



Methodology for Calculating Greenhouse Gas (GHG) Emission Factors for Electricity (2025)

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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 2025 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 2024 Emissions Factor Methodology

The methodology for calculating the 2025 emissions factors largely mirrors that of the 2024 version. The only modifications relate to the calculation of residual mix emission factors, and Transmission and Distribution Loss factors for European countries.

Previously, for the 2024 factors, residual mix emission factors were determined by first calculating a residual mix percentage. This percentage was derived using country-specific residual mix and generation factors provided by the Association of Issuing Bodies' (AIB) and I-TRACK Foundation. The calculated residual mix percentage was then applied to the generation-based emission factors (derived using the fuel mix method) for each respective country to produce the final residual mix emission factor.

It was observed that for a limited number of countries, this methodology could lead to significant year-on-year fluctuations in their residual mix emission factors.

Commencing with the 2025 factors, we have adopted an updated approach leveraging the detailed residual fuel mix data (from AIB and I-TRACK Foundation), which itemises the percentage of each fuel type within the residual mix. This enables a more direct calculation of the residual mix emission factor, using the same methodology used for calculating generation emission factors. This revised method is anticipated to yield more accurate and consistent results.

For 2025 factors, data from Eurostat on electricity grid losses is now used to increase the accuracy of the Transmission and Distribution Loss factors for most European countries.

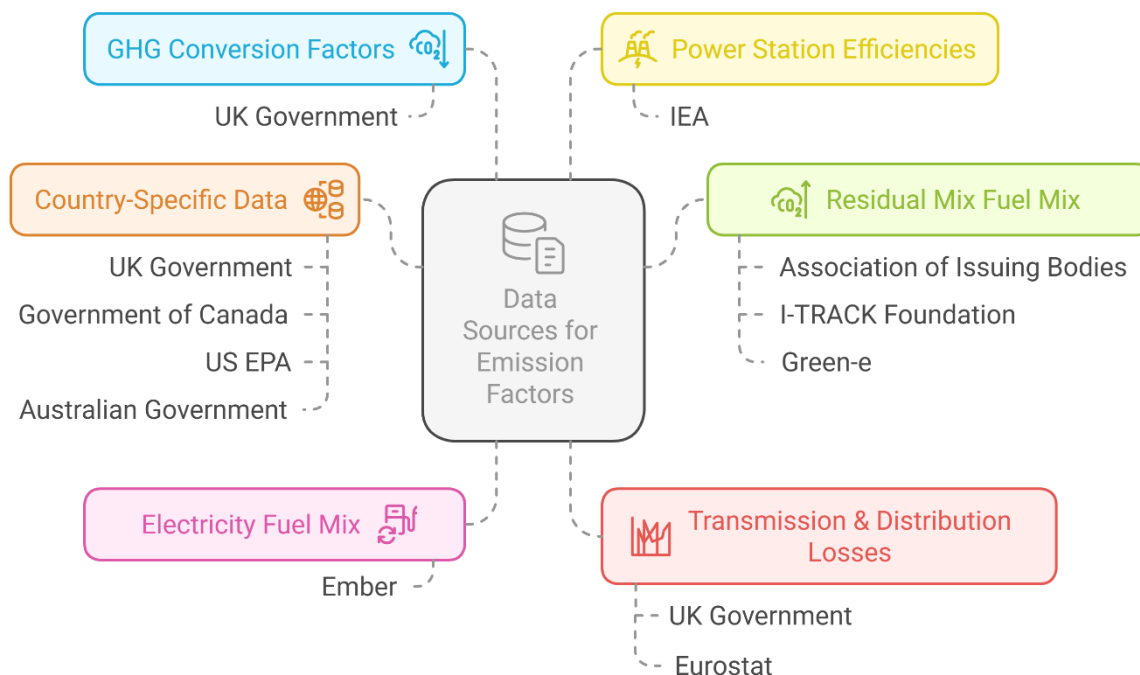
Data Sources

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

- **Electricity Fuel Mix Data:** Sourced from Ember (2025).
- **GHG Conversion Factors:** Fuel emission and fuel WTT emission factors are obtained from the UK Government's "Greenhouse gas reporting: conversion factors 2025."
- **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:** Grid average electricity factors provided by UK Government. Specific supplier generation factors provided by UK energy providers.
- **Canada, US, and Australia Data:** Regional data for these countries are obtained directly from their respective government sources. Specifically:
 - Australia: Australian Government (by State)
 - Canada: Government of Canada (by Province)
 - US: US Environmental Protection Agency (EPA) (calculated from Fuel Mix by State)
- **Transmission & Distribution (T&D) Losses:** For all countries except the UK and European Countries, T&D losses are obtained from the UK Government's "Greenhouse gas reporting: conversion factors 2015". For countries where T&D data was not available in the 2015 UK Government factors, the UN GeoScheme is used to assign countries to subregions. Continental averages are applied where subregional data is unavailable. For the UK T&D emissions factors are sourced from the UK government (2025). For European countries the T&D losses are calculated from data published by Eurostat on losses and consumption (published 2025, using 2023 electricity grid data), allowing a T&D loss factor to be calculated.
- **Residual Mix Emission Factors:** Residual mix factors are calculated from the residual fuel mix data provided by the Association of Issuing Bodies (published 2025, using 2023 electricity grid data) and the I-TRACK Foundation (published 2025, using 2023 electricity grid data). The US residual mix factors were sourced from Green-e¹.

¹ Comprehensive residual mix Emission Factors (EFs) that exclude all voluntary or specified electricity purchases are not yet available from a national data source for all U.S. regions. Consequently, we use the Green-e® residual mix EF to better represent the emissions from electricity generation not claimed in specified purchases. It is important to note that this EF is not a complete residual mix; it only removes generation certified by the Green-e® Energy programme from the eGRID data, not all voluntary claims.

Data Sources for Emission Factor Calculations

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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 2025 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:** For most countries, historical T&D loss data is utilised. The transmission & distribution loss percentages were calculated from the UK Government's 2015 factors and applied to the newly calculated generation factors. For countries where T&D data was not available in the 2015 UK Government factors, the UN

GeoScheme is used to assign countries to subregions. Continental averages are applied where subregional data is unavailable. For UK, the T&D factor is provided by the UK government directly (2025). For most European countries the T&D factor has been calculated using ratios between consumption and losses (published by Eurostat 2025, based on 2023 consumption data)

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 2025 WTT conversion factors for fuels.
4. **Residual Emissions:** The residual emissions factors (where available) have been calculated using the residual fuel mix data from AIB (for European countries) and the I-TRACK Foundation. Where residual mix data is not available the generation emissions factor for that location has been provided.

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 for many countries. 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. For European countries, actual loss data has been used to calculate the T&D factor for most countries, which has improved the accuracy of this year's published T&D data.
3. **Well-to-Tank (WTT) Emissions:** Due to the challenges in obtaining up-to-date, country-specific WTT emission factors for fuels, the UK Government's WTT conversion factors for fuels are applied to all countries.

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 emissions factors are calculated from the residual mix fuel data provided by the Association of Issuing Bodies (AIB) and I-TRACK Foundation, for countries listed in these databases.

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 2025 factors) should be used to assess electricity-related GHG emissions during that corresponding year (2025).

The emission factors are typically calculated using electricity generation data from two years previous (e.g., the 2025 factors utilise energy mix data from 2023). 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 (2025) 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, 2025)
 - Reference list: CaDI. (2025). 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). 2025. www.carbondi.com. Accessed [date].

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