



# **WORLD CO<sub>2</sub> EMISSIONS FROM FUEL COMBUSTION**

## **CO<sub>2</sub> emission factors: Documentation**

This document contains a description of the electricity and heat emissions factors files distributed together with the 2017 edition of the CO<sub>2</sub> data package. These files include a set of carbon emission factors for electricity and electricity/heat generation (previously available in the file World\_CO2kWh.ivt of the IEA [CO<sub>2</sub> emissions from fuel combustion](#) online services). The factors are described below:

- 1990 to 2015 CO<sub>2</sub> emission factors for electricity and heat generation for world countries (in CO<sub>2</sub> per kWh of electricity and heat generated).
- 1990 to 2015 CO<sub>2</sub> emission factors for electricity only generation (CHP electricity included) for world countries (in CO<sub>2</sub> per kWh of electricity generated).
- These emission factors are given for electricity and electricity/heat generation for the total electricity generation, and for generation from oil, coal, gas and from non-renewable wastes, as well as from biofuels.
- 1990 to 2015 CH<sub>4</sub> and N<sub>2</sub>O emission factors for electricity generated (based on default IPCC factors) (in CO<sub>2</sub>eq per kWh).
- 2016 provisional emission factors for electricity and electricity/heat generation for the most recent year, based on provisional electricity generation data (for OECD countries).
- 1990 to 2015 correction factors to emission factors from electricity generation for indirect emissions induced by electricity trade between countries (for OECD countries).
- 1990 to 2015 correction factors to emission factors from electricity generation for emissions associated to transmission and distribution losses of electricity in the grid (for countries with available data).
- 1990 to 2015 Emission factors from direct combustion of fuels in other sectors than electricity and heat production.

Please address your inquiries to [emissions@iea.org](mailto:emissions@iea.org)

*Please note that all IEA data are subject to the following Terms and Conditions found on the IEA's website:*

<http://www.iea.org/t&c/termsandconditions/>.

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# 1. DEFINITIONS

Electricity and Heat Output and Emissions per kWh		
Flow	Short name	Definition
Emissions per kWh of electricity (gCO <sub>2</sub> eq per kWh)	GHGKWHIN	<p>This ratio is expressed in grammes of CO<sub>2</sub> per kWh.</p> <p>Characteristics</p> <p>This ratio is based on total emissions from fossil fuels consumed for electricity generation, in both electricity-only and combined heat and power plants (CHP), divided by output of electricity generated from all fossil and non-fossil sources. Both main activity producers and autoproducers have been included in the calculation.</p> <p>The calculation methodology is available in part III.</p>
Emissions per kWh of electricity (gCO <sub>2</sub> per kWh)	GHGKWHHIN	<p>This ratio is based on total CO<sub>2</sub> emissions from fossil fuels consumed for electricity and heat generation divided by the output of electricity and heat (in kWh) from all fossil and non-fossil sources. It includes electricity-only plants, combined heat and power plants, and heat-only plants.</p> <p>Both main activity producers and autoproducers have been included in the calculation.</p> <p>The calculation methodology is available in part III.</p>
Trade adjustment (gCO <sub>2</sub> /kWh)	TRADECORREC	<p>Part of the electricity consumed in one country may have been generated in another one. Similarly, part of the electricity generated in one country can be exported to other countries. Therefore, adjustments may be done to the emission factors calculated above to account for electricity trade. Such adjustments are based on the share of electricity that is imported or exported compared to the domestic supply. The data needed to calculate such adjustment are only available for OECD countries. This adjustment can be positive or negative.</p> <p>The calculation methodology is available in part III.</p>
Transmission and distribution losses adjustment (gCO <sub>2</sub> /kWh)	LOSSCORREC	<p>As electricity is transmitted through a grid from the generation point to the consumption point, losses can occur for different reasons - they usually represent between 5 and 15% of the energy transmitted, mainly depending on the distance of the lines. Basically, for each kWh being consumed, a higher amount had to be generated.</p> <p>The calculation methodology is available in part III.</p>

GHG		
GHG	Short name	Definition
CO <sub>2</sub>	CO <sub>2</sub>	
CH <sub>4</sub>	CH <sub>4</sub>	The emission factors are converted from gCH <sub>4</sub> and gN <sub>2</sub> O to gCO <sub>2</sub> eq using the 100-year Global Warming Potential (GWP). For the purpose of comparability with international data submission guidelines, the factors from the 4th Assessment of the IPCC are used. 1gCH <sub>4</sub> = 25 gCO <sub>2</sub> eq
N <sub>2</sub> O	N <sub>2</sub> O	The emission factors are converted from gCH <sub>4</sub> and gN <sub>2</sub> O to gCO <sub>2</sub> eq using the 100-year Global Warming Potential (GWP). For the purpose of comparability with international data submission guidelines, the factors from the 4th Assessment of the IPCC are used. 1gN <sub>2</sub> O = 298 gCO <sub>2</sub> eq

Aggregated product categories		
Flow	Short name	Definition
Total	TOTAL	TOTAL = the total of all CO <sub>2</sub> emissions from fuel combustion, <i>i.e.</i> COAL + OIL + NATGAS + OTHER.
Coal, peat and oil shale	COAL	Coal, peat and oil shale 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.
Oil	OIL	Oil includes crude oil, natural gas liquids, refinery feedstocks, additives/blending components, orimulsion, other hydrocarbons, refinery gas, ethane, LPG, motor gasoline excl. 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.
Natural gas	NATGAS	Gas represents natural gas. It excludes natural gas liquids.
Non-renewables wastes	OTHER	Other includes industrial waste and non-renewable municipal waste.
Memo: Biofuels and renewable wastes	BIOPROD	Includes biofuels (primary solid biofuels, biogases, biogasoline, biodiesels, bio jet kerosene and other liquid biofuels) and renewable wastes.

## 2. GEOGRAPHICAL COVERAGE AND COUNTRY NOTES

<b>Countries and regions</b>		
<p>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. Data start in 1960 for OECD countries and regions, and in 1971 for non-OECD countries and regions, unless otherwise specified.</p>		
Country/Region	Short name	Definition
World	WORLD	Includes OECD Total; Africa; non-OECD Asia (excluding China); China (P.R. of China and Hong Kong, China); Non-OECD Americas; Middle East; Non-OECD Europe and Eurasia; World aviation bunkers and World marine bunkers. It is also the sum of Africa (UN), Americas (UN), Asia (UN), Europe (UN), Oceania (UN), World aviation bunkers and World marine bunkers.
OECD Americas	OECDAM	Includes Canada, Chile, Mexico and the United States.
OECD Asia Oceania	OECDAO	Includes Australia, Israel <sup>1</sup> , Japan, Korea and New Zealand.
OECD Europe	OECDEUR	Includes Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia <sup>2</sup> , Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. Estonia, Latvia <sup>Error! Bookmark not defined.</sup> and Slovenia are included starting in 1990. Prior to 1990, data for Estonia and Latvia are included in Former Soviet Union and data for Slovenia in Former Yugoslavia.
Africa	AFRICA	Includes Algeria, Angola, Benin, Botswana (from 1981), Cameroon, Republic of Congo (Congo) <sup>3</sup> , Côte d'Ivoire, Democratic Republic of Congo (from 1981), Egypt, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libya, Mauritius, Morocco, Mozambique, Namibia (from 1991), Niger (from 2000), Nigeria, Senegal, South Africa, South Sudan (from 2012), Sudan, United Republic of Tanzania, Togo, Tunisia, Zambia, Zimbabwe and <b>Other Africa</b> . Note that Africa is identical to Memo: Africa (UN).

<sup>1</sup>. The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

<sup>2</sup>. Latvia became an OECD Member in July 2016. Accordingly, Latvia appears in the list of OECD Members and is included in the zone aggregates for data from 1990, starting with the 2017 edition. Prior to 1990, data for Latvia are included in Former Soviet Union.

<sup>3</sup>. Country short names are included in parentheses.

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Country/Region	Short name	Definition
Non-OECD Americas	LATAMER	Includes Argentina, the Plurinational State of Bolivia (Bolivia), Brazil, Colombia, Costa Rica, Cuba, Curaçao <sup>4</sup> , Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname (from 2000), Trinidad and Tobago, Uruguay, the Bolivarian Republic of Venezuela (Venezuela) and <b>Other non-OECD America</b> .
Middle East	MIDEAST	Includes Bahrain, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates and Yemen.
Non-OECD Europe and Eurasia	EURASIA	Includes Albania; Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Cyprus <sup>5</sup> ; Former Yugoslav Republic of Macedonia; Georgia; Gibraltar; Kazakhstan; Kosovo <sup>6</sup> ; Kyrgyzstan; Lithuania; Malta; Republic of Moldova (Moldova); Montenegro; Romania; Russian Federation; Serbia <sup>7</sup> ; Tajikistan; Turkmenistan; Ukraine; Uzbekistan; Former Soviet Union (prior to 1990) and Former Yugoslavia (prior to 1990). <small>Error! Bookmark not defined.</small>
Non-OECD Asia (excluding China)	ASIA	Includes Bangladesh, Brunei Darussalam, Cambodia (from 1995), DPR of Korea, India, Indonesia, Malaysia, Mongolia (from 1985), Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Chinese Taipei, Thailand, Viet Nam and <b>Other non-OECD Asia</b> .
China (including Hong Kong, China)	CHINAREG	Includes the People's Republic of China and Hong Kong, China.
World Aviation Bunkers	WORLDAV	World Aviation Bunkers represents the sum of International Aviation Bunkers from all countries.
World Marine Bunkers	WORLDMAR	World Marine Bunkers represents the sum of International Marine Bunkers from all countries.

<sup>4</sup>. The Netherlands Antilles was dissolved on 10 October 2010 resulting in two new “constituent countries” (Curaçao and Sint Maarten) with the other islands joining The Netherlands as ‘special municipalities’. However, due to lack of detailed data the IEA secretariat’s data and estimates under the “Curaçao” still refer to the whole territory of the Netherlands Antilles as it was known prior to 10 October 2010 up to the end of 2011. Data refer only to the island of Curaçao from 2012. The other islands of the former Netherlands Antilles are added to **Other non-OECD Americas** from 2012.

<sup>5</sup>. **Note by Turkey:**

*The information in this document 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. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey 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 Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.*

<sup>6</sup>. This designation is without prejudice to positions on status, and is in line with United Nations Security Council Resolution 1244/99 and the Advisory Opinion of the International Court of Justice on Kosovo’s declaration of independence.

<sup>7</sup>. Serbia includes Montenegro until 2004 and Kosovo until 1999.

## Countries and regions

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Country/Region	Short name	Definition
Albania	ALBANIA	
Algeria	ALGERIA	
Angola	ANGOLA	
Argentina	ARGENTINA	
Armenia	ARMENIA	Data for Armenia are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Australia	AUSTRALI	Excludes the overseas territories.
Austria	AUSTRIA	
Azerbaijan	AZERBAIJAN	Data for Azerbaijan are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Bahrain	BAHRAIN	
Bangladesh	BANGLADESH	Data for Bangladesh are reported on a fiscal year basis. Data for 2015 are for 1 July 2015 – 30 June 2016.
Belarus	BELARUS	Data for Belarus are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Belgium	BELGIUM	
Benin	BENIN	
Bolivia	BOLIVIA	
Bosnia and Herzegovina	BOSNIAHERZ	Data for Bosnia and Herzegovina are available starting in 1990. Prior to that, they are included in Former Yugoslavia.
Botswana	BOTSWANA	Data for Botswana are available starting in 1995. Prior to that, they are included in <b>Other Africa</b> .
Brazil	BRAZIL	
Brunei Darussalam	BRUNEI	
Bulgaria	BULGARIA	According to the provisions of Article 4.6 of the Convention and Decisions 9/CP.2 and 11/CP.4, Bulgaria is allowed to use 1988 as the base year.
Cambodia	CAMBODIA	Data for Cambodia are available starting in 1995. Prior to that, they are included in <b>Other non-OECD Asia</b> .
Cameroon	CAMEROON	
Canada	CANADA	
Chile	CHILE	Data start in 1971.



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Country/Region	Short name	Definition
People’s Republic of China	CHINA	
Colombia	COLOMBIA	
Congo	CONGO	
Costa Rica	COSTARICA	
Côte d’Ivoire	COTEIVOIRE	
Croatia	CROATIA	Data for Croatia are available starting in 1990. Prior to that, they are included in Former Yugoslavia.
Cuba	CUBA	
Curaçao	CURACAO	The Netherlands Antilles was dissolved on 10 October 2010 resulting in two new “constituent countries” (Curaçao and Sint Maarten) with the other islands joining The Netherlands as ‘special municipalities’. However, due to lack of detailed data the IEA secretariat’s data and estimates under the “Curaçao” still refer to the whole territory of the Netherlands Antilles as it was known prior to 10 October 2010 up to the end of 2011. Data refer only to the island of Curaçao from 2012. The other islands of the former Netherlands Antilles are added to <b>Other non-OECD Americas</b> from 2012.

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Country/Region	Short name	Definition
Cyprus	CYPRUS	<p><b>Note by Turkey:</b></p> <p>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. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus" issue.</p> <p><b>Note by all the European Union Member States of the OECD and the European Union:</b></p> <p>The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this report relates to the area under the effective control of the Government of the Republic of Cyprus.</p> <p>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.</p>
Czech Republic	CZECH	Data start in 1971.
Democratic People's Republic of Korea	KOREADPR	
Democratic Republic of Congo	CONGOREP	
Denmark	DENMARK	Excludes Greenland and the Danish Faroes, except prior to 1990, where data on oil for Greenland were included with the Danish statistics. The Administration is planning to revise the series back to 1974 to exclude these amounts.
Dominican Republic	DOMINICANR	
Ecuador	ECUADOR	
Egypt	EGYPT	Data for Egypt are reported on a fiscal year basis. Data for 2015 are for 1 July 2015 – 30 June 2016.
El Salvador	ELSALVADOR	
Eritrea	ERITREA	Data for Eritrea are available from 1992. Prior to that, they are included in Ethiopia.

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Country/Region	Short name	Definition
Estonia	ESTONIA	Data start in 1990. Prior to that, they are included within Former Soviet Union. <i>Note: Estonia joined the IEA in May 2014.</i>
Ethiopia	ETHIOPIA	Ethiopia energy data include Eritrea from 1971 to 1991. From 1992 onwards the two countries are reported separately.
Finland	FINLAND	
Former Yugoslav Rep. of Macedonia	FYROM	Data for Former Yugoslav Rep. of Macedonia are available starting in 1990. Prior to that, they are included in Former Yugoslavia.
France	FRANCE	Includes Monaco, and excludes the following overseas departments: Guadeloupe, French Guiana, Martinique, Mayotte, and Réunion, and collectivities: New Caledonia, French Polynesia, Saint Barthélemy, Saint Martin, Saint Pierre and Miquelon, and Wallis and Futuna.
Gabon	GABON	
Georgia	GEORGIA	Data for Georgia are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Germany	GERMANY	Includes the new federal states of Germany from 1970 onwards.
Ghana	GHANA	
Gibraltar	GIBRALTAR	
Greece	GREECE	
Guatemala	GUATEMALA	
Haiti	HAITI	
Honduras	HONDURAS	
Hong Kong, China	HONGKONG	
Hungary	HUNGARY	Data start in 1965. According to the provisions of Article 4.6 of the Convention and Decisions 9/CP.2 and 11/CP.4, Hungary is allowed to use average 1985-1987 as the base year.
Iceland	ICELAND	
India	INDIA	Data are reported on a fiscal calendar year basis. Data for 2015 are for 1 April 2015 – 31 March 2016.

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Country/Region	Short name	Definition
Indonesia	INDONESIA	
Islamic Republic of Iran	IRAN	Data are reported according to the Iranian calendar year. Data for 2015 correspond to 20 March 2015 – 19 March 2016.
Iraq	IRAQ	
Ireland	IRELAND	
Israel	ISRAEL	Data start in 1971. The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.
Italy	ITALY	Includes San Marino and the Holy See.
Jamaica	JAMAICA	
Japan	JAPAN	Includes Okinawa.
Jordan	JORDAN	
Kazakhstan	KAZAKHSTAN	Data for Kazakhstan are available starting in 1990. Prior to that they are included in Former Soviet Union.
Kenya	KENYA	
Korea	KOREA	Data start in 1971.
Kosovo	KOSOVO	This designation is without prejudice to positions on status, and is in line with United Nations Security Council Resolution 1244/99 and the Advisory Opinion of the International Court of Justice on Kosovo's declaration of independence. Data for Kosovo are available starting in 2000. From 1990-1999, data for Kosovo are included in Serbia. Prior 1990 that, they are included in Former Yugoslavia. For data in the NONCO2 file, from 2000 onwards, all emissions other than CO <sub>2</sub> from fuel combustion are included in Serbia.
Kuwait	KUWAIT	
Kyrgyzstan	KYRGYZSTAN	Data for Kyrgyzstan are available starting in 1990. Prior to that, they are included in Former Soviet Union.

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Country/Region	Short name	Definition
Latvia	LATVIA	Data for Latvia are available starting in 1990. Prior to that, they are included in Former Soviet Union. Latvia became an OECD Member in July 2016. Accordingly, Latvia appears in the list of OECD Members and is not included in the non-OECD aggregates for data from 1990, starting with the 2017 edition.
Lebanon	LEBANON	
Libya	LIBYA	
Lithuania	LITHUANIA	Data for Lithuania area available starting in 1990. Prior to that, they are included in Former Soviet Union.
Luxembourg	LUXEMBOU	
Malaysia	MALAYSIA	
Malta	MALTA	At its fifteenth session, the Conference of the Parties decided to amend Annex I to the Convention to include Malta (Decision 3/CP.15). The amendment entered into force on 26 October 2010.
Mauritius	MAURITIUS	
Mexico	MEXICO	Data start in 1971.
Republic of Moldova	MOLDOVA	Data for the Republic of Moldova are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Mongolia	MONGOLIA	Data for Mongolia are available starting in 1985. Prior to that, they are included in Other Asia.
Montenegro	MONTENEGRO	Data for Montenegro are available starting in 2005. From 1990 to 2004, data for Montenegro are included in Serbia. Prior to 1990, data are included in Former Yugoslavia. For data in the NONCO2 file, from 2005 onwards, all emissions other than CO <sub>2</sub> from fuel combustion are included in Serbia.
Morocco	MOROCCO	
Mozambique	MOZAMBIQUE	
Myanmar	MYANMAR	
Namibia	NAMIBIA	Data for Namibia are available starting in 1991. Prior to that, they are included in <b>Other Africa</b> .
Nepal	NEPAL	Data for Nepal are reported on a fiscal year basis. Data for 2015 are for 16 July 2015 - 15 July 2016.

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Country/Region	Short name	Definition
Netherlands	NETHLAND	Excludes Suriname, Aruba and the other former the Netherlands Antilles (Bonaire, Curaçao, Saba, Saint Eustatius and Sint Maarten).
New Zealand	NZ	
Nicaragua	NICARAGUA	
Niger	NIGER	Data for Niger are available starting in 2000. Prior to that, they are included in <b>Other Africa</b> . For data in the NONCO2 file, for 1990 and 1995, <b>Other Africa</b> includes Niger for all CO <sub>2</sub> emissions from fuel combustion.
Nigeria	NIGERIA	
Norway	NORWAY	Discrepancies between Reference and Sectoral Approach estimates and the difference in the resulting growth rates arise from statistical differences between supply and consumption data for oil and natural gas. For Norway, supply of these fuels is the residual of two very large and opposite terms, production and exports.
Oman	OMAN	
Pakistan	PAKISTAN	
Panama	PANAMA	
Paraguay	PARAGUAY	
Peru	PERU	
Philippines	PHILIPPINES	
Poland	POLAND	According to the provisions of Article 4.6 of the Convention and Decisions 9/CP.2 and 11/CP.4, Poland is allowed to use 1988 as the base year.
Portugal	PORTUGAL	Includes the Azores and Madeira.
Qatar	QATAR	
Romania	ROMANIA	According to the provisions of Article 4.6 of the Convention and Decisions 9/CP.2 and 11/CP.4, Romania is allowed to use 1989 as the base year.
Russian Federation	RUSSIA	Data for Russian Federation are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Saudi Arabia	SAUDIARABI	

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Country/Region	Short name	Definition
Senegal	SENEGAL	
Serbia	SERBIA	<p>Data for Serbia are available starting in 1990. Prior to that, they are included in Former Yugoslavia. Serbia includes Kosovo<sup>6</sup> from 1990 to 1999 and Montenegro from 1990 to 2004.</p> <p>For data in the NONCO2 file, Serbia includes Kosovo<sup>6</sup> for all emissions other than CO<sub>2</sub> from fuel combustion from 2000 onwards, and Montenegro for all emissions other than CO<sub>2</sub> from fuel combustion from 2005 onwards.</p>
Singapore	SINGAPORE	<p>Due to Singapore's large trade volume in comparison to its final consumption, a slight misalignment of trade figures can have a significant impact on the Energy balance of Singapore. As a result, large discrepancies between the Reference and Sectoral Approach estimates arise from statistical differences between supply and consumption of oil and oil products.</p> <p>The IEA secretariat, the Energy Market Authority and the National Climate Change Secretariat (NCCS) are working closely together on improving data quality for Singapore. Efforts are continuing on this project, therefore breaks in time series between 2008 and 2009 and differences in trends when compared to previous publications may occur for some products.</p>
Slovak Republic	SLOVAKIA	
Slovenia	SLOVENIA	<p>Data for Slovenia are available from 1990. Prior to that, they are included in Former Yugoslavia in the full publication.</p> <p>According to the provisions of Article 4.6 of the Convention and Decisions 9/CP.2 and 11/CP.4, Slovenia is allowed to use 1986 as the base year.</p>
South Africa	SOUTHAFRIC	<p>Large differences between the Reference and Sectoral Approach estimates are due to losses associated with coal-to-liquid and to a lesser extent gas-to-liquid transformation.</p>
South Sudan	SSUDAN	<p>South Sudan became an independent country on 9 July 2011. Data for South Sudan are available from 2012. Prior to 2012, they are included in Sudan.</p> <p>For data in the NONCO2 file, data for South Sudan is included in Sudan for all years.</p>
Spain	SPAIN	Includes the Canary Islands.

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Country/Region	Short name	Definition
Sri Lanka	SRILANKA	
Sudan	SUDAN	South Sudan became an independent country on 9 July 2011. Data for South Sudan are available from 2012. Prior to 2012, they are included in Sudan. For data in the NONCO2 file, data for South Sudan is included in Sudan for all years.
Suriname	SURINAME	Data for Suriname are available from 2000. Prior to 2000, data for Suriname are presented in <b>Other non-OECD Americas</b> . For data in the NONCO2 file, for 1990 and 1995, <b>Other non-OECD Americas</b> includes Suriname for all CO <sub>2</sub> emissions from fuel combustion.
Sweden	SWEDEN	
Switzerland	SWITLAND	Includes Liechtenstein for the oil data. Data for other fuels do not include Liechtenstein.
Chinese Taipei	TAIPEI	
Tajikistan	TAJIKISTAN	Data for Tajikistan are available starting in 1990. Prior to that, they are included in Former Soviet Union.
United Republic of Tanzania	TANZANIA	
Thailand	THAILAND	
Togo	TOGO	
Trinidad and Tobago	TRINIDAD	
Tunisia	TUNISIA	
Turkey	TURKEY	
Turkmenistan	TURKMENIST	Data for Turkmenistan are available starting in 1990. Prior to that, they are included in Former Soviet Union.
Ukraine	UKRAINE	Data for Ukraine are available starting in 1990. Prior to that, they are included in Former Soviet Union.
United Arab Emirates	UAE	



## Countries and regions

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Country/Region	Short name	Definition
United Kingdom	UK	Shipments of coal and oil to the Channel Islands and the Isle of Man from the United Kingdom are not classed as exports. Supplies of coal and oil to these islands are, therefore, included as part of UK supply. Exports of natural gas to the Isle of Man are included with the exports to Ireland.
United States	USA	Includes the 50 states and the District of Columbia but generally excludes all territories, and all trade between the U.S. and its territories. Oil statistics include Guam, Puerto Rico <sup>8</sup> and the United States Virgin Islands; trade statistics for coal include international trade to and from Puerto Rico and the United States Virgin Islands.
Uruguay	URUGUAY	
Uzbekistan	UZBEKISTAN	Data for Uzbekistan are available starting in 1990. Prior to that, data are included in Former Soviet Union.
Venezuela	VENEZUELA	
Viet Nam	VIETNAM	
Yemen	YEMEN	
Zambia	ZAMBIA	
Zimbabwe	ZIMBABWE	
Former Soviet Union (if no detail)	FSUND	Before 1990, includes Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia <sup>Error! Bookmark not defined.</sup> , Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.
Former Yugoslavia (if no detail)	YUGOND	Before 1990, includes Bosnia and Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, Kosovo <sup>6</sup> , Montenegro, Slovenia, Serbia <sup>7</sup> .

<sup>8</sup>. Natural gas and electricity data for Puerto Rico are included under **Other Non-OECD Americas**. Oil statistics as well as coal trade statistics for Puerto Rico are included under the United States.

## Countries and regions

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Country/Region	Short name	Definition
Other Africa	OTHERAFRIC	Includes Botswana (until 1980); Burkina Faso; Burundi; Cape Verde; Central African Republic; Chad; Comoros; Djibouti; Equatorial Guinea; Gambia; Guinea; Guinea-Bissau; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Namibia (until 1990); Niger (until 1999) Réunion; Rwanda; Sao Tome and Principe; Seychelles; Sierra Leone; Somalia; Swaziland; and Uganda.  For data in the NONCO2 file, for 1990 and 1995, <b>Other Africa</b> includes Niger for all CO <sub>2</sub> emissions from fuel combustion.
Other non-OECD Americas	OTHERLATIN	Includes Antigua and Barbuda; Aruba; Bahamas; Barbados; Belize; Bermuda; British Virgin Islands; Cayman Islands; Dominica; Falkland Islands (Malvinas); French Guiana; Grenada; Guadeloupe; Guyana; Martinique; Montserrat; Puerto Rico <sup>8</sup> (for natural gas and electricity); Saba (from 2012); Saint Eustatius (from 2012); Saint Kitts and Nevis; Saint Lucia; Saint Pierre and Miquelon; Saint Vincent and the Grenadines; Sint Maarten (from 2012); Suriname (until 1999); and the Turks and Caicos Islands.
Other non-OECD Asia	OTHERASIA	Includes Afghanistan; Bhutan; Cambodia (until 1994); Cook Islands; East Timor; Fiji; French Polynesia; Kiribati; Lao People's Democratic Republic; Macau, China; Maldives; Mongolia (until 1984); New Caledonia; Palau (from 1994); Papua New Guinea; Samoa; Solomon Islands; Tonga and Vanuatu.
Memo: Greenland	MGREENLAND	Data start in 2004. Prior to 1990, data on oil for Greenland were included with the Danish statistics, within the OECD region. They are not included in any region after 1990.
Memo: Mali	MMALI	Data start in 2000. Mali data are also included in the <b>Other Africa</b> region.

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Country/Region	Short name	Definition
Memo: Africa (UN)	UNAFRICA	<p>Includes Algeria; Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; the Republic of the Congo (Congo); Côte d'Ivoire; the Democratic Republic of the Congo; Djibouti; Egypt; Equatorial Guinea; Eritrea; Ethiopia; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Libya; Madagascar; Malawi; Mali; Mauritania; Mauritius; Morocco; Mozambique; Namibia; Niger; Nigeria; Réunion; Rwanda; Sao Tome and Principe; Senegal; the Seychelles; Sierra Leone; Somalia; South Africa; South Sudan (from 2012), Sudan; Swaziland; the United Republic of Tanzania (Tanzania); Togo; Tunisia; Uganda; Zambia; Zimbabwe.</p> <p>Note that Memo: Africa (UN) is identical to Africa.</p>
Memo: Americas (UN)	UNAMERICAS	<p>Includes Antigua and Barbuda; Argentina; Aruba; the Bahamas; Barbados; Belize; Bermuda; the Plurinational State of Bolivia (Bolivia); Bonaire (from 2012); the British Virgin Islands; Brazil; Canada; the Cayman Islands; Chile; Colombia; Costa Rica; Cuba; Curaçao<sup>4</sup>; Dominica; the Dominican Republic; Ecuador; El Salvador; the Falkland Islands (Malvinas); Guatemala; French Guiana; Grenada; Guadeloupe; Guyana; Haiti; Honduras; Jamaica; Martinique; Mexico; Montserrat; Nicaragua; Panama; Paraguay; Peru; Puerto Rico (for natural gas and electricity)<sup>8</sup>; Saba (from 2012); Saint Kitts and Nevis; Saint Lucia; Saint Pierre and Miquelon; Saint Vincent and the Grenadines; Sint Eustatius (from 2012); Sint Maarten (from 2012); Suriname; Trinidad and Tobago; the Turks and Caicos Islands; the United States; Uruguay; the Bolivarian Republic of Venezuela (Venezuela).</p>

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Country/Region	Short name	Definition
Memo: Asia (UN)	UNASIATOT	Data for Asia (UN) are available from 1990. Includes Afghanistan; Armenia; Azerbaijan; Bahrain; Bangladesh; Bhutan; Brunei Darussalam; Cambodia; the People's Republic of China; Cyprus <sup>9</sup> ; Georgia; Hong Kong, China; India; Indonesia; the Islamic Republic of Iran; Iraq; Israel <sup>10</sup> ; Japan; Jordan; the Democratic People's Republic of Korea; Korea; Kazakhstan; Kuwait; Kyrgyzstan; Lao People's Democratic Republic; Lebanon; Macau, China; Malaysia; the Maldives; Mongolia; Myanmar; Nepal; Oman; Pakistan; the Philippines; Qatar; Saudi Arabia; Singapore; Sri Lanka; the Syrian Arab Republic; Tajikistan; Chinese Taipei; Thailand; Timor-Leste; Turkey; Turkmenistan; the United Arab Emirates; Uzbekistan; Viet Nam; and Yemen.
Memo: Europe (UN)	UNEUROPE	Data for Europe (UN) are available from 1990. Includes Albania; Austria; Belarus; Belgium; Bosnia and Herzegovina; Bulgaria; Croatia; the Czech Republic; Denmark; Estonia; Finland; the Former Yugoslav Republic of Macedonia; France; Germany; Gibraltar; Greece; Hungary; Iceland; Ireland; Italy; Kosovo <sup>6</sup> ; Latvia <sup>Error! Bookmark not defined.</sup> ; Lithuania; Luxembourg; Malta; the Republic of Moldova (Moldova); Montenegro; the Netherlands; Norway; Poland; Portugal; Romania; the Russian Federation; Serbia <sup>7</sup> ; the Slovak Republic; Slovenia; Spain; Sweden; Switzerland; Ukraine; the United Kingdom.
Memo: Oceania (UN)	UNOCEANIA	Includes Australia; New Zealand; Cook Islands; Fiji; French Polynesia; Kiribati; New Caledonia; Palau; Papua New Guinea; Samoa; the Solomon Islands; Tonga; Vanuatu.

<sup>9</sup>. Refer to the country note for Cyprus earlier in this chapter.

<sup>10</sup>. The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

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Country/Region	Short name	Definition
Memo: OECD Total	OECDTOT	<p>Includes Australia; Austria; Belgium; Canada; Chile; the Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Israel<sup>11</sup>; Italy; Japan; Korea; Latvia; Luxembourg; Mexico; the Netherlands; New Zealand; Norway; Poland; Portugal; the Slovak Republic; Slovenia; Spain; Sweden; Switzerland; Turkey; the United Kingdom and the United States.</p> <p>Latvia became an OECD Member in July 2016. Accordingly, Latvia appears in the list of OECD Members and is included in the zone aggregates for data from 1990, starting with the 2017 edition. Estonia, Latvia and Slovenia are included starting in 1990. Prior to 1990, data for Estonia and Latvia are included in Former Soviet Union and data for Slovenia in Former Yugoslavia.</p>
Memo: non-OECD total	NOECDTOT	<p>Includes Africa; Asia (excluding China); China (P.R. of China and Hong Kong, China); Non-OECD Americas; Middle East and Non-OECD Europe and Eurasia.</p>
Memo: IEA Total	IEATOT	<p>Includes Australia; Austria; Belgium; Canada; the Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Japan; Korea; Luxembourg; the Netherlands; New Zealand; Norway; Poland; Portugal; the Slovak Republic; Spain; Sweden; Switzerland; Turkey; the United Kingdom and the United States.</p> <p>Estonia is included starting in 1990. Prior to 1990, data for Estonia are included in Former Soviet Union.</p>
Memo: IEA and Accession/Association countries	IEAFAMILY	<p>Includes: IEA member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States; Accession countries: Chile and Mexico; Association countries: the People's Republic of China; India; Indonesia; Morocco; Singapore; Thailand.</p>

<sup>11</sup>. The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

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Country/Region	Short name	Definition
Memo: European Union – 28	EU28	Includes Austria, Belgium, Bulgaria, Croatia, Cyprus <sup>12</sup> , the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia <sup>Error! Bookmark not defined.</sup> , Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom. Please note that in the interest of having comparable data, all of these countries are included since 1990 despite different entry dates into the European Union.
Memo: Former Yugoslavia	MYUGO	Includes Former Yugoslavia (if no detail); Bosnia and Herzegovina; Croatia; the Former Yugoslav Republic of Macedonia; Kosovo <sup>6</sup> ; Montenegro; Slovenia and Serbia <sup>7</sup> .
Memo: Former Soviet Union	MFSU15	Includes the Former Soviet Union with all 15 countries for all years.
Memo: OPEC 13	OPEC13	Includes Algeria; Angola; Ecuador; Gabon; Islamic Republic of Iran; Iraq; Kuwait; Libya; Nigeria; Qatar; Saudi Arabia; the United Arab Emirates and Bolivarian Republic of Venezuela (Venezuela). <sup>13</sup>
Memo: G7	MG7	Includes Canada, France, Germany, Italy, Japan, the United Kingdom and the United States.
Memo: G8	MG8	Includes Canada, France, Germany, Italy, Japan, Russian Federation, the United Kingdom and the United States.
Memo: G20	MG20	Includes Argentina, Australia, Brazil, Canada, China (including Hong Kong, China), India, Indonesia, Japan, Korea, Mexico, Russian Federation, Saudi Arabia, South Africa, Turkey, the United States and the European Union – 28.

<sup>12</sup>. Refer to the country note for Cyprus earlier in this chapter.

<sup>13</sup>. Data for Gabon, that re-joined OPEC in July 2016, are included in the OPEC aggregate starting with the 2017 edition. Data for Equatorial Guinea, that joined OPEC in January 2017, are not included in the OPEC aggregate in this edition.

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Country/Region	Short name	Definition
Memo: Annex I Parties	ANNEX1	<p>Includes Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Cyprus<sup>14</sup>, the Czech Republic<sup>15,16</sup>, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia<sup>Error! Bookmark not defined.</sup>, Liechtenstein (not available in this publication)<sup>17</sup>, Lithuania, Luxembourg, Malta, Monaco (included with France), the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, the Russian Federation, the Slovak Republic<sup>16,18</sup>, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States.<sup>19</sup></p> <p><i>The countries that are listed above are included in Annex I of the United Nations Framework Convention on Climate Change as amended on 11 December 1997 by the 12<sup>th</sup> Plenary meeting of the Third Conference of the Parties in Decision 4/CP.3. This includes the countries that were members of the OECD at the time of the signing of the Convention, the EEC, and fourteen countries in Central and Eastern Europe and the Former Soviet Union that were undergoing the process of transition to market economies. During subsequent sessions, the Conference of the Parties agreed to amend Annex I to the Convention to include Malta (Decision 3/CP.15, effective from 26 October 2010) and Cyprus<sup>14</sup> (Decision 10/CP.17, effective from 9 January 2013).</i></p>
Memo: Annex II Parties	ANNEX2	<p>Includes Australia, Austria, Belgium, Canada, Denmark, Finland, France<sup>20</sup>, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland<sup>21</sup>, the United Kingdom and the United States.</p> <p><i>According to Decision 26/CP.7 in document FCCC/CP/2001/13/Add.4, Turkey has been deleted from the list of Annex II countries to the Convention. This amendment entered into force on 28 June 2002.</i></p>

<sup>14</sup>. Refer to the country note for Cyprus earlier in this chapter.

<sup>15</sup>. Czechia in official UN documents.

<sup>16</sup>. Czechoslovakia was in the original list of Annex I countries.

<sup>17</sup>. Oil data for Liechtenstein are included under Switzerland.

<sup>18</sup>. Slovakia in official UN documents.

<sup>19</sup>. The European Union is also an Annex I Party in its own right. The EU was assigned an overall reduction target under the Kyoto Protocol, which by agreement, was used to determine the individual targets of the fifteen states that were EU members in 1997 when the Kyoto Protocol was adopted.

<sup>20</sup>. In IEA data, France also includes Monaco, which is not in the list of Annex II Parties.

<sup>21</sup>. In IEA data, Switzerland includes Oil data for Liechtenstein, which is not in the list of Annex II Parties.

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Country/Region	Short name	Definition
Memo: Annex II North America	ANNEX2NA	Includes Canada and the United States.
Memo: Annex II Europe	ANNEX2EU	Includes Austria, Belgium, Denmark, Finland, France <sup>20</sup> , Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland <sup>21</sup> and the United Kingdom.
Memo: Annex II Asia Oceania	ANNEX2AO	Includes Australia, Japan and New Zealand.
Memo: Annex I Economies in Transition	ANNEX1EIT	Annex I: Economies in Transition (EITs) are those countries in Annex I that are undergoing the process of transition to a market economy. This includes Belarus, Bulgaria, Croatia, the Czech Republic <sup>15,16</sup> , Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russian Federation, the Slovak Republic <sup>16,18</sup> , Slovenia and Ukraine.
Memo: Non-Annex I Parties	NONANNEX1	
Memo: Annex B Kyoto Parties	ANNEXB	<p>Includes Australia, Austria, Belgium, Belarus, Bulgaria, Croatia, Cyprus<sup>22</sup>, the Czech Republic<sup>15,16</sup>, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia<sup>Error! Bookmark not defined.</sup>, Liechtenstein (not available in this publication)<sup>Error! Bookmark not defined.</sup>, Lithuania, Luxembourg, Malta, Monaco (included with France), the Netherlands, Norway, Poland, Portugal, Romania, the Slovak Republic<sup>16,18</sup>, Slovenia, Spain, Sweden, Switzerland, Ukraine and the United Kingdom.<sup>23</sup></p> <p><i>Refers to countries with emission targets under the second commitment period (CP) of the Kyoto Protocol (2013-2020) as per the Doha Amendment. This differs from the list of countries with targets under the first CP (2008-2012). Please note that the Doha Amendment has not yet entered into force. Membership of Annex B in the second CP of the Kyoto Protocol differs from that in Annex I. In particular, Annex B excludes, or does not contain targets for Canada, Japan, New Zealand, the Russian Federation, Turkey and the United States (all Annex I member states), but includes Kazakhstan (a non-Annex I Party under the Convention, but an Annex I Party under the Kyoto Protocol (as per decision 9/CMP.8).</i></p>

<sup>22</sup>. Refer to the country note for Cyprus earlier in this chapter.

<sup>23</sup>. The European Union is also an Annex I Party in its own right. The EU was assigned an overall reduction target under the Kyoto Protocol, which by agreement, was used to determine the individual targets of the fifteen states that were EU members in 1997 when the Kyoto Protocol was adopted.



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Country/Region	Short name	Definition
<p>Please note that the following countries have not been considered:</p> <ul style="list-style-type: none"> <li>• <b>Non-OECD Europe and Eurasia:</b> Andorra; Faroe Islands (after 1990); Liechtenstein <sup>Error! Bookmark not defined.</sup> (except for oil data); the Palestinian Authority; Svalbard; Jan Mayen Islands;</li> <li>• <b>Africa:</b> British Indian Ocean Territory; French Southern and Antarctic Lands; Mayotte; Saint Helena; Western Sahara;</li> <li>• <b>Non-OECD Americas:</b> Anguilla; Bouvet Island; Saint Barthélemy; Greenland (after 1990); Saint Martin (French Part); South Georgia and the South Sandwich Islands;</li> <li>• Antarctica;</li> <li>• <b>Non-OECD Asia (excluding China):</b> American Samoa; Cocos (Keeling) Islands; Christmas Island; Heard Island and McDonald Islands; Marshall Islands; Micronesia (Federated States of); Nauru; Niue; Norfolk Island; Northern Mariana Islands; Pitcairn; Tokelau; Tuvalu; United States Minor Outlying Islands; Wallis and Futuna Islands.</li> </ul>		

## 3. Methodology: CO<sub>2</sub>/kWh emission factors

### Data source

The estimates of CO<sub>2</sub> emissions in this publication are based on the *2006 IPCC Guidelines* and the IEA *World Energy Balances* data; they represent the total emissions from fuel combustion.

For OECD Member countries, these figures are derived based on information provided in the five annual OECD questionnaires completed by the national administrations. For the member countries of the Economic Commission for Europe of the United Nations (UNECE) and a few others, the data shown are mostly based on information provided by the national administrations through the same annual questionnaires. The commodity balances for all other countries are based on national energy data of heterogeneous nature, converted and adapted to fit the IEA format and methodology.

Considerable effort has been made to ensure that the data presented adhere to the IEA definitions reported in the section on Methodological notes in the general documentation<sup>24</sup>. These definitions, based on the *United Nations International Recommendations on Energy Statistics*<sup>25</sup>, are used by most of the international organisations that collect energy statistics.

Nevertheless, energy statistics at the national level are often collected using criteria and definitions which differ, sometimes considerably, from those of international organisations. This is especially true for non-OECD countries, which are submitting data to the IEA on a voluntary basis. The IEA secretariat has identified most of these differences and, where possible, adjusted the data to meet international definitions.

### The indicator: definition

In the **total** CO<sub>2</sub> emissions per kWh, for electricity or for electricity and heat generation, the numerator presents the CO<sub>2</sub> emissions from fossil fuels consumed for electricity generation, while the denominator presents the total electricity generated, coming from fossil fuels, but also from nuclear, hydro, geothermal, solar, biofuels, etc. As a result, the emissions per kWh vary a lot across countries and from year to year, depending on the generation mix.

In the CO<sub>2</sub> emissions per kWh **by fuel** the numerator and denominator only refer to the electricity generation from a given fuel:

- Coal includes primary and secondary coal, and coal gases. Peat and oil shale have also been aggregated with coal, where applicable.
- Oil includes oil products (and crude oil for some countries).
- Gas represents natural gas.
- Non-renewable wastes includes industrial waste and non-renewable municipal waste.
- Biofuels includes both biofuels and renewable wastes. Note that these emission factors are included for information, as CO<sub>2</sub> emissions from biofuel are not accounted for in the total CO<sub>2</sub> emissions of the energy sector according to the IPCC guidelines.

Note: Emissions per kWh should be used with caution due to data quality problems relating to electricity efficiencies for some countries.

24. [http://wds.iea.org/wds/pdf/WorldCO2\\_documentation.pdf](http://wds.iea.org/wds/pdf/WorldCO2_documentation.pdf)

25. [http://unstats.un.org/unsd/energy/ires/IRES\\_Whitecover.pdf](http://unstats.un.org/unsd/energy/ires/IRES_Whitecover.pdf).

## Electricity-only carbon emission factors: allocation of emissions from CHP plants

Calculating emission factors for electricity-only generation from the IEA energy balances require specific assumptions, as for combined heat and power (CHP) plants only data for a combined input are available.

The IEA adopts the **fixed-heat-efficiency approach**, which consist in fixing the efficiency of heat generation to compute the input to heat, and calculating the input to electricity as a residual from the total input. The standard heat efficiency was set to that of a typical heat boiler, 90%.

The **proportionality approach** would conversely allocate inputs based on the proportion of electricity and heat in the output. This is equivalent to fixing the efficiency of electricity and heat to be equal. With the advantage of simplicity and transparency, the proportionality approach however tends to overstate electricity efficiency and to understate heat efficiency. For example, for CHP generation in OECD countries, total efficiency is around 60%. However, total electricity-only plant efficiency is around 41% in OECD countries. Similarly, 60% is quite low for heat generation (given typical heat-only plant efficiencies of 80-95%).

In general, the fixed-heat-efficiency approach attributes larger emissions to electricity than the proportionality approach, with values much closer to those of electricity-only plants. While the fixed-heat-efficiency approach has proven to provide sensible results in most cases, implementation problems arise in two cases:

- i) When the observed efficiency is over 100% (i.e. there are problems in data quality).
- ii) When the observed efficiency is between 90% and 100% (the total efficiency may be correct or it may be overstated).

In both cases, it is not possible to use the fixed-heat-efficiency approach and, by default, the proportionality approach is used to allocate the inputs based on the output shares.

## Calculation of the carbon emission factor

CO<sub>2</sub>kWh for electricity and heat generation =

$$\frac{\sum_{fuels} \langle (Input_{Electricity\ plants} + Input_{CHP\ plants} + Input_{Heat\ plants} + Own\ use_{plants}) \times EF_{fuel} \rangle}{Ele_{Inland} + Heat_{Inland}}$$

Where:

- CO<sub>2</sub>kWh : Carbon factors (in CO<sub>2</sub>/kWh) calculated at the generation point
- $\sum_{fuels}$  : Sum over the fuels.
- $Input_{plants}$  : Fuel input into the plants (both main activity and autoproducer) expressed in energy unit.
- $EF_{fuel}$  : Default emission factors as provided in the *2006 IPCC Guidelines*.
- $Ele_{Inland} + Heat_{Inland}$  :
  - For the total emission factor: includes the generation from all sources (i.e. as well the non-emitting sources).
  - For the emission factors by fuel (oil, coal, gas, non-renewable waste and Memo: biofuels): includes only the electricity generated by the corresponding fuel.

CO<sub>2</sub>kWh for electricity generation =

$$= \frac{\sum_{fuels} \langle (Input_{Electricity\ plants} + Input_{CHP\ plants/Ele} + Own\ use_{plants/Ele}) \times EF_{fuel} \rangle}{Ele_{Inland}}$$

Where:

- CO<sub>2</sub>kWh : Carbon factors (in CO<sub>2</sub>/kWh) calculated at the generation point
- $\sum_{fuels}$  : Sum over the fuels.
- $Input_{plants}$  : Fuel input into the plants (both main activity and autoproducer) expressed in energy unit.
- $Input_{CHP\ plants/Ele} = Input_{CHP\ plants} - \frac{Heat\ output}{\eta_{heat}}$
- $\eta_{heat}$  efficiency of heat generation - assumed to be 0.9 (i.e. 90%) except when the observed efficiency of CHP generation is higher than 90%, in which case emissions are allocated using the proportionality approach ( $EFF_{HEAT} = EFF_{ELEC} = EFF_{CHP}$ ).
- $Own\ use_{plants/Ele} = Own\ use_{plants} \times \frac{Total\ electricity\ output}{Total\ electricity\ output + Total\ heat\ output}$
- $EF_{fuel}$  : default emission factors as provided in the 2006 IPCC Guidelines.
- $Ele_{Inland}$  :
  - For the total emission factor: includes the generation from all sources (i.e. as well the non-emitting sources).
  - For the emission factors by fuel (oil, coal, gas, non-renewable waste and Memo: biofuels): includes only the electricity generated by the corresponding fuel.

Note that in some cases, when the output of electricity is very small for a given fuel, rounding effects can cause the corresponding emission factor to appear very high. It is advised to disregard these emission factors which are clearly out of the range.

## Comparison between electricity-only and combined electricity and heat ratios

For the majority of OECD countries, the electricity-only indicator is not significantly different from the combined electricity and heat indicator, shown in previous editions of this publication and in the online database. For the OECD total in 2014, the electricity-only indicator is 4% higher, while 19 of the OECD's 34 countries saw a difference of 5% or less. Of the 15 countries with differences of more than 5%, 7 countries had large amounts of non-emitting electricity generation, giving them a small ratio to begin with (thus more prone to change). In addition, non-emitting generation is generally electricity-only, and so when the heat-only and heat CHP emissions are removed from the calculation, greater weight is attached to the non-emitting generation, with a lower level for the final indicator.

The countries in the OECD with larger differences are generally coal-intensive countries with large amounts of heat generation. As mentioned, in general, heat plants are more efficient than electricity-only or CHP plants; therefore, excluding heat plants from the calculation increases CO<sub>2</sub> intensity. The same is true if we allocate a high efficiency to the heat part of CHP generation; this decreases the efficiency of the electricity part and thus increases electricity's carbon intensity. Further, CHP and heat plants are more likely to be powered by CO<sub>2</sub>-light natural gas while electricity-only plants tend to be powered by CO<sub>2</sub>-heavy coal, making the new ratio more CO<sub>2</sub> intensive for these countries.

## 4. Methodology: Other factors

### Provisional carbon emission factors

The carbon factor for the latest year (Y) is only available for OECD countries. The available data for the year Y only include the breakdown of electricity generated by fuel, but not the fuel input to plant. Therefore, the assumption required is that there was no change in the efficiency of plants, and in the energy content of the input products compared to the year Y-1.

With these assumptions, the factor was derived as follows:

$$CO_2kWh(Y) = \frac{\sum_{fuels} (CO_2kWh_{fuel}(Y-1) \times Ele_{Inland_{fuel}}(Y))}{Ele_{Inland}(Y)}$$

Only the total carbon emission factor is included for the provisional year.

### Correction factor for electricity trade

Part of the electricity consumed in one country may have been generated in another one. Similarly, part of the electricity generated in one country can be exported to other countries. Therefore, adjustments may be done to the emission factors calculated above to account for electricity trade. Such adjustments are based on the share of electricity that is imported or exported compared to the domestic supply. The data needed to calculate such adjustment (i.e. the breakdown of electricity import by trade partner) are only available for OECD countries. This adjustment can be positive or negative, and is calculated as follows:

$$CO_2kWh_{trade} = \frac{C_{Indigenous} + C_{Imported} - C_{Exported}}{Net\ electricity} - CO_2kWh$$

With

$$C_{Indigenous} = Ele_{Inland} * CO_2kWh$$

And

$$C_{Imported} = \sum_{partner} Ele_{Imports_{partner}} * CO_2kWh_{partner}$$

And

$$C_{Exported} = Ele_{Exports} * \frac{C_{Indigenous} + C_{Imported}}{Ele_{Inland} + Ele_{Imports}}$$

Where

- $CO_2kWh_{trade}$ : Adjustment of the carbon factor (in CO<sub>2</sub>/kWh) for emissions induced by the trade of electricity with partner countries.
- $CO_2kWh_{partner}$ : Carbon emission factor for electricity generation of the partner country.
- $Net\ electricity$ :  $Ele_{Inland} + Ele_{Imports} - Ele_{Exports}$

Note that for a given country, trade data are those reported by the country for which the factor is calculated, which in some cases can differ from those reported from trade partners. Also, since the emission factors from trading partners are used, the quality of this adjustment depends not only on the quality of the data reported by the country, but also on the quality of the data reported by the trading partners. Moreover, in some cases, country

report imports from non-specified countries. In such cases, assumptions were made based on transmission grid and data reported by potential partners.

This adjustment does not take into account geographically localized connections between countries. For example, Luxembourg reports trade from Germany, which is mostly related to electricity from the Vianden hydro plant; however the trade adjustment would be calculated using the nationally averaged carbon emission factor for Germany. As this case was known, the figure was set as “not available”. But other similar issue may occur.

## Correction factor for electricity T&D losses

As electricity is transmitted through a grid from the generation point to the consumption point, losses can occur for different reasons - they usually represent between 5 and 15% of the energy transmitted, mainly depending on the distance of the lines. Basically, for each kWh being consumed, a higher amount had to be generated.

The adjustment due to losses was calculated as follows:

$$CO_2kWh_{loss} = CO_2kWh \times loss\ factor$$

Where

- $CO_2kWh_{loss}$  : Adjustment (in CO<sub>2</sub>/kWh) for emission induced by the losses of electricity in transmission and distribution.
- $loss\ factor = \frac{Losses}{Total\ grid}$

Where

- *Losses* : Total transmission and distribution losses in the grid.
- *Total grid* : Total amount of electricity transiting through the country electricity grid, calculated as gross electricity generation – own use in plant + imports.

Note that data quality for electricity transmission and distribution losses may be very variable across countries.

## CH<sub>4</sub> and N<sub>2</sub>O emissions for electricity generation

If CO<sub>2</sub> represent a large majority in term of greenhouse gas emissions from fuel combustion, it is not the only one.

Emission factors for CH<sub>4</sub> and N<sub>2</sub>O were calculated using the same methodology as for the CO<sub>2</sub> per kWh, using the Tier 1 methodology and the default emission factors of the *2006 IPCC Guidelines*, including also emissions from biofuels in this case (as opposed to CO<sub>2</sub> only emissions). The emission factors are converted from gCH<sub>4</sub> and gN<sub>2</sub>O to gCO<sub>2</sub>eq using the 100-year Global Warming Potential (GWP) given below. For the purpose of comparability with international data submission guidelines, the factors from the 4<sup>th</sup> Assessment of the IPCC are used.

Designation or Name	Chemical formula	100-Year GWP
Carbon dioxide	CO <sub>2</sub>	1
Methane	CH <sub>4</sub>	25
Nitrous oxide	N <sub>2</sub> O	298

Note that the uncertainty associated with CH<sub>4</sub> and N<sub>2</sub>O emissions factors is very large, therefore these emission factors are provided as an indication when no better information is available. Please see the *2006 IPCC guidelines*<sup>26</sup> for more information about the uncertainty associated to emission factors.

<sup>26</sup> [http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2\\_Volume2/V2\\_2\\_Ch2\\_Stationary\\_Combustion.pdf](http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf)

## Use of the adjustment indicators

In order to allow more flexibility for the users depending on their reporting needs, the CO<sub>2</sub> emission factors are presented in a disaggregated manner. Since the CO<sub>2</sub> emission per kWh represents the emissions at the generation point, this factor can be completed by adding the transmission and distribution losses factor, and the correction for electricity trade. By adding these figures one can obtain a closer figure to the CO<sub>2</sub> per kWh at the final user point. Please note that in order to calculate completely the scope 3 emissions, the losses from Well to Tank (WTT) would have to be included as well, and these figures are not provided here.

This factor can also be completed with the CH<sub>4</sub> and N<sub>2</sub>O figures to obtain a more complete greenhouse gas per kWh indicator. As stipulated above, these figures are to be taken with caution due to the uncertainty associated with the corresponding IPCC emission factors. The CH<sub>4</sub> and N<sub>2</sub>O adjustment for trade and losses are not provided here due to the negligible impact compared to the uncertainty associated with the figure.

## Implied emission factors from direct combustion of fuels

In most cases fuels are combusted directly for other purposes than electricity generation. The direct emissions factors (IEF) vary according to the fuel used, and are computed as weighted average of the consumption across all sectors excluding electricity generation, as follows:

$$IEF = \frac{E_{Industry} + E_{Transport} + E_{Others}}{FC_{Industry} + FC_{Transport} + FC_{Others}}$$

Where:

- IEF : Implied emission factors for fuel combustion other than for electricity and heat generation, in kg CO<sub>2</sub> / kg of fuel
- $E_{Industry}$  : Total CO<sub>2</sub> emissions from fuel combustion in the *Industry* sector plus emission in the *Energy* sector except electricity and CHP plants in kg CO<sub>2</sub>.
- $E_{Transport}$  : Total CO<sub>2</sub> emissions from fuel combustion in the *Transport* sector in kg CO<sub>2</sub>.
- $E_{Others}$  : Total CO<sub>2</sub> emissions from fuel combustion in the *Residential, Commercial and Public services, Agriculture/Forestry, Fishing and Other non-specified* sectors in kg CO<sub>2</sub>.
- $FC_{sector}$  : Total fuel consumption in the respective sector, expressed in kg.

Which is equivalent to:

$$DEF = \frac{(FC_{Industry} \times NCV_{Industry} + FC_{Transport} \times NCV_{Transport} + FC_{Others} \times NCV_{Others}) \times EF_{fuel}}{FC_{Industry} + FC_{Transport} + FC_{Others}}$$

Where:

- $NCV_{sector}$ : Net Calorific Value, which is product-, country-, sector- and time-specific.

These emission factors are presented for individual and for some average fuels described below:

- For coal: individual primary products (anthracite, coking coal, other bituminous coal, sub-bituminous coal and lignite); as well as the weighted average coal mix;
- For oil: individual secondary products (refinery gas, ethane, LPG, motor gasoline excl. biofuels, aviation gasoline, gasoline type jet fuel, kerosene type jet fuel excl. biofuels, kerosene, gas/diesel oil excl. biofuels, fuel oil, naphtha, white spirit, bitumen, petroleum coke and non-specified oil products); as well as the weighted average oil product mix.

When no data is reported for a fuel and year, the data is marked as X: Not applicable.

## 5. UNITS AND CONVERSIONS

### General conversion factors for energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
<i>From:</i>	multiply by:				
terajoule (TJ)	1	2.388x10 <sup>2</sup>	2.388x10 <sup>-5</sup>	9.478x10 <sup>2</sup>	2.778x10 <sup>-1</sup>
gigacalorie (Gcal)	4.187x10 <sup>-3</sup>	1	1.000x10 <sup>-7</sup>	3.968	1.163x10 <sup>-3</sup>
million tonnes of oil equivalent (Mtoe)	4.187x10 <sup>4</sup>	1.000x10 <sup>7</sup>	1	3.968x10 <sup>7</sup>	1.163x10 <sup>4</sup>
million British thermal units (MBtu)	1.055x10 <sup>-3</sup>	2.520x10 <sup>-1</sup>	2.520x10 <sup>-8</sup>	1	2.931x10 <sup>-4</sup>
gigawatt hour (GWh)	3.600	8.598x10 <sup>2</sup>	8.598x10 <sup>-5</sup>	3.412x10 <sup>3</sup>	1

### Conversion factors for mass

To:	kg	t	lt	st	lb
<i>From:</i>	multiply by:				
kilogramme (kg)	1	1.000x10 <sup>-3</sup>	9.842x10 <sup>-4</sup>	1.102x10 <sup>-3</sup>	2.205
tonne (t)	1.000x10 <sup>3</sup>	1	9.842x10 <sup>-1</sup>	1.102	2.205x10 <sup>3</sup>
long ton (lt)	1.016x10 <sup>3</sup>	1.016	1	1.120	2.240x10 <sup>3</sup>
short ton (st)	9.072x10 <sup>2</sup>	9.072x10 <sup>-1</sup>	8.929x10 <sup>-1</sup>	1	2.000x10 <sup>3</sup>
pound (lb)	4.536x10 <sup>-1</sup>	4.536x10 <sup>-4</sup>	4.464x10 <sup>-4</sup>	5.000x10 <sup>-4</sup>	1

### Conversion factors for volume

To:	gal U.S.	gal U.K.	bbl	ft <sup>3</sup>	l	m <sup>3</sup>
<i>From:</i>	multiply by:					
U.S. gallon (gal U.S.)	1	8.327x10 <sup>-1</sup>	2.381x10 <sup>-2</sup>	1.337x10 <sup>-1</sup>	3.785	3.785x10 <sup>-3</sup>
U.K. gallon (gal U.K.)	1.201	1	2.859x10 <sup>-2</sup>	1.605x10 <sup>-1</sup>	4.546	4.546x10 <sup>-3</sup>
barrel (bbl)	4.200x10 <sup>1</sup>	3.497x10 <sup>1</sup>	1	5.615	1.590x10 <sup>2</sup>	1.590x10 <sup>-1</sup>
cubic foot (ft <sup>3</sup> )	7.481	6.229	1.781x10 <sup>-1</sup>	1	2.832x10 <sup>1</sup>	2.832x10 <sup>-2</sup>
litre (l)	2.642x10 <sup>-1</sup>	2.200x10 <sup>-1</sup>	6.290x10 <sup>-3</sup>	3.531x10 <sup>-2</sup>	1	1.000x10 <sup>-3</sup>
cubic metre (m <sup>3</sup> )	2.642x10 <sup>2</sup>	2.200x10 <sup>2</sup>	6.290	3.531x10 <sup>1</sup>	1.000x10 <sup>3</sup>	1



## Decimal prefixes

10 <sup>1</sup>	deca (da)	10 <sup>-1</sup>	deci (d)
10 <sup>2</sup>	hecto (h)	10 <sup>-2</sup>	centi (c)
10 <sup>3</sup>	kilo (k)	10 <sup>-3</sup>	milli (m)
10 <sup>6</sup>	mega (M)	10 <sup>-6</sup>	micro (μ)
10 <sup>9</sup>	giga (G)	10 <sup>-9</sup>	nano (n)
10 <sup>12</sup>	tera (T)	10 <sup>-12</sup>	pico (p)
10 <sup>15</sup>	peta (P)	10 <sup>-15</sup>	femto (f)
10 <sup>18</sup>	exa (E)	10 <sup>-18</sup>	atto (a)

## Tonne of CO<sub>2</sub>

The 2006 GLs and the UNFCCC *Reporting Guidelines on Annual Inventories* both ask that CO<sub>2</sub> emissions and removals be reported in Gg (gigagrammes) of CO<sub>2</sub>. A million tonnes of CO<sub>2</sub> is equal to 1 000 Gg of CO<sub>2</sub>, so to compare the numbers in this publication with national inventories expressed in Gg, multiply the IEA emissions by 1 000.

Other organisations may present CO<sub>2</sub> emissions in tonnes of carbon instead of tonnes of CO<sub>2</sub>. To convert from tonnes of carbon, multiply by 44/12, which is the molecular weight ratio of CO<sub>2</sub> to C.

## 6. ABBREVIATIONS

Btu	British thermal unit
BKB	Brown coal briquettes (braunkohlebriketts)
Gg	gigagramme
GJ	gigajoule
GWh	gigawatt hour
J	joule
kcal	kilocalorie
kg	kilogramme
kt	thousand tonnes
ktoe	thousand tonnes of oil equivalent
kWh	kilowatt hour
MJ	megajoule
Mt	million tonnes
Mtoe	million tonnes of oil equivalent
MtCO <sub>2</sub>	million tonnes of carbon dioxide
m <sup>3</sup>	cubic metre
PJ	petajoule
t	metric ton = tonne = 1 000 kg
tC	tonne of carbon
TJ	terajoule
toe	tonne of oil equivalent = 10 <sup>7</sup> kcal
CC	carbon content
CEF	carbon emission factor
COF	carbon oxidation factor
CHP	combined heat and power
GCV	gross calorific value
GDP	gross domestic product
GWP	global warming potential
NCV	net calorific value
PPP	purchasing power parity
TPES	total primary energy supply
Convention	United Nations Framework Convention on Climate Change
COP	Conference of the Parties to the Convention
G20	Group of Twenty (See the chapter <i>Geographical coverage and country notes</i> )
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
OECD	Organisation for Economic Co-Operation and Development
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
..	not available
-	nil
x	not applicable
CO <sub>2</sub>	carbon dioxide