CO_2 EMISSIONS FROM FUEL COMBUSTION

DOCUMENTATION FOR BEYOND 2020 FILES

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1. CHANGES FROM LAST EDITION

Flows

Electricity and Heat Output and Emissions per kWh

- In previous editions of this publication, the IEA has published an indicator for CO_2 emissions per kWh for the electricity and heat generating industries. This indicator was useful as an overall carbon intensity measure of a country's electricity and heat generating sectors, and it was easy to calculate. However, this indicator had a number of drawbacks and the IEA received many requests for electricity-only emission factors. We are pleased to announce that starting with this edition, we have replaced the former indicator with an electricity-only factor expressed in grammes of CO_2 per kWh. For a complete description of the methodology used to estimate this indicator, please see Chapter 5.

New Name	New Code
CO_2 per kWh of electricity (gCO_2 per kWh)	CO2KWH

Indicators

- In this edition, the GDP and GDP PPP series have been rebased from 2000 USD to 2005 USD. As a result, those series and all associated ratios now refer to 2005 USD.

Old name	New Name	Old Code	New Code
GDP (billion 2000 US dollars)	GDP (billion 2005 US dollars)	GDP	same
GDP PPP (billion 2000 US dollars)	GDP PPP (billion 2005 US dollars)	GDPPPP	same
CO_2 / GDP (kg CO_2 per 2000 US dollar)	CO_2 / GDP ($kgCO_2$ per 2005 US dollar)	CO2GDP	same
CO_2 / GDP PPP (kg CO_2 per 2000 US dollar)	CO_2 / GDP PPP ($kgCO_2$ per 2005 US dollar)	CO2GDPPP	same

Emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6 ($MtCO_2$ equivalent)

- In this edition, a new indicator for total GHG emissions was added and one long name was modified.

Old name	New Name	Old Code	New Code
Share of energy in total	Share of energy in total GHG	ESHARE	same
N/A	Total GHG emissions / GDP PPP	N/A	GHGGDP

Country dimension

- Starting with this edition, **Kosovo** and **Montenegro** are now available separately. Data for Kosovo are available starting in 2000. Between 1990 and 1999, data for Kosovo are included in Serbia. Prior to 1990, they are included in Former Yugoslavia. Data for Montenegro are available starting in 2005. Between 1990 and 2004, data for Montenegro are included in Serbia. Prior to 1990, they are included in Former Yugoslavia.
- The IEA has also made some small changes in the terminology of countries and regions. The region Latin America and the region Other Latin America have been renamed **Non-OECD Americas** and **Other Non-OECD Americas**.

Old name	New Name	Old Code	New Code
N/A	Kosovo	N/A	KOSOVO
N/A	Montenegro	N/A	MONTENEGRO
Latin America	Non-OECD Americas	LATAMER	same
Other Latin America	Other Non-OECD Americas	OTHERLATIN	same
Libya Arab Jamahiriya	Libya	LIBYA	same

Aggregated products

Old name	New Name	Old Code	New Code
Gas	Natural Gas	GAS	NATGAS

2. DEFINITIONS

CO_2 emissions from fuel combustion (Mt of CO_2)

Flow	Short name	Definition
CO_2 Sectoral Approach	CO2SA	Sectoral Approach contains total CO_2 emissions from fuel combustion as calculated using the IPCC Tier 1 Sectoral Approach and corresponds to IPCC Source/Sink Category 1 A. Emissions calculated using a Sectoral Approach include emissions only when the fuel is actually combusted.
Main activity producer of electricity and heat	MAINPROD	Main activity producer electricity and heat contains the sum of emissions from main activity producer electricity generation, combined heat and power generation and heat plants. Main activity producers (formerly known as public utilities) are defined as those undertakings whose primary activity is to supply the public. They may be publicly or privately owned. This corresponds to IPCC Source/Sink Category 1 A 1 a. For the CO_2 emissions from fuel combustion (summary) file, emissions from own on-site use of fuel in power plants (EPOWERPLT) are also included.
Main activity electricity plants	MAINELEC	Electricity plants refers to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs can not be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Main activity producer (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.
Main activity CHP plants	MAINCHP	Combined heat and power plants (CHP), refers to plants which are designed to produce both heat and electricity. UNIPEDE refers to these as co-generation power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Main activity producer (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.

CO_2 emissions from fuel combustion (Mt of CO_2)		
Flow	**Short name**	**Definition**
Main activity heat plants	MAINHEAT	Heat plants refers to plants designed to produce heat only, which is sold to a third party under the provisions of a contract. The products show the use of primary and secondary fuels in a heating system that transmits and distributes heat from one or more energy source to, among others, residential, industrial, and commercial consumers for space heating, cooking, hot water and industrial processes. Main activity producer (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.
Own use in electricity, CHP and heat plants	EPOWERPLT	Emissions from own on-site use of fuel in electricity, CHP and heat plants.
Unallocated autoproducers	AUTOPROD	Unallocated autoproducers contains the emissions from the generation of electricity and/or heat by autoproducers. Autoproducers are defined as undertakings that generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned. In the *1996 IPCC Guidelines*, these emissions would normally be distributed between industry, transport and "other" sectors.
Autoproducer electricity plants	AUTOELEC	Electricity plants refers to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs can not be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Autoproducer undertakings generate electricity, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.
Autoproducer CHP plants	AUTOCHP	Combined heat and power plants (CHP), refers to plants which are designed to produce both heat and electricity. UNIPEDE refers to these as co-generation power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Note that for autoproducer CHP plants, all fuel inputs to electricity production are taken into account, while only the part of fuel inputs to heat sold is shown. Fuel inputs for the production of heat consumed within the autoproducer's establishment are not included here but are included with figures for the final consumption of fuels in the appropriate consuming sector. Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.

CO_2 emissions from fuel combustion (Mt of CO_2)		
Flow	**Short name**	**Definition**
Autoproducer heat plants	AUTOHEAT	Heat plants refers to plants designed to produce heat only, which is sold to a third party under the provisions of a contract. This flow shows the use of primary and secondary fuels in a heating system that transmits and distributes heat from one or more energy source to, among others, residential, industrial and commercial consumers for space heating, cooking, hot water and industrial processes. Autoproducer undertakings generate heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.
Other energy industry own use	OTHEN	Other energy industry own use contains emissions from fuel combusted in oil refineries, for the manufacture of solid fuels, coal mining, oil and gas extraction and other energy-producing industries. This corresponds to the IPCC Source/Sink Categories 1 A 1 b and 1 A 1 c. According to the *1996 IPCC Guidelines*, emissions from coke inputs to blast furnaces can either be counted here or in the Industrial Processes source/sink category. Within detailed sectoral calculations, certain non-energy processes can be distinguished. In the reduction of iron in a blast furnace through the combustion of coke, the primary purpose of the coke oxidation is to produce pig iron and the emissions can be considered as an industrial process. Care must be taken not to double count these emissions in both Energy and Industrial Processes. In the IEA estimations, emissions from energy industry own use have been included in this category.
Manufacturing industries and construction	TOTIND	Manufacturing industries and construction contains the emissions from combustion of fuels in industry. The IPCC Source/Sink Category 1 A 2 includes these emissions. However, in the *1996 IPCC Guidelines*, the IPCC category also includes emissions from industry autoproducers that generate electricity and/or heat. The IEA data are not collected in a way that allows the energy consumption to be split by specific end-use and therefore, autoproducers are shown as a separate item (unallocated autoproducers). Manufacturing industries and construction also includes some emissions from coke inputs into blast furnaces, which may be reported either in transformation, other energy industry own use, industry or the separate IPCC Source/Sink Category 2, Industrial Processes.
Iron and steel	IRONSTL	[ISIC Rev. 4 Group 241 and Class 2431]
Chemical and petrochemical	CHEMICAL	[ISIC Rev. 4 Divisions 20 and 21] Excluding petrochemical feedstocks
Non-ferrous metals	NONFERR	[ISIC Rev. 4 Group 242 and Class 2432] Basic industries.
Non-metallic minerals	NONMET	[ISIC Rev. 4 Division 23] Such as glass, ceramic, cement, etc.
Transport equipment	TRANSEQ	[ISIC Rev. 4 Divisions 29 and 30]

CO_2 emissions from fuel combustion (Mt of CO_2)

Flow	Short name	Definition
Machinery	MACHINE	[ISIC Rev. 4 Divisions 25 to 28] Fabricated metal products, machinery and equipment other than transport equipment.
Mining and quarrying	MINING	[ISIC Rev. 4 Divisions 07 and 08 and Group 099] Mining (excluding fuels) and quarrying.
Food and tobacco	FOODPRO	[ISIC Rev. 4 Divisions 10 to 12]
Paper, pulp and printing	PAPERPRO	[ISIC Rev. 4 Divisions 17 and 18]
Wood and wood Products	WOODPRO	[ISIC Rev. 4 Division 16] Wood and wood products other than pulp and paper.
Construction	CONSTRUC	[ISIC Rev. 4 Division 41 to 43]
Textile and leather	TEXTILES	[ISIC Rev. 4 Divisions 13 to 15]
Non-specified industry	INONSPEC	[ISIC Rev. 4 Divisions 22, 31 and 32] Any manufacturing industry not included above. Note: Most countries have difficulties supplying an industrial breakdown for all fuels. In these cases, the *non-specified* industry row has been used. Regional aggregates of industrial consumption should therefore be used with caution.
Non-energy use industry/ transformation/energy	NEINTREN	Non-energy in industry, transformation and other energy industry own use.
Transport	TOTTRANS	Covers emissions from all transport activity (in mobile engines) regardless of the economic sector to which it is contributing [ISIC Rev. 4 Divisions 49 to 51]. This corresponds to IPCC Source/Sink Category 1 A 3.
Road	ROAD	Road contains the emissions arising from fuel use in road vehicles, including the use of agricultural vehicles on highways. This corresponds to the IPCC Source/Sink Category 1 A 3 b. Excludes emissions from military consumption as well as motor gasoline used in stationary engines and diesel oil for use in tractors that are not for highway use.
Domestic aviation	DOMESAIR	Domestic aviation includes emissions from aviation fuels delivered to aircraft for domestic aviation – commercial, private, agriculture, etc. It includes use for purposes other than flying, e.g. bench testing of engines, but not airline use of fuel for road transport. The domestic/international split should be determined on the basis of departure and landing locations and not by the nationality of the airline. Note that this may include journeys of considerable length between two airports in a country (e.g. San Francisco to Honolulu).For many countries this also incorrectly includes fuel used by domestically owned carriers for outbound international traffic.
Rail	RAIL	Emissions from rail traffic, including industrial railways.

CO_2 emissions from fuel combustion (Mt of CO_2)

Flow	Short name	Definition
Pipeline transport	PIPELINE	Emissions from fuels used in the support and operation of pipelines transporting gases, liquids, slurries and other commodities, including the energy used for pump stations and maintenance of the pipeline. Energy for the pipeline distribution of natural or coal gases, hot water or steam (ISIC Rev. 4 Division 35) from the distributor to final users is excluded and should be reported in other energy industry own use, while the energy used for the final distribution of water (ISIC Rev. 4 Division 36) to household, industrial, commercial and other users should be included in commercial/public services. Losses occurring during the transport between distributor and final users should be reported as distribution losses.
Domestic navigation	DOMESNAV	Domestic navigation includes emissions from fuels delivered to vessels of all flags not engaged in international navigation (see international marine bunkers). The domestic/international split should be determined on the basis of port of departure and port of arrival and not by the flag or nationality of the ship. Note that this may include journeys of considerable length between two ports in a country (e.g. San Francisco to Honolulu). Fuel used for ocean, coastal and inland fishing and military consumption are excluded.
Non-specified transport	TRNONSPE	Includes all emissions from transport not elsewhere specified. Note: International marine bunkers and international aviation bunkers are not included in transport as part of final consumption.
Non-energy use in transport	NETRANS	Emissions from non-energy use in transport.
Other	TOTOTHER	Other contains the emissions from commercial/institutional activities, residential, agriculture/forestry, fishing and other emissions not specified elsewhere that are included in the IPCC Source/Sink Categories 1 A 4 and 1 A 5. In the *1996 IPCC Guidelines*, the category also includes emissions from autoproducers in the commercial/public services, residential and agriculture that generate electricity and/or heat. The IEA data are not collected in a way that allows the energy consumption to be split by specific end-use and therefore, autoproducers are shown as a separate item (unallocated autoproducers).
Residential	RESIDENT	Residential contains all emissions from fuel combustion in households. This corresponds to IPCC Source/Sink Category 1 A 4 b.
Commercial and public services	COMMPUB	Commercial and public services includes emissions from all activities of ISIC Rev. 4 Divisions 33, 36-39, 45-47, 52, 53, 55-56, 58-66, 68-75, 77-82, 84 (excluding Class 8422), 85-88, 90-96 and 99.
Agriculture/forestry	AGRICULT	Agriculture/forestry includes deliveries to users classified as agriculture, hunting and forestry by the ISIC, and therefore includes energy consumed by such users whether for traction (excluding agricultural highway use), power or heating (agricultural and domestic) [ISIC Rev. 4 Division 03].

CO_2 emissions from fuel combustion (Mt of CO_2)

Flow	Short name	Definition
Fishing	FISHING	Fishing includes emissions from fuels used for inland, coastal and deep-sea fishing. Fishing covers fuels delivered to ships of all flags that have refuelled in the country (including international fishing) as well as energy used in the fishing industry [ISIC Rev.4 Division 03].
Non-specified other	ONONSPEC	Includes emissions from all fuel use not elsewhere specified as well as consumption in the above-designated categories for which separate figures have not been provided. Emissions from military fuel use for all mobile and stationary consumption are included here (e.g. ships, aircraft, road and energy used in living quarters) regardless of whether the fuel delivered is for the military of that country or for the military of another country.
Non-energy use in other	NEOTHER	Emissions from non-energy use in “other”.
CO_2 Reference Approach	CO2EMIS	Reference Approach contains total CO_2 emissions from fuel combustion as calculated using the IPCC Reference Approach. The Reference Approach is based on the supply of energy in a country and as a result, all inventories calculated using this method include fugitive emissions from energy transformation (e.g. from oil refineries) which are normally included in Category 1 B. For this reason, Reference Approach estimates are likely to overestimate national CO_2 emissions. In these tables, the difference between the Sectoral Approach and the Reference Approach includes statistical differences, product transfers, transformation losses and distribution losses.
Differences due to losses and/or transformation	TRANDIFF	Differences due to losses and/or transformation contains emissions that result from the transformation of energy from a primary fuel to a secondary or tertiary fuel. Included here are solid fuel transformation, oil refineries, gas works and other fuel transformation industries. These emissions are normally reported as fugitive emissions in the IPCC Source/Sink Category 1 B, but will be included in 1 A in inventories that are calculated using the IPCC Reference Approach. Theoretically, this category should show relatively small emissions representing the loss of carbon by other ways than combustion, such as evaporation or leakage. Negative emissions for one product and positive emissions for another product would imply a change in the classification of the emission source as a result of an energy transformation between coal and gas, between coal and oil, etc. In practice, however, it often proves difficult to correctly account for all inputs and outputs in energy transformation industries, and to separate energy that is transformed from energy that is combusted. Therefore, the row differences due to losses and/or transformation sometimes shows quite large positive emissions or even negative ones due to problems in the underlying energy data.

CO_2 emissions from fuel combustion (Mt of CO_2)		
Flow	**Short name**	**Definition**
Statistical differences	STATDIFF	Statistical differences can be due to unexplained discrepancies in the underlying energy data. They can also be caused by differences between emissions calculated using the Reference Approach and the Sectoral Approach.
Memo: International marine bunkers	MARBUNK	International marine bunkers contains emissions from fuels burned by ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded. Emissions from international marine bunkers should be excluded from the national totals. This corresponds to IPCC Source/Sink Category 1 A 3 d i.
Memo: International aviation bunkers	AVBUNK	International aviation bunkers contains emissions from fuels used by aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split should be determined on the basis of departure and landing locations and not by the nationality of the airline. Emissions from international aviation bunkers should be excluded from the national totals. This corresponds to IPCC Source/Sink Category 1 A 3 a i.

Electricity and Heat Output and Emissions per kWh

Flow	Short name	Definition
CO_2 per kWh of electricity (gCO_2 per kWh)	CO2KWH	This ratio is expressed in grammes of CO_2 per kWh. It has been calculated using CO_2 emissions from generation of electricity (“main activity producer" and "autoproducer") divided by output of electricity. The CO_2 emissions include emissions from fossil fuels, industrial waste and non-renewable municipal waste that are consumed for electricity generation in the transformation sector and the output includes electricity generated from fossil fuels, nuclear, hydro (excluding pumped storage), geothermal, solar, wind, tide, wave, ocean and biofuels. As a result, the emissions per kWh can vary from year to year depending on the generation mix. In order to calculate this ratio of CO_2 from electricity generation divided by electricity output, it was necessary to allocate the inputs (and thus the emissions) of combined heat and power (CHP) plants between electricity and heat. It was assumed that heat generation within CHP plants had a 90% efficiency (or higher if the total CHP efficiency was higher) and the electricity input was calculated accordingly. In the ratios of CO_2 emissions per kWh by fuel: • Coal includes primary and secondary coal, peat and coal gases. • Oil includes oil products (and small amounts of crude oil for some countries). • Gas represents natural gas. Note: Emissions per kWh should be used with caution due to data quality problems relating to electricity efficiencies for some countries.
Electricity and heat output (TWh)	ELECHEAT	Total output includes electricity and heat generated in the transformation sector using fossil fuels, nuclear, hydro (excluding pumped storage), geothermal, solar, biofuels, etc. Both public and autoproducer plants have been included. For electricity, data include the total number of TWh generated by power plants (including both electricity plants and CHP plants). For heat, data include the total amount of TWh generated by power plants (including both CHP plants and heat plants).
Electricity output (TWh)	ELOUTPUT	Electricity generated shows the total number of TWh generated by thermal power plants separated into electricity plants and CHP plants, as well as production by nuclear and hydro (excluding pumped storage production), geothermal, etc.

Electricity and Heat Output and Emissions per kWh

Flow	Short name	Definition
Electricity output-main activity producer electricity plants (TWh)	ELMAINE	Electricity plants refer to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs can not be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Main activity producers (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.
Electricity output-autoproducer electricity plants (TWh)	ELAUTOE	Electricity plants refer to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs can not be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.
Electricity output-main activity producer CHP plants (TWh)	ELMAINC	Combined heat and power plants (CHP) refers to plants which are designed to produce both heat and electricity, sometimes referred to as co-generation power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Main activity producers (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.
Electricity output-autoproducer CHP plants (TWh)	ELAUTOC	Combined heat and power plants (CHP) refers to plants which are designed to produce both heat and electricity, sometimes referred to as co-generation power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Note that for autoproducer CHP plants, all fuel inputs to electricity production are taken into account, while only the part of fuel inputs to heat sold is shown. Fuel inputs for the production of heat consumed within the autoproducer's establishment are not included here but are included with figures for the final consumption of fuels in the appropriate consuming sector.
Heat output (TWh)	HEATOUT	Heat generated shows the total amount of TWh generated by power plants separated into CHP plants and heat plants.

Electricity and Heat Output and Emissions per kWh

Flow	Short name	Definition
Heat output-main activity producer CHP plants (TWh)	HEMAINC	Combined heat and power plants (CHP) refers to plants which are designed to produce both heat and electricity, sometimes referred to as co-generation power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Main activity producers (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.
Heat output-autoproducer CHP plants (TWh)	HEAUTOC	Combined heat and power plants (CHP) refers to plants which are designed to produce both heat and electricity, sometimes referred to as co-generation power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Note that for autoproducer CHP plants, all fuel inputs to electricity production are taken into account, while only the part of fuel inputs to heat sold is shown. Fuel inputs for the production of heat consumed within the autoproducer's establishment are not included here but are included with figures for the final consumption of fuels in the appropriate consuming sector. Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.
Heat output-main activity producer heat plants (TWh)	HEMAINH	Heat plants refers to plants (including heat pumps and electric boilers) designed to produce heat only, which is sold to a third party under the provisions of a contract. Main activity producers (formerly known as public supply undertakings) generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. Note that the sale need not take place through the public grid.
Heat output-autoproducer heat plants (TWh)	HEAUTOH	Heat plants refers to plants (including heat pumps and electric boilers) designed to produce heat only, which is sold to a third party under the provisions of a contract. Autoproducer undertakings generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity. They may be privately or publicly owned.

Electricity and Heat Output and Emissions per kWh		
Flow	**Short name**	**Definition**
CO_2 per kWh of electricity and heat (gCO_2 per kWh)	CO2KWHH	This ratio is expressed in grammes of CO_2 per kWh. It has been calculated using CO_2 emissions from electricity and heat ("main activity producer" and "autoproducer"). The CO_2 emissions include emissions from fossil fuels, industrial waste and non-renewable municipal waste that are consumed for electricity and heat generation in the transformation sector and the output includes electricity and heat generated from fossil fuels, nuclear, hydro (excluding pumped storage), geothermal, solar, biofuels, etc. As a result, the emissions per kWh can vary from year to year depending on the generation mix. In the ratios of CO_2 emissions per kWh by fuel: • Coal includes primary and secondary coal, peat and coal gases. • Oil includes oil products (and small amounts of crude oil for some countries). • Gas represents natural gas. Note: Emissions per kWh should be used with caution due to data quality problems relating to electricity efficiencies for some countries.

Indicators

Flow	Short name	Notes
Total primary energy supply (PJ)	TPESPJ	Total primary energy supply from the *IEA Energy Balances* (converted into PJ). Total primary energy supply (TPES) is made up of production + imports - exports - international marine bunkers - ***international aviation bunkers*** ± stock changes. The IPCC methodology does not assign any CO_2 emissions to fuel use of biofuels *per se*, only if it is used in an unsustainable way. This is evaluated in the Land Use Change and Forestry module of the *1996 IPCC Guidelines*. So although the inclusion of biomass in the IEA energy data does not alter its CO_2 emission estimates, it gives more insight into the CO_2 intensity of national energy use. *Please note: the TPES series (and underlying energy data) contained in this publication have been slightly revised in October 2012 after the original publication of the paper copy of Energy Balances of Non-OECD Countries. Countries that were revised include Bosnia and Herzegovina, Côte d'Ivoire, People's Republic of China, Qatar, Singapore, Ukraine and Other Africa.*
Total primary energy supply (Mtoe)	TPESMTOE	Total primary energy supply from the *IEA Energy Balances*. Total primary energy supply (TPES) is made up of production + imports - exports - international marine bunkers - ***international aviation bunkers*** ± stock changes. The IPCC methodology does not assign any CO_2 emissions to fuel use of biofuels *per se*, only if it is used in an unsustainable way. This is evaluated in the Land Use Change and Forestry module of the *1996 IPCC Guidelines*. So although the inclusion of biomass in the IEA energy data does not alter its CO_2 emission estimates, it gives more insight into the CO_2 intensity of national energy use. *Please note: the TPES series (and underlying energy data) contained in this publication have been slightly revised in October 2012 after the original publication of the paper copy of Energy Balances of Non-OECD Countries. Countries that were revised include Bosnia and Herzegovina, Côte d'Ivoire, People's Republic of China, Qatar, Singapore, Ukraine and Other Africa.*

Indicators		
Flow	**Short name**	**Notes**
GDP (billion 2005 US dollars)	GDP	In this edition, the GDP series have been rebased from 2000 USD to 2005 USD. As a result, those series and all associated ratios now refer to 2005 USD. The main source of the 1970 to 2010 GDP series for the OECD member countries is *National Accounts of OECD Countries, Volume 1*, 2012. GDP data for Australia, France, Greece and Sweden for 1960 to 1969 and Denmark for 1966 to 1969 as well as for Netherlands for 1969 come directly from the most recent volume of National Accounts. GDP data for 1960 to 1969 for the other countries have been estimated using the growth rates from the series in the *OECD Economic Outlook No 76* and data previously published by the OECD Secretariat. Data prior to 1986 for Chile, prior to 1990 for the Czech Republic and Poland, prior to 1991 for Hungary, and prior to 1992 for the Slovak Republic are IEA Secretariat estimates based on GDP growth rates from the World Bank. The main source of the GDP series for the non-OECD member countries is *World Development Indicators*, World Bank, Washington D.C., 2012. Prior to 1980, GDP figures for all non-OECD countries are based on the CHELEM-CEPII online databases, 2012. In addition, the following countries have also been based on the CHELEM-CEPII databases for the specified time periods. Angola (1980-1984), Bahrain (2009-2010), Bosnia and Herzegovina (1990-1993), Brunei Darussalam (2010), Chinese Taipei, Cuba, Ethiopia (1980), Gibraltar, Haiti (1980-1990), Islamic Republic of Iran (2010), Iraq (1980-1996), North Korea, Kuwait (1990-1991 and 2008-2010), Lebanon (1980-1987), Libya (1980-1998 and 2010), Netherlands Antilles, Oman (2010), Qatar (1980-1999 and 2010), Senegal (1980), Tanzania (1980-1987), Vietnam (1980-1983), Yemen (1980-1989 and 2010), Zimbabwe, Former Soviet Union (1980-1989), Former Yugoslavia (1980-1989) and a few countries within the regions Other Africa, Other Non-OECD Americas and Other Asia. The World Bank GDP figures for Kosovo are available starting in 2000. The GDP data have been compiled for individual countries at market prices in local currency and annual rates. These data have been scaled up/down to the price levels of 2005 and then converted to US dollars using the yearly average 2005 exchange rates. Due to lack of complete time series, figures for GDP of Other Non-OECD Americas do not include British Virgin Islands, Cayman Islands, Falkland Islands, Martinique, Montserrat, Saint Pierre and Miquelon, and Turks and Caicos Islands; and figures for GDP of Other Asia do not include Cook Islands.. *Please note: the GDP series contained in this publication have been slightly revised in October 2012 after the original publication of the paper copy of Energy Balances of Non-OECD Countries.*

Indicators

Flow	Short name	Notes
GDP PPP (billion 2005 US dollars)	GDPPPP	In this edition, the GDP and GDP PPP series have been rebased from 2000 USD to 2005 USD. As a result, those series and all associated ratios now refer to 2005 USD. The main source of the 1970 to 2010 GDP series for the OECD member countries is *National Accounts of OECD Countries, Volume 1*, 2012. GDP data for Australia, France, Greece and Sweden for 1960-1969 and Denmark for 1966 to 1969 as well as for Netherlands for 1969 come directly from the most recent volume of National Accounts. GDP data for 1960 to 1969 for the other countries have been estimated using the growth rates from the series in the *OECD Economic Outlook No 76* and data previously published by the OECD Secretariat. Data prior to 1986 for Chile, prior to 1990 for the Czech Republic and Poland, prior to 1991 for Hungary, and prior to 1992 for the Slovak Republic are IEA Secretariat estimates based on GDP growth rates from the World Bank. The main source of the GDP series for the non-OECD member countries is *World Development Indicators*, World Bank, Washington D.C., 2012. Prior to 1980, GDP figures for all non-OECD countries are based on the CHELEM-CEPII online databases, 2012. In addition, the following countries have also been based on the CHELEM-CEPII databases for the specified time periods. Angola (1980-1984), Bahrain (2009-2010), Bosnia and Herzegovina (1990-1993), Brunei Darussalam (2010), Chinese Taipei, Cuba, Ethiopia (1980), Gibraltar, Haiti (1980-1990), Islamic Republic of Iran (2010), Iraq (1980-1996), North Korea, Kuwait (1990-1991 and 2008-2010), Lebanon (1980-1987), Libya (1980-1998 and 2010), Netherlands Antilles, Oman (2010), Qatar (1980-1999 and 2010), Senegal (1980), Tanzania (1980-1987), Vietnam (1980-1983), Yemen (1980-1989 and 2010), Zimbabwe, Former Soviet Union (1980-1989), Former Yugoslavia (1980-1989) and a few countries within the regions Other Africa, Other Non-OECD Americas and Other Asia. The World Bank GDP figures for Kosovo are available starting in 2000. The GDP PPP figures have been estimated using the World Bank ratio of exchange rate to PPP in 2005 for Serbia since the ratio for Kosovo was not available. The GDP data have been compiled for individual countries at market prices in local currency and annual rates. These data have been scaled up/down to the price levels of 2005 and then converted to US dollars using purchasing power parities (PPPs). Purchasing power parities are the rates of currency conversion that equalise the purchasing power of different currencies. A given sum of money, when converted into different currencies at the PPP rates, buys the same basket of goods and services in all countries. In other words, PPPs are the rates of currency conversion which eliminate the differences in price levels between different countries. Due to lack of complete time series, figures for GDP of Other Non-OECD Americas do not include British Virgin Islands, Cayman Islands,

Indicators		
Flow	**Short name**	**Notes**
GDP PPP (billion 2005 US dollars) (cont)	GDPPPP	Falkland Islands, Martinique, Montserrat, Saint Pierre and Miquelon, and Turks and Caicos Islands; and figures for GDP of Other Asia do not include Cook Islands. *Please note: the GDP and GDP PPP series contained in this publication have been slightly revised in October 2012 after the original publication of the paper copy of Energy Balances of Non-OECD Countries.*
Population (millions)	POP	The main source of the 1970 to 2010 population data for the OECD member countries is *National Accounts of OECD Countries, Volume 1*, OECD, Paris, 2012. Data for 1960 to 1969 have been estimated using the growth rates from the population series published in the *OECD Economic Outlook No. 76*. For the Czech Republic, Hungary and Poland (1960 to 1969) and Mexico (1960 to 1962), the data are estimated using the growth rates from the population series from the World Bank published in the *World Development Indicators CD-ROM*. For the Slovak Republic, population data for 1960 to 1989 are from the Demographic Research Centre, Infostat, Slovak Republic. The main source of the population data for the OECD non-member countries is *World Development Indicators*, World Bank, Washington D.C., 2012. Population data for Chinese Taipei, Gibraltar, Iraq and a few countries within the regions Other Africa, Other Non-OECD Americas and Other Asia are based on the CHELEM-CEPII online database, 2012. Population data for 2010 for Cyprus were calculated using the population growth rate supplied by Eurostat, 2012. Due to lack of complete time series, figures for population of Other Non-OECD Americas America do not include British Virgin Islands, Cayman Islands, Falkland Islands, Martinique, Montserrat, Saint Pierre and Miquelon, and Turks and Caicos Islands; and figures for population of Other Asia do not include Cook Islands.
CO_2 / TPES (tCO_2 per TJ)	CO2TPES	This ratio is expressed in tonnes of CO_2 per terajoule. It has been calculated using the Sectoral Approach CO_2 emissions and total primary energy supply (including biofuels and other non-fossil forms of energy).
CO_2 / GDP ($kgCO_2$ per 2005 US dollar)	CO2GDP	This ratio is expressed in kilogrammes of CO_2 per 2005 US dollar. It has been computed using the Sectoral Approach CO_2 emissions and the GDP calculated using exchange rates.
CO_2 / GDP PPP ($kgCO_2$ per 2005 US dollar)	CO2GDPPP	This ratio is expressed in kilogrammes of CO_2 per 2005 US dollar. It has been calculated using the Sectoral Approach CO_2 emissions and the GDP calculated using purchasing power parities.
CO_2 / Population (tCO_2 per capita)	CO2POP	This ratio is expressed in tonnes of CO_2 per capita. It has been calculated using the Sectoral Approach CO_2 emissions.

Allocation of emissions from electricity/heat

Flow	Allocation	Definition
Emissions by sector	NO	Expressed in million tonnes of CO_2. This allocation type shows emissions for the same sectors which are present in the file CO_2 Emissions From Fuel Combustion. In particular, the emissions from electricity and heat production are shown separately and not reallocated.
Emissions with electricity and heat allocated to consuming sectors	YES	Expressed in million tonnes of CO_2. Emissions from electricity and heat generation have been allocated to final consuming sectors in proportion to the electricity and heat consumed.
Per capita emissions by sector	NOP	These ratios are expressed in kilogrammes of CO_2 per capita. This allocation type shows per capita emissions for the same sectors which are present in the file CO_2 Emissions From Fuel Combustion. In particular, the emissions from electricity and heat production are shown separately and not reallocated.
Per capita emissions with electricity and heat allocated to consuming sectors	YESP	These ratios are expressed in kilogrammes of CO_2 per capita. Emissions from electricity and heat generation have been allocated to final consuming sectors in proportion to the electricity and heat consumed.

Emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6 ($MtCO_2$ equivalent)

Gas	Short name	Definition
CO_2 - Fuel combustion	CO2COMB	Fuel combustion refers to fossil fuel combustion and non-energy/feedstock use (IPCC Source/Sink Category 1A) estimated using the IPCC Sectoral Approach.
CO_2 - Fugitive	CO2FUG	Fugitive refers to flaring of associated gas in oil and gas production (IPCC Source/Sink Category 1B).
CO_2 - Industrial processes	CO2IND	Industry refers to cement production (IPCC Source/Sink Category 2).
CO_2 – Other	CO2OTHER	Other refers to the sum of direct emissions from tropical forest fires and of 10% of biofuel combustion emissions, which is the fraction assumed to be produced unsustainably (IPCC Source/Sink Category 5).
CO_2 – Total	CO2TOT	Total CO_2 Emissions.

Emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6 (MtCO_2 equivalent)

Gas	Short name	Definition
CO_2 - Share of energy in total	CO2ESHARE	Share of Energy in total for CO_2 emissions (%).
CH_4 - Energy	CH4ENERGY	Energy comprises production, handling, transmission and combustion of fossil fuels and biofuels (IPCC Source/Sink Category 1).
CH_4 – Agriculture	CH4AGRI	Agriculture comprises animals, animal waste, rice production, agricultural waste burning (non-energy, on-site) and savannah burning (IPCC Source/Sink Category 4).
CH_4 – Waste	CH4WASTE	Waste comprises landfills, wastewater treatment, human wastewater disposal and waste incineration (non-energy) (IPCC Source/Sink Category 6).
CH_4 – Other	CH4OTHER	Other includes industrial process emissions and tropical and temperate forest fires and other vegetation fires (IPCC Source/ Sink Categories 2 and 5).
CH_4 – Total	CH4TOT	Total CH_4 emissions.
CH_4 - Share of energy in total	CH4ESHARE	Share of Energy in total for CH_4 emissions (%).
N_2O – Energy	N2OENERGY	Energy comprises combustion of fossil fuels and biofuels (IPCC Source/Sink Category 1).
N_2O – Industrial processes	N2OIND	Industrial Processes comprises non-combustion emissions from manufacturing of adipic acid and nitric acid (IPCC Source/Sink Category 2).
N_2O – Agriculture	N2OAGRI	Agriculture comprises fertiliser use (synthetic and animal manure), animal waste management, agricultural waste burning (non-energy, on-site) and savannah burning (IPCC Source/Sink Category 4).
N_2O – Other	N2OOTHER	Other includes N_2O usage, tropical and temperate forest fires, and human sewage discharge and waste incineration (non-energy) (IPCC Source/Sink Categories 3, 5 and 6).
N_2O – Total	N2OTOT	Total N_2O emissions.
N_2O – Share of energy in total	N2OESHARE	Share of energy in total for N_2O emissions (%).
HFC - Industrial processes	HFCIND	HFC emissions comprise by-product emissions of HFC-23 from HCFC-22 manufacture and the use of HFCs (IPCC Source/Sink Categories 2E and 2F).

Emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6 ($MtCO_2$ equivalent)

Gas	Short name	Definition
PFC - Industrial processes	PFCIND	PFC emissions comprise by-product emissions of CF4 and C_2F_6 from primary aluminium production and the use of PFCs, in particular for semiconductor manufacture (IPCC Source/Sink Categories 2C, 2E and 2F).
SF_6 - Industrial processes	SF6IND	SF6 emissions stem from various sources of SF_6 use, of which the largest is the use and manufacture of Gas Insulated Switchgear (GIS) used in the electricity distribution networks (IPCC Source/Sink Categories 2C and 2F).
Total	TOTAL	Total of all greenhouse gases covered by the Kyoto Protocol.
Share of energy in total GHG	ESHARE	Share of energy in total emissions (%).
Total GHG emissions / GDP PPP	GHGGDP	Total emissions per GDP PPP ratio is expressed in kg of CO_2-equivalent per 2005 USD. It has been calculated using total GHG emissions covered by the Kyoto Protocol and the GDP calculated using purchasing power parities.

Aggregated Products

Flow	Short name	Definition
Coal/peat	COAL	Coal includes all coal, both primary (including hard coal and lignite) and derived fuels (including patent fuel, coke oven coke, gas coke, BKB, coke oven gas, blast furnace gas and gas works gas). Peat is also included in this category.
Oil	OIL	Oil comprises crude oil, natural gas liquids, refinery feedstocks, additives, refinery gas, ethane, LPG, aviation gasoline, motor gasoline, jet fuels, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and other oil products.
Natural gas	NATGAS	Gas represents natural gas. It excludes natural gas liquids.
Other	OTHER	Other includes industrial waste and non-renewable municipal waste.
Total	TOTAL	TOTAL = the total of all CO_2 emissions from fuel combustion, i.e. COAL + OIL + NATGAS + OTHER.

Coal (including coal gases)

Flow	Short name	Definition
Hard coal (if no detail)	HARDCOAL	This item is used prior to 1978. It includes anthracite, coking coal, other bituminous coal and (depending on the country) also may include sub-bituminous coal.
Brown coal (if no detail)	BROWN	This item is used prior to 1978. It includes lignite and (depending on the country) also may include sub-bituminous coal.
Anthracite	ANTCOAL	Anthracite is a high rank coal used for industrial and residential applications. It is generally less than 10% volatile matter and a high carbon content (about 90% fixed carbon). Its gross calorific value is greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis.
Coking coal	COKCOAL	Coking coal refers to coal with a quality that allows the production of a coke suitable to support a blast furnace charge. Its gross calorific value is greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis.
Other bituminous coal	BITCOAL	Other bituminous coal is used for steam raising and space heating purposes and includes all bituminous coal that is not included under coking coal. It is usually more than 10% volatile matter and a relatively high carbon content (less than 90% fixed carbon). Its gross calorific value is greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis.
Sub-bituminous coal	SUBCOAL	Non-agglomerating coals with a gross calorific value between 17 435 kJ/kg (4165 kcal/kg) and 23 865 kJ/kg (5 700 kcal/kg) containing more than 31 per cent volatile matter on a dry mineral matter free basis.
Lignite	LIGNITE	Lignite is a non-agglomerating coal with a gross calorific value of less than 17 435 kJ/kg (4 165 kcal/kg), and greater than 31 per cent volatile matter on a dry mineral matter free basis.
Oil shale	OILSHALE	Oil shale is an inorganic, non-porous rock containing various amounts of solid organic material that yields hydrocarbons, along with a variety of solid products, when subject to pyrolysis (a treatment that consists of heating the rock at high temperature).
Patent Fuel	PATFUEL	Patent fuel is a composition fuel manufactured from hard coal fines with the addition of a binding agent. The amount of patent fuel produced is, therefore, slightly higher than the actual amount of coal consumed in the transformation process. Consumption of patent fuels during the patent fuel manufacturing process is included under other energy industry own use

Coal (including coal gases)

Flow	Short name	Definition
Coke oven coke	OVENCOKE	Coke oven coke is the solid product obtained from the carbonisation of coal, principally coking coal, at high temperature. It is low in moisture content and volatile matter. Coke oven coke is used mainly in the iron and steel industry, acting as energy source and chemical agent. Also included are semi-coke (a solid product obtained from the carbonisation of coal at a low temperature), lignite coke (a semi-coke made from lignite), coke breeze and foundry coke. Other energy industry own use includes the consumption at the coking plants themselves. Consumption in the iron and steel industry does not include coke converted into blast furnace gas. To obtain the total emissions from coke oven coke in the iron and steel industry, the quantities converted into blast furnace gas have to be added (these are aggregated under differences due to transformations and/or losses).
Gas coke	GASCOKE	Gas coke is a by-product of hard coal used for the production of town gas in gas works. Gas coke is used for heating purposes. Other energy industry own use data includes the consumption of gas coke at gas works.
Coal tar	COALTAR	Coal tar is a result of the destructive distillation of bituminous coal. Coal tar is the liquid by-product of the distillation of coal to make coke in the coke oven process. Coal tar can be further distilled into different organic products (e.g. benzene, toluene, naphthalene), which normally would be reported as a feedstock to the petrochemical industry.
BKB/peat briquettes	BKB	BKB are composition fuels manufactured from lignite, produced by briquetting under high pressure. These figures include peat briquettes, dried lignite fines and dust.
Gas works gas	GASWKSGS	Gas works gas covers all types of gas produced in public utility or private plants, whose main purpose is the manufacture, transport and distribution of gas. It includes gas produced by carbonisation (including gas produced by coke ovens and transferred to gas works), by total gasification (with or without enrichment with oil products) and by reforming and simple mixing of gases and/or air.
Coke oven gas	COKEOVGS	Coke oven gas is obtained as a by-product of the manufacture of coke oven coke for the production of iron and steel.
Blast furnace gas	BLFURGS	Blast furnace gas is produced during the combustion of coke in blast furnaces in the iron and steel industry. It is recovered and used as a fuel partly within the plant and partly in other steel industry processes or in power stations equipped to burn it.
Other recovered gases	OXYSTGS	Oxygen steel furnace gas is obtained as a by-product of the production of steel in an oxygen furnace and is recovered on leaving the furnace. Oxygen steel furnace gas is also known as converter gas, LD gas or BOS gas. This category may also cover other recovered gases.

Gas

Flow	Short name	Definition
Natural gas	NATGAS	Natural gas comprises gases, occurring in underground deposits, whether liquefied or gaseous, consisting mainly of methane. It includes both "non-associated" gas originating from fields producing only hydrocarbons in gaseous form, and "associated" gas produced in association with crude oil as well as methane recovered from coal mines (colliery gas) or from coal seams (coal seam gas). Production represents dry marketable production within national boundaries, including offshore production and is measured after purification and extraction of NGL and sulphur. It includes gas consumed by gas processing plants and gas transported by pipeline. Quantities of gas that are re-injected, vented or flared are excluded.

Crude, NGL, Refinery Feedstocks		
Flow	**Short name**	**Definition**
Crude/NGL/feedstocks (if no detail)	CRNGFEED	This item is only used prior to 1971. It includes crude oil, natural gas liquids, refinery feedstocks, additives/blending components and other hydrocarbons.
Crude oil	CRUDEOIL	Crude oil is a mineral oil consisting of a mixture of hydrocarbons of natural origin and associated impurities, such as sulphur. It exists in the liquid phase under normal surface temperatures and pressure and its physical characteristics (density, viscosity, etc.) are highly variable. It includes field or lease condensates (separator liquids) which are recovered from associated and non-associated gas where it is commingled with the commercial crude oil stream.
Natural gas liquids	NGL	NGLs are the liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. These are those portions of natural gas which are recovered as liquids in separators, field facilities, or gas processing plants. NGLs include but are not limited to ethane, propane, butane, pentane, natural gasoline and condensate.
Refinery feedstocks	REFFEEDS	A refinery feedstock is a processed oil destined for further processing (e.g. straight run fuel oil or vacuum gas oil) other than blending in the refining industry. It is transformed into one or more components and/or finished products. This definition covers those finished products imported for refinery intake and those returned from the petrochemical industry to the refining industry.
Additives/blending components	ADDITIVE	Additives are non-hydrocarbon substances added to or blended with a product to modify its properties, for example, to improve its combustion characteristics. Alcohols and ethers (MTBE, methyl tertiary-butyl ether) and chemical alloys such as tetraethyl lead are included here. The biofuel fractions of biogasoline, biodiesel and ethanol are not included here.
Orimulsion	ORIMUL	Emulsified oil made of water and natural bitumen.
Other hydrocarbons	NONCRUDE	Other hydrocarbons, synthetic crude oil, mineral oils extracted from bituminous minerals, bituminous sand, etc. and liquids from coal liquefaction, are included here. Orimulsion and oil shale are presented separately and not included here.

Oil Products

Flow	Short name	Definition
Refinery gas	REFINGAS	Refinery gas is defined as non-condensable gas obtained during distillation of crude oil or treatment of oil products (e.g. cracking) in refineries. It consists mainly of hydrogen, methane, ethane and olefins. It also includes gases which are returned from the petrochemical industry.
Ethane	ETHANE	Ethane is a naturally gaseous straight-chain hydrocarbon (C_2H_6). It is a colourless paraffinic gas which is extracted from natural gas and refinery gas streams.
Liquefied petroleum gases	LPG	These are the light hydrocarbons fraction of the paraffin series, derived from refinery processes, crude oil stabilisation plants and natural gas processing plants comprising propane (C_3H_8) and butane (C_4H_{10}) or a combination of the two. They could also include propylene, butylene, isobutene and isobutylene. They are normally liquefied under pressure for transportation and storage.
Motor gasoline	MOTORGAS	This is light hydrocarbon oil for use in internal combustion engines such as motor vehicles, excluding aircraft. Motor gasoline is distilled between 35 degrees C and 215 degrees C and is used as a fuel for land based spark ignition engines. Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds such as TEL (tetraethyl lead) and TML (tetramethyl lead). It does not include the liquid biofuel or ethanol blended with gasoline.
Aviation gasoline	AVGAS	Aviation gasoline is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine, a freezing point of -60 degrees C, and a distillation range usually within the limits of 30 degrees C and 180 degrees C.
Gasoline type jet fuel	JETGAS	This includes all light hydrocarbon oils for use in aviation turbine power units. They distil between 100 degrees C and 250 degrees C. It is obtained by blending kerosenes and gasoline or naphthas in such a way that the aromatic content does not exceed 25% in volume, and the vapour pressure is between 13.7 kPa and 20.6 kPa. Additives can be included to improve fuel stability and combustibility.
Kerosene type jet fuel	JETKERO	This is medium distillate used for aviation turbine power units. It has the same distillation characteristics and flash point as kerosene (between 150 degrees C and 300 degrees C but not generally above 250 degrees C). In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA). It includes kerosene blending components.
Other kerosene	OTHKERO	Kerosene (other than kerosene used for aircraft transport which is included with aviation fuels) comprises refined petroleum distillate intermediate in volatility between gasoline and gas/diesel oil. It is a medium oil distilling between 150 degrees C and 300 degrees C.

Oil Products

Flow	Short name	Definition
Gas/diesel oil	GASDIES	Gas/diesel oil includes heavy gas oils. Gas oils are obtained from the lowest fraction from atmospheric distillation of crude oil, while heavy gas oils are obtained by vacuum redistillation of the residual from atmospheric distillation. Gas/diesel oil distils between 180 degrees C and 380 degrees C. Several grades are available depending on uses: diesel oil for diesel compression ignition (cars, trucks, marine, etc.), light heating oil for industrial and commercial uses, and other gas oil including heavy gas oils which distil between; 380 degrees C and 540 degrees C and which are used as petrochemical feedstocks. It does not include the liquid biofuels blended with gas/diesel oil.
Fuel oil	RESFUEL	Fuel oil defines oils that make up the distillation residue. It comprises all residual fuel oils, including those obtained by blending. Its kinematic viscosity is above 10 cSt at 80 degrees C. The flash point is always above 50 degrees C and the density is always more than 0.90 kg/l.
Naphtha	NAPHTHA	Naphtha is a feedstock destined either for the petrochemical industry (e.g. ethylene manufacture or aromatics production) or for gasoline production by reforming or isomerisation within the refinery. Naphtha comprises material that distils between 30 degrees C and 210 degrees C.
White spirit & SBP	WHITESP	White spirit and SBP are refined distillate intermediates with a distillation in the naphtha/kerosene range. White Spirit has a flash point above 30 degrees C and a distillation range of 135 degrees C to 200 degrees C. Industrial Spirit (SBP) comprises light oils distilling between 30 degrees C and 200 degrees C, with a temperature difference between 5% volume and 90% volume distillation points, including losses, of not more than 60 degrees C. In other words, SBP is a light oil of narrower cut than motor spirit. There are seven or eight grades of industrial spirit, depending on the position of the cut in the distillation range defined above.
Lubricants	LUBRIC	Lubricants are hydrocarbons produced from distillate or residue; they are mainly used to reduce friction between bearing surfaces. This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.
Bitumen	BITUMEN	Bitumen is a solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in colour It is obtained by vacuum distillation of oil residues from atmospheric distillation of crude oil. Bitumen is often referred to as asphalt and is primarily used for surfacing of roads and for roofing material. This category includes fluidised and cut back bitumen.

Oil Products		
Flow	**Short name**	**Definition**
Paraffin waxes	PARWAX	Paraffin waxes are saturated aliphatic hydrocarbons. These waxes are residues extracted when dewaxing lubricant oils, and they have a crystalline structure which is more or less fine according to the grade. Their main characteristics are that they are colourless, odourless and translucent, with a melting point above 45 degrees C.
Petroleum coke	PETCOKE	Petroleum coke is defined as a black solid residue, obtained mainly by cracking and carbonising of petroleum derived feedstocks, vacuum bottoms, tar and pitches in processes such as delayed coking or fluid coking. It consists mainly of carbon (90 to 95%) and has a low ash content. It is used as a feedstock in coke ovens for the steel industry, for heating purposes, for electrode manufacture and for production of chemicals. The two most important qualities are "green coke" and "calcinated coke". This category also includes "catalyst coke" deposited on the catalyst during refining processes: this coke is not recoverable and is usually burned as refinery fuel.
Non-specified oil products	ONONSPEC	Other oil products not classified above (e.g. tar, sulphur, and grease) are included here. This category also includes aromatics (e.g. BTX or benzene, toluene and xylene) and olefins (e.g. propylene) produced within refineries.
Peat	PEAT	Peat is a combustible soft, porous or compressed, fossil sedimentary deposit of plant origin with high water content (up to 90 per cent in the raw state), easily cut, of light to dark brown colour. Peat used for non-energy purposes is not included.

Wastes

Flow	Short name	Definition
Industrial waste	INDWASTE	Industrial waste of non-renewable origin consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power. Renewable industrial waste is not included here.
Municipal waste (non-renewable)	MUNWASTEN	Municipal waste (non-renewable) consists of the non-renewable part of municipal waste products that are combusted directly to produce heat and/or power and comprises wastes produced by households, industry, hospitals and the tertiary sector that are collected by local authorities for incineration at specific installations.

3. GEOGRAPHICAL COVERAGE AND COUNTRY NOTES

Countries and Regions		
Flow	**Short name**	**Definition**
World	WORLD	World = OECD Total + Non-OECD Total + international marine bunkers + international aviation bunkers. World = Annex I Parties + Non-Annex I Parties + international marine bunkers and international aviation bunkers. Please note that the following countries have not been considered due to lack of data: Africa: Saint Helena; Asia and Oceania: Christmas Island, Nauru, Niue; Non-OECD Americas: Anguilla; Non-OECD Europe and Eurasia: Liechtenstein (except for oil data which is included under Switzerland).
OECD Americas	OECDAM	Includes Canada, Chile, Mexico and the United States.
OECD Asia Oceania	OECDAO	Includes Australia, Israel, Japan, Korea and New Zealand.
OECD Europe	OECDEUR	Includes Austria, Belgium, the Czech Republic, Denmark, Estonia (from 1990), Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia (from 1990), Spain, Sweden, Switzerland, Turkey and the United Kingdom.
Africa	AFRICA	Includes Algeria, Angola, Benin, Botswana (from 1981), Cameroon, Congo, Democratic Republic of Congo (from 1981), Côte d'Ivoire, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libyan Arab Jamahiriya, Morocco, Mozambique, Namibia (from 1991), Nigeria, Senegal, South Africa, Sudan, United Republic of Tanzania, Togo, Tunisia, Zambia, Zimbabwe and Other Africa.

Countries and Regions

Flow	Short name	Definition
Non-OECD Americas	LATAMER	Includes Argentina, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela and Other Non-OECD America.
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	NOECDEUR	Includes Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Estonia (prior to 1990), Georgia, Gibraltar, Kazakhstan, Kosovo, Kyrgyzstan, Latvia, Lithuania, Former Yugoslav Republic of Macedonia (FYROM), Malta, Republic of Moldova, Montenegro, Romania, Russian Federation, Serbia, Slovenia (prior to 1990), Tajikistan, Turkmenistan, Ukraine and Uzbekistan.
Asia (excluding China)	ASIA	Includes Bangladesh, Brunei Darussalam, Cambodia (from 1995), Chinese Taipei, India, Indonesia, DPR of Korea, Malaysia, Mongolia (from 1985), Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam and Other Asia. In this series, Asia excludes China and Hong Kong.
China (including Hong Kong)	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.
Albania	ALBANIA	
Algeria	ALGERIA	
Angola	ALGOLA	
Argentina	ARGENTINA	
Armenia	ARMENIA	
Australia	AUSTRALI	Excludes the overseas territories.
Austria	AUSTRIA	
Azerbaijan	AZERBAIJAN	
Bahrain	BAHRAIN	
Bangladesh	BANGLADESH	
Belarus	BELARUS	
Belgium	BELGIUM	

Countries and Regions

Flow	Short name	Definition
Benin	BENIN	
Bolivia	BOLIVIA	
Bosnia-Herzegovina	BOSNIAHERZ	
Botswana	BOTSWANA	
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	
Cameroon	CAMEROON	
Canada	CANADA	
Chile	CHILE	
People's Republic of China	CHINA	In 2012, the National Bureau of Statistics (NBS) revised the format and detail of their energy balance. Data for new products and flows were added. However, for the purposes of this publication, the old time series format was kept and updated for 2010. Over the next year, the IEA Secretariat plans to work with NBS to incorporate the new format.
Chinese Taipei	TAIPEI	
Colombia	COLOMBIA	
Congo	CONGO	
Democratic Republic of Congo	CONGOREP	
Costa Rica	COSTARICA	
Côte d'Ivoire	COTEIVOIRE	
Croatia	CROATIA	
Cuba	CUBA	International marine bunkers for residual fuel oil in the period 1971-1983 were estimated on the basis of 1984 figures and the data reported as internal navigation in the energy balance.

Countries and Regions

Flow	Short name	Definition
Cyprus	CYPRUS	*Note by Turkey:* 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. *Note by all the European Union Member States of the OECD and the European Commission:* 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.
Czech Republic	CZECH	
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	
El Salvador	ELSALVADOR	
Eritrea	ERITREA	
Estonia	ESTONIA	The data reported as lignite in the energy balance have been considered as oil shale for the calculation of CO_2 emissions.
Ethiopia	ETHIOPIA	
Finland	FINLAND	
France	FRANCE	Includes Monaco, and excludes the following overseas departments: Guadeloupe, Guyana, Martinique, New Caledonia, French Polynesia, Reunion and Saint Pierre et Miquelon. The methodology for calculating main activity electricity and heat production from gas changed in 2000.
Gabon	GABON	
Georgia	GEORGIA	
Germany	GERMANY	Includes the new federal states of Germany from 1970 onwards.
Ghana	GHANA	
Gibraltar	GIBRALTAR	

Countries and Regions

Flow	Short name	Definition
Greece	GREECE	
Guatemala	GUATEMALA	
Haiti	HAITI	
Honduras	HONDURAS	
Hong Kong, China	HONGKONG	
Hungary	HUNGARY	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	
Indonesia	INDONESIA	
Islamic Republic of Iran	IRAN	
Iraq	IRAQ	
Ireland	IRELAND	
Israel	ISRAEL	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 Vatican. Prior to 1990, gas use in commercial/public services was included in residential.
Jamaica	JAMAICA	

Countries and Regions

Flow	Short name	Definition
Japan	JAPAN	Includes Okinawa. Between 2004 and 2007, the IEA received revisions from the Japanese Administration. The first set of revisions received in 2004 increased the 1990 supply by 5% for coal, 2% for natural gas and 0.7% for oil compared to the previous data. This led to an increase of 2.5% in 1990 CO_2 emissions calculated using the Reference Approach while the Sectoral Approach remained fairly constant. For the 2006 edition, the IEA received revisions to the coal and oil data which had a significant impact on both the energy data and the CO_2 emissions. The most significant revisions occurred for coke oven coke, naphtha, blast furnace gas and petroleum coke. These revisions affected consumption rather than supply in the years concerned. As a result, the sectoral approach CO_2 emissions increased for all the years, however at different rates. For example, the sectoral approach CO_2 emissions for 1990 were 4.6% higher than those calculated for the 2005 edition while the 2003 emissions were 1.1% higher than those of the previous edition. Due to the impact these successive revisions have had on the final energy balance as well as on CO_2 emissions, the IEA was in close contact with the Japanese Administration to better understand the reasons be-hind these changes. These changes are mainly due to the Government of Japan's efforts to improve the input-output balances in the production of oil products and coal products in response to inquiries from the UNFCCC Secretariat. To cope with this issue, the Japanese Administration established a working group in March 2004. The working group completed its work in April 2006. Many of its conclusions were incorporated in the 2006 edition but some further revisions to the time series (especially in industry and other sectors) were submitted for the 2007 edition.
Jordan	JORDAN	
Kazakhstan	KAZAKHSTAN	
Kenya	KENYA	
Democratic People’s Republic of Korea	KOREADPR	
Korea	KOREA	
Kosovo	KOSOVO	Data for Kosovo are included in Serbia from 1990 to 1999. For data in the NONCO2 file, from 2000 onwards, all emissions other than CO_2 from fuel combustion are included in Serbia.
Kuwait	KUWAIT	
Kyrgyzstan	KYRGYZSTAN	
Latvia	LATVIA	
Lebanon	LEBANON	

Countries and Regions

Flow	Short name	Definition
Libya	LIBYA	
Lithuania	LITHUANIA	
Luxembourg	LUXEMBOU	
Former Yugoslav Rep. of Macedonia	FYROM	
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.
Mexico	MEXICO	
Republic of Moldova	MOLDOVA	
Mongolia	MONGOLIA	
Morocco	MOROCCO	
Montenegro	MONTENEGRO	Data for Montenegro are included in Serbia from 1990 to 2004. For data in the NONCO2 file, from 2005 onwards, all emissions other than CO_2 from fuel combustion are included in Serbia.
Mozambique	MOZAMBIQUE	
Myanmar	MYANNMAR	
Namibia	NAMIBIA	
Nepal	NEPAL	
Netherlands	NETHLAND	Excludes Suriname and the Netherlands Antilles.
Netherlands Antilles	NANTILLES	The Netherlands Antilles was dissolved on 10 October 2010 resulting in two new constituent countries, Curaçao and Saint Maarten, with the other islands joining the Netherlands. However, due to lack of detailed data, the IEA data and estimates under Netherlands Antilles cover the whole territory of the Netherlands Antilles. Prior to 1992, the Reference Approach overstates emissions since data for lubricants and bitumen (which store carbon) are not available.
New Zealand	NZ	
Nicaragua	NICARAGUA	
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.

Countries and Regions

Flow	Short name	Definition
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	
Saudi Arabia	SAUDIARABI	
Senegal	SENEGAL	
Serbia	SERBIA	Serbia includes Kosovo from 1990 to 1999 and Montenegro from 1990 to 2004. For data in the NONCO2 file, Serbia includes Kosovo for all emissions other than CO_2 from fuel combustion from 2000 onwards, and Montenegro for all emissions other than CO_2 from fuel combustion from 2005 onwards.
Singapore	SINGAPORE	
Slovak Republic	SLOVAKIA	
Slovenia	SLOVENIA	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.
South Africa	SOUTHAFRIC	
Spain	SPAIN	Includes the Canary Islands.
Sri Lanka	SRILANKA	
Sudan	SUDAN	
Sweden	SWEDEN	

Countries and Regions

Flow	Short name	Definition
Switzerland	SWITLAND	Includes Liechtenstein for the oil data. Data for other fuels do not include Liechtenstein. The sectoral breakdown for gas/diesel oil used in the residential sector before 1978 was estimated on the basis of commercial and residential consumption in 1978 and the data reported as commercial consumption in the energy balance in previous years.
Syrian Arab Republic	SYRIA	
Tajikistan	TAJIKISTAN	
United Republic of Tanzania	TANZANIA	
Thailand	THAILAND	
Togo	TOGO	
Trinidad and Tobago	TRINIDAD	
Tunisia	TUNISIA	
Turkey	TURKEY	
Turkmenistan	TURKMENIST	
Ukraine	UKRAINE	To provide a better Reference Approach estimate of CO_2 emissions in 2010, for the purposes of this publication, the IEA Secretariat has adjusted the stock change and statistical difference of natural gas to better match international definitions.
United Arab Emirates	UAE	
United Kingdom	UK	For reasons of confidentiality, gas for main activity electricity is included in autoproducers for 1990. 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. Oil statistics as well as coal trade statistics also include Puerto Rico, Guam, the U.S. Virgin Islands, American Samoa, Johnston Atoll, Midway Islands, Wake Island and the Northern Mariana Islands.
Uruguay	URUGUAY	
Uzbekistan	UZBEKISTAN	
Venezuela	VENEZUELA	
Vietnam	VIETNAM	A detailed sectoral breakdown is available starting in 1980.
Yemen	YEMEN	

Countries and Regions

Flow	Short name	Definition
Zambia	ZAMBIA	
Zimbabwe	ZIMBABWE	
Former Soviet Union (if no detail)	FSUND	Includes Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.
Former Yugoslavia (if no detail)	YUGOND	Includes Bosnia-Herzegovina, Croatia, Kosovo, Former Yugoslav Republic of Macedonia, Montenegro, Slovenia, Serbia.
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, Mauritius, Namibia (until 1990), Niger, Reunion, Rwanda, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia, Swaziland, Uganda and Western Sahara (from 1990).
Other Non-OECD Americas	OTHERLATIN	Includes Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands, French Guyana, Grenada, Guadeloupe, Guyana, Martinique, Montserrat, Puerto Rico (for natural gas and electricity), St. Kitts and Nevis, Saint Lucia, Saint Pierre et Miquelon, St. Vincent and Grenadines, Suriname and Turks/Caicos Islands. Oil statistics as well as coal trade statistics for Puerto Rico are included under the United States.
Other Asia	OTHERASIA	Includes Afghanistan, Bhutan, Cambodia (until 1994), Cook Islands, East Timor, Fiji, French Polynesia, Kiribati, Laos, Macau, Maldives, Mongolia (until 1984), New Caledonia, Palau (from 1994), Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu.
Memo: OECD Total	OECDTOT	The Organisation for Economic Co-Operation and Development (OECD) includes Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia (1990 onwards), Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia (1990 onwards), Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.
Memo: Non-OECD Total	NOECDTOT	Includes Africa, Latin America, Asia, Non-OECD Europe and Eurasia, Middle East and China Region.

Countries and Regions

Flow	Short name	Definition
Memo: IEA Total	IEATOT	The International Energy Agency (IEA) includes Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, 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.
Memo: European Union 27	EU27	Includes Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom.
Memo: Former Yugoslavia	MYUGO	Includes Bosnia and Herzegovina, Croatia, Kosovo, Former Yugoslav Republic of Macedonia, Montenegro, Serbia and Slovenia.
Memo: Former Soviet Union	MFSU15	Includes Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.
Memo: Annex I Parties	ANNEX1	Annex I Parties include Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein (not available here), Lithuania, Luxembourg, Malta, Monaco (included with France), the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States. The countries listed above are included in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC) as amended on 11 December 1997 by the 12th 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 are undergoing the process of transition to market economies. 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.

Countries and Regions

Flow	Short name	Definition
Memo: Annex II Parties	ANNEX2	Annex II Parties include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Liechtenstein (not available here), Luxembourg, Monaco (included in France), the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. 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.
Memo: Annex II North America	ANNEX2NA	Annex II North America includes Canada and United States.
Memo: Annex II Europe	ANNEX2EU	Annex II Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein (not available here), Luxembourg, Monaco (included in France), the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. 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.
Memo: Annex II Asia Oceania	ANNEX2PA	Annex II Pacific includes Australia, Japan and New Zealand.
Memo: Economies in Transition	ANNEX1EIT	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, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russian Federation, the Slovak Republic, Slovenia and Ukraine.
Memo: Non Annex I Parties	NONANNEX1	
Memo: Annex I Kyoto Parties	ANNEXB	Annex I Kyoto Parties include Australia, Austria, Belgium, Bulgaria, Canada, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein (not available in this publication), Lithuania, Luxembourg, Monaco (included with France), the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Ukraine and the United Kingdom. Membership in the Kyoto Protocol is almost identical to that of Annex I, except for Malta, Turkey and Belarus which did not agree to a target under the Protocol, and the United States which has expressed their intention not to ratify the Protocol. Australia ratified the Protocol on 12 December 2007 and has been included in the Kyoto aggregate in this edition.

4. UNITS AND CONVERSIONS

General conversion factors for energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
terajoule (TJ)	1	238.8	2.388×10^{-5}	947.8	0.2778
gigacalorie (Gcal)	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
million tonne of oil equivalent (Mtoe)	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11630
million British thermal unit (MBtu)	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
gigawatt hour (GWh)	3.6	860	8.6×10^{-5}	3412	1

Conversion factors for mass

To:	kg	T	lt	st	lb
From:	multiply by:				
kilogramme (kg)	1	0.001	9.84×10^{-4}	1.102×10^{-3}	2.2046
tonne (t)	1000	1	0.984	1.1023	2204.6
long ton (lt)	1016	1.016	1	1.120	2240.0
short ton (st)	907.2	0.9072	0.893	1	2000.0
pound (lb)	0.454	4.54×10^{-4}	4.46×10^{-4}	5.0×10^{-4}	1

Conversion factors for volume

To:	gal U.S.	gal U.K.	bbl	ft^3	l	m^3
From:	multiply by:					
U.S. gallon (gal)	1	0.8327	0.02381	0.1337	3.785	0.0038
U.K. gallon (gal)	1.201	1	0.02859	0.1605	4.546	0.0045
barrel (bbl)	42.0	34.97	1	5.615	159.0	0.159
cubic foot (ft^3)	7.48	6.229	0.1781	1	28.3	0.0283
litre (l)	0.2642	0.220	0.0063	0.0353	1	0.001
cubic metre (m^3)	264.2	220.0	6.289	35.3147	1000.0	1

Decimal prefixes

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

Tonne of CO_2

The *1996 IPCC Guidelines* and the UNFCCC *Reporting Guidelines on Annual Inventories* both ask that CO_2 emissions be reported in Gg of CO_2. A million tonnes of CO_2 is equal to 1 000 Gg of CO_2, 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_2 emissions in tonnes of carbon instead of tonnes of CO_2. To convert from tonnes of carbon, multiply by 44/12, which is the molecular weight ratio of CO_2 to C.

ABBREVIATIONS

Btu:	British thermal unit
GJ:	gigajoule
Gt C:	gigatonnes of carbon
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
m^3:	cubic metre
PJ:	petajoule
t:	metric ton = tonne = 1 000 kg
t C:	tonne of carbon
Tcal:	teracalorie
TJ:	terajoule
toe:	tonne of oil equivalent = 10^7 kcal
CEF:	carbon emission factor
CHP:	combined heat and power
GCV:	gross calorific value
GDP:	gross domestic product
HHV:	higher heating value = GCV
LHV:	lower heating value = NCV
NCV:	net calorific value
PPP:	purchasing power parity
TPES:	total primary energy supply
AIJ:	Activities Implemented Jointly under the United Nations Framework Convention on Climate Change
Annex I:	See Chapter 3, Geographical coverage and country notes
Annex II:	See Chapter 3, Geographical coverage and country notes
CDM:	Clean Development Mechanism
Convention:	United Nations Framework Convention on Climate Change
COP:	Conference of the Parties to the Convention
EITs:	Economies in Transition (see Chapter 3, Geographical coverage and country notes)
IEA:	International Energy Agency
IPCC:	Intergovernmental Panel on Climate Change
OECD:	Organisation for Economic Co-Operation and Development
SBI:	Subsidiary Body for Implementation
SBSTA:	Subsidiary Body for Scientific and Technological Advice
TCA:	Technology Co-operation Agreement
UN:	United Nations
UNECE:	United Nations Economic Commission for Europe
UNFCCC:	United Nations Framework Convention on Climate Change
e	estimated
..	not available
-	nil
x	not applicable
+	growth greater than 1 000%

5. IEA EMISSIONS ESTIMATES

The estimates of CO_2 emissions from fuel combustion presented in this publication are calculated using the IEA energy data[1] and the default methods and emission factors from the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, IPCC/ OECD/IEA, Paris, 1997 (*1996 IPCC Guidelines*).

Although the IPCC approved the *2006 Guidelines* at the 25th session of the IPCC in April 2006 in Mauritius, many countries (as well as the IEA Secretariat) are still calculating their inventories using the *1996 IPCC Guidelines* since this was the version used for the Kyoto Protocol. In December 2011 in Durban, the Parties adopted Decision 15/CP.17 to update their reporting tables so as to implement the *2006 Guidelines*. These tables are currently under development and there will be a trial period that runs until end May 2013. The new reporting tables will be mandatory from 15 April 2015.

The IEA Secretariat reviews its energy databases each year. In the light of new assessments, important revisions may be made to the time series of individual countries. Therefore, certain data in this publication may have been revised with respect to previous editions.

Inventory quality

The *IPCC Guidelines* allow Parties under the UNFCCC to prepare and periodically update national inventories that are accurate, complete, comparable and transparent. Inventory quality is an important issue since countries are now implementing legally-binding commitments.

One way to assess inventory quality is to do comparisons among inventories, methodologies and input data. The *IPCC Guidelines* recommend that countries which have used a detailed Sectoral Approach for CO_2 emissions from energy combustion also use the Reference Approach for verification purposes. This will identify areas where a full accounting of emissions may not have been made (see Chapter 6, IPCC methodologies).

1. Published in *Energy Statistics of OECD Countries, Energy Balances of OECD Countries, Energy Statistics of Non-OECD Countries* and *Energy Balances of Non-OECD Countries*, IEA, Paris, 2012.

Reference Approach vs. Sectoral Approach

The Reference Approach and the Sectoral Approach often give different results because the Reference Approach is a top-down approach using a country's energy supply data and has no detailed information on how the individual fuels are used in each sector.

The Reference Approach provides estimates of CO_2 to compare with estimates derived using a Sectoral Approach. Theoretically, it indicates an upper bound to the Sectoral Approach "1A fuel combustion", because some of the carbon in the fuel is not combusted but will be emitted as fugitive emissions (as leakage or evaporation in the production and/or transformation stage).

Calculating CO_2 emissions inventories with the two approaches can lead to different results for some countries. In general the gap between the two approaches is relatively small (5 per cent or less) when compared to the total carbon flows involved. In cases where 1) fugitive emissions are proportional to the mass flows entering production and/or transformation processes, 2) stock changes at the level of the final consumer are not significant and 3) statistical differences in the energy data are limited, the Reference Approach and the Sectoral Approach should lead to similar evaluations of the CO_2 emissions trends.

When significant discrepancies and/or large time-series deviations do occur, they may be due to various reasons such as:

Large statistical differences between the energy supply and the energy consumption in the basic energy data. Statistical differences arise from the collection of data from different parts of the fuel flow from its supply origins to the various stages of downstream conversion and use. They are a normal part of a fuel balance. Large random statistical differences must always be examined to determine the reason for the difference, but equally importantly smaller statistical differences which systematically show an excess of supply over demand (or vice versa) should be pursued.

Significant mass imbalances between crude oil and other feedstock entering refineries and the (gross) oil products manufactured.

The use of aggregate net calorific and carbon content values for primary fuels which are converted rather than combusted. For example, it may appear that there is not conservation of energy or carbon depending on the calorific value and/or the carbon content chosen for the crude oil entering refineries and for the mix of products produced from the refinery for a particular year. This may cause an overestimation or underestimation of the emissions associated with the Reference Approach.

The misallocation of the quantities of fuels used for conversion into derived products (other than power or heat) ***or quantities combusted in energy industry own use***. When reconciling differences between the Reference Approach and a Sectoral Approach it is important to ensure that the quantities reported in transformation and energy industry own use (e.g. for coke ovens) reflect correctly the quantities used for conversion and for fuel use, respectively, and that no misallocation has occurred. Note that the quantities of fuels converted to derived products should have been reported in transformation in the energy balance. If any derived products are used to fuel the conversion process, the amounts involved should have been reported in energy industry own use of the energy balance. In a Sectoral Approach the inputs to transformation should not be included in the activity data used to estimate emissions.

Missing information on certain transformation outputs. Emissions from combustion of secondary fuels produced in integrated processes (for example, coke oven gas) may be overlooked in a Tier 1 Sectoral Approach if data are poor or unavailable. The use of secondary fuels (the output from the transformation process) should be included in the Sectoral Approach. Failure to do so will result in an underestimation of the Sectoral Approach.

Simplifications in the Reference Approach. Certain quantities of carbon should be included in the Reference Approach because their emissions fall under fuel combustion. These quantities have been excluded where the flows are small or not represented by a major statistic available within energy data. Examples of quantities not accounted for in the Reference Approach include lubricants used in two-stroke engines, blast furnace and other by-product gases which are used for fuel combustion outside their source category of production and combustion of waxed products in waste plants with heat recovery. On the other hand, certain flows of carbon should be excluded from the Reference Approach, but for reasons similar to the above no practical means can be found to exclude them without over complicating the calculations. These include coals and other hydrocarbons injected into blast furnaces as well as cokes used as reductants in the manufacture of inorganic chemicals. These simplifications will determine discrepancies between the Reference Approach and a Sectoral Approach. If data are available, the magnitudes of these effects can be estimated.

Missing information on stock changes that may occur at the final consumer level. The relevance of consumer stocks depends on the method used for the Sectoral Approach. If delivery figures are used (this is often the case) then changes in consumers' stocks are irrelevant. If, however, the Sectoral Approach is using actual consumption of the fuel, then this could cause either an overestimation or an underestimation of the Reference Approach.

High distribution losses or unrecorded consumption for natural gas may mean that the emissions are overestimated by the Reference Approach or underestimated by the Sectoral Approach.

The treatment of transfers and reclassifications of energy products may cause a difference in the Sectoral Approach estimation since different net calorific values and emission factors may be used depending on how the fuel is classified.

Differences between IEA estimates and UNFCCC submissions

It is possible to use the IEA CO_2 estimates for comparison with the greenhouse-gas (GHG) inventories reported by countries to the UNFCCC Secretariat. In this way, problems in methods, input data or emission factors may become apparent. However, care should be used in interpreting the results of any comparison since the IEA estimates may differ from a country's official submission for many reasons.

A recent comparison of the IEA estimates with the inventories submitted to the UNFCCC showed that for most Annex II countries, the two calculations were within 5-10% depending on the coverage of the fuel combustion sector in the national inventory. For some EIT and non-Annex I countries, differences between the IEA estimates and national inventories were larger. In some of the countries the underlying energy data were different, suggesting that more work is needed on the collecting and reporting of energy statistics for those countries.

Some countries have incorrectly defined bunkers as fuel used abroad by their own ships and planes. Still other countries have made calculation errors for carbon oxidation or have included international bunkers in their totals. Since all of the above will affect the national totals of CO_2 emissions from fuel combustion, a systematic comparison with the IEA estimates would allow countries to verify their calculations and produce more internationally comparable inventories.

In addition, the main bias in the energy data and emission factors will probably be systematic and not random. This means that the emission trends will usually be more reliable than the absolute emission levels. By comparing trends in the IEA estimates with trends in emissions as reported to the UNFCCC, it should be possible to identify definition problems or changes in the calculations, which were not reflected in the base year.

For many reasons the IEA estimates may differ from the numbers that a country submits to the UNFCCC, even if a country has accounted for all of its energy use and correctly applied the *IPCC Guidelines*. No attempt has been made to quantify the effects of these differences. In most cases these differences will be relatively small. Some of the reasons for these differences are:

- **The IEA uses a Tier 1 method.**

The IEA uses a Tier 1 Sectoral Approach based on the *1996 IPCC Guidelines*. Countries may be using a Tier 2 or Tier 3 method that takes into account different technologies.

- **The IEA is using the *1996 IPCC Guidelines*.**

The IEA continues to use the *1996 IPCC Guidelines*. Some countries may have already started using the *2006 IPCC Guidelines*.

- **Energy activity data are extracted from the IEA energy balances and may differ from those used for the UNFCCC calculations.**

Countries often have several "official" data sources such as a Ministry, a Central Bureau of Statistics, a nationalised electricity company, etc. Data can also be collected from the energy suppliers, the energy consumers or customs statistics. The IEA Secretariat tries to collect the most accurate data, but does not necessarily have access to the complete data set that may be available to national experts calculating emission inventories for the UNFCCC. In addition to different sources, the methodology used by the national bodies providing the data to the IEA and to the UNFCCC may differ. For example, general surveys, specific surveys, questionnaires, estimations, combined methods and classifications of data used in national statistics and in their subsequent reclassification according to international standards may result in different series.

- **The IEA uses average net calorific values.**

The IEA uses an average net calorific value (NCV) for each secondary oil product. These NCVs are region-specific and constant over time. Country-specific NCVs that can vary over time are used for NGL, refinery feedstocks and additives. Crude oil NCVs are further split into production, imports, exports and average. Different coal types have specific NCVs for production, imports, exports, inputs to main activity power plants and coal used in coke ovens, blast furnaces and industry, and can vary over time for each country.

Country experts may have the possibility of going into much more detail when calculating the heat content of the fuels. This in turn could produce different values than the IEA.

- **The IEA uses average emission factors.**

The IEA uses the default emission factors which are given in the *1996 IPCC Guidelines*. Country experts may have better information available.

- **The IEA does not have detailed information for the stored carbon calculation.**

The IEA does not have complete information on the non-energy use of fuels. The amount of carbon stored is estimated using the default values given in the *1996 IPCC Guidelines*. For "other products" in the stored carbon calculation, the IEA assumes that 100% of kerosene, white spirit and petroleum coke that is reported as non-energy use in the energy balance is also stored. Country experts calculating the inventories may have more detailed information.

- **The IEA cannot allocate emissions from autoproducers into the end-use sectors.**

The *1996 IPCC Guidelines* recommend that emissions from autoproduction should be included with emissions from other fuel use by end-consumers. At the same time, the emissions from the autoproduction of electricity and heat should be excluded from the energy transformation source category to avoid double counting. The IEA is not able to allocate the fuel use from autoproducers between industry and *other*. Therefore, this publication shows a category called "Unallocated autoproducers". However, this should not affect the total emissions for a country.

- **Military emissions may be treated differently.**

According to the *1996 IPCC Guidelines*, military emissions should be reported in Source/Sink Category 1 A 5, *Other (not elsewhere specified)*. Previously, the IEA questionnaires requested that warships be included in international marine bunkers and that the military use of aviation fuels be included in domestic air. All other military use should have been reported in *non-specified other*.

At the IEA/Eurostat/UNECE Energy Statistics Working Group meeting (Paris, November 2004), participants decided to harmonise the definitions used to collect energy data on the joint IEA/Eurostat/UNECE questionnaires with those used by the IPCC to report GHG inventories. As a result, starting in the 2006 edition of this publication, all military consumption should be reported in *non-specified other*. Sea-going versus coastal is no longer a criterion for splitting international and domestic navigation.

However, it is not clear whether countries are reporting on the new basis, and if they are, whether they will be able to revise their historical data. The IEA has found that in practice most countries consider information on military consumption as confidential and therefore either combine it with other information or do not include it at all.

- **The IEA estimates include emissions from coke inputs into blast furnaces. Countries may have included these emissions in the IPCC category industrial processes.**

National GHG inventories submitted to the UNFCCC divide emissions according to source categories. Two of these IPCC Source/Sink Categories are energy and industrial processes. The IPCC Reference Approach estimates national emissions from fuel combustion based on the supply of fuel to a country and by implication includes emissions from coke inputs to blast furnaces in energy industry own use. However, within detailed sectoral calculations certain non-energy processes can be distinguished. In the reduction of iron in a blast furnace through the combustion of coke, the primary purpose of coke oxidation is to produce pig iron and the emissions can be considered as an industrial process. Care must be taken not to double count these emissions in both energy and industrial processes. The IEA estimates of emissions from fuel combustion in this publication include the coke inputs to blast furnaces.

- **The units may be different.**

The *1996 IPCC Guidelines* and the UNFCCC *Reporting Guidelines on Annual Inventories* both ask that CO_2 emissions be reported in Gg of CO_2. A million tonnes of CO_2 is equal to 1 000 Gg of CO_2, so to compare the numbers in this publication with national inventories expressed in Gg, the IEA emissions must be multiplied by 1 000.

CO_2 emissions per kWh

Coverage

In the first table on CO_2 emissions per kWh, the CO_2 emissions in the numerator include emissions from fossil fuels, industrial waste and non-renewable municipal waste that are consumed for electricity generation and electricity output in the denominator includes electricity generated from fossil fuels, nuclear, hydro (excluding pumped storage), geothermal, solar, biofuels, etc. As a result, the emissions per kWh can vary from year to year depending on the generation mix.

In the ratios of CO_2 emissions per kWh **by fuel**:

- Coal/peat includes primary and secondary coal, peat and coal gases.
- Oil includes oil products (and small amounts of crude oil for some countries).
- Gas represents natural gas.

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

Background on this indicator

In previous editions of this publication, the IEA has published an indicator for CO_2 emissions per kWh for the electricity and heat generating industries. The indicator is useful as an overall carbon intensity measure of a country's electricity and heat generating sectors, and it is easy to calculate. However, the indicator has a number of drawbacks. As the efficiency of heat generation is almost always higher than electricity generation, countries with large amounts of district heating (generally colder countries) will see a higher efficiency (therefore lower CO_2 intensity) than warmer countries with less district heating. Further, the applications of an indicator for electricity and heat are limited; many users have been searching for an electricity-only carbon intensity indicator.

It is not possible to obtain such an indicator directly from IEA energy balance data. For combined heat and power (CHP) plants, outputs of both electricity and heat exist, but there is only one input amount. While various methods exist to allocate this input amount between electricity and heat, none has previously been used by the IEA for the purposes of calculating a carbon intensity indicator. It would be possible to calculate an electricity-only indicator using data for electricity-only plants, which would not encounter the problem of assigning CHP inputs between electricity and heat. But this would not give a true comparison between countries; some countries get a majority of their electricity from CHP, while for others 100% of electricity comes from electricity-only plants. As non-thermal renewables are solely electricity-only plants, and over 99% of non-emitting global nuclear generation is from electricity-only plants, then calculating this electricity-only plants indicator would significantly understate the carbon intensity for many countries.

Allocation of emissions from CHP plants

After deciding that it was best to allocate the CHP inputs, a method had to be chosen. The simplest one would be to use the **proportionality approach** that is used by the IEA electricity questionnaire, which allocates inputs based upon the proportion of electricity and heat in the output. This is equivalent to fixing the efficiency of electricity and heat to be equal. This method has the advantage of simplicity and transparency. The disadvantage, however, is that the proportionality approach usually overstates electricity efficiency and understates heat efficiency. For CHP generation in OECD countries, total efficiency is around 60%. Applying this 60% to electricity generation is inaccurate, given that the OECD's total electricity-only plant efficiency is around 41% (and this includes 100% efficiency hydro and other renewables). Similarly, 60% is quite low for heat generation (given typical heat-only plant efficiencies of 80-95%), so a better allocation method was sought.

One way of avoiding the unrealistic efficiencies is to use a **fixed-heat-efficiency approach** which fixes the efficiency of the heat part of the generation, and calculates the electricity part of the input accordingly. As a typical heat boiler has an efficiency of 90%, it was decided to use this as the standard heat efficiency (except when the total CHP efficiency was greater than 90%, in which case the observed efficiency would be used). Of course in certain circumstances, this may be overstating the actual heat efficiency. Employing this method gave results that attributed more emissions to the electricity than when the proportionality approach is used, but that were much closer to those of electricity-only plants. Already the IEA has used the fixed-heat-efficiency approach for the last two editions of *World Energy Outlook*.

Comparison with the previous ratio

Applying this new methodology, the new electricity indicator is not significantly different from the previous electricity and heat indicator for the majority of OECD countries; for the OECD total in 2010, the new indicator is 3.2% higher. In this year, 20 of the OECD's 34 countries saw a change of 5% or less. Of the 14 countries changing more than 5%, six 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, thus lowering the indicator.

The countries in the OECD that saw larger increases to their ratio with the new method were generally coal-intensive countries with large amounts of heat generation; as mentioned, in general, heat plants are more efficient than electricity-only (or indeed CHP) plants and so excluding heat plants from the calculation increases CO_2 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_2-light natural gas while electricity-only plants tend to be powered by CO_2-heavy coal, making the new ratio more CO_2 intensive for these countries.

Fixed-heat-efficiency approach

$$CO2kWh = \frac{CO2_{ELE} + (CO2_{CHP}\ x\ \%\ from\ elec.) + OWNUSE_{ELE}}{ELoutput_{ELE} + ELoutput_{CHP}}$$

where:

$$\%\ from\ elec. = \frac{CHPinputs - ((HEoutput_{CHP}\ x\ 0.02388) \div EFF_{HEAT})}{CHPinputs}$$

and:

$$OWNUSE_{ELE} = OWNUSE\ x\ \frac{ELoutput}{ELoutput + (HEoutput \div 3.6)}$$

$CO2_{ELE}$ = CO_2 emissions from electricity only plants in ktCO_2
$CO2_{CHP}$ = CO_2 emissions from CHP plants in ktCO_2
OWNUSE = CO_2 emissions from own use in electricity, CHP and heat plants in ktCO_2

ELoutput = total electricity output from electricity and CHP plants in GWh
$ELoutput_{ELE}$ = electricity output from electricity only plants in GWh
$ELoutput_{CHP}$ = electricity output from CHP plants in GWh
HEoutput = total heat output from CHP and heat plants in TJ
$HEoutput_{CHP}$ = heat output from CHP plants in TJ

CHPinputs = energy inputs to CHP plants in ktoe
EFF_{HEAT} is assumed to be 0.9 (*i.e.* 90%) except when the efficiency of CHP generation is higher than 90%, in which case it is set at the higher value

Specific country examples

The country that increased its ratio the most within the OECD was **Estonia**; in 2010 the new electricity indicator was 38% higher than the previous electricity and heat indicator. This can be explained by the majority of electricity-only generation coming from oil shale, a fuel with a relatively high carbon emission factor, while heat plants (with a relatively large share of output) are largely fuelled by natural gas.

Another OECD country with a high ratio increase was **Denmark** (32% higher in 2010). The majority of fossil generation in Denmark is from CHP and the output from these plants is approximately half electricity and half heat. In addition, CHP plants in Denmark have efficiencies of 60-70%. When the heat part of CHP is set to be 90%, the efficiency of the electricity generation is lowered and thus moves the new indicator upwards.

In many non-member countries, heat data are either zero or not available, which leads to changes of less than 1% in three-quarters of the non-member countries in 2010. The majority of countries which do change are the European and former Soviet Union countries (where district heating is often present).

As **China** has no (reported) CHP generation, the current IEA energy balance shows electricity-only and heat-only plants, not CHP plants. Heat-only plants are in general much more efficient per unit of energy than electricity-only plants and this explains why the new ratio is 8% higher in 2010.

In the **Russian Federation**, a large amount (33% of total power output) comes from heat-only plants, whose relatively efficient generation is excluded from the new ratio. The large amount of heat output generated by CHP plants also explains why the new ratio is 108% higher in 2010.

The ratios for the following non-member countries are also lower than the previous estimates: **Georgia**, **Kyrgyzstan** and **Tajikistan**. This is because their electricity production is exclusively clean hydro, while their CHP and heat-only are exclusively fossil based. Implementing the new electricity-only indicator using the fixed-heat-efficiency approach increased hydro's weight (therefore decreasing the carbon intensity).

Implied emission factors from electricity generation

Summary tables presenting CO_2 emissions per kWh from electricity generation by country are presented in Part II. However, these values will vary enormously depending on the fuel mix of individual countries. Average implied emission factors by individual product for this sector are presented below. These values represent the average grammes of CO_2 per kWh of electricity produced in the OECD member countries between 2008 and 2010. These figures will reflect any problems that may occur in net calorific values or in input/output efficiencies. Consequently, these values are given as an approximation and actual values may vary considerably.

Fuel	**gCO_2 / kWh**
Anthracite *	920
Coking coal *	780
Other bituminous coal	860
Sub-bituminous coal	920
Lignite	990
Coke oven coke *	770
Coal tar *	720
BKB/peat briquettes *	800-1500
Gas works gas *	420
Coke oven gas *	420
Blast furnace gas *	2200
Other recovered gases *	2000
Natural gas	400
Crude oil *	630
Natural gas liquids *	480
Refinery gas *	400
Liquefied petroleum gases *	500
Kerosene *	650
Gas/diesel oil *	690
Fuel oil	670
Petroleum coke *	1000
Peat *	750
Industrial waste *	400-2000
Municipal waste (non-renewable)*	450-3500

* These fuels represent less than 1% of electricity output in the OECD. Values will be less reliable and should be used with caution.

6. IPCC METHODOLOGIES

General notes

The ultimate objective of the UNFCCC (the Convention) is the stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Convention also calls for all Parties to commit themselves to the following objectives:

- to develop, update periodically, publish and make available to the Conference of the Parties (COP) their national inventories of anthropogenic emissions by sources and removals by sinks, of all greenhouse gases not controlled by the Montreal Protocol.
- to use comparable methodologies for inventories of GHG emissions and removals, to be agreed upon by the COP.

As a response to the objectives of the UNFCCC, the IEA Secretariat, together with the IPCC, the OECD and numerous international experts, has helped to develop and refine an internationally-agreed methodology for the calculation and reporting of national GHG emissions from fuel combustion. This methodology was published in 1995 in the *IPCC Guidelines for National Greenhouse Gas Inventories*. After the initial dissemination of the methodology, revisions were added to several chapters, and published as the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*1996 IPCC Guidelines*). In April 2006, the IPCC approved the *2006 Guidelines* at the 25th session of the IPCC in Mauritius. For now, many countries (as well as the IEA Secretariat) are still calculating their inventories using the *1996 IPCC Guidelines* since this was the version used for the Kyoto Protocol.[2] In December 2011 in Durban, the Parties adopted Decision 15/CP.17 to update their reporting tables so as to implement the *2006 Guidelines*. These tables are currently under development and there will be a trial period that runs until end May 2013. The new reporting tables will be mandatory from 15 April 2015.

Since the IPCC methodology for fuel combustion is largely based on energy balances, the IEA estimates for CO_2 from fuel combustion published in this document have been calculated using the IEA energy balances and the default IPCC methodology. However, other possibly more detailed methodologies may be used by Parties to calculate their inventories. This may lead to different estimates of emissions.

The calculation of CO_2 emissions from fuel combustion may be done at three different levels referred to as Tiers 1, 2 and 3. The Tier 1 methods estimate the emissions from the carbon content of fuels supplied to the country as a whole (the Reference Approach) or to the main fuel combustion activities (Sectoral Approach). The following chapter summarises the IPCC Tier 1 methodology from the *1996 IPCC Guidelines*.

2. Both the *1996 IPCC Guidelines* and the *2006 IPCC Guidelines* are available from the IPCC Greenhouse Gas Inventories Programme (*www.ipcc-nggip.iges.or.jp*).

Reference Approach

Introduction

Carbon dioxide emissions are produced when carbon-based fuels are burned. National emissions estimates are based on the amounts of fuels used and on the carbon content of fuels.

Fuel combustion is widely dispersed throughout most activities in national economies and a complete record of the quantities of each fuel type consumed in each end-use activity is a considerable task, which some countries have not undertaken. Fortunately, it is possible to obtain a relatively accurate estimate of national CO_2 emissions by accounting for the carbon in fuels supplied to the economy. The supply of fuels is simple to record and the statistics are more likely to be available in many countries.

In accounting for fuels supplied[3] it is important to distinguish between *primary fuels* (i.e. fuels which are found in nature such as coal, crude oil, natural gas), and *secondary fuels* or fuel products, such as gasoline and lubricants, which are derived from primary fuels.

Accounting for carbon is based mainly on the supply of primary fuels and the net quantities of secondary fuels brought into the country.

To calculate supply of fuels to the country necessitates the following data for each fuel and year chosen:

- the amounts of primary fuels produced (production of secondary fuels is excluded);
- the amounts of primary and secondary fuels imported;
- the amounts of primary and secondary fuels exported;
- the amounts of fuel used for international marine and aviation bunkers (hereafter referred to as bunkers);
- the net increases or decreases in stocks of the fuels.

For each fuel, the production (where appropriate) and imports are added together and the exports, bunkers, and stock changes are subtracted to calculate the apparent consumption of the fuels. In cases where exports of secondary fuels exceed imports or stock increases exceed net imports, negative numbers will result.

The manufacture of secondary fuels is ignored in the main calculation, as the carbon in these fuels has already been accounted for in the supply of primary fuels from which they are derived. However, information on production of some secondary fuel products is required to adjust for carbon stored in these products.

Three other important points influence the accounting methodology:

3. The following discussion excludes all non-carbon energy sources such as nuclear, hydro, geothermal, solar, etc.

- **Stored carbon**

Not all fuel supplied to an economy is burned for heat energy. Some is used as a raw material (or feedstock) for manufacture of products such as plastics or in a non-energy use (e.g. bitumen for road construction), without oxidation (emissions) of the carbon. This is called s*tored carbon*, and is deducted from the carbon emissions calculation. Estimation of the stored carbon requires data for fuel use by activities using the fuel as raw material.

- **International bunker fuels**

The procedures given for calculating emissions ensure that emissions from the use of fuels for **international** marine and air transport are excluded from national emissions totals. However, for information purposes, the quantities and types of fuels delivered and the corresponding emissions from international marine and aviation bunkers should be separately reported.

- **Biomass fuels**

In the IPCC methodology, biofuels (fuels derived from biomass) are not included in the CO_2 emissions from fuel combustion and are only shown for informational purposes. This is because for CO_2 emissions, biomass consumption for fuel is assumed to equal its regrowth. Any departures from this hypothesis are counted within the land use, land use change and forestry module of the *1996 IPCC Guidelines*. For this reason, emissions from the burning of biomass for energy are not included in the CO_2 emissions from fuel combustion in this publication.

Methodology

The IPCC methodology breaks the calculation of carbon dioxide emissions from fuel combustion into six steps:

Step 1: Estimate apparent fuel consumption in original units

Step 2: Convert to a common energy unit

Step 3: Multiply by emission factors to compute the carbon content

Step 4: Compute carbon stored

Step 5: Correct for carbon unoxidised

Step 6: Convert carbon oxidised to CO_2 emissions

Completing Worksheet 1

This section is from the Workbook of the *1996 IPCC Guidelines* and provides step-by-step instructions for calculating emissions at the detailed fuels and fuel products level. Worksheet 1 can be consulted at the end of this chapter.

NOTE: The main worksheet allows CO_2 emissions from biofuels to be calculated but it does not include them in the national total.

Step 1 Estimating apparent fuel consumption

1 Apparent consumption is the basis for calculating the carbon supply for the country. To calculate apparent consumption (or total fuel supplied) for each fuel, the following data for primary fuels are entered:

- Production (Column A)
- Imports (Column B)
- Exports (Column C)
- International bunkers (Column D)
- Stock change (Column E)

For secondary fuels and products, the only figures entered are:

- Imports (Column B)
- Exports (Column C)
- International bunkers (Column D)
- Stock change (Column E)

These allow the overall calculation to account for all consumption.

Amounts of all fuels can be expressed in joules (J), megajoules (MJ), gigajoules (GJ), terajoules (TJ) or thousands of tonnes of oil equivalent (ktoe). Solid or liquid fuels can be expressed as thousands of tonnes (kt) and dry natural gas can be expressed as teracalories (Tcal) or cubic metres (m^3).

NOTE: The figure for production of natural gas, used in Worksheet 1, **does not** include quantities of gas vented, flared or re-injected into the well.

Quantities are expressed in terms of the net calorific values (NCV) of the fuels concerned. NCV is sometimes referred to as the lower heating value (LHV). NCVs are approximately 95% of the gross calorific value (GCV) for liquid fossil, solid fossil and biofuels, and 90% of the GCV for natural gas.

2 Apparent consumption is calculated for each fuel using this formula:

Apparent consumption =

Production + Imports - Exports - International bunkers - Stock change

The results are entered in Column F.

Particular attention is given to the algebraic sign of “stock change” as it is entered in Column E. When more fuel is added to stock than is taken from it during the year there is a net stock build and the quantity is entered in Column E with a plus sign. In the converse case (a stock draw) the quantity is entered in Column E with a minus sign.

Step 2 Converting to a common energy unit (TJ)

1 The conversion factor used for each fuel is entered in Column G.

2 The Apparent consumption is multiplied by the relevant conversion factor (NCV or scaling factor) to give apparent consumption in terajoules. The result is entered in Column H.

TABLE 1
CONVERSION FACTORS

Unit	*Conversion factor*
J, MJ or GJ	Number is divided by the appropriate factor, 10^{12}, 10^6 or 10^3 respectively, to convert to TJ.
10^6 toe	Number is multiplied by the conversion factor, 41868 TJ/10^6 toe, to convert to TJ.
Tcal	Number is multiplied by the conversion factor, 4.1868 TJ/Tcal.
10^3 t	The net calorific value of each fuel is used (see Table 2).

TABLE 2
SELECTED NET CALORIFIC VALUES

	Factors (TJ/10^3 tonnes)
Refined petroleum products	
Gasoline	44.80
Jet kerosene	44.59
Other kerosene	44.75
Shale oil	36.00
Gas/diesel oil	43.33
Fuel oil	40.19
LPG	47.31
Ethane	47.49
Naphtha	45.01
Bitumen	40.19
Lubricants	40.19
Petroleum coke	31.00
Refinery feedstocks	44.80
Refinery gas	48.15
Other oil products	40.19
Other products	
Coal oils and tars derived from coking coals	28.00
Oil shale	9.40
Orimulsion	27.50

NOTE: When converting from 10^3 t, for anthracite, coking coal, other bituminous coal, sub-bituminous coal and lignite, separate country-specific net calorific values are used for production (Column A), imports (Column B), and exports (Column C). For these fuels, apparent consumption is calculated by converting production, imports, exports, and stock changes to TJ first. For international bunkers (Column D) and stock change (Column E), either a weighted average net calorific value or a factor appropriate to the dominant source of supply is used.

Step 3 Multiplying by carbon emission factors

1 The carbon emission factor (CEF) used to convert apparent consumption into carbon content is entered in Column I.

Table 3 shows the default values used in this publication.

TABLE 3
CARBON EMISSION FACTORS (CEF)

Fuel	*Carbon emission factor (t C/TJ)*
LIQUID FOSSIL	
Primary fuels	
Crude oil	20.0
Orimulsion	22.0
Natural gas liquids	17.2
Secondary fuels/products	
Gasoline	18.9
Jet kerosene	19.5
Other kerosene	19.6
Shale oil	20.0
Gas/diesel oil	20.2
Residual fuel oil	21.1
LPG	17.2
Ethane	16.8
Naphtha	(20.0) [a]
Bitumen	22.0
Lubricants	(20.0) [a]
Petroleum coke	27.5
Refinery feedstocks	(20.0) [a]
Refinery gas	18.2 [b]
Other oil	(20.0) [a]
SOLID FOSSIL	
Primary fuels	
Anthracite	26.8
Coking coal	25.8
Other bituminous coal	25.8
Sub-bituminous coal	26.2
Lignite	27.6
Oil shale	29.1
Peat	28.9
Secondary fuels/products	
BKB & patent fuel	(25.8) [a]
Coke oven / gas coke	29.5
Coke oven gas	13.0 [b]
Blast furnace gas	66.0 [b]
GASEOUS FOSSIL	
Natural gas (dry)	15.3
BIOFUELS [c]	
Solid biofuels	29.9
Liquid biofuels	(20.0) [a]
Gas biofuels	(30.6) [a]

Notes to Table 3

(a) This value is a default value until a fuel specific CEF is determined. For biogases, the CEF is based on the assumption that 50% of the carbon in the biomass is converted to methane and 50% is emitted as CO_2. The CO_2 emissions from biogases should not be included in national inventories. If biogases are released and not combusted, 50% of the carbon content should be included as methane.

(b) For use in the sectoral calculations.

(c) Emissions from the use of biofuels are not shown in this publication.

2 The apparent consumption in TJ (in Column H) is multiplied by the carbon emission factor (in Column I) to give the carbon content in tonnes of C. The result is entered in Column J.

3 The carbon content in tonnes C is divided by 10^3 to give gigagrammes of carbon. The result is entered in Column K.

Step 4 Calculating carbon stored

1 **Estimating fuel quantities**

Bitumen and lubricants

Domestic production for bitumen and lubricants is added to the apparent consumption (shown in Column F of the main Worksheet 1) for these products and the sum is entered in Column A of Auxiliary Worksheet 1.

Coal oils and tars

For coking coal, the default assumption is that 6% of the carbon in coking coal consumed is converted to oils and tars. The apparent consumption for coking coal (from Worksheet 1, Column F) is multiplied by 0.06.

Starting with the 2006 edition, the IEA Secretariat has requested coal tar data on its annual coal questionnaire. In cases where this information has been provided, to be consistent with the *1996 IPCC Guidelines*, 75% of the part reported as non-energy was considered to be stored and the default 6% of coking coal was not applied.

Natural gas, LPG, ethane, naphtha and gas/diesel oil

The amount of these fuels used as a feedstock for non-energy purposes is entered in Column A.

2 **Converting to TJ**

The appropriate conversion factors are inserted in Column B of Auxiliary Worksheet 1. The estimated fuel quantities (Column A) are multiplied by the relevant conversion factor to give the estimated fuel quantities in TJ. The result is entered in Column C.

3 **Calculating carbon content**

The estimated fuel quantities in TJ (Column C of Auxiliary Worksheet 1) are multiplied by the emission factor in tonnes of carbon per terajoule (Column D) to give the carbon content in tonnes of C (Column E). The figures are divided by 10^3 to express the amount as gigagrammes of carbon. The results are entered in Column F.

4 **Calculating actual carbon stored**

The carbon content (Column F of Auxiliary Worksheet 1) is multiplied by the fraction of carbon stored (Column G) to give the carbon stored. The result is entered in Column H.

When Auxiliary Worksheet 1 is completed

5 The values for carbon stored for the relevant fuels/ products are entered in Column L of the main Worksheet 1.

6 The values for carbon stored (Column L) are subtracted from carbon content (Column K) to give net carbon emissions. The results are entered in Column M.

Step 5 Correcting for carbon unoxidised

1 The values for fraction of carbon oxidised are entered in Column N of Worksheet 1. Table 4 provides information on typical values measured from various facilities and suggests global default values for solid, liquid and gaseous fuels.

2 Net carbon emissions (Column M) are multiplied by the fraction of carbon oxidised (Column N) and the results are entered in Column O, actual carbon emissions.

TABLE 4
FRACTION OF CARBON OXIDISED

Coal[1]	0.98
Oil and oil products	0.99
Natural gas	0.995
Peat for electricity generation[2]	0.99

1.This figure is a global average but varies for different types of coal, and can be as low as 0.91.
2.The fraction for peat used in households may be much lower.

Step 6 Converting to CO_2 emissions

1 Actual carbon emissions (Column O) are multiplied by 44/12 (which is the molecular weight ratio of CO_2 to C) to find total carbon dioxide (CO_2) emitted from fuel combustion. The results are entered in Column P.

2 The sum is total national emissions of carbon dioxide from fuel combustion. These are the numbers shown for total CO_2 emissions from fuel combustion in this publication.

Sectoral Approach

Introduction

A sectoral breakdown of national CO_2 emissions using the defined IPCC Source/Sink Categories is needed for monitoring and abatement policy discussions. The IPCC Reference Approach provides a rapid estimate of the total CO_2 emissions from fuels supplied to the country but it does not break down the emissions by sector.

The more detailed calculations used for the Sectoral Approach are essentially similar in content to those used for the Reference Approach.

Completing Worksheet 2

This section is from the Workbook of the *1996 IPCC Guidelines* and provides step-by-step instructions for calculating emissions by fuels for each of the main source categories using the IPCC Tier 1 Sectoral Approach. A sample sheet of Worksheet 2 can be consulted at the end of this chapter.

Step 1 Estimating sectoral fuel consumption

The amount of each fuel consumed by sector is entered in Column A.

Energy industries and transformation

Special care needs to be taken when considering the fuel use of energy industries and transformation so that double counting is avoided.

Fuel use in energy industries and transformation can be divided into three groups:

Transformation

1 Fuels transformed into secondary fuels by physical or chemical processes not involving combustion (e.g. crude oil to petroleum products in refineries, coal to coke and coke oven gas in coke ovens);

2 Fuels combusted to generate electricity and/or heat (excluding fuels used for autoproduction of electricity and heat, which are reported in the sector where they are used);

Energy industries

3 Fuels combusted by energy industries (for energy extraction and transformation) for heating, pumping, traction and lighting purposes (e.g. refinery gas for heating distillation columns, use of colliery methane at mines for heating purposes).

In this worksheet, only fuel use by Groups 2 and 3 (fuels that are combusted) is included. However, see Step 4 for the reporting of lubricants used by energy industries. For emissions resulting from fuel use by Group 1, no worksheets are available. They should be reported under the IPCC Source/Sink Category 1B: fugitive emissions from fuels. It is most important that this distinction be appreciated. The quantities of ***primary*** fuels reported in Column A will understate the quantities used for Group 1 activities. The reported quantities cover only the combustion needs of these industries.

Step 2 Converting to a common energy unit (TJ)

1 The conversion factor (NCV or scaling factor) to convert to terajoules is entered in Column B.

2 The consumption is multiplied by the relevant conversion factor to give consumption in terajoules. The result is entered in Column C.

Step 3 Multiplying by carbon emission factors

1 The carbon emission factor used to convert consumption into carbon content is entered in Column D.

2 The consumption in TJ (in Column C) is multiplied by the carbon emission factor (in Column D) to give the carbon content in tonnes of carbon. The result is entered in Column E.

3 The carbon content in tonnes of carbon is divided by 10^3 to be expressed as gigagrammes of carbon. The result is entered in Column F.

Step 4 Calculating carbon stored

For the calculation of carbon stored, fuels are distinguished into four groups:

- Fuels used as feedstocks, such as naphtha, natural gas, gas/diesel oil, LPG or ethane;
- Lubricants;
- Bitumen and coal tars;
- Fuels for which no carbon is stored.

Fuels used as feedstocks, such as naphtha, natural gas, gas/diesel oil, LPG or ethane:

This subsection on feedstocks applies only to the industry source category.

1 **Estimating fuel quantities**

The amount of fuel used as a feedstock for non-energy purposes is entered in Column A of Auxiliary Worksheet 2.

2 **Converting to TJ**

The appropriate conversion factor is inserted in Column B. Feedstock use (Column A) is multiplied by the relevant conversion factor to give the feedstock use in TJ. The result is entered in Column C of Auxiliary Worksheet 2.

3 **Calculating carbon content**

The feedstock use in TJ (Column C) is multiplied by the emission factor in tonnes of carbon per terajoule (Column D) to give the carbon content in tonnes C (Column E). The figures are divided by 10^3 to express the amount as gigagrammes of carbon. The results are entered in Column F of Auxiliary Worksheet 2.

4 **Calculating actual carbon stored**

The carbon content (Column F) is multiplied by the fraction of carbon stored (Column G) to give the carbon stored. The result is entered in Column H of Auxiliary Worksheet 2.

After completion of Auxiliary Worksheet 2

5 The amount of carbon stored for the relevant fuel/ product is entered in Column H of Worksheet 2 for the industry source category.

6 The amount of carbon stored (Column H) is subtracted from the carbon content (Column F) to give net carbon emissions. The results are entered in Column I.

Lubricants:

It has been estimated that during the first use, recycling and final disappearance of lubricants, approximately half of the production is oxidised as CO_2.

1 For each sector where lubricants are used, the fraction of carbon stored for lubricants is entered in Column G. The default value of 0.5 is used for this publication.

2 The carbon content (Column F) is multiplied by the fraction of carbon stored (Column G) to obtain the amount of carbon stored. The result is entered in Column H.

3 The amount of carbon stored (Column H) is subtracted from the carbon content (Column F) to obtain the net carbon emissions. The result is entered in Column I.

Bitumen and coal tars:

Bitumen and coal tars are usually not combusted but used in a manner that stores almost all of the carbon. Emissions of non-methane volatile organic compounds (NMVOCs) from the use of bitumen for road paving are estimated in the industrial processes chapter.

Fuels for which no carbon is stored:

Step 4 is skipped and the values from Column F are entered in Column I before continuing with Step 5.

Step 5 Correcting for carbon unoxidised

1 Values for fraction of carbon oxidised are entered in Column J of Worksheet 2. Table 4 provides information on typical values measured from coal facilities and suggests global default values for solid, liquid and gaseous fuels.

2 Net carbon emissions (Column I) are multiplied by fraction of carbon oxidised (Column J) and the results are entered in Column K, actual carbon emissions.

Step 6 Converting to CO_2 emissions

1 Actual carbon emissions (Column K) are multiplied by 44/12 (which is the molecular weight ratio of CO_2 to C) to find actual carbon dioxide (CO_2) emissions. The results are entered in Column L and correspond to the sectoral emissions included in the present publication.

		MODULE	**ENERGY**					
		SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**					
		WORKSHEET	**1**					
		SHEET	**1 OF 5**					
			STEP 1					
			A Production	B Imports	C Exports	D International Bunkers	E Stock Change	F Apparent Consumption
FUEL TYPES								F=(A+B -C-D-E)
Liquid Fossil	Primary Fuels	Crude Oil						
		Orimulsion						
		Natural Gas Liquids						
	Secondary Fuels	Gasoline						
		Jet Kerosene						
		Other Kerosene						
		Shale Oil						
		Gas / Diesel Oil						
		Fuel Oil						
		LPG						
		Ethane						
		Naphtha						
		Bitumen						
		Lubricants						
		Petroleum Coke						
		Refinery Feedstocks						
		Other Oil						
Liquid Fossil Totals								
Solid Fossil	Primary Fuels	Anthracite[a]						
		Coking Coal						
		Other Bit. Coal						
		Sub-Bit. Coal						
		Lignite						
		Oil Shale						
		Peat						
	Secondary Fuels	BKB & Patent Fuel						
		Coke Oven/Gas Coke						
Solid Fossil Totals								
Gaseous Fossil		Natural Gas (Dry)						
Total								
Biofuels Total								
		Solid biofuels						
		Liquid biofuels						
		Biogases						

(a) If anthracite is not separately available, include with other bituminous coal.

		MODULE	ENERGY				
		SUBMODULE	CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)				
		WORKSHEET	1				
		SHEET	2 OF 5				
			STEP 2		STEP 3		
			G(a) Conversion Factor (TJ/Unit)	H Apparent Consumption (TJ)	I Carbon Emission Factor (tC/TJ)	J Carbon Content (tC)	K Carbon Content (GgC)
FUEL TYPES				H=(FxG)		J=(HxI)	K=(Jx10^{-3})
Liquid Fossil	Primary Fuels	Crude Oil					
		Orimulsion					
		Natural Gas Liquids					
	Secondary Fuels	Gasoline					
		Jet Kerosene					
		Other Kerosene					
		Shale Oil					
		Gas / Diesel Oil					
		Fuel Oil					
		LPG					
		Ethane					
		Naphtha					
		Bitumen					
		Lubricants					
		Petroleum Coke					
		Refinery Feedstocks					
		Other Oil					
Liquid Fossil Totals							
Solid Fossil	Primary Fuels	Anthracite(b)					
		Coking Coal					
		Other Bit. Coal					
		Sub-Bit. Coal					
		Lignite					
		Oil Shale					
		Peat					
	Secondary Fuels	BKB & Patent Fuel					
		Coke Oven/Gas Coke					
Solid Fossil Totals							
Gaseous Fossil		Natural Gas (Dry)					
Total							
Biofuels Total							
		Solid biofuels					
		Liquid biofuels					
		Biogases					

(a) Please specify units.
(b) If anthracite is not separately available, include with other bituminous coal.

		MODULE	**ENERGY**				
		SUBMODULE	**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**				
		WORKSHEET	**1**				
		SHEET	**3 OF 5**				
			STEP 4		**STEP 5**		**STEP 6**
			L Carbon Stored (GgC)	M Net Carbon Emissions (GgC)	N Fraction of Carbon Oxidised	O Actual Carbon Emissions (GgC)	P Actual CO_2 Emissions ($GgCO_2$)
FUEL TYPES				M=(K-L)		O=(MxN)	P=(Ox[44/12])
Liquid Fossil	Primary Fuels	Crude Oil					
		Orimulsion					
		Natural Gas Liquids					
	Secondary Fuels	Gasoline					
		Jet Kerosene					
		Other Kerosene					
		Shale Oil					
		Gas / Diesel Oil					
		Fuel Oil					
		LPG					
		Ethane					
		Naphtha					
		Bitumen					
		Lubricants					
		Petroleum Coke					
		Refinery Feedstocks					
		Other Oil					
Liquid Fossil Totals							
Solid Fossil	Primary Fuels	Anthracite[(a)]					
		Coking Coal					
		Other Bit. Coal					
		Sub-Bit. Coal					
		Lignite					
		Oil Shale					
		Peat					
	Secondary Fuels	BKB & Patent Fuel					
		Coke Oven/Gas Coke					
Solid Fossil Totals							
Gaseous Fossil		Natural Gas (Dry)					
Total							
Biofuels Total							
		Solid biofuels					
		Liquid biofuels					
		Biogases					

(a) If anthracite is not separately available, include with other bituminous coal.

MODULE		**ENERGY**					
SUBMODULE		**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**					
WORKSHEET		**1**					
SHEET		**4 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)**					
		STEP 1	**STEP 2**		**STEP 3**		
		A Quantities Delivered(a)	B Conversion Factor (TJ/unit)	C Quantities Delivered (TJ)	D Carbon Emission Factor (tC/TJ)	E Carbon Content (tC)	F Carbon Content (GgC)
FUEL TYPES				C=(AxB)		E=(CxD)	F=(E x 10^{-3})
Solid Fossil	Other Bituminous Coal						
	Sub-Bituminous Coal						
Liquid Fossil	Gasoline						
	Jet Kerosene						
	Gas/Diesel Oil						
	Fuel Oil						
	Lubricants						
			Total				

(a) Enter the quantities from Worksheet 1, Sheet 1, Column D: "International Bunkers".

MODULE		**ENERGY**					
SUBMODULE		**CO_2 FROM ENERGY SOURCES (REFERENCE APPROACH)**					
WORKSHEET		**1**					
SHEET		**5 OF 5 EMISSIONS FROM INTERNATIONAL BUNKERS (INTERNATIONAL MARINE AND AIR TRANSPORT)**					
		STEP 4			**STEP 5**		**STEP 6**
		G Fraction of Carbon Stored	H Carbon Stored (GgC)	I Net Carbon Emissions (GgC)	J Fraction of Carbon Oxidised	K Actual Carbon Emissions (GgC)	L Actual CO_2 Emissions ($GgCO_2$)
FUEL TYPES			H=(FxG)	I=(F-H)		K=(IxJ)	L=(Kx44/12)
Solid Fossil	Other Bituminous Coal	0	0				
	Sub-Bituminous Coal	0	0				
Liquid Fossil	Gasoline	0	0				
	Jet Kerosene	0	0				
	Gas/Diesel Oil	0	0				
	Fuel Oil	0	0				
	Lubricants	0.5					
						Total(a)	

(a) The bunker emissions are not to be added to national totals.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM ENERGY**
WORKSHEET	**AUXILIARY WORKSHEET 1: ESTIMATING CARBON STORED IN PRODUCTS**
SHEET	**1 OF 1**

	A Estimated Fuel Quantities	B Conversion Factor (TJ/Units)	C Estimated Fuel Quantities (TJ)	D Carbon Emission Factor (tC/TJ)	E Carbon Content (tC)	F Carbon Content (GgC)	G Fraction of Carbon Stored	H Carbon Stored (GgC)
FUEL TYPES			C=(AxB)		E=(CxD)	F=(Ex10^{-3})		H=(FxG)
Naphtha[(a)]							0.80	
Lubricants							0.50	
Bitumen							1.0	
Coal Oils and Tars (from Coking Coal)							0.75	
Natural Gas[(a)]							0.33	
Gas/Diesel Oil[(a)]							0.50	
LPG[(a)]							0.80	
Ethane[(a)]							0.80	
Other fuels[(b)]								

(a) Enter these fuels when they are used as feedstocks.
(b) Use the other fuels rows to enter any other products in which carbon may be stored.

MODULE	**ENERGY**					
SUBMODULE	**CO_2 FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)**					
WORKSHEET	**2 STEP BY STEP CALCULATIONS**					
SHEET	***SAMPLE SHEET - FILLED OUT FOR EACH SECTOR***					
Energy Industries	A Consumption	B Conversion Factor (TJ/unit)	C Consumption (TJ)	D Carbon Emission Factor (tC/TJ)	E Carbon Content (tC)	F Carbon Content (GgC)
specific fuels listed for each sector (a)			C=(AxB)		E=(CxD)	F=(E x 10^{-3})
		Total				
Memo items:						
Wood/Wood Waste						
Charcoal						
Other Solid Biofuels						
Liquid Biofuels						
Biogases						
		Total Biomass				

(a) Certain sectors have specific calculations for some products. See the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* for further details.

Module	**ENERGY**					
SUBMODULE	**CO_2 FROM FUEL COMBUSTION (TIER I SECTORAL APPROACH)**					
WORKSHEET	**2 STEP BY STEP CALCULATIONS**					
SHEET	***SAMPLE SHEET - FILLED OUT FOR EACH SECTOR***					
Energy Industries	G Fraction of Carbon Stored	H Carbon Stored (GgC)	I Net Carbon Emissions (GgC)	J Fraction of Carbon Oxidised	K Actual Carbon Emissions (GgC)	L Actual CO_2 Emissions ($GgCO_2$)
specific fuels listed for each sector (a)		H=(FxG)	I=(F-H)		K=(IxJ)	L=(K x [44/12])
					Total	
Memo items:						
Wood/Wood Waste						
Charcoal						
Other Solid Biofuels						
Liquid Biofuels						
Biogases						
					Total Biomass	

(a) Certain sectors have specific calculations for some products. See the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* for further details.

MODULE	**ENERGY**
SUBMODULE	**CO_2 FROM FUEL COMBUSTION BY (TIER I SECTORAL APPROACH)**
WORKSHEET	**AUXILIARY WORKSHEET 2: ESTIMATING CARBON STORED IN PRODUCTS**
SHEET	**1**

	A Feedstock Use	B Conversion Factor (TJ/Units)	C Feedstock Use (TJ)	D Carbon Emission Factor (tC/TJ)	E Carbon Content (tC)	F Carbon Content (GgC)	G Fraction of Carbon Stored	H Carbon Stored[a] (GgC)
FUEL TYPES			C=(AxB)		E=(CxD)	F=(Ex10^{-3})		H=(FxG)
Gas/Diesel Oil							0.5	
LPG							0.8	
Ethane							0.8	
Naphtha							0.8	
Natural Gas							0.33	
Other Fuels[b]								

(a) Enter the result of this calculation in Worksheet 2 Step by Step Calculation, in the m*anufacturing industries and construction* sector.
(b) Please specify.

7. GHG EMISSIONS: SOURCES AND METHODS

When looking at GHG emission trends, limiting the emissions to CO_2 from fuel combustion means that the estimates give an incomplete picture of total GHG emissions. Therefore, to put the CO_2 emissions from fuel combustion into context, information has been added from the emissions model “EDGAR”, developed by the Netherlands Environmental Assessment Agency (PBL) and the European Commission’s Joint Research Centre (JRC) to provide global anthropogenic emissions of greenhouse gases to be used as a reference database for science and policy applications.

The information in Part III (with the exception of CO_2 emissions from fossil fuel combustion) has been provided by Jos G.J. Olivier from PBL and Greet Janssens-Maenhout based on the EDGAR 4.2 FT2010 dataset. PBL and JRC are responsible for the calculation of the EDGAR 4.2 FT2010 data. Please see below for further details.

Background on PBL and JRC

The **PBL Netherlands Environmental Assessment Agency** is a government-funded agency that supports national and international policy makers by exploring future spatial and social trends that influence environmental, ecological and spatial quality, and by evaluating possible policy options. PBL explores the future quality of the environment and identifies possible strategic options. It aims to contribute to improving the quality of political and administrative decision-making at a regional, national, European and global scale by conducting outlook studies, analyses and evaluations in which an integrated approach and policy relevance are considered paramount.

PBL provides independent integrated assessments on topics such as sustainable development, energy and climate change, biodiversity, spatial planning, transport, land use and air quality. PBL acts as an interface between science and policy and provides the Netherlands government and international organisations such as EU/EEA, IEA/OECD, UN and the World Bank with sound, evidence-based assessments. PBL employs about 200 staff members and works in close collaboration with national and international partners, to assess future policies and the effects of policies already in place. A key feature of PBL research is taking a broad view of the subject matter and revealing the links between different spatial scales of investigation. This ranges from Dutch problems in the European and global context to global topics such as climate change, as well as European and global sustainability issues. PBL participates in the Topic Centre on Air and Climate Change of the European Environmental Agency (EEA), whose aim is to support EU policy on air pollution and climate change, together with 12 other organisations in Europe. PBL was also involved in the work of the IPCC’s National Greenhouse Gas Inventory Programme (NGGIP).

The **Joint Research Centre (JRC)** is a Directorate General of the European Commission (EC). The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. A service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether national or private. The Institute for Environment and Sustainability (IES) is one of seven institutes of the JRC, located in Ispra (Italy). The mission of IES is to provide scientific-technical support to the European Union's policies for the protection and sustainable development of the European and global environment. The IES adopts a systems-based approach to understand the complex interactions between human activity and the physical environment, and manage strategic resources (water, land, forests, food, minerals, etc.) in a more sustainable manner. Together with other JRC institutes, the IES provides the scientific basis for the conception, development, implementation and evaluation of EU policies that promote the greening of Europe and the global sustainable management of natural resources. The IES has over 400 staff members and manages several large-scale research infrastructures and hosts a large number of unique pan-European and global databases. The main customers of the IES are the Policy Directorates-General of the European Commission, other European bodies such as the European Environment Agency (EEA) and the European Space Agency (ESA), and global organisations such as the United Nations Environment Programme (UNEP) and the United Nations Food and Agricultural Organisation (FAO). The IES cooperates with international organisations such as UN-ECE, WHO, IPCC and NASA.

General note on EDGAR

Version 4 of the *Emission Database for Global Atmospheric Research*, in short the *EDGAR 4 system*, has been developed jointly by the European Commission’s Joint Research Centre (JRC) and the PBL Netherlands Environmental Assessment Agency. The aim of the EDGAR system, which was started in 1992 with financial support from the Netherlands’ former Ministry of Housing, Spatial Planning and the Environment (VROM) and the Netherlands’ National Research Programme on Global Air Pollution and Climate Change (NRP), is to provide global anthropogenic emissions of greenhouse gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 and of precursor gases and air pollutants CO, NO_x, NMVOC, SO_2 and the aerosols BC/OC, per source category, both at country/region levels as well as on a 0.1x0.1 degree grid. It is meant to serve as a reference database for policy applications, *e.g.* to provide JRC’s POLES global economic energy scenario model and PBL's integrated global change model IMAGE 2 with emissions data and for assessments of potentials for emission reductions, as well as for scientific studies by providing gridded emissions as input for atmospheric models. The latter function is part of the *Global Exchange and Interactions Activity* (GEIA), that combines efforts to produce gridded inventories for all compounds relevant for the modelling activities within the *Analysis, Integration and Modelling of the Earth System* (AIMES) project of the *International Geosphere-Biosphere Programme* (IGBP) and of ACCENT, a Network of Excellence funded by the EC, 6th Framework Programme (FP6), Priority 1.1.6.3 Global Change and Ecosystems. EDGAR data have also been used in the Fourth Report of IPCC Working Group III (IPCC, 2007).

Activity data were mostly taken from international statistical sources and emission factors for greenhouse gases were selected mostly from the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006) to ensure a consistent approach across countries. JRC and PBL have made all reasonable efforts to ensure that the information was generated correctly, but it is the responsibility of the EDGAR consortium to modify activity data when required to arrive at complete time series and for selecting the emission factors. It is stressed that the uncertainty in the resulting dataset at national level may be substantial, especially for methane and nitrous oxide, and even more so for the F-gases. The uncertainty is caused by the limited accuracy of international activity data used and in particular of emission factors selected for calculating emissions on a country level (Olivier *et al.*, 1999, 2001; Olivier and Berdowski, 2001; Olivier, 2002; Olivier *et al.*, 2005). However, since the methods used are either IPCC methodologies or comparable to them (see below), global totals comply with budgets used in atmospheric studies, plus the data were based on international information sources, this dataset provides a sound basis for comparability.

The main aim of the EDGAR 4.2 Fast Track 2010 (FT 2010) dataset was to provide an extended time series by adding emissions for 2009 and 2010. For the GHG update, the impact of CDM projects in developing countries to reduce CH_4, N_2O and HFC-23 emissions was taken into account. This applies to sources such as coal mines and landfills (CH_4 recovery), nitric acid and adipic acid production (N_2O) and the production of HCFC-22 (HFC-23), which now start to influence significantly global emission trends. In addition, a few errors found in the dataset have been corrected.

Although this dataset has been constructed with great care, JRC and PBL do not accept any liability from use of the data provided in this report including any inaccuracies or omissions in the data provided. For details on uncertainty and caveats identified in the dataset, as well as more detailed source category estimates, we refer user to the EDGAR 4 website at *edgar.jrc.ec.europa.eu*. Note that preliminary estimates for other more recent years than 2010 will be made publicly available through this website. Preliminary global trends of GHG emissions will also be made available at PBL (2012). For CO_2 emissions through to 2011 please refer to Olivier et al. (2012).

Source definitions

For carbon dioxide:

Fuel combustion refers to fossil fuel combustion and the unstored fraction of non-energy/feedstock use (IPCC Source/Sink Category 1A) estimated using the IPCC Sectoral Approach from the *Revised 1996 IPCC Guidelines* (see Chapter 6).

Fugitive refers to flaring of associated gas in oil and gas production (in some cases including indirect CO_2 from methane venting) (IPCC Source/Sink Category 1B).

Industrial Processes refers to production of cement, lime, soda ash, carbides, ammonia, methanol, ethylene and other chemicals, metals and to the use of soda ash, limestone and dolomite, and non-energy use of lubricants and waxes (IPCC Source/Sink Category 2). However, from EDGAR 4.1, only emissions from production of cement, lime and soda ash and from the use of soda ash, limestone and dolomite are included here, since all others were estimated by the IEA and reported under 'Fuel combustion'.

Other refers to direct emissions from forest fires and peat fires plus emissions from decay (decomposition) of aboveground biomass that remains after logging and deforestation and emissions from peat fires and decay of drained peat soils (IPCC Source/Sink Category 5). CO_2 from solvent use (IPCC Source/Sink Category 3), application of agricultural lime (IPCC Source/Sink Category 4) and from fossil fuel fires, notably coal fires and the Kuwait oil fires (IPCC Source/Sink Category 7), is also included here.

For methane:

Energy comprises production, handling, transmission and combustion of fossil fuels and biofuels (IPCC Source/Sink Categories 1A and 1B).

Agriculture comprises animals, animal waste, rice production, agricultural waste burning (non-energy, on-site) and savannah burning (IPCC Source/Sink Category 4).

Waste comprises landfills, wastewater treatment, human wastewater disposal and waste incineration (non-energy) (IPCC Source/Sink Category 6).

Others includes industrial process emissions such as methanol production, forest and peat fires and other vegetation fires (IPCC Source/Sink Categories 2 and 5).

For nitrous oxide:

Energy comprises combustion of fossil fuels and biofuels (IPCC Source/Sink Categories 1A and 1B).

Agriculture comprises fertiliser use (synthetic and animal manure), animal waste management, agricultural waste burning (non-energy, on-site) and savannah burning (IPCC Source/Sink Category 4).

Industrial Processes comprises non-combustion emissions from manufacturing of adipic acid, nitric acid, caprolactam and glyoxal (IPCC Source/Sink Category 2).

Others includes N_2O usage, forest and peat fires (including post-burn emissions from remaining biomass) and other vegetation fires, human sewage discharge and waste incineration (non-energy) and indirect N_2O from atmospheric deposition of NO_x and NH_3 from non-agricultural sources (IPCC Source/Sink Categories 3, 5, 6 and 7).

For fluorinated gases:

HFC emissions comprise by-product emissions of HFC-23 from HCFC-22 manufacture and the use of HFCs (IPCC Source/Sink Categories 2E and 2F).

PFC emissions comprise by-product emissions of CF_4 and C_2F_6 from primary aluminium production and the use of PFCs, in particular for the manufacture of semiconductors, flat panel displays and photovoltaic cells (IPCC Source/Sink Categories 2C, 2E and 2F). *SF_6 emissions* stem from various sources of SF_6 use, of which the largest is the use and manufacture of Gas Insulated Switchgear (GIS) used in the electricity distribution networks (IPCC Source/Sink Categories 2C and 2F) and from SF_6 production (Category 2E).

Data sources and methodology for EDGAR 4.2 FT2010

For EDGAR 4.2 Fast Track 2010 (EDGAR 4.2 FT2010) the same methods and data were applied for 1970-2008 as for EDGAR 4.2 FT 2008 that was used in last year's edition, however, with some corrections (CO_2 from power generation in the United States in 2008). For greenhouse gases the default emission factors from the *2006 IPCC Guidelines* (IPCC, 2006) were used instead of those of the *Revised 1996 IPCC Guidelines* (IPCC, 1997), except for CH_4 and N_2O from road transport where technology-specific factors were used from the EMEP-EEA emission inventory guidebook (EEA, 2009).

EDGAR 4.2 FT2010 provides an extended time series for all sources by adding emissions for 2009 and 2010. For the new Fast Track estimates for 2009 and 2010, for the main sources of each greenhouse gas as proxy of the emissions trend in these years, either the official national reported emissions trend from UNFCCC (2012) was used, or the trend in the latest activity data for 2008 to 2010, or statistics for an activity that was assumed to be a good proxy for that source. These statistics were sectoral CO_2 emissions (IEA, this publication), fossil-fuel production (IEA, 2012), gas flaring (NOAA/NCDC, 2012), production of steel, aluminium, cement, lime and ammonia (USGS, 2012; WSA, 2012), animal numbers, crop production and nitrogen fertiliser consumption (FAO, 2012), large-scale biomass burning (GFED 3; Van der Werf et al., 2010), photovoltaic solar cell production and flat panel display sales (IEA, 2011; and others).

For small-scale sources, such as industrial process sources of methane and nitrous oxide from caprolactam production, linear extrapolation of the past trend from 2005 to 2008 was assumed. These proxies – sometimes adjusted to incorporate significant trends in the emission factors – were applied to most sources, comprising more than 95% of the global total for gas. For important sources, where significant trends in the technology mix or in the application rate of emission control technology had occurred, trend estimates were included. In all other cases the mix and fraction of end-of-pipe abatement technology has been left unchanged after 2008.

To take into account non-CO_2 emission reductions that have occurred due to control measures implemented since 1990, officially reported emissions were used for Annex I countries (mainly countries that were already members of the OECD in 1990). These emission trends have been taken from the CRF emission data files which make up part of the National Inventory Reports (NIR) to the UNFCCC (UNFCCC, 2008, 2010, 2012). In addition, for non-CO_2 emission reductions in developing countries up to 2010, we used information on so-called CDM projects that have been implemented according to the “CDM pipeline” database maintained by the UNEP-Risø Centre (2011). This was done for methane recovery from coal mining and landfills, N_2O abatement in industrial processes and HFC-23 emission reductions from HCFC-22 manufacture.

Methods and data applied for all years except 2009 and 2010 are described below.

Energy / Fugitive / Biofuel

The data sources for **fugitive CO_2 emissions** and **CH_4 and N_2O from energy** are listed below. Data for fossil fuel production and use for 138 countries were taken from the IEA energy statistics for OECD and Non-OECD countries 1970-2008 (extended energy balances, in energy units) (IEA, 2007, 2010). This dataset comprises 94 sectors and 64 fuel types. For the countries of the Former Soviet Union and Former Yugoslavia a modified dataset was used to achieve a complete time series for the new countries from 1970 to 2008, the sum of which converges to the older dataset for the total Former Soviet Union and Yugoslavia. For another 62 countries, the aggregated IEA data for the regions ‘Other America’, ‘Other Africa’ and ‘Other Asia’ have been split using the sectoral IEA data per region together with total production and consumption figures per country of coal, gas and oil from energy statistics reported by the US Energy Information Administration (EIA, 2007, 2010).

Please note that the figures of CO_2 from fuel combustion and non-energy use of fuels in this report differ somewhat from the EDGAR 4.2 FT2010 dataset, for the following reasons:

- IEA energy statistics used for 1970-2008 may differ slightly due to revisions included in subsequent IEA releases. For EDGAR 4.2 FT2010 the releases of 2007 and 2010 were used for 1970-1999 and 2000-2008, respectively (IEA, 2007, 2010);
- the IEA uses the default CO_2 emission factors from the *Revised 1996 IPCC Guidelines*, which differ slightly due to different default oxidation factors (coal updated value +2%, oil products +1%, natural gas +0.5%) and updated defaults for carbon content for some fuels, the quality of which may vary considerably (mainly refinery gas, updated value -7%, coke oven gas -7%, blast furnace gas +7%, coke -1%);
- the IEA estimates CO_2 emissions from carbon released in fossil fuel use labelled in the sectoral energy balance as ‘non-energy use’ or ‘chemical feedstock’ using default fractions stored. For EDGAR 4.2 FT2010, for 1970-2008 default emission factors and methods from the *2006 IPCC Guidelines* were applied, which may give rise to considerable differences compared to the 1996 guidelines.

In addition, subtraction of the non-energy/feedstock fuel use part of the EDGAR 4.2 FT2010 dataset in order to combine it with the IEA CO_2 dataset also introduces some uncertainty.

To estimate CH_4 emissions from fossil fuel production and transmission, hard coal and brown coal production data have been separated into surface and underground mining based on various national reports. For gas transport and distribution, pipeline length was used as activity data. Pipeline length and material statistics are taken from reports on Europe by Eurogas and Marcogaz, national reports (*e.g.* the United States and Canada), UNFCCC (2008) and supplemental data from CIA (2008). Total amounts of natural gas flared (sometimes including gas vented) for most countries for 1994 onwards are primarily based on amounts of gas flared determined from the satellite observations of the intensity of flaring lights (Elvidge et al., 2009), reported by NOAA (2011). For other years before 1994 and for other countries emissions or emissions trends were supplemented by CO_2 trends from CDIAC (Marland *et al.*, 2006), EIA (2011) and UNFCCC (2010).

Biofuel data were also taken from IEA (2007). However, to avoid incomplete time series for large sectors, solid biomass consumption in the residential and commercial sectors in non-OECD countries were replaced by fuelwood and charcoal consumption from FAO (2007a). Vegetal waste used as fuel is based on the amounts of crop residues per country and fractions used as fuel based on Yevich and Logan (2003) and IPCC (2006). The amount of dung used as fuel is based on the total amount of manure produced per country and the fraction of total manure burned as fuel with fractions from IPCC (2006) and UNFCCC (2008). The results are rather close to the work of Fernandes *et al.* (2007) who made an extensive analysis of global and regional biofuel use in 2000. Charcoal production data were taken from IEA (2010) and supplemented or extrapolated using data from UN (2010) for 1990-2005 and FAO (2010) for pre-1990 data and 49 more countries not included in the IEA dataset.

Emission factors for fossil fuel production and use are based on the default values in the *2006 IPCC Guidelines* (IPCC, 2006). Methane emission factors for coal mining are based on average depths of coal production based on CIAB (1994), EURACOAL (2008), Kirchgessner *et al.* (1993) and include post mining emissions. Methane recovery from coal mining was included for twelve countries amounting to about 1.3 Tg in 1990 (of which about one-third was allocated to the United States and Germany). Recovery in 2005 was estimated at 2.8 Tg (of which 50% in China and 25% in the United States (UNFCCC, 2010; Thakur *et al.*, 1994, 1996; EPA, 2008; Cheng et al., 2011).

Emission factors for oil and gas production, transport and distribution were taken from IPCC (2006), supplemented with data from UNFCCC (2008), except for the emission factor for CH_4 from oil tanker transport which is from Rudd and Hill (2001). The CH_4 emission factor for venting and flaring has been derived from country-specific data reported to UNFCCC (2010), with the average value used as global default, applied to all other countries. The CO_2 emission factor excludes the indirect emissions through gas venting.

For N_2O from gasoline cars in road transport, the fraction of cars equipped with different types of catalytic converters was taken into account (based on various references). The factors for biofuel combustion were taken from the *2006 IPCC Guidelines*. For charcoal production the emissions factors are from Andreae (2011).

Industrial processes

Production data for the CO_2 sources cement, iron and steel, non-ferrous metals and various chemicals were based on UN Industrial Commodity Statistics (UN, 2006a), often supplemented for recent years by data from the US Geological Survey (USGS, 2007). The same method applied to paper, wine, beer and bread production. Data for other CO_2 sources such as production of lime, soda ash, ammonia, ferroalloys and non-ferrous metals were from USGS (2007, 2010), supplemented by data reported to the UNFCCC (2010). IFA (2007) was used for urea production (where it is assumed that the fossil carbon in CO_2 from ammonia production is stored) and FAO (2007a,c) for production of pulp, meat and poultry. Iron and steel production was further split into technologies (basic oxygen furnace, open hearth, electric arc furnace) using data from WSA (2010).

For the N_2O sources nitric acid, adipic acid and caprolactam, production data are based on UNFCCC (2010) and on smoothed and averaged SRIC (2005) data. For other industrial production for which no international statistics were available, such as silicon carbide and glyoxal, UNFCCC (2010) was used, though limited to Annex I countries.

However, for many countries interpolations and extrapolations were necessary to arrive at complete time series per country for 1970-2005/2008. Special attention had to be given to new EIT countries, in particular to Former Soviet Union and Former Yugoslavia countries, to maintain consistency with the older totals for the former countries.

Emission factors for CO_2, CH_4 and N_2O are described in IPCC (2006). Note that emissions of CO_2 from cement production are only a proxy for cement clinker production. The N_2O emission factors for the production of adipic acid, nitric acid, caprolactam and glyoxal are based on IPCC (2006). For adipic acid, abatement is only assumed from 1990 onwards if indicated in UNFCCC (2010) combined with activity data from SRIC (2005). For nitric acid in 1970, all old technology is assumed, changing their technology towards 1990 into high pressure plants in non-Annex I countries and a mix of low and medium pressure plants in Annex I countries that matches reported emissions in UNFCCC (2010). In addition, about 20% of global total production, all in Annex II countries, is equipped with Non-Selective Catalytic Reduction (NSCR) technology (Choe *et al.*, 1993). The emission factors for the F-gases as by-product emissions were based on IPCC (2006), but modified to match global emissions to observations of atmospheric concentrations.

Global annual total production of HCFC-22 was taken from AFEAS (2008) and McCulloch and Lindley (2007) and included captive production, but was modified using UNFCCC (2010) and other data sources. Primary aluminium production statistics per country from UN (2006a) were combined with smelter types characterised by one of five technologies according to Aluminium Verlag (2007) and Hunt (2004) for China. The default emission factor for HFC-23 from HCFC-22 manufacture was set for non-OECD countries at the IPCC default for old, un-optimised plants and for OECD countries at a somewhat lower and which decreased over time to reflect atmospheric concentrations. Country-specific fractions of emission abatement were estimated for six Annex II countries based on reported emissions in UNFCCC (2010) and UNEP Risø Centre (2011) for other countries. For aluminium production the CF_4 emission factors per technology were based on large-survey factors for 1990 to 2002 reported by IAI (2006, 2008), but with modifications for Söderberg technologies to comply with atmospheric concentration trends, and for C_2F_6 based on the ratio to CF_4 reported in IPCC (2006) for default Tier 2 emission factors.

Global consumption of HFC-125, 134a (in three applications) and 143a was taken from AFEAS (2008), for HFC-152a, 227ea, 245fa, 32 and 365mfc from Ashford *et al.* (2004) and for HFC-23, 236fa and 43-10-mee from UNFCCC (2008). Global HFC consumption was distributed to countries according to their share in global CFC-12 or CFC-11 consumption (ODP consumption statistics from the UN Ozone Secretariat) depending on their characteristics (either mostly for refrigeration/air-conditioning or mostly for other applications, largely foams/aerosols) and calibrated to regional totals calculated by Ashford *et al.* (2004)). Global emission factors for HFC use were derived from the emissions also reported by these data sources, except for HFC-125 and 143a which were from Ashford *et al.* (2004).

Global consumption data of PFCs (and SF_6) for semiconductor manufacture for Annex I countries in 1990 to 2005 were based on UNFCCC (2008) and the *National Inventory Report 2008* of Japan, for Taiwan on Lu (2006) and for other non-Annex I countries for 1995 and 2005 based on their global share in semiconductor manufacture (SEMI, 1998; SEMI, 2009). The trend from 1982 to 2005 of PFC use within four regions/countries (the United States, Japan, Europe and Rest of the World) was estimated from world market sales (SIA, 2006). Global CF_4 and SF_6 consumption and consumption in Taiwan for the production of flat panel displays for 2003 is from Lu (2006); trends and market shares per country from SEMI (2007). National consumption of PFCs for PV cells is based on the production per country of PV systems in m^2 (estimated from production statistics in MW for 1985-2003: Kammen, 2005; and for 1990, 1995, 2000-2007: Jäger-Waldau, 2008). The emission factors are from IPCC (2006), for semiconductors and FPD using the Tier 2a factors and for PV production taking into account the fraction of thin film production per country and assuming that 50% of the manufacturers uses PFCs. PFC consumption for other PFC uses was based on data for PFC use in fire extinguishing and air-conditioning, together with use as solvent reported by a few Annex I countries (UNFCCC, 2008), extrapolated to all Annex I countries and assuming an emission factor of 1.

Global consumption of SF_6 per application was taken from Knopman and Smythe (2007). For SF_6 containing switchgear, equipment manufacture and utility stock estimates were adjusted using the method in Mais and Brenninkmeijer (1998) with the regional and per country distribution based on various references (*e.g.* Mais and Brenninkmeijer, 1998; Bitsch, 1998, personal communication) and for missing countries and years based on the trend in the increase of electricity consumption as a proxy for GIS stock additions. For primary magnesium production and diecasting global consumption was distributed using production statistics from USGS (2007) and IMA (1999a,b) and others for the number of diecasting companies per country. Other sources were distributed as follows: sport shoes among Annex I countries based on GDP, tyres according to reported consumption in Germany (UNFCCC, 2008), sound insulating windows mainly in Germany with 10% used in neighbouring countries, aluminium production as reported in UNFCCC (2010), accelerators were distributed according to the number of high-energy physics laboratories and miscellaneous sources according to the number of airborne early warning systems such as AWACs. A major revision was made to soundproof window production and small revisions to other sources, partly based on UNFCCC (2010).

Note that both the variables for distributing global total consumption per source category and the emission factors vary widely between different plants and countries. This implies that the estimated emissions of F-gases at country level should be considered as very uncertain (an order of magnitude).

Please note that CO_2 from fossil carbon accounted for in this sector (such as from ammonia and carbide production, iron and steel production using a blast furnace and metal production through smelting processes with carbon anode consumption) and CO_2 from urea application in agriculture have been subtracted from the EDGAR 4.2 FT2010 data. This avoids double counting compared with the IEA CO_2 dataset for fuel combustion that includes these emissions (see section on Energy).

Solvent and other product use

For N_2O from the use of anaesthesia, an amount of 24 gN_2O and 34 gN_2O per capita in 2000 was used for EIT and Annex II countries, respectively, based on the average values in UNFCCC (2010) and tentatively set at 5 g/cap/year for non-Annex I countries, based on Kroeze (1994). A global declining rate of 20% between 1990 and 2005 was assumed as observed for total Annex I countries.

For N_2O from aerosol spray cans, an amount of 10 gN_2O per capita in 2000 was used for Annex I countries based on the average values in UNFCCC (2010), and none for non-Annex I countries. A uniform inclining rate from 1990 to 2005 of 50% was assumed as observed for total Annex I countries.

Agriculture

In general, the IPCC (2006) methodology and new default emission factors for CO_2, CH_4 and N_2O were used to estimate agricultural emissions, except for the instances specified below. Please note that N_2O emissions from agriculture as reported in EDGAR 4.2 FT2010 are substantially lower than those presently reported by most Annex I countries due to two markedly lower emission factors: 1) the default IPCC emission factor ("EF1") for direct soil emissions of N_2O from the use of synthetic fertilisers, manure used as fertiliser and from crop residues left in the field has been reduced by 20%; and 2) the default emission factor ("EF5") for indirect N_2O emissions from nitrogen leaching and run-off been reduced by 70% compared to the values recommended in the *1996 IPCC Guidelines* and the *IPCC Good Practice Guidance* (IPCC, 1997, 2000).

Livestock numbers were taken from FAO (2007b,c, 2010). For enteric fermentation by cattle, country-specific methane emission factors were calculated following the IPCC methodology (IPCC, 2006) using country-specific milk yield (dairy cattle) and carcass weight (other cattle) trends from FAO (2007c) to estimate the trends in the emission factors. For other animal types, regional emission factors from IPCC (2006) were used.

Livestock numbers were combined with estimates for animal waste generated per head to estimate the total amount of animal waste generated. Nitrogen excretion rates for cattle, pigs and chicken in Europe were based on the CAPRI model (Pérez, 2005; Britz, 2005; Leip *et al.*, 2007) and for all other countries and animal types in IPCC (2006), The trend in carcass weight was used to determine the development in nitrogen excretion over time. The shares of different animal waste management systems were based on regional defaults provided in IPCC (2006) and regional trend estimates for diary and non-dairy cattle for the fractions stall-fed, extensive grazing and mixed systems from Bouwman *et al.* (2005). Methane emissions from manure management were estimated by applying default IPCC emission factors for each country and temperature zone. For the latter, the 1x1 degree grid map for non-dairy cattle from Lerner *et al.* (1988) was used and the annual average temperature per grid cell from New *et al.* (1999) to calculate the livestock fractions of the countries in 19 annual mean temperature zones for cattle, swine and buffalo and three climates zones for other animals (cold, temperate, warm). N_2O emissions from manure management were based on distribution of manure management systems from Annex I countries reporting to the UNFCCC (2008), Zhou *et al.* (2007) for China and IPCC (2006) for the rest of the countries.

The total area for rice cultivation was obtained from FAO (2007d, 2010), which was split over different ecology types (rainfed, irrigated, deep water and upland) using IRRI (2007). The total harvested area of rice production in China was increased by 40%, due to recognition that official harvested rice area statistics for China largely underestimate the actual area (Denier van der Gon, 1999; 2000; personal communication, 2000). However, methane emission factors were not taken from IPCC (2006) but from a review of Neue (1997), and country-specific studies by Mitra *et al.* (2004), Gupta *et al.* (2002) and IIASA (2007). For the period 1970-2000 a trend in the emission factors was assumed based on data from Denier van der Gon (1999, 2000).

The same data as described above for manure management were used to estimate N_2O emissions from the use of animal waste as fertilizer by taking into account the loss of nitrogen that occurs from manure management systems before manure is applied to soils and additional nitrogen introduced by bedding material. N_2O emissions from fertilizer use and CO_2 from urea fertilization were estimated based on IFA (2007) and FAO (2007e) statistics and emission factors from IPCC (2006).

CO_2 emissions from liming of soils were estimated from Annex I country reports to the UNFCCC (2010), and on the use of ammonium fertilizers for other countries (FAO, 2007e) as liming is needed to balance the acidity caused by ammonium fertilizers.

Areas of cultivated histosols were estimated by combining three different maps: the FAO climate map (FAO Geonetwork, 2007a), the FAO soil map (FAO Geonetwork, 2007b) and the land use map of Goldewijk *et al.* (2007). However, where available areas reported by Annex I countries to the UNFCCC (2008) were used. Separate N_2O emission factors were applied for tropical and non-tropical regions (IPCC, 2006).

Nitrogen and dry-matter content of agricultural residues were estimated based on cultivation area and yield for 24 crop types from FAO (2007d) and IPCC (2006) factors. The fractions of crop residues removed from and burned in the field were estimated using data of Yevich and Logan (2003) and UNFCCC (2008) for fractions burned in the field by Annex I countries. Subsequently, N_2O emissions from crop residues left in the field and non-CO_2 emissions from field burning of the residues were calculated using IPCC (2006) emission factors.

Indirect N_2O emissions from leaching and runoff were estimated based on nitrogen input to agricultural soils as described above. Leaching and run-off was assumed to occur in other areas than non-irrigated dryland regions, which were identified based on FAO (1999; 2000; 2005) and Murray *et al.* (1999). The fraction of nitrogen lost through leaching and runoff was based on a study of Van Drecht *et al.* (2003). IPCC (2006) emission factors were used for indirect N_2O from leaching and runoff, as well as from deposition of agricultural NH_3 and NO_x emissions.

For savannah burning, estimates for areas burned are based on satellite measurements (see next section) and emission factors from IPCC (2006).

Large-scale biomass burning

For estimating the amounts of biomass burned in large-scale fires the three key parameters have to be multiplied: (a) area burned, (b) aboveground biomass density (fuel load) (kg/ha), and (c) fraction of aboveground biomass burned (combustion completeness). Country-specific data for large-scale biomass burning (total amount of dry matter burned, which were subdivided into tropical and non-tropical forest fires, savannah fires and grassland fires), have been taken from the gridded data at 1x1 degree grid of the *Global Fire Emissions Database* (GFED version 2; Van der Werf *et al.,* 2006) for the years 1997-2005. For years prior to 1997, the GFED v2.0 data were scaled back to 1970 using regional biomass burning trends from the RETRO dataset, covering the period 1960-2000 (Schultz *et al.*, 2008). GFED data for agricultural areas were attributed to savannah and grassland fires. There is an insignificant overlap with the EDGAR category for agricultural waste burning. The GFED data on biomass burning were estimated using burned area time series for 2001-2005 derived from the MODIS satellite sensors in combination with the fuel load estimated by the satellite-driven Carnegie-Ames-Stanford-Approach (CASA) biogeochemical model that was adjusted to account for fires. The 1997–2000 period was included using fire counts from the VIRS/ATSR sensors. The burning areas were mapped at 0.5x0.5 km spatial resolution. For some countries a correction was made to the time series for the allocation of biomass burned in savannahs and tropical forests. Since these sources have different emission factors, total emissions have changed for these countries. For 2006-2008 the trend in the activity data from the GFED v3 model (Van der Werf et al., 2010) was used, since the new dataset is not consistent with the previous version. The non-CO_2 emission factors for large scale biomass burning have been updated using data from Andreae (2011). The GHG emission factors were not taken from IPCC (2006), (which were from Andreae and Merlet (2001)), but updated values from Andreae (2011), including the carbon content of 0.47 kg C/kg dry matter, which is the default value for tropical forest. For greenhouse gas accounting purposes, net CO_2 emissions from savannah and grassland fires have been assumed to be zero (organic carbon in a short cycle). There is a large uncertainty in the assumptions for the carbon contents and the fraction of carbon that is actually being burned and thus in the amount of burned carbon.

CO_2 emissions from large-scale biomass burning are only one component of emissions from forest fires. Roughly half of the aboveground biomass is not burned, but rather decomposes over time. This results in delayed decay emissions of approximately the same level of magnitude as the direct emissions from the fires but distributed over a period of 10 to 20 years (IPCC, 2006). Post-burn CO_2 emissions have been estimated from the same activity data as direct burning emissions by assuming that remaining aboveground biomass decays in the 15 year2 after the year the fire or deforestation occurred, *i.e.* 1/15 per year and a carbon content of 0.47 kg C/kg dry matter tropical forest from IPCC (2006).

For CO_2 emissions from drained peatlands the comprehensive dataset of Joosten (2009) was used, comprising of activity data for 1990 and 2008 and CO_2 emission factors per hectare of drained peatland. For intervening years, the activity data were linearly interpolated, except for Indonesia, for which the trend in the area of palm oil plantations was used as proxy for the interpolation. For years before 1990 a linear increase from 0 in 1970 was assumed, with a few exceptions, where the area was assumed to remain constant prior to 1990. In EDGAR 4.2 FT2010 the amount of peat burned (in Indonesia only) has been separated from the amount of tropical forest burned in the GFED v2.0 dataset and different emission factors have been applied for most substances (Christian et al., 2003; Weiss (2002), resulting in different emissions.

In addition, enhanced N_2O emissions that occur after large-scale tropical biomass burning (Bouwman *et al.*, 1997) were calculated from the post-burn biomass dataset.

Waste handling

To estimate the amount of organic solid waste in landfills three key parameters have to be determined: (a) Municipal Sold Waste (MSW) generated per year (kg/cap), (b) fraction of total solid waste that is landfilled, and (c) fraction of Degradable Organic Carbon (DOC) in the MSW (%). Total and urban population figures were taken from UN (2006b).The amounts of Municipal Sold Waste (MSW) generated are the primary statistics for emissions from landfills. For 70 countries, the *2006 IPCC Guidelines* provide country-specific data for 2000 of the amount of MSW generated per year per capita (urban capita in case of non-Annex I countries) and the fraction landfilled and incinerated. For 58 more countries, country-specific values for the MSW generation per capita were found in the literature. For the remaining 91 countries, the waste generation per capita in 2000 was estimated using an exponential fit of the IPCC (2006) country-specific data for 70 countries of MSW/cap for 2000 to GDP/cap. For Annex I countries trend data for MSW generation/cap are available for the period 1990-2005 (UNFCCC, 2008). For other years and for other countries for which these data are not available, extrapolation from 2000 back and forward was done using the exponential fit mentioned above. When the country-specific fraction of MSW landfilled was missing, regional defaults provided in IPCC (2006) were used. In addition, UN statistics on MSW treatment may provide country-specific data for years other than 2000. Based on regional defaults for the composition of MSW, IPCC (2006) provides regional defaults for the fraction of Degradable Organic Carbon (DOC). For Annex I countries, country-specific data from UNFCCC (2008) were used (sometimes including a change over time) and for 94 Non-Annex I countries, country-specific MSW composition data were found, from which the average DOC value was calculated. However, in version 4.2, for a number of Annex I countries, the DOC fraction was adjusted to better reflect the overall emission trends for landfills as reported to UNFCCC (2008).

Calculation of methane emissions from landfills using the First Order Decay (FOD) model of IPCC (2006), the Methane Conversion Factor (MCF), requires the k-value and the Oxidation Factor (OX). The MCF is characterised by the type of landfill: managed aerobic or anaerobic, unmanaged deep or shallow. Apart from country-specific time series which are available for 11 Annex I countries, two sets of MCF time series for Annex I and non-Annex I countries were determined based on assumptions about the fractions of the four landfill types over time. For the k-value, which is the methane generation rate (inversely proportional to the half life value of the DOC), default regional MSW composition weighted k-values for four climate zones (tropical dry/wet and non-tropical dry/wet) were provided by IPCC (2006). For EDGAR 4.2 FT2010, country-specific values were calculated using the country-specific fractions of the population (urban population for non-Annex I countries) in each climate zone. The IPCC default values were used to estimate the Oxidation Factor (0.1 for Annex I and 0 for non-Annex I). Finally, the amounts of methane recovered (and used or flared) to be subtracted from the gross methane emissions, were taken as reported by Annex I countries in UNFCCC (2010) and for 23 non-Annex I countries from CDM projects reported by the UNEP Risø Centre (2011). Total recovery in 2010 is estimated at 12.9 Tg CH_4, half of which was by the United States and almost one fifth by the United Kingdom; about 13% is recovered by non-Annex I countries.

For domestic wastewater, total organics in wastewater (BOD_5) was estimated using regional default or country-specific default values for BOD_5 generation per capita per day provided by IPCC (2006). For industrial wastewater, total organically degradable material in wastewater from industry was calculated per type of industry from WW generation per ton of product and COD values (chemical oxygen demand (industrial degradable organic component in wastewater) in kg/m^3 WW, using defaults from IPCC (2006). Production statistics for industry types that produce most organics in wastewater are available from UN (2006a). Examples are meat and poultry, raw sugar, alcohol, pulp and organic chemicals. To estimate methane emissions from domestic wastewater, additional information is required on the WW treatment systems, such as sewer systems (to wastewater treatment plants (WWTP) or to raw discharge), latrines by type, open pits and septic tanks. Regional or country-specific default fractions for 2000 were from IPCC (2006). In addition, country-specific fractions of improved sanitation over time from Van Drecht *et al.* (2009) were used, based on the UN Water Supply and Sanitation (WSS) dataset and other national reports, and fractions reported by Doorn and Liles (1999). For industrial methane emissions, fractions of on-site treatment in WWTP, sewer with and without city-WWTP, and raw discharge were based on regional values reported by Doorn *et al.* (1997). To calculate methane emissions from wastewater, default factors provided by IPCC (2006) per type of WW treatment were used, with default methane correction factors (MCF) per type of treatment. For Annex I countries, OECD or EIT average fractions of methane recovered in WWTPs (and either used as biogas or flared) were used, except for five countries for which country-specific values reported in UNFCCC (2008) were used.

To estimate N_2O emissions from wastewater, the activity data used is the total annual amount of nitrogen in the wastewater, which was calculated from annual protein consumption per capita reported by FAO (2007f), using correction factors for non-consumed protein and for the fraction of industrial and commercial protein that is co-discharged. For the correction factors and the N_2O emission factor, defaults provided in IPCC (2006) were used.

Other waste sources are incineration, with activity data from UNFCCC (2008) and IPCC (2006) and extrapolations assuming a fixed ratio to landfilling, and composting (UNFCCC, 2008; ECN, 2008; CCC, 2008).

Other sources

Indirect N_2O emissions from atmospheric deposition of nitrogen of NO_x and NH_3 emissions from non-agricultural sources, mainly fossil fuel combustion and large scale biomass burning, were estimated using nitrogen in NO_x and NH_3 emissions from these sources as activity data, based on preliminary EDGAR 4.2 FT2010 data for these gases. The same IPCC (2006) emission factor was used for indirect N_2O from atmospheric deposition of nitrogen from NH_3 and NO_x emissions as was used for agricultural emissions.

General Note

We note that EDGAR 4.2 FT2010 estimates for all sources have been made for all years. For more detailed data of the EDGAR 4.2 FT2010 dataset, including the complete period 1970-2010 and possible small revisions upon the final release of the dataset and preliminary estimates for more recent years we refer to the EDGAR version 4 website at *edgar.jrc.ec.europa.eu*. Aggregated preliminary estimates can also be found at PBL (2012) and for CO_2 in Olivier et al. (2012).

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