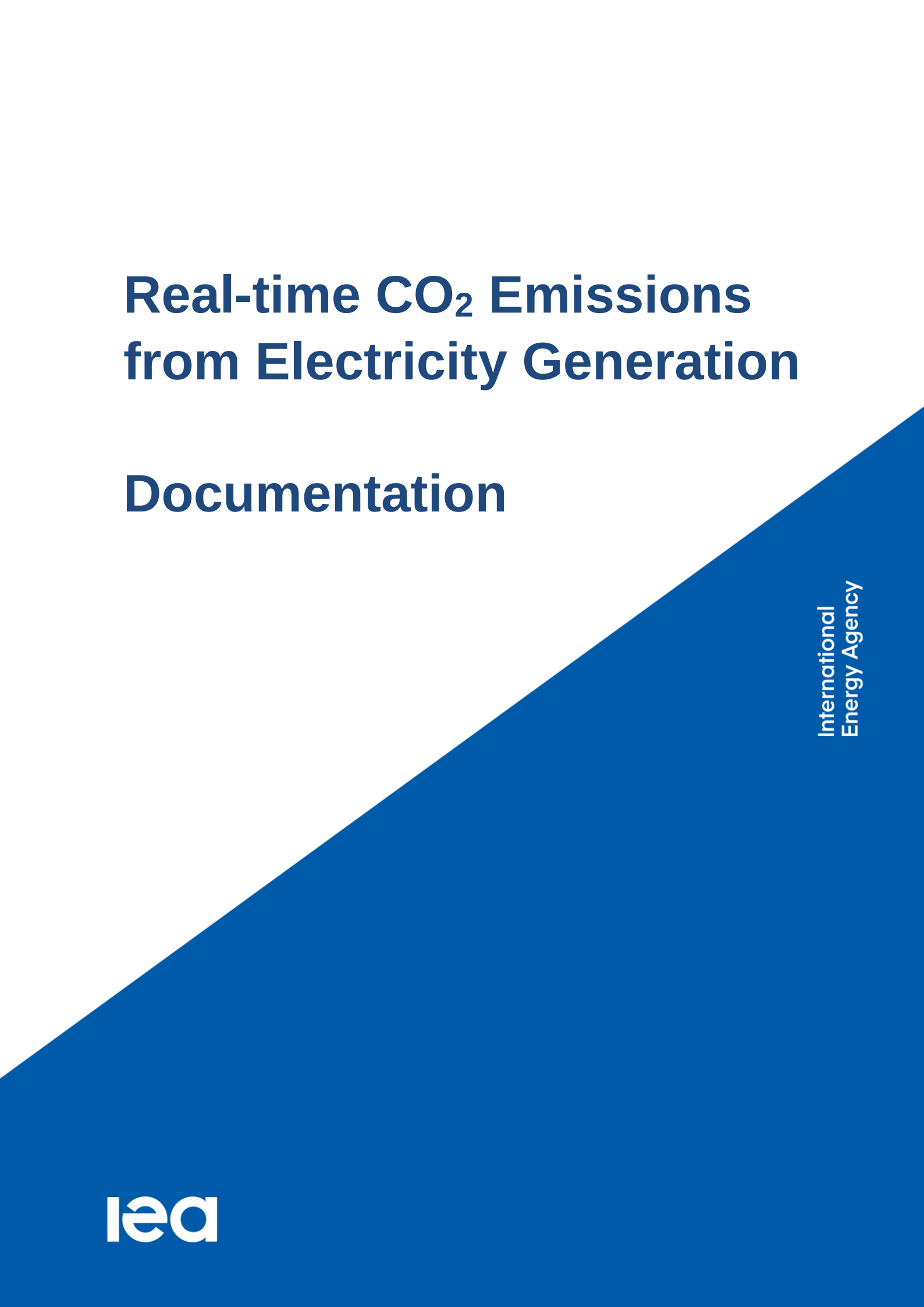
Real-time CO_2 Emissions from Electricity Generation

Documentation

International Energy Agency



INTERNATIONAL ENERGY AGENCY

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Acknowledgements

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Scope and objectives

Electricity plays a central role in modern life and power generation is currently the largest source of carbon dioxide (CO_2) emissions globally. Additionally, with significant potential to mitigate emissions and decarbonise energy supply chains, electrification is an important strategy to reach climate objectives. Most climate mitigation scenarios entail electrification of energy end uses and a substantial increase of the share of electricity in total final energy consumption. Considering the climate impacts of electricity generation provides a better understanding of the emission reduction benefits from electrification and how penetration of low carbon generation sources may contribute to decarbonisation goals.

The IEA Real-Time Electricity Tracker exhibits real-time data on electricity demand, generation, trade and spot prices for more than 60 countries. The data are available with daily and hourly resolutions at country or regional levels. The IEA World Energy Balances database contains yearly energy balances for over 150 countries and includes granular fuel/technology specific input and output data to electricity generation plants.

Electricity grids are sensitive to a variety of macro and micro events including wars, pandemics, extreme weather events, seasonality and the adoption of new climate and energy policy measures. Granular emissions data will enable monitoring and analysing the influence of such events on the climate impacts of the grid. As detailed in the *Methodology* section, merging the data from these two products enables the development of real-time CO_2 intensity and corresponding CO_2 emissions associated with the electricity grids with hourly and daily resolutions. Timely and granular emissions data can help to inform effective policy decisions like price signals and tariffs to incentivise consumers to shift consumption. This flexibility will facilitate the reduction of climate impacts due to electricity generation and is expected to be increasingly important as grids become progressively dominated by variable power generation.

On top of the above, the disclosure of GHG emissions and other environmental impacts has increased significantly in recent years, with over 20 000 organisations participating in the Carbon Disclosure Project (CDP) in 2023. This type of reporting will continue to increase as more mandatory disclosure regulations such as the European Corporate Sustainability Reporting Directive (CSRD) come into effect. Experts suggest that in case of access to high quality real-time data, applying timely grid intensity factors for reporting the footprint corresponding to electricity consumption is advantageous. Such reporting requirements may better incentivise load management and procurement strategies that could support the decarbonisation of grids. However, at present, the real-time electricity data published by the IEA Real-Time Electricity Tracker may not capture the globality of generation data for a given country. This is because this data is derived from the information published by transmission system operators (TSOs) and does not always include all generation from

small scale/distributed sources nor generation from autoproducers. Moreover, there may be existing grid-connected generation which are not reported to TSOs, for instance in countries in which markets are not fully liberalised. As a result, the developed real-time grid carbon intensities are not well-suited for reporting purposes.

On the other hand, the IEA Emissions Factors database currently publishes the emission factors at the point of electricity generation. These factors reflect annual average intensities of the national grid and can be used for the estimation of location-based Scope 2 emissions corresponding to consumption of purchased electricity under the Greenhouse Gas Protocol (GHG Protocol). The database also provides adjustment factors for emissions associated with transmission and distribution (T&D) losses of electricity in the grid, as well as electricity trade between countries. These adjustments can be added to the default factors, as required, to obtain a closer estimate of emissions at the point of final consumption. Additionally, the IEA Life Cycle Upstream Emission Factors is a new database including life cycle upstream and adjustment factors for T&D losses which may be applied for reporting Scope 3, Category 3 emissions under the GHG Protocol.

Definitions

Flow categories

Name	Definition
CO_2 intensity (gCO_2/kWh)	Correspond to the real-time CO_2 intensity of electricity generation expressed in gCO_2/kWh. The indicator is computed by multiplying the fuel-specific CO_2 intensities of electricity generation with respective real-time generation data and dividing the result by the total real-time electricity generation from all emitting and non-emitting sources for a given country and timeframe (hour, day, week, etc). Please refer to the *Methodology* section for details.
CO_2 emissions ($ktCO_2$)	Correspond to real-time CO_2 emissions of electricity generation expressed in $ktCO_2$. The indicator is obtained by multiplying the real-time CO_2 intensity of electricity grids with the corresponding real-time generation data. Please refer to the *Methodology* section for details.
CO_2 emissions per capita ($ktCO_2$ per M people)	Corresponds to the ratio of real-time CO_2 emissions of electricity generation per population expressed in $ktCO_2$ per million people. For OECD countries the main source of population data is the OECD National Accounts Statistics database [ISSN: 2221- 433X (online)], last published in book format as National Accounts of OECD Countries, Volume 2023 Issue 1: Detailed Tables, OECD 2023. For non-OECD countries the main source of this data is World Development Indicators, The World Bank, Washington D.C., 2023. Population data for Cyprus are taken from the Eurostat online database.
Min hourly emissions ($ktCO_2$)	Represents the minimum real-time hourly CO_2 emissions over a selected period expressed in $ktCO_2$.
Max hourly emissions ($ktCO_2$)	Represents the maximum real-time hourly CO_2 emissions over a selected period expressed in $ktCO_2$.
Average hourly emissions ($ktCO_2$)	Represents the average real-time hourly CO_2 emissions over a selected period expressed in $ktCO_2$.

Hour with max average emissions	Represents the hour of the day (local time zone) with the maximum average emissions over a selected period.
Min hourly intensity (gCO_2/kWh)	Represents the minimum real-time CO_2 intensity of electricity generation over a selected period expressed in gCO_2/kWh.
Max hourly intensity (gCO_2/kWh)	Represents the maximum real-time CO_2 intensity of electricity generation over a selected period expressed in gCO_2/kWh.
Average daily intensity (gCO_2/kWh)	Represents the average real-time daily CO_2 intensity of electricity generation over a selected period expressed in gCO_2/kWh.
Hour with max average intensity	Represents the hour of the day (local time zone) with the maximum average CO_2 intensity of electricity generation over a selected period.
Average CO_2 intensity profile (gCO_2/kWh)	Represents the average real-time hourly CO_2 intensity of electricity generation throughout the day over a selected period expressed in gCO_2/kWh. The figures are represented for Saturdays, Sundays and weekdays.

Product categories

Name	Definition
Coal	This product category includes all coal, both primary (hard coal, brown coal, anthracite, coking coal, other bituminous coal, sub-bituminous coal and lignite) and derived fuels (patent fuel, coke oven coke, gas coke, coal tar, BKB, gas works gas, coke oven gas, blast furnace gas and other recovered gases). Peat, peat products and oil shale are also aggregated in this category. For additional details please refer to the IEA World Energy Balances documentation.
Oil	This product category includes crude oil, natural gas liquids, refinery feedstocks, additives/blending components, orimulsion, other hydrocarbons, refinery gas, ethane, LPG, motor gasoline excluding biofuels, aviation gasoline, gasoline type jet fuel, kerosene type jet fuel excl. biofuels, kerosene, gas/diesel oil excl. biofuels, fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and non-specified oil products. For additional details please refer to the IEA World Energy Balances documentation.

Natural gas	This product category represents natural gas. It excludes natural gas liquids.
Thermal/Unspecified	This product category includes all or part of thermal generation sources including fossil fuels, waste and biofuels contributing to the electricity generation mix for a given country and year depending on the available product mapping in between the real-time and yearly data. Please refer to the *Methodology* section for details.
Waste	This product category includes industrial waste and both renewable and non-renewable fractions of municipal waste. For additional details please refer to the IEA World Energy Balances documentation.
Cogeneration	This category includes fuel inputs to combined heat and power (CHP) plants. ***Note:*** *Special cases exist where this product is reported in the real-time generation data while there is no CHP output reported in the yearly data from the IEA World Energy Balances. In such instances, the CO_2 intensity of this aggregated product is estimated based on the weighted average of the fossil fuels, biomass and waste contributing to the electricity mix. Please refer to the Methodology section for details.*

Real-Time Electricity Tracker Product categories

Category	Definition
Thermal	This product category includes thermal and cogeneration.
Coal	This product category includes brown coal, hard coal, peat and unspecified coal.
Natural Gas	This product category includes natural gas
Other combustibles	This product category includes diesel, landfill gas, oil and unspecified combustibles
Biomass/Waste	This product category includes biomass and waste

Methodology

The following sections detail the methodology corresponding to the development of the CO_2 intensity, emissions and related indicators based on the real-time electricity data. The first section describes the overall methodology, the second section explains the methodological choices needed for dealing with specific data points.

Overall methodology

The IEA Real-Time Electricity Tracker exhibits real-time data on electricity generation for more than 60 countries. The data is available with daily and hourly resolutions at country or regional levels.

The IEA World Energy Balances database contains yearly energy balances for over 150 countries. The database includes granular fuel/technology specific input and output data to electricity generation plants. This enables estimating fuel-specific electricity generation CO_2 intensities at country-level. Merging these derived intensities with the real-time generation data enables developing real-time CO_2 intensities and emissions associated with the electricity grids with hourly and daily resolutions. The overall methodology includes three main steps as detailed below:

Step 1: Developing annual fuel-specific CO_2 intensities corresponding to electricity generation

The first step involves estimating electricity generation fuel-specific CO_2 intensities at country-level. The following formula is used to calculate these factors:

$$CO_2\ intensity_{i,t,w}\left(\frac{gCO_2}{kWh}\right) = \frac{\left(Input_{\ plants} + Input_{CHP\ plants/Ele} + \ Own\ use_{\ plants/Ele}\ \right)_{\ i,t,w} \times \ EF_i}{Electricity\ output_{i,t,w}}$$

$CO_2\ intensity_{i,t,w}\left(\frac{gCO_2}{kWh}\right)$: *CO_2 intensity of electricity generation for fuel i and country w in year t expressed in gCO_2/kWh.*

Note: *The above corresponds to the direct intensity at the point of generation. As a result, the intensities corresponding to renewable sources (including biofuels) and nuclear are equal to zero.*

$Input_{\ plants}$: *Fuel input into the electricity plants for fuel i and country w in year t expressed in energy unit*

$Input_{CHP\ plants/Ele}$: *Portion of the fuel input to CHP plants which is allocated to electricity generation for fuel i and country w in year t expressed in energy unit*

Note: *The IEA adopts the fixed-heat-efficiency approach to estimate the proportion of the input to the combined heat and power plants (CHP) which is allocated to electricity generation. For additional details, please refer to the documentation file corresponding to the IEA Emission Factors database.*

$Own\ use_{Plants/Ele}$: *Fuel input to the electricity plants and CHP plants (the portion allocated to electricity generation) which is used by the generation plant for its own operation for fuel i and country w in year t expressed in energy unit*

$Electricity\ output_{i,t,w}$: *Electricity generation from fuel i and country w in year t expressed in kWh*

$EF_{i,}$: Default Tier 1 IPCC emission factor for fuel i expressed in gCO_{2eq}/kWh

Step 2: Developing aggregated annual CO_2 intensities corresponding to electricity generation

The fuel-specific intensities estimated in step 1, are developed based on granular energy data available from the *IEA World Energy Balances* database. On the other hand, the real-time generation data from the *IEA Real-Time Electricity Tracker* does not have the same level of granularity and data is mainly available in an aggregated format. Thus, the second step corresponds to estimating CO_2 intensities for the aggregated fuels for which the real-time generation data are available.

For this purpose, the granular fuel-specific intensities developed in step 1, are mapped against the aggregated product categories which are available from the real-time data. Please refer to the Definitions Section for the list of products included in each aggregated product category.

Following the mapping, the yearly shares of each granular fuel in the aggregated product category from the *IEA World Energy Balances* are applied to the fuel-specific CO_2 intensities developed in step 1. This enables estimating the intensities corresponding to the fuel categories available from the *Real-Time Electricity Tracker* based on the weighted average of the respective granular fuels as per the following formula:

$$CO_2\ intensity_{j,t,w}\left(\frac{gCO_2}{kWh}\right) = x_{ij,t,w} \times\ CO_2\ intensity_{i,t,w}\left(\frac{gCO_2}{kWh}\right)$$

$CO_2\ intensity_{j,t,w}\left(\frac{gCO_2}{kWh}\right)$: *CO_2 intensity of electricity generation for aggregated fuel category j and country w in year t expressed in gCO_2/kWh*

$x_{ij,t,w}$ *: Yearly share of fuel i in aggregated fuel category j for country w in year t*[1] *from the IEA World Energy Balances*

$CO_2\ intensity_{i,t,w}\left(\frac{gCO_2}{kWh}\right)$: *CO_2 intensity of electricity generation for fuel i and country w in year t*[1] *expressed in gCO_2/kWh*

For some countries and years the *Real-Time Electricity Tracker reports* the fuels "Thermal" and "Unspecified combustibles", which will be marked as "Thermal/Unspecified" and correspond to two general cases as detailed below:

a) For some countries/years, "Thermal" and/or "Unspecified combustibles" are the only product available in the *Real-Time Electricity Tracker* to accommodate for all thermal generation. In other cases, "Thermal"/ "Unspecified combustibles" are reported even though all the fuels in the *Real-Time Electricity Tracker* have already been mapped with corresponding yearly fuel data. For both cases, to estimate the CO_2 intensity corresponding to this aggregated product category, all the applicable thermal generation sources including fossil fuels, waste and biofuels from IEA *World Energy Balances* are consolidated in the above formula.

b) When the real-time generation data reports any emitting fuel(s) separately from the "Thermal"/"Unspecified combustibles" aggregate, the reported fuel(s) are excluded from the above weighted average.

For some countries/years a fuel category called "cogeneration" is reported in the *Real-Time Electricity Tracker*. To estimate the CO_2 intensity corresponding to this aggregated product category, the applicable yearly fuel inputs to CHP plants from *IEA World Energy Balances* are consolidated in the above formula. In the rare cases, when "cogeneration" is present in the real-time data but does not exist in the yearly data, all the applicable yearly thermal generation sources including fossil fuels, waste and biofuels from *IEA World Energy Balances* are consolidated in the above formula to estimate the CO_2 intensity for this aggregated product.

[1] The yearly energy data from the IEA World Energy Balances are available with a time lag of two years. This means that in the present year Y, the global coverage of the World Energy Balances is up to year Y-2. Hence, for estimating the CO_2 intensity of the aggregated fuel for the present year (year Y) and Y-1, step 2 is computed based on the latest available yearly data (year Y-2 or Y-3 for the 1st half of year Y). This approach assumes that there are no changes in the efficiency of the generation plants, the quality of the fuel inputs to plants and the fuel shares in the respective aggregated product categories comparing to year Y-2 or Y-3.

Step 3: Developing real-time grid CO_2 intensities and corresponding real-time emissions

In order to estimate the real-time CO_2 intensity of electricity grids, the aggregated CO_2 intensities developed in step 2 are applied to the real-time generation data as per the following formula:

$$CO_2\ intensity_{h,t,w}\left(\frac{gCO_2}{kWh}\right) = \frac{\sum_j CO_2\ intensity_{j,t,w} \times\ Electricity\ output_{j,h,t,w}}{Total\ electricity\ output_{h,t,w}}$$

$CO_2\ intensity_{h,t,w}\left(\frac{gCO_2}{kWh}\right)$: *Real-time CO_2 intensity of electricity generation for country w in hour h of year t expressed in gCO_2/kWh*

$CO_2\ intensity_{j,t,w}\left(\frac{gCO_2}{kWh}\right)$: *CO_2 intensity of electricity generation for aggregated fuel category j for country w in year t expressed in gCO_2/kWh.*

$Electricity\ output_{j,h,t,w}$: *Real-time electricity generation of aggregated fuel j for country w in hour h of year t from Real-Time Electricity Tracker expressed in kWh*

$Total\ electricity\ output_{h,t,w}$: *Total real-time electricity generation from all emitting and non-emitting generation sources for country w in hour h of year t from Real-Time Electricity Tracker expressed in kWh*

Applying the above developed real-time CO_2 intensity of the grid to the corresponding real-time generation data enables estimating the respective real-time CO_2 emissions as per the following formula:

$$CO_2\ emissions_{h,t,w} = Total\ electricity\ output_{h,t,w} \times\ CO_2\ intensity_{h,t,w}$$

$CO_2\ emissions_{h,t,w}$: *Real-time CO_2 emissions of electricity generation for country w in hour h of year t*

$Total\ electricity\ output_{h,t,w}$: *Total real-time electricity generation from all emitting and non-emitting generation sources for country w in hour h of year t from Real-Time Electricity Tracker*

$CO_2\ intensity_{h,t,w}\left(\frac{gCO_2}{kWh}\right)$: *Real-time CO_2 intensity of electricity generation for country w in hour h of year t expressed in gCO_2/kWh*

Additional methodological choices

This section describes the additional methodological choices needed for dealing with specific data points.

Special case 1: Absence of granular yearly energy data

For a handful of countries, the *IEA World Energy Balances* does not include the complete granular fuel inputs to the plants and the respective electricity generation figures. Therefore, developing the granular fuel-specific CO_2 intensities as detailed in step 1 in the *Overall methodology* section is not feasible. However, it is possible to carry out step 1 with aggregated energy data which results in development of aggregated fuel-specific CO_2 intensities. Step 2 is bypassed and the aggregated intensities developed in step 1 are directly applied in step 3 as per the formula detailed below. The current list of countries which require this special treatment includes Peru, Philippines, Nigeria and Uruguay.

$$CO_2\ intensity_{h,t,w}\left(\frac{gCO_2}{kWh}\right) = \frac{\sum_j CO_2\ intensity_{j,t,w} \times\ Electricity\ output_{j,h,t,w}}{Total\ electricity\ output_{h,t,w}}$$

$CO2\ intensity_{h,t,w}\left(\frac{gCO2}{kWh}\right)$: *Real-time CO_2 intensity of electricity generation for country w in hour h of year t expressed in gCO_2/kWh*

$CO2\ intensity_{j,t,w}\left(\frac{gCO2}{kWh}\right)$: *CO_2 intensity of electricity generation for aggregated fuel category j and country w in year t[2] developed from the yearly data expressed in gCO_2/kWh*

$Electricity\ output_{j,h,t,w}$: *Real-time electricity generation of aggregated fuel j and country w in hour h of year t from Real-Time Electricity Tracker expressed in kWh*

[2] The yearly energy data from the IEA World Energy Balances are available with a time lag of two years. This means that in the present year Y, the global coverage of the World Energy Balances is up to year Y-2. Hence, for estimating the real-time CO_2 intensity and the corresponding CO_2 emissions for the present year (year Y) and Y-1, the aggregated intensity is computed based on the latest available yearly data (year Y-2 or Y-3 for the 1st half of year Y). This approach assumes that there are no changes in the efficiency of the generation plants, the quality of the fuel inputs to plants and the fuel shares in the respective aggregated product categories comparing to year Y-2 or Y-3.

$Total\ electricity\ output_{h,t,w}$: *Total real-time electricity generation from all emitting and non-emitting generation sources for country w in hour h of year t from Real-Time Electricity Tracker expressed in kWh*

Special case 2: Reported real-time fuels not available in yearly generation data

For a handful of countries, there are real-time generation figures reported for fuels which are missing from the yearly data included in the *IEA World Energy Balances*. In such cases, following steps 1 and 2 is not possible. As a result, the average CO_2 intensity of electricity generation for a given aggregated fuel from all the other countries with available real-time data is selected and applied in step 3 as per the following formula:

$$CO_2\ intensity_{h,t,w}\left(\frac{gCO_2}{kWh}\right) = \frac{\sum_j Average\ CO_2\ intensity_{j,t} \times\ Electricity\ output_{j,h,t,w}}{Total\ electricity\ output_{h,t,w}}$$

$CO_2\ intensity_{h,t,w}\left(\frac{gCO_2}{kWh}\right)$: *Real-time CO_2 intensity of electricity generation for country w in hour h of year t expressed in gCO_2/kWh*

$Average\ CO_2\ intensity_{j,t}\left(\frac{gCO_2}{kWh}\right)$: *Average CO_2 intensity of electricity generation for aggregated fuel category j in year t expressed in gCO_2/kWh. from countries for which both real-time data and granular yearly energy data exist.*

Note: *Countries including intensities which represent outliers for a given aggregated fuel have been excluded from computing the above average.*

Note: *In rare instances where Special case 2 applies, while there are no other existing countries with available real-time data for a given fuel, applying the average CO_2 intensity as detailed above is not possible. Hence, the yearly average CO_2 intensity corresponding to a given fuel is applied in the above equation. Years with marginal corresponding generation are excluded from the average to avoid arbitrary noise in the intensities. This special case is currently only applicable to waste generation from Brazil for years 2010, 2011 and 2012.*

$Electricity\ output_{j,h,t,w}$: *Real-time electricity generation of aggregated fuel j and country w in hour h of year t year t from Real-Time Electricity Tracker expressed in kWh*

$Total\ electricity\ output_{h,t,w}$: *Total real-time electricity generation from all emitting and non-emitting generation sources for country w in hour h of year t from Real-Time Electricity Tracker expressed in kWh*

Special case 3: Marginal generation and distorted CO_2 intensities

When the electricity output from a given fuel is marginal, the fuel-specific CO_2 intensities developed in step 1 could be distorted due to rounding effects and/or data quality issues. This results in abnormal emission intensities which are clearly out of the expected range for a given fuel. Due to the negligible contribution of these fuels to the generation mix, this does not create a problem in the case of developing yearly grid CO_2 intensities. However, these fuels may have a notable contribution in real-time generation considering the hourly/daily resolution of the data. As a result, the estimated real-time CO_2 intensities may be out of range.

To resolve the issue, the following steps are completed:

a) The CO_2 intensities developed for the aggregated product categories in step 2 (including the ones computed for Special cases 1 and 2) are checked against maximum thresholds of 2000 gCO_2/kWh for “Coal”, “Thermal/Unspecified” and “Waste” and 1500 gCO_2/kWh for “Oil”.

b) For the cases where the figures are above the thresholds, the corresponding granular fuel-specific CO_2 intensities developed in step 1 are checked against maximum thresholds of 50% above the world average for a given fuel and year. The intensities which are higher than these maximums are replaced by the selected threshold figures.

c) Following the adjustment of the fuel-specific CO_2 intensities, the CO_2 intensities developed for the aggregated product categories in step 2 are checked against new maximum thresholds of 3000 gCO_2/kWh for “Coal”, “Thermal/Unspecified” and “Waste” and 2000 gCO_2/kWh for “Oil”.

The above steps will ensure that the developed real-time CO_2 intensities and corresponding CO_2 emissions are not distorted by rounding effects and/or low-quality data.

Special case 4: Negative figures reported for Cogeneration

The generation data for Malaysia included in the *IEA Real-Time Electricity Tracker* consists of both positive and negative values reported as cogeneration. The nature of the reported negative figures is not clear to the IEA. Therefore, in the case of negative figures for real-time cogeneration data, the respective CO_2 emissions are set to zeroes.

Geographical coverage and country notes

Countries

This document is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. In this publication, ‘country’ refers to country or territory, as case may be.

Country	Source	Notes
Argentina	Cammesa	
Australia	AEMO NEM, NTESMO	
Austria	Entso-e	
Bangladesh	PGCB	
Belgium	Entso-e	
Bolivia	CNDC.bo	
Bosnia and Herzegovina	Entso-e	
Brazil	ONS	
Bulgaria	Entso-e	
Chile	Coordinador Electrico Nacional	
Chinese Taipei	Taipower	
Colombia	xm.com.co	
Costa Rica	CENCE	
Croatia	Entso-e	

Country	Source	Notes
Cyprus	Entso-e	**Note by the Republic of Türkiye (Türkiye):** The information in the report with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the “Cyprus” issue. **Note by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this report relates to the area under the effective control of the Government of the Republic of Cyprus. At its seventeenth session, the Conference of the Parties decided to amend Annex I to the Convention to include Cyprus (Decision 10/CP.17). The amendment entered into force on 9 January 2013.
Czech Republic	Entso-e	
Denmark	Entso-e	
Estonia	Entso-e	
Finland	Entso-e	
France	Entso-e	
Georgia	Entso-e	
Germany	Entso-e	

Country	Source	Notes
Greece	Entso-e	
Hungary	Entso-e	
India	Merit India	
Ireland	Entso-e	
Italy	Entso-e	
Japan	Rikuden, Energia, Tepco, Chubu, Kansai TD, Hepco, Okiden, Kyuden, Yonden, Tohoku-Epco	Japanese data is scraped at the regional level, with each regional data coming from a different source.
Korea	Korea Power Exchange	
Kosovo	Entso-e	
Latvia	Entso-e	
Lithuania	Entso-e	
Luxembourg	Entso-e	
Malaysia	GSO	Malaysian data is not available as of 18/02/2024
Mexico	cenace.gob.mx	Mexican data is not available as of 01/06/2023
Republic of Moldova	ENERGO	
Montenegro	Entso-e	
Netherlands	Entso-e	
New Zealand	transpower.co.nz	
Nicaragua	CNDC.org.ni	

Country	Source	Notes
Nigeria	Transmission Company of Nigeria	
Republic of North Macedonia	Entso-e	
Norway	Entso-e	
Peru	coes.pe	
Philippines	IEMOP	
Poland	Entso-e	
Portugal	Entso-e	
Romania	Entso-e	
Russian Federation	ATS ENERGO	
Serbia	Entso-e	
Slovak Republic	Entso-e	
Slovenia	Entso-e	
South Africa	Eksom	
Spain	Entso-e	
Sri Lanka	CEB	
Sweden	Entso-e	
Switzerland	Entso-e	
Republic of Türkiye	EPIAS	
Ukraine	UKRENERGO	Ukraine data is not available as of 28/10/2022
United Kingdom	Elexon - BMRS	United Kingdom data excludes Northern Ireland which is accounted for in the Ireland data. The Single Electricity Market (SEM) was created across the island of Ireland,

Country	Source	Notes
		encompassing both Northern Ireland and the Republic of Ireland, to optimise energy management, enhance competition, and ensure security of supply. The SEM operates separately from the broader UK electricity market due to different regulatory environments and the physical separation of the Irish grid from Great Britain. This arrangement supports energy efficiency and stability on the island of Ireland.
United States	EIA	
Uruguay	ADME	

Abbreviations

CO2 carbon dioxide

CDP Carbon Disclosure Project

CSRD Corporate Sustainability Reporting Directive

TSO transmission system operator

GHG Protocol Greenhouse Gas Protocol

T&D transmission and distribution

CHP combined heat and power

g gramme

kWh kilowatt hour

IEA International Energy Agency

IPCC Intergovenmental Panel on Climate Change

GHG greenhouse gas

LCA life cycle assessment

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