solar[2]. The first is the *instantaneous generation mix* (FUELINST), categorised by fuel type, which provides 24-hour data divided into five-minute periods, updated every five minutes.[3] The second is the *actual or estimated wind and solar power generation* (AGWS/B1630) over the previous 48 hours, divided into 30 minute settlement periods, updated every 30 minutes.[4] This source provides estimates of wind and solar generation from both metered and un-metered sources (small scale generation within the distribution network), but only the wind generation is used by the app. The final data source is an estimated solar generation over the previous 48 hours from Solar Sheffield API.[5]

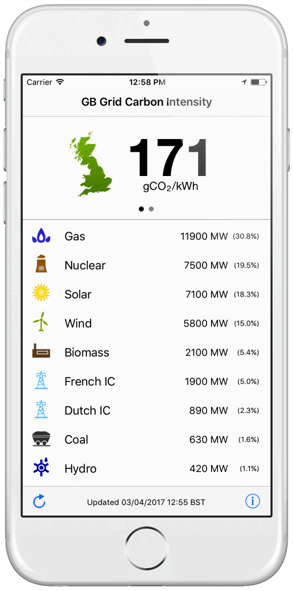

Figure 1: GridCarbon app showing live carbon intensity.

The carbon intensity of each unit of electricity gen-

[1] https://bmrs.elexon.co.uk/api-documentation/
[2] www.solar.sheffield.ac.uk/pvlive/
[3] https://bmrs.elexon.co.uk/api-documentation/endpoint/datasets/FUELINST
[4] https://bmrs.elexon.co.uk/api-documentation/endpoint/datasets/AGWS
[5] https://api.solar.sheffield.ac.uk/pvlive/api/v4/pes/0?start=<StartDate>T00:00:00&end=<EndDate>T23:59:59

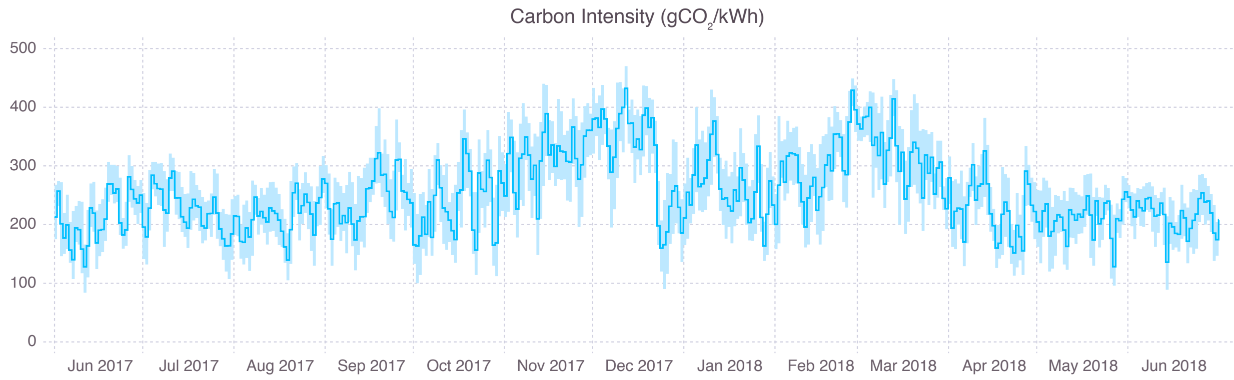

Figure 2: Daily minimum, average and maximum GB grid carbon intensity from 1st July 2017 to 30th June 2018.

Table 1: *Carbon intensity of GB generation sources.*

	Carbon Intensity gCO_2/kWh
Coal	937
Oil	935
Gas (Open Cycle)	651
Gas (Closed Cycle)	394
Other	300
Biomass	120
Hydro	0
Nuclear	0
Pumped Storage	0
Solar	0
Wind	0

Table 2: *Carbon intensity of interconnectors.*

	Carbon Intensity gCO_2/kWh
Netherlands	354
Ireland	346
Northern Ireland	346
Denmark	180
Belgium	167
France	85
Norway	29

erated is then simply found by weighting the carbon intensity, ci, of each individual generation source, i, by how much its generation, g, contributes to the total:

$$CI_{\text{gen}} = \frac{\sum_{i=1}^{N} g_i \times ci_i}{\sum_{i=1}^{N} g_i} \tag{1}$$

Table 1 shows the carbon intensity of the individual sources. The values for generation sources are taken from Staffell, 2017. Table 2 shows the carbon intensity of the interconnectors. These values are taken from Hannah, Rosado, and Roser, 2023.[6]

Since we wish to express the carbon intensity for each unit of electricity consumed, as opposed to each unit of electricity generated, we also include losses, l, in the transmission and distribution networks. Thus, the carbon intensity of consumption is given by:

$$CI_{\text{con}} = \frac{CI_{\text{gen}}}{1 - l} \tag{2}$$

We use a value of 8.4% for these losses (Department for Business, Energy & Industrial Strategy, 2022). Figure 2 shows the daily minimum, average and maximum carbon intensity, calculated using this methodology, over 12 months.

Missing Data

The two data sources used often exhibit periods of missing data. These are typically short; lasting less than one hour. In these instances, we replace any missing data with the last available data. In addition, we find that the actual or estimated wind generation data often exhibits extended periods of missing data; sometimes lasting several days. Thus, we read wind data from both the instantaneous generation mix (FUELINST) and the actual or estimated wind generation (B1630) data feeds and use the maximum of the two.

Predicting Wind and Solar

Finally, we note that the actual or estimated wind (AGWS/B1630) data feed is typically delayed by 30 to 90 minutes compared to the instantaneous generation mix (FUELINST) data feed. The solar generation data feed is also only updated every 30 minutes and thus lags behind the instantaneous generation mix (FUELINST) data feed. To ensure that the app displays the most up-to-date data we make predictions of wind and solar generation over this short period. We display these predicted regions in the generation plot as highlighted bars at the extreme right of the generation mix bar graph (see Figure 3).

[6] `https://ourworldindata.org/grapher/carbon-intensity-electricity`

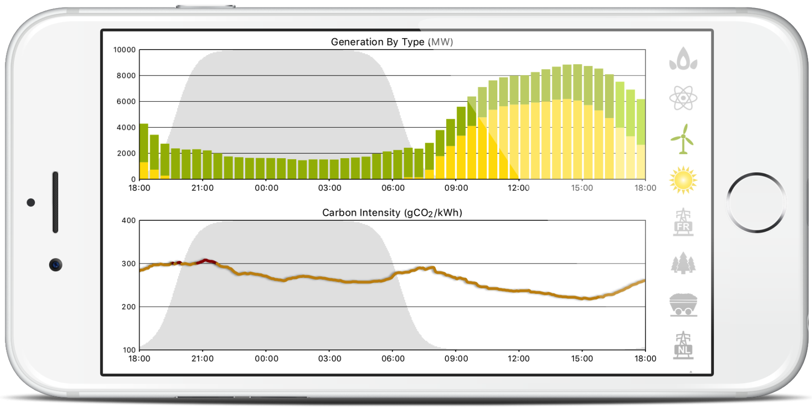

Figure 3: Highlighted bars (at extreme right of graph) indicating predicted wind and solar data.

Wind

To predict the wind generation we make use of the relationship between the value of metered wind generation within the instantaneous generation mix (FUELINST) data feed and that within the actual or estimated wind generation (AGWS/B1630) data feed. In doing so we assume that metered wind generation is a constant factor of the total of metered wind and unmetered wind generation. We calculate this factor over the last four hours of the actual or estimated wind generation data, and then use the metered instantaneous generation mix (FUELINST) data, scaled by the reciprocal of this factor, over this short prediction period.

Solar

Predicting solar generation is more complex as we have no parallel data feed, and solar generation can exhibit significant change over this short period. However, solar generation has a characteristic increase and decrease over the day and we can use historic data to predict this behaviour.

To do so, we approximate the pattern of solar generation over the day using a simple three-parameter model consisting of a sunrise time, t_{sr}, a sunset time, t_{ss}, and a peak solar generation value, g_{max}. Our predicted solar generation, g_{solar}, is then assumed to be zero when the time, t is earlier than t_{sr} or later than t_{ss}, and given by:

$$g_{\text{solar}} = g_{\text{max}} \times \sin^2(\pi r) \tag{3}$$

otherwise, where r is given by:

$$r = \frac{t - t_{\text{sr}}}{t_{\text{ss}} - t_{\text{sr}}} \tag{4}$$

Solar generation exhibits significant variation between days due to changing weather conditions. Thus, as with the prediction of wind generation, we calibrate the peak value, g_{max}, using the last half hour of solar generation data available. This provides an effective and robust short-term prediction of solar generation over one to two hours.

References

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