



Methodology for Calculating Greenhouse Gas (GHG) Emission Factors for Electricity (2024)

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Introduction

This document outlines the methodology used to calculate Greenhouse Gas (GHG) emission factors for electricity generation, transmission and distribution (T&D), well-to-tank (WTT), and residual mix factors for various countries.

This methodology document accompanies the 2024 GHG emission factors published on CaDI, the Carbon Database Initiative (carbondi.com), and should be consulted when using those factors for GHG accounting and reporting.

These factors are provided to support organisations and individuals in calculating their GHG Emissions.

Data Availability

The calculated GHG emission factors are made freely available for use in GHG reporting and target setting. Data is provided for over 200 countries. Specific data for the UK, Canada, the US, and Australia are provided as these provide sub-national levels (e.g., state or province).

Updates from the 2023 Emissions Factor Methodology

The 2024 emissions factors use an updated methodology compared to the 2023 version. The key change is the adoption of a unified fuel mix-based approach for calculating emission factors for *all* countries. While the fuel mix method was previously used for many countries, the 2023 edition also compiled data from a variety of sources, including the Association of Issuing Bodies (AIB), Climate Transparency, the Singapore Energy Market Authority, the Dubai Electricity and Water Authority, and others. These sources often employed slightly different calculation methodologies and scopes (e.g., AIB factors only included CO₂ emissions and not other GHGs), leading to inconsistencies and difficulties in comparing emission factors across different regions.

The 2024 methodology addresses these issues by calculating emission factors from fuel mix data for every country. This standardized approach ensures consistency and comparability across all reported emission factors. By relying on a single methodology, the 2024 update improves the robustness and transparency of the data.

Furthermore, the fuel mix-based approach adopted in 2024 allows for the inclusion of additional factors, such as Well-to-Tank (WTT) emissions. This provides a more comprehensive assessment of the GHG emissions associated with electricity generation and consumption, which was not consistently available in the 2023 version due to the reliance on diverse data sources. The 2024 methodology, therefore, represents a significant advancement in the consistency and comprehensiveness of the reported emission factors.

This updated methodology has been used on CaDI to recalculate emissions factors back to 2019 for consistency. Previously published emission factors are also available for reference and comparison.

Should past emissions be recalculated with the updated emissions factors for past years?

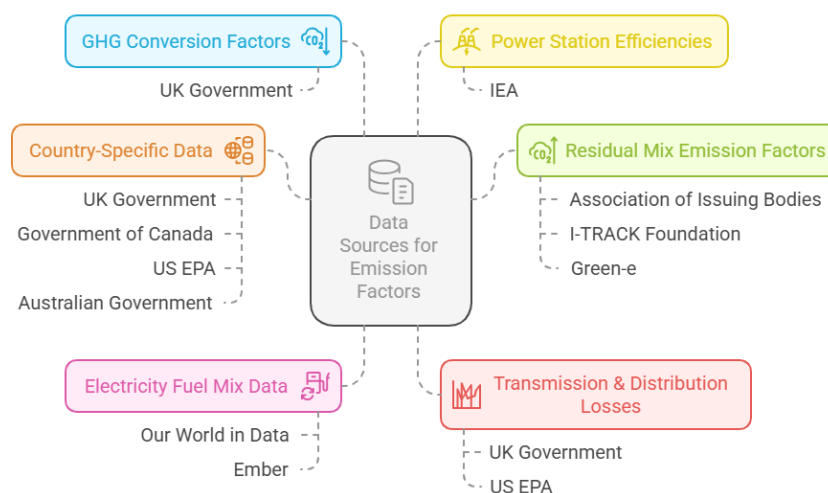
Recalculations are typically not required for past emissions unless the change would produce a material difference. Typically a materiality level of 5% is used, so any potential changes that result in less than 5% to the overall reported emissions do not typically require recalculating and updated reporting.

Data Sources

The following data sources have been used in the calculation of emission factors:

- **Electricity Fuel Mix Data:** Sourced from Our World in Data, which is primarily sourced from Ember (2024) and the Energy Institute - Statistical Review of World Energy (2024), with major processing by Our World in Data.
- **GHG Conversion Factors:** Fuel emission and fuel WTT emission factors are obtained from the UK Government's "Greenhouse gas reporting: conversion factors 2024."
- **Power Station Efficiencies:** Data on power station efficiencies for fossil fuels is derived from the IEA's "Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels" (July 2008).
- **UK Grid, Canada, US, and Australia Data:** Country-specific or regional data for these countries are obtained directly from their respective government sources. Specifically:
 - UK Grid: UK Government
 - Canada: Government of Canada (by Province)
 - US: US Environmental Protection Agency (EPA) (by State)
 - Australia: Australian Government (by State)
- **Transmission & Distribution (T&D) Losses:** For all countries except the UK and USA, T&D losses are obtained from the UK Government's "Greenhouse gas reporting: conversion factors 2017". For the UK and USA the respective emissions factors are sourced from the UK government and EPA based on the release year.
- **Residual Mix Emission Factors:** For European countries, the claimed renewable energy ratios are sourced from the Association of Issuing Bodies (AIB) and for other countries, from the I-TRACK Foundation. The US residual mix factors were sourced from Green-e.

Data Sources for Emission Factor Calculations



Calculation Methodology

The following steps describe the process used to calculate the GHG emission factors for electricity, encompassing generation, T&D, WTT, and residual mix factors. These calculations are performed annually, incorporating the latest available data and following established best practices for GHG accounting.

1. **Generation Factors (from country specific fuel mix):** Emission factors for each country are calculated based on the fuel mix used for electricity generation in country, adjusted based on power station efficiency.
 - **GHG Conversion Factors:** The UK Government's 2024 carbon conversion factors for fuels are applied to the fuel mix data to determine the GHG emissions associated with each fuel type.
 - **Power Station Efficiency Adjustment:** Power station efficiencies, sourced from the IEA, are incorporated into the calculations to account for variations in fuel conversion efficiency.
 - **Zero-Emission Sources:** Hydro, solar, wind, and nuclear energy sources are assumed to have zero GHG emissions.
2. **Transmission & Distribution (T&D) Emissions:** Historical T&D loss data is utilised. The transmission & distribution loss percentages were calculated from the UK Government's 2017 factors and applied to the newly calculated generation factors, except for the UK and US (EPA), where the T&D factors were provided for each year. For countries where T&D data was not available in the 2017 UK Government factors, the UN GeoScheme is used to assign countries to subregions. Continental averages are applied where subregional data is unavailable.
3. **Well-to-Tank (WTT) Emissions:** WTT emissions, representing emissions from fuel extraction, processing, and transportation, are included using the same method as the Generation Factors but using the UK Government's 2024 WTT conversion factors for fuels.
4. **Residual Emissions:** The Residual emissions factors have been calculated using the claimed renewable energy ratios from the AIB (for European countries) and the I-TRACK Foundation. These ratios are then applied to the factors obtain via the Fuel Mix approach to provide Residual Mix Factors where available.

GHG Emission Factor Calculation Process



Potential Limitations

1. **Generation Factors (from country specific fuel mix):** The fuel mix factors account for the energy generated within the country, and do not currently account for imports and exports of electricity into and out of the country.
2. **Transmission & Distribution (T&D) Emissions:** Due to the challenges in obtaining up-to-date and accurate, country-specific T&D loss data for all countries, the percentage loss based on historical data approach is employed. This method uses the past relationship between generation and T&D emission factors, as a proxy for T&D emission factors in countries where current data is limited. The underlying assumption is that T&D losses and their relative contribution to overall electricity emissions remain relatively stable over short periods (e.g., year to year) unless significant infrastructure changes occur. While this approach offers a pragmatic solution in the face of data scarcity, it has limitations. T&D losses can be affected by various factors, including infrastructure improvements or degradation, changes in electricity demand, technological advancements, and policy changes.
3. **Well-to-Tank (WTT) Emissions:** Due to the challenges in obtaining up-to-date, country-specific WTT emission factors, the UK Government's WTT conversion factors for fuels are applied to all countries as a proxy.

Residual Mix Emissions Explained

Residual mix emission factors are based on the fuel sources that remain after accounting for all claims on specific energy generation. The residual mix typically contains a higher share of high-carbon fuels like coal and gas than the grid average mix. This means that the emission factors of the residual mix are usually higher than those of the grid average mix.

Tracking mechanisms, such as Guarantees of Origin (GOs) in Europe or Renewable Energy Certificates (RECs) in other regions, are used to certify and track the generation and sale of renewable electricity.

Residual Mix Emissions Factors should be used only for calculating Market Based Scope 2 emissions from electricity when supply specific factors are not available.

Calculation of Residual Mix Emission Factors:

The residual mix emission factors are not calculated directly from fuel mix data. Instead, they are derived by analysing the relationship between generation-based emission factors and residual mix emission factors provided by the Association of Issuing Bodies (AIB) for European countries, and the residual mix percentages provided by I-TRACK Foundation for other countries. Specifically, the following process is used:

1. **Residual mix percentage calculation:** The residual mix percentage is provided by I-TRACK, with the residual mix percentage is calculated from AIB by using their provided residual mix factor and their generation factor. This method is applied because the AIB emissions factors are for CO₂ not CO₂e.
2. **Application to Grid Factors:** This calculated ratio is then applied to the generation-based emission factors (calculated via the fuel mix method) for each respective country. This adjusted value becomes the final residual mix emission factor for that country.

By using the residual mix percentage calculation method, the residual mix emission factor are scaled appropriately relative to the grid's overall emission intensity.

Units and Calculating tCO₂e

The reported GHG emission factors are expressed in **kilograms of carbon dioxide equivalent per kilowatt-hour (kgCO₂e/kWh)**. This represents the amount of GHG emissions associated with generating and delivering one kilowatt-hour of electricity.

To calculate the total amount of greenhouse gas emissions in tonnes of carbon dioxide equivalent (tCO₂e) from your electricity consumption, you can use the following formula:

$$tCO_2e = (Electricity\ Consumption\ in\ kWh) \times (Emission\ Factor\ in\ kgCO_2e/kWh) / 1000$$

Explanation:

1. **Electricity Consumption in kWh:** This is the amount of electricity you have consumed, measured in kilowatt-hours (kWh). This data should be available from your electricity bills or smart meter readings.
2. **Emission Factor in kgCO₂e/kWh:** This is the emission factor for your country or region, as provided in this dataset.
3. **/ 1000:** This division converts the result from kilograms (kg) to tonnes (t), as there are 1000 kilograms in one tonne.

Example:

Suppose your electricity consumption is 10,000 kWh, and the emission factor for your country is 0.5 kgCO₂e/kWh. Then the calculation would be:

$$tCO_2e = (10,000\ kWh) \times (0.5\ kgCO_2e/kWh) / 1000 = 5\ tCO_2e$$

Therefore, your electricity consumption would result in 5 tonnes of carbon dioxide equivalent emissions.

The same method should be used for calculating the T&D and WTT elements for Scope 3.

Annual Updates and Temporal Considerations

The GHG emission factors are updated on an annual basis. The emission factors published for a given year (e.g., the 2024 factors) should be used to assess electricity-related GHG emissions during that corresponding year (2024).

The emission factors are typically calculated using electricity generation data from two years previous (e.g., the 2024 factors utilise energy mix data from 2022). This approach aligns with the standard practice followed by the UK Government and other international governmental bodies, recognising the time lag in data availability and reporting.

Updates and Revisions

This methodology and the associated emission factors are subject to periodic review and updates. We are committed to continuous improvement and incorporate advancements in best practices for GHG accounting, as well as better data sources and calculation methods as they become available. Any changes to the methodology will be documented and explained in future updates. Users are encouraged to consult the latest versions of the data and methodology documentation.

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 - Reference list: CaDI (2024) Greenhouse Gas Emissions Factors for International Grid Electricity (calculated from fuel mix). Available at: www.carbondi.com (Accessed: [date]).
- **APA Style:**
 - In-text citation: (CaDI, 2024)
 - Reference list: CaDI. (2024). Greenhouse Gas Emissions Factors for International Grid Electricity (calculated from fuel mix). Retrieved from www.carbondi.com
- **MLA Style:**
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 - Works Cited: CaDI. Greenhouse Gas Emissions Factors for International Grid Electricity (calculated from fuel mix). 2024. www.carbondi.com. Accessed [date].

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