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Carbon Intensity Forecast Methodology

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National Energy System Operator (NESO), in partnership with Environmental Defense Fund Europe and WWF, has developed a series of Regional Carbon Intensity forecasts for the GB electricity system, with weather data provided by the Met Office.

Introduction

NESO's Carbon Intensity API provides an indicative trend of carbon intensity for the electrical grid of Great Britain up to 48 hours ahead of real-time [1]. It provides programmatic and timely access to forecast carbon intensity. This report details the methodology behind the regional carbon intensity estimates. For more information about the Carbon Intensity API see here.

What's included in the forecast

The Regional Carbon Intensity forecasts include CO_2 emissions related to electricity generation only. The forecasts include CO_2 emissions from all large metered power stations, interconnector imports, transmission and distribution losses, and accounts for national electricity demand, and both regional embedded wind and solar generation.

While we recognise upstream emissions and indirect land use change impacts and other GHG emissions are important, it is only CO_2 emissions related to electricity generation that are included in the forecast. This work does not consider the CO_2 emissions of unmetered and embedded generators for which NESO does not have visibility of.

Methodology

The Carbon Intensity forecast is particularly sensitive to short-term forecast errors in demand, wind and solar generation, as this impacts the amount of dispatchable generation that is required to meet demand.

The forecast also makes use of historic generation data to make predictions about future generation, which invariably changes per system conditions. It is therefore important to note that these forecasts are likely to be less accurate than forecasts such as electricity demand, since it includes the confluence of uncertainties from demand, wind, solar, and CO2 emissions by fuel type.

Estimated carbon intensity data is provided at the end of each half hour settlement period. Forecast carbon intensity is provided 48 hours ahead of real-time for each half hour settlement period and uses NESO's latest forecasts for national demand, wind and solar generation.

The GB carbon intensity C_t at time t is found by weighting the carbon intensity c_g for fuel type g by the generation $P_{g,t}$ of that fuel type. This is then divided by national demand D_t to give the carbon intensity for GB:

$$C_t = \frac{\sum_{g=1}^{G} P_{g,t} \times C_g}{D_t}$$

The carbon intensity is then corrected to account for transmission losses to give the intensity of consumption [3]. Table 1 shows the peer-reviewed carbon intensity factors of GB fuel types used in this methodology. Carbon intensity factors are based on the output-weight average efficiency of generation in GB and DUKES CO2 emission factors for fuels [4].

Interconnector carbon intensity factors

Daily at 6am, the average generation mix of each network the GB grid is connected to through interconnectors is collected for the previous 24 hours through the ENTSO-E Transparency Platform API [6].

The factors from Table 1 are applied to each technology type for each import generation mix to calculate the import carbon intensity factors. If the ENTSO-E API is down, the import carbon factors default to those listed in Table 1.

Fuel Type	Carbon Intensity gCO_2/kWh
Biomass[i]	120
Coal	937
Gas (Combined Cycle)	394
Gas (Open Cycle)	651
Hydro	0
Nuclear	0
Oil	935
Other	300
Solar	0
Wind	0
Pumped Storage	0
French Imports	~ 53
Dutch Imports	~ 474
Belgium Imports	~ 179
Irish Imports	~ 458

The estimated carbon intensity uses metered data for each fuel type, which is also available from ELEXON via the Balancing Mechanism Reporting Service, and includes fuel types such as metered wind, nuclear, combined cycle gas turbines, coal etc. Estimated data is used for embedded wind and solar generation.

Weather data, such as wind speeds and solar radiation, are procured separately by NESO and so are not publicly available. A rolling-window linear regression for each fuel type is performed and used with forecast demand, wind, and solar data to estimate forecast carbon intensity.

An index for carbon intensity has been developed to illustrate times when the carbon intensity of GB system is high/low. Table 2 (overleaf) shows the numerical bands for the Carbon Intensity index.

Table 2: Numerical bands for the Carbon Intensity Index. Carbon Intensity values are given in gCO_2/kWh:

Year / Index	Very Low	Low	Moderate	High	Very High
2017	0 to 99	100 to 199	200 to 299	300 to 399	400+
2018	0 to 79	80 to 179	180 to 279	280 to 380	380+
2019	0 to 59	60 to 159	160 to 259	260 to 360	360+
2020	0 to 54	55 to 149	150 to 229	230 to 350	350+
2021	0 to 49	50 to 139	140 to 219	220 to 330	330+
2022	0 to 44	45 to 129	130 to 209	210 to 310	310+
2023	0 to 39	40 to 119	120 to 199	200 to 290	290+
2024	0 to 34	35 to 109	110 to 189	190 to 270	270+
2025	0 to 29	30 to 99	100 to 179	180 to 250	250+
2026	0 to 24	25 to 89	90 to 169	170 to 230	230+
2027	0 to 19	20 to 79	80 to 159	160 to 210	210+
2028	0 to 14	15 to 69	70 to 149	150 to 190	190+
2029	0 to 9	10 to 59	60 to 139	140 to 170	170+
2030	0 to 4	5 to 49	50 to 129	130 to 150	150+

Limitations

There are several limitations with this methodology. This approach does not use Physical Notifications (PNs) of Balancing Mechanism (BM) units in the forecast. This is to ensure that the commercial sensitivities surrounding the balancing market are maintained. This means that only historic data is used in the analysis, limiting forecast accuracy. Finally, this work does not consider the emissions of embedded generation of which NESO does not have visibility. Future work will look at estimating these contributions to GB carbon intensity.

Contact

For any suggestions, comments or queries please contact: lyndon.ruff@nationalgrideso.com

References

[1] Carbon Intensity API (2017): www.carbonintensity.org.uk

[2] GridCarbon (2017): www.gridcarbon.uk

[3] Staffell, Iain (2017) "Measuring the progress and impacts of decarbonising British electricity". In Energy Policy 102, pp. 463-475, DOI: 10.1016/j.enpol.2016.12.037

[4] DUKES (2017): www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

[5] BM Reports (2017): https://www.bmreports.com/bmrs/?q=generation/

[6] ENTSO-E Transparency Platform: https://transparency.entsoe.eu/

[i] Using 'consumption-based' accounting, the carbon intensity attributable to biomass electricity is reported to be 120 ± 120 gCO_2/kWh [2]. The large uncertainty relates to the complex nature of biomass supply chains and the difficulty in quantifying non-biogenic emissions.