WORLD TRANSITION INDICATORS
2019 EDITION

DATA DOCUMENTATION

This documentation provides support information for the IEA World *Transition Indicators* dataset. This document can be found online at: http://www.iea.org/statistics/.

Please address your inquiries to stats@iea.org.

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1. DATASET STRUCTURE

The dataset *World Transition Indicators* includes annual data for:

- countries: 162 countries and regional aggregates (see section *Geographical coverage*);
- years: 1990-2017;
  2018 (provisional data).

Detailed definitions of each flow are presented in section *Flow Definitions*.

2. FLOW DEFINITIONS

Transition Indicators		
Flow	**Short name**	**Definition**
Total CO2 fuel combustion (MtCO2)	CO2FUEL	*Total CO_2 fuel combustion* presents total CO_2 emissions from fuel combustion. This includes CO_2 emissions from fuel combustion in IPCC Source/Sink Category 1 A Fuel Combustion Activities and those which may be reallocated to IPCC Source/Sink Category 2 Industrial Processes and Product Use under the *2006 GLs*. This flow is calculated according to the following equation: $CO2FUEL = MAINPROD + AUTOPROD + OTHEN + TOTIND + TOTRANS + RESIDENT + COMMPUB + AGRICULT + FISHING + ONONSPEC$ For detailed definitions of the flows refer to the "CO_2 emissions from fuel combustion" database documentation: http://wds.iea.org/wds/pdf/Worldco2_Documentation.pdf For the most recent year available, this value is estimated for all OECD countries. Values are calculated based on provisional data for Total Primary Energy Supply (TPES) and on previous year's emissions from fuel combustion, according to the following equation: $CO2_y = \sum_i (\frac{CO2_{y-1,i}}{TPES_{y-1,i}}) \cdot TPES_{y,i}$ where: • *y: provisional year* • *i: fuel category: coal, oil, natural gas, other (industrial waste + non-renewable municipal waste)* • $CO2_{y-1}$ *: previous year's emissions from fuel combustion, calculated according to the 2006 GLs as specified above.*
CO2 / GDP (kgCO2 per 2010 USD)	CO2GDP	This ratio is expressed in kilogrammes of CO2 per 2010 US dollar. It has been computed using the total CO2 fuel combustion (CO2FUEL) emissions and GDP calculated using exchange rates. For a detailed definition of GDP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
CO2 / GDP PPP (kgCO2 per 2010 USD)	CO2GDPPP	This ratio is expressed in kilogrammes of CO2 per 2010 US dollar. It has been calculated using CO2 Fuel Combustion emissions (CO2FUEL) and GDP calculated using purchasing power parities. For a detailed definition of GDP PPP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Coal CO2 fuel combustion (MtCO2)	COALCO2	*Coal CO_2 fuel combustion* includes CO_2 emissions from fuel combustion deriving from coal, peat and oil shale. For the list of products included in coal refer to the "CO_2 emissions from fuel combustion" database documentation: http://wds.iea.org/wds/pdf/Worldco2_Documentation.pdf

Transition Indicators		
Flow	**Short name**	**Definition**
Oil CO2 fuel combustion (MtCO2)	OILCO2	*Oil CO_2 fuel combustion* includes CO_2 emissions from fuel combustion deriving from oil. For the list of products included in oil refer to the "CO_2 emissions from fuel combustion" database documentation: http://wds.iea.org/wds/pdf/Worldco2_Documentation.pdf
Gas CO2 fuel combustion (MtCO2)	GASCO2	*Gas CO_2 fuel combustion* includes CO_2 emissions from fuel combustion deriving from natural gas. For the list of products included in natural gas refer to the "CO_2 emissions from fuel combustion" database documentation: http://wds.iea.org/wds/pdf/Worldco2_Documentation.pdf
Total electricity and heat generation emissions (MtCO2)	ELECHEAT	Is the sum of emissions from electricity production, combined heat and power plants and heat plants. It is the sum of main activity producers and autoproducers. Emissions from own on-site use of fuel are included. For the most recent year available, this value is estimated for all countries with available provisional information on electricity and heat production. Values for every type of fuel are calculated based on provisional data for electricity and heat outputs and on previous year's carbon emission factors, according to the following equation: $$ELECHEAT_{i,y} = (ELOUTPUT_{i,y} + HEATOUT_{i,y}) \times CO2/kWh_{i,y-1}$$ where: • *y : provisional year* • *CO2kWh: carbon emission factors (in CO2/kWh) for electricity and heat together, for y-1 .* • $ELOUTPUT + HEATOUT$*: total electricity plus heat output (GWh).* • i*: fuel type, e.g. anthracite, diesel, natural gas…*
Transport emissions (MtCO2)	TOTTRANS	It contains emissions from the combustion of fuel for all transport activity, regardless of the sector, except for *international marine bunkers* and *international aviation bunkers*, which are not included in *transport* at a national or regional level (except for World transport emissions). This includes domestic aviation, domestic navigation, road, rail and pipeline transport, and corresponds to IPCC Source/Sink Category 1 A 3. The IEA data are not collected in a way that allows the autoproducer consumption to be split by specific end-use and therefore, this publication shows autoproducers as a separate item (*unallocated autoproducers*). Note: Starting in the 2006 edition, military consumption previously included in *domestic aviation* and in *road* should be in *non-specified other*.

Transition Indicators		
Flow	**Short name**	**Definition**
Industry emissions (MtCO2)	TOTIND	It contains the emissions from combustion of fuels in industry. The IPCC Source/Sink Category 1 A 2 includes these emissions. However, in the *2006 GLs*, 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*). This includes CO_2 emissions from fuel combustion which may be reallocated to IPCC Source/Sink Category 2 Industrial Processes and Product Use under the *2006 GLs*.
Residential emissions (MtCO2)	RESIDENT	It contains all emissions from fuel combustion in households. This corresponds to IPCC Source/Sink Category 1 A 4 b.
Commercial & public services emissions (MtCO2)	COMMPUB	It 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.
Other energy industries emissions (MtCO2)	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. This includes CO2 emissions from fuel combustion which may be reallocated to IPCC Source/Sink Category 2 Industrial Processes and Product Use under the *2006 IPCC Guidelines for GHG inventories.*
Agriculture and forestry emissions (MtCO2)	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].
Fishing emissions (MtCO2)	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].

Transition Indicators		
Flow	**Short name**	**Definition**
Final consumption not elsewhere specified emissions (MtCO2)	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.
Coal electricity and heat generation emissions (MtCO2)	ELECHEAT_C	It contains the sum of emissions from electricity production, combined heat and power plants and heat plants associated with coal combustion. It is the sum of main activity producers and autoproducers. Emissions from own on-site use of coal are included. For the most recent year available, this value is estimated for all countries with available provisional information on electricity and heat production from coal. Values are calculated based on provisional data for electricity and heat outputs and on previous year's coal carbon emission factor, according to the following equation: $\text{ELECHEAT}_y = (ELOUTPUT_y + HEATOUT_y) \times \text{CO}_2/\text{kWh}_{y-1}$ where: • y : provisional year • CO2kWh: carbon emission factors (in CO2/kWh) for electricity and heat together, for y-1 . • $ELOUTPUT + HEATOUT$: total electricity plus heat output (GWh).
Oil electricity and heat generation emissions (MtCO2)	ELECHEAT_O	It contains the sum of emissions from electricity production, combined heat and power plants and heat plants associated with oil combustion. It is the sum of main activity producers and autoproducers. Emissions from own on-site use of oil are included. For the most recent year available, this value is estimated for all countries with available provisional information on electricity and heat production form oil. Values are calculated based on provisional data for electricity and heat outputs and on previous year's oil carbon emission factor, according to the following equation: $\text{ELECHEAT}_y = (ELOUTPUT_y + HEATOUT_y) \times \text{CO}_2/\text{kWh}_{y-1}$ where: • y : provisional year • CO2kWh: carbon emission factors (in CO2/kWh) for electricity and heat together, for y-1 . • $ELOUTPUT + HEATOUT$: total electricity plus heat output (GWh).

Transition Indicators		
Flow	**Short name**	**Definition**
Gas electricity and heat generation emissions (MtCO2)	ELECHEAT_G	It contains the sum of emissions from electricity production, combined heat and power plants and heat plants associated with gas combustion. It is the sum of main activity producers and autoproducers. Emissions from own on-site use of gas are included. For the most recent year available, this value is estimated for all countries with available provisional information on electricity and heat production form gas. Values are calculated based on provisional data for electricity and heat outputs and on previous year's gas carbon emission factor, according to the following equation: $$\mathrm{ELECHEAT}_y = (ELOUTPUT_y + HEATOUT_y) \times \mathrm{CO_2/kWh}_{y-1}$$ where: • y : provisional year • CO2kWh: carbon emission factors (in CO2/kWh) for electricity and heat together, for y-1 . • ELOUTPUT + HEATOUT: total electricity plus heat output (GWh).
Final Energy Carbon Intensity (gCO2/MJ)	FECI	It is the ratio of *total CO2 fuel combustion* total Final Consumption and is calculated according to the following equation: $$FECI = \frac{\mathrm{CO2FUEL}}{TFC}$$
TPES/GDP (toe per thousand 2010 USD)	TPESGDP	Expressed as toe per thousand 2010 USD. Based on national GDP. For a detailed definition of TPES and GDP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
TPES/GDP (toe per thousand 2010 USD PPP)	TPESGDPPPP	Expressed as toe per thousand 2010 USD PPP. Based on national GDP. For a detailed definition of TPES and GDP PPP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Transport share in TFC (-)	TRANS_ENE	It represents the share of transport in Total Final Consumption and is calculated according to the following equation: $$TRANS\_ENE = \frac{\mathrm{TOTTRANS}}{TFC}$$ For a detailed definition of flows refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf

Transition Indicators		
Flow	**Short name**	**Definition**
Industry share in TFC (-)	TOTIND_ENE	It represents the share of industry in Total Final Consumption and is calculated according to the following equation: $$TRANS\_ENE = \frac{\text{TOTIND}}{TFC}$$ For a detailed definition of flows refer to the “World Energy Balances” database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Residential share in TFC (-)	RESID_ENE	It represents the share of residential in Total Final Consumption and is calculated according to the following equation: $$TRANS\_ENE = \frac{\text{RESIDENT}}{TFC}$$ For a detailed definition of flows refer to the “World Energy Balances” database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Commercial and public services share in TFC (-)	SERV_ENE	It represents defines the share of Commercial and public services in Total Final Consumption emissions and is calculated according to the following equation: $$TRANS\_ENE = \frac{\text{COMMPUB}}{TFC}$$ For a detailed definition of flows refer to the “World Energy Balances” database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Agriculture and forestry share in TFC (-)	AGRICULT_ENE	It represents defines the share of agriculture and forestry in Total Final Consumption emissions and is calculated according to the following equation: $$AGRICULT\_ENE = \frac{\text{AGRICULT}}{TFC}$$ For a detailed definition of flows refer to the “World Energy Balances” database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Fishing share in TFC (-)	FISHING_ENE	It represents defines the share of fishing in Total Final Consumption emissions and is calculated according to the following equation: $$FISHING\_ENE = \frac{\text{FISHING}}{TFC}$$ For a detailed definition of flows refer to the “World Energy Balances” database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf

Transition Indicators		
Flow	**Short name**	**Definition**
Final consumption not elsewhere specified share in TFC (-)	ONONSPEC_ENE	It represents defines the share of not elsewhere specified in Total Final Consumption emissions and is calculated according to the following equation: $$ONONSPEC\_ENE = \frac{\text{ONONSPEC}}{TFC}$$ For a detailed definition of flows refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Non-energy use share in TFC (-)	NONENUSE_ENE	It represents defines the share of non-energy use in Total Final Consumption emissions and is calculated according to the following equation: $$NONENUSE\_ENE = \frac{\text{NONENUSE}}{TFC}$$ For a detailed definition of flows refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Share of electricity in TFC (-)	ELECTFC	It represents the share of electricity in Total Final Consumption. For a detailed definition of Total Final Consumption refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Share of renewables in power generation (-)	RENEH	It represents the share of renewables sources in total electricity and heat generation. For a detailed definition of renewables refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Share of low carbon sources in power generation (-)	LOWCARBEH	It represents the share of low carbon sources (renewables + nuclear) in total electricity and heat generation. For a detailed definition of renewables and nuclear refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Share of coal in power generation (-)	COALEH	It represents the share of coal in total electricity and heat generation.
Share of oil in power generation (-)	OILEH	It represents the share of oil in total electricity and heat generation.
Share of gas in power generation (-)	GASEH	It represents the share of natural gas in total electricity and heat generation.

Transition Indicators		
Flow	**Short name**	**Definition**
Carbon intensity of road consumption (gCO2/MJ)	CO2ROAD	It represents the carbon intensity of *road* transport. For a detailed definition of road transport refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Share of biofuels in transport consumption (-)	BIOTRANS	It represents the share of biofuels in transport and is calculated according to the following equation: $BIOTRANS = \frac{\text{PRIMSBIO} + \text{BIOGASES} + \text{BIOGASOL} + \text{BIOJETKERO} + \text{BIODIESEL} + \text{OBIOLIQ}}{TOTTRANS}$ For a detailed definition of the flows refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf. Please note that in the documentation the shortname is TOTTRANS.
Carbon intensity of industry consumption (gCO2/MJ)	CO2IND	It defines the carbon intensity of industry. For a detailed definition of the flow refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf.
Passenger transport energy intensity per passenger-kilometres (MJ/pkm)	EI_PKM_TOT	It represents the energy consumed to drive one passenger over the distance of one kilometre and it is calculated as the ratio between energy consumption and passenger-kilometres travelled.
Manufacturing energy intensity per value added (MJ/USD PPP 2010)	EI_GDP_IND	This indicator represents the energy intensity of industry per value added (USD PPP 2010) and it is calculated as the ratio between energy consumption and value added. For a detailed definition of GDP PPP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Residential energy intensity per floor area temperature corrected (GJ/m2)	EI_PC_RES	Energy intensity per floor area (residential) calculated as energy consumption divided by floor area (temperature corrected to take into account different average temperatures in different years).

Transition Indicators

Flow	Short name	Definition
Services energy intensity per value added (MJ/USD PPP 2010)	EI_GDP_SER	This indicator represents the energy intensity of commercial and public services per value added (USD PPP 2010) and it is calculated as the ratio between energy consumption and value added. For a detailed definition of GDP PPP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
CO2 emissions index	ICO2EMIS	CO_2 Fuel Combustion emissions (CO2FUEL) expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions.
Population index	IPOP	Population expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions. For a detailed definition of POP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
GDP PPP per population index	IGDPPOP	GDP PPP per population expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions. For a detailed definition of GDPPOP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Energy intensity index - TPES / GDP PPP	ITPESGDP	TPES / GDP PPP expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions. For a detailed definition of TPES and GDP refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Carbon intensity index - CO2 / TPES	ICO2TPES	CO2 emissions / TPES expressed as an index, where the reference year = 100. Calculated using CO2 Fuel Combustion emissions (CO2FUEL). Year 2000 has been used as the reference year for all the countries and regions. For a detailed definition of TPES refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf
Elec output in GWh index	ELOUTPUT	Total electricity output in GWh expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions. For a detailed definition of total electricity output refer to the "World Energy Balances" database documentation: http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf

Transition Indicators		
Flow	**Short name**	**Definition**
Share of elec output from fossil fuels index	FOSSILELE	Share of electricity output from fossil fuels expressed as an index, where the reference year = 100. Fossil fuels include coal, oil shale, peat and peat products, oil and natural gas. Year 2000 has been used as the reference year for all the countries and regions.
CO2 intensity of fossil fuel mix index	CO2INTMIX	CO2 intensity of fossil fuel mix expressed as an index, where the reference year = 100. Fossil fuels include coal, oil shale, peat and peat products, oil and natural gas. Year 2000 has been used as the reference year for all the countries and regions.
Thermal eff of elec plants incl CHP elec index	THERMELEC	Thermal efficiency of electricity plants including CHP electricity expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions.
CO2 emissions from elec gen (incl CHP elec) index	CO2ELEC	CO2 emissions from electricity generation (including CHP electricity) expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions.
CO2 intensity of power index	CO2KWHHI	CO2 intensity of electricity and heat generation expressed as an index, where the reference year = 100. Year 2000 has been used as the reference year for all the countries and regions.

3. GEOGRAPHICAL COVERAGE

For the detailed list of countries and regions, please refer to: http://www.iea.org/statistics/topics/energybalances/.

4. METHODOLOGICAL NOTES

This publication is based on the data in physical units of the IEA *World Energy Statistics* publication, which follow the definitions of the *United Nations International Recommendations for Energy Statistics (IRES)*[1] and on the IEA energy balance methodology, briefly summarised below.

Energy balance: key concepts

Energy data are generally collected independently across different commodities. Energy statistics are the simplest format to present all the data together, assembling the individual balances of all products, each expressed in its own physical unit (e.g. TJ for natural gas, kt for coal, etc). These are called commodity balances.

However, energy products can be converted into one another through a number of transformation processes. Therefore, it is very useful to also develop one comprehensive national energy balance, to understand how products are transformed into one another, and to highlight the various relationships among them.

By presenting all the data in a common energy unit, the energy balance allows users to see the total amount of energy used and the relative contribution of each different source, for the whole economy and for each individual consumption sector; to compute the different fuel transformation efficiencies; to develop various aggregated indicators (for example consumption per capita or per unit of GDP) and to estimate CO_2 emissions from fuel combustion.

The energy balance is a natural starting point to study the evolution of the domestic energy market, forecast energy demand, monitor impacts of energy policies and assess potential areas for action. The statistician also uses the energy balance as a high-level check on the data accuracy, as large statistical differences in energy units, apparent energy gains or large losses in transformation processes, or large unexplained variations in shares or in high-level indicators may all indicate underlying data problems.

The energy balance takes the form of a matrix, where columns present all the different energy sources ("products") categories and rows represent all the different "flows", grouped in three main blocks: energy supply, transformation/energy use and final consumption.

To develop an energy balance from the set of commodity balances, the two main steps are: i) all the data are converted to a common energy unit – also allowing to compute a "total" product; and ii) some re-formatting is performed to avoid double counting when summing all products together. For example, for secondary products (e.g. motor gasoline) the production appears in the production row in commodity balances, but is reported as an output of the relevant transformation (e.g. oil refineries) in an energy balance, where the production row only refers to production of primary products (e.g. crude oil).

The methodological assumptions underlying energy balances, discussed in the next section, are particularly important to understand differences across balances derived by different national and international organisations starting from the same energy commodity data.

1. https://unstats.un.org/UNSD/energy/ires/default.htm.

IEA energy balances methodology

The unit adopted by the IEA is the tonne of oil equivalent (toe), defined as 10^7 kilocalories (41.868 gigajoules). This quantity of energy is, within a few per cent, equal to the net heat content of 1 tonne of crude oil. Conversion of the IEA energy balances to other energy units would be straightforward.

The main methodological choices underlying energy balances that can differentiate the final balances layout across organisations are: i) "net" versus "gross" energy content; ii) calorific values; and iii) primary energy conventions.

Net versus gross energy content

The IEA energy balances are based on a "**net**" energy content, which excludes the energy lost to produce water vapour during combustion. All the elements of the energy balance are expressed on the same net basis to ensure comparability. Even elements (e.g. natural gas) that in commodity balances may be already in energy units but on a different basis (e.g. "gross") are converted (e.g. from "gross" to "net").

The difference between the "net" and the "gross" calorific value for each fuel is the latent heat of vaporisation of the water produced during combustion of the fuel. For coal and oil, the net calorific value is about 5% less than gross, for most forms of natural and manufactured gas the difference is 9-10%, while for electricity and heat there is no difference as they are not combusted.

Calorific values

Generally, the IEA adopts country-specific, time-varying, and for some products flow-dependent, net calorific values supplied by national administrations for most products; and regional default values (in conjunction with Eurostat for the European countries) for the oil products. More detailed explanations on the IEA conversion to energy units for the different energy sources are given in Section 2, Units and conversions.

Primary energy conventions

A very important methodological choice is the definition of the "**primary energy equivalent**" for the electricity and heat produced from non-combustible sources, such as nuclear, geothermal, solar, hydro, wind. The information collected is generally the amount of electricity and heat produced, represented in the balance as an output of transformation. Conventions are needed to compute the most appropriate corresponding primary energy, input to the transformation, both in form and in amount.

The principle adopted by the IEA is that the **primary energy form** is *the first energy form downstream in the production process for which multiple energy uses are practical*. For example, the first energy form that can be used as energy in the case of nuclear is the nuclear heat of the reactor, most of which is then transformed into electricity. The application of this principle leads to the choice of the following primary energy forms:

- **Electricity** for primary electricity (hydro, wind, tide/wave/ocean and solar photovoltaic).
- **Heat** for heat and secondary electricity (nuclear, geothermal and solar thermal).

Once the primary energy form is identified for all electricity and heat generated from non-combustible sources, the IEA adopts the **physical energy content method** to compute the corresponding primary energy equivalent amounts: the primary energy equivalent is simply the physical energy content of the corresponding primary energy form.

For primary electricity, such as hydro and solar PV, as electricity is identified as the primary energy form, the primary energy equivalent is simply the gross electricity generated in the plant.

For nuclear electricity, the primary energy equivalent is the quantity of heat generated in the reactors. In the absence of country-specific information, the IEA estimates the primary energy equivalent from the electricity generated by assuming an efficiency of 33%, derived as the average efficiency of nuclear power plants across Europe. Note that the principle of using the heat from nuclear reactors as the primary energy form for the energy statistics has an important effect on any indicators of energy supply dependence. Under the present convention, the primary nuclear heat appears as an indigenous resource. However, the majority of countries using nuclear power import their nuclear fuel, and if this fact could be taken into account, it would lead to an increase in the supply dependence on other countries.

For geothermal electricity, the primary energy equivalent is the quantity of heat and a similar back-calculation is used where the quantities of steam supplied to the plant are not measured, assuming a thermal efficiency of 10%. This figure is only approximate and reflects the fact that the steam from geothermal sources is generally of low quality. If data for the steam input to geothermal power plants are available, they are used directly as primary energy equivalent.

Similarly, for solar thermal plants the heat supply is back-calculated assuming a 33% efficiency of conversion of heat into electricity, reflecting relatively low working temperatures, although central receiver systems can reach higher temperatures and therefore higher efficiencies.

In summary, for geothermal and solar thermal, if no country-specific information is reported, the primary energy equivalent is calculated using the following efficiencies:

- 10% for geothermal electricity;
- 50% for geothermal heat;
- 33% for solar thermal electricity;
- 100% for solar thermal heat.

An alternative to the physical energy content method is the **partial substitution method**, used in the past by the IEA. In this case, the primary energy equivalent of the electricity generated from non-combustible sources is computed as the hypothetical amount of energy necessary to generate the same amount of electricity in thermal power plants, assuming an average generation efficiency. The method was abandoned by the IEA and other organisations because it had little meaning for countries with significant hydro electricity generation, and because the actual substitution values were hard to establish, as they depended on the efficiency of the marginal electricity production. It also had unreal effects on the energy balance, as transformation losses appeared without a physical basis.

Since the two methods differ significantly in the treatment of solar, hydro, etc., the share of renewables in total energy supply varies depending on the method. To interpret shares of various energy sources in total supply, it is important to understand the conventions used to calculate the primary energy supply.

5. NOTES ON DATA QUALITY

Methodology

For OECD Member countries, the data shown in this publication are derived based on information provided in the five annual OECD questionnaires[2]: "Oil", "Natural Gas", "Solid Fossil Fuels and Manufactured Gases", "Renewables" and "Electricity and Heat" completed by the national administrations. For the member countries of the Economic Commission for Europe of the United Nations (UNECE) and a few others, the data shown in this publication are mostly based on information provided by the national administrations through the same annual questionnaires. The commodity balances for all other countries are based on national energy data of heterogeneous nature, converted and adapted to fit the IEA format and methodology.

Considerable effort has been made to ensure that the data presented in this publication adhere to the IEA definitions reported in the section on Methodological notes. These definitions, based on the *United Nations International Recommendations on Energy Statistics*[3], are used by most of the international organisations that collect energy statistics.

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

Recognised anomalies occurring in specific countries are presented in the section on Country notes and sources. Country notes present the most important deviations from the IEA methodology, and are by no means a comprehensive list of anomalies by country.

Estimation

In addition to adjustments addressing differences in definitions, estimations[4] are sometimes required to complete major aggregates, when key statistics are missing.

The IEA secretariat has attempted to provide all the elements of energy balances down to the level of final consumption, for all countries and years. Providing all the elements of supply, as well as all inputs and outputs of the main transformation activities (such as oil refining and electricity generation), has often required estimations. Estimations have been generally made after consultation with national statistical offices, oil companies, electricity utilities and national energy experts.

Time series and political changes

The IEA secretariat reviews its databases each year. In the light of new assessments, important revisions may be made to time series of individual countries during the course of this review. Therefore, some data in this publication have been substantially revised with respect to previous editions. Please always consult the section on Country notes and sources.

2. See link to the annual questionnaires: www.iea.org/statistics/resources/questionnaires/annual/
3. https://unstats.un.org/UNSD/energy/ires/default.htm.

4. Data may not include all informal and/or illegal trade, production or consumption of energy products, although the IEA Secretariat makes efforts to estimate these where reliable information is available.

More in general, energy statistics for some countries undergo continuous changes in their coverage or methodology. Consequently, breaks in time series are considered to be unavoidable.

For example, energy balances for the individual countries of the Former Soviet Union and the Former Yugoslavia have been constructed since 1990 and are not available for previous years. These balances are generally based on official submissions, but estimations also have been made by the IEA secretariat. The section on Country notes and sources describes in detail these elements country by country.

Classification of fuel uses

National statistical sources often lack adequate information on the consumption of fuels in different categories of end use. Many countries do not conduct annual surveys of consumption in the main sectors of economic activity, and published data may be based on out-of-date surveys. Therefore, sectoral disaggregation of consumption should generally be interpreted with caution.

In transition economies (countries of non-OECD Europe and Eurasia) and in China, the sectoral classification of fuel consumption before the reforms of the 1990's significantly differed from that of market economies. Sectoral consumption was defined according to the economic branch of the user, rather than according to the purpose or use of the fuel. For example, consumption of gasoline in the vehicle fleet of an enterprise attached to the economic branch 'Iron and steel' was classified as consumption in the 'Iron and steel' industry itself.

Where possible, data have been adjusted to fit international classifications, for example by assuming that most gasoline is consumed in transport. However, it has not been possible to reclassify products other than gasoline and jet fuel as easily, and few other adjustments have been made to other products.

Specific issues by fuel

Coal

Data on sectoral coal consumption are usually reported in metric tonnes. Net calorific values of different coal types used in different end use sectors are not always available. In the absence of specific information, the IEA secretariat estimates end use net calorific values based on the available net calorific values for production, imports and exports.

Oil

The IEA secretariat collects comprehensive statistics for oil supply and use, including oil for own use of refineries, oil delivered to international bunkers, and oil used as petrochemical feedstock. National statistics often do not report all these amounts.

Reported production of refined products may refer to net rather than gross refinery output; consumption of oil products may be limited to sales to domestic markets and may not include deliveries to international shipping or aircraft. Oil consumed as petrochemical feedstock in integrated refinery/petrochemical complexes is often not included in available official statistics.

Where possible, the IEA secretariat has estimated those unreported data, in consultation with the oil industry. In the absence of any other indication, refinery fuel use is estimated to be a percentage (e.g. 5%) of refinery throughput, and where possible, split between refinery gas and fuel oil. For a descript-tion of some adjustments made to the sectoral con-sumption of oil products, see the above section 'Classification of fuel uses'.

Natural gas

Natural gas should be comprised mainly of methane; other gases, such as ethane and heavier hydrocarbons, should be reported under the heading of 'oil'. The IEA defines natural gas production as the marketable production, i.e. net of field losses, flaring, venting and re-injection.

However, the lack of adequate definitions makes it difficult or impossible to identify all quantities of gas at all different stages of its separation into dry gas (methane) and heavier fractions. National data for natural gas do not always explicitly show separate quantities for field losses, flaring, venting and re-injection.

Natural gas supply and demand statistics are normally reported in volumetric units and it is difficult to obtain accurate data on the calorific value. In the absence of specific information, the IEA generally applies an average gross calorific value of 38 TJ/million m^3.

Reliable consumption data for natural gas at a disaggregated level are often difficult to find. This is especially true for some of the largest natural gas consuming countries in the Middle East. Therefore, industrial use of natural gas for these countries is frequently missing from the data published here.

Electricity

The IEA classification shows 'main activity producers' separately from 'autoproducers' of electricity and heat. An autoproducer of electricity is an establishment which, in addition to its main activities, generates electricity wholly or partly for its own use. For non-OECD countries, data on autoproducers are not always reported. In such cases, the quantities of fuels used as input to electricity are included under the appropriate end-use sector.

When statistics of production of electricity from biofuels and waste are available, they are included in total electricity production. However, these data are not comprehensive; for example, much of the electricity generated from waste biomass in sugar refining facilities remains unreported.

When unreported, inputs of fuels for electricity generation are estimated using information on electricity output, fuel efficiency and type of generation capacity.

Heat

For heat, transition economies (countries of non-OECD Europe and Eurasia) and China used to adopt a different methodology from that adopted in market economies. They allocated the transformation of primary fuels (coal, oil and gas) by industry into heat *for consumption on site* to the transformation activity '*heat production*', ***not*** to industrial consumption, as in the IEA methodology[5]. The transformation output of *Heat* was then allocated to the various end use sectors. The losses occurring in the transformation of fuels into heat in industry were not included in final consumption of industry.

Although a number of countries have recently switched to the practice of international organisations, this important issue reduces the possibility of cross-country comparisons for sectoral end use consumption between transition economies and market economies.

Biofuels and waste

The IEA publishes data on production, domestic supply and consumption of biofuels and waste for all countries and all regions.

Data for non-OECD countries are often based on secondary sources and may be of variable quality, which makes comparisons between countries difficult. For many countries, historical data are derived from surveys which were often irregular, irreconcilable and conducted at a local rather than national level.

Where historical series were incomplete or unavailable, they were estimated using a methodology consistent with the projection framework of the IEA's 1998 edition of *World Energy Outlook* (September 1998). First, nation-wide domestic supply per capita of biofuels and wastes was compiled or estimated for 1995. Then, per capita supply for the years 1971 to 1994 was estimated using a log/log equation with either GDP per capita or percentage of urban population as exogenous variables, depending on the region. Finally, supply of total biofuels and waste after 1996 was estimated assuming a growth rate either constant, equal to the population growth rate, or based on the 1971-1994 trend.

Those estimated time series should be treated very cautiously. The chart below provides a broad indication of the estimation methodology and of the data quality by region.

Region	Main source of data	Data quality	Exogenous variables
Africa	FAO database and AfDB	low	population growth rate
Non-OECD Americas	national and OLADE	high	none
Asia	surveys	high to low	population growth rate
Non-OECD Europe and Eurasia	questionnaires and FAO	high to medium	none
Middle East	FAO	medium to low	none

Given the importance of vegetal fuels in the energy picture of many developing countries, balances down to final consumption by end-use for individual products or product categories have been compiled for all countries.

The IEA hopes that the inclusion of these data will encourage national administrations and other agencies active in the field to enhance the level and quality of data collection and coverage for biofuels and waste. More details on the methodology used by each country may be provided on request and comments are welcome.

5. For autoproducer plants, the international methodology restricts the inclusion of heat in transformation processes to that sold to third parties.

6. UNITS AND CONVERSIONS

General conversion factors for energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
terajoule (TJ)	1	2.388×10^{2}	2.388×10^{-5}	9.478×10^{2}	2.778×10^{-1}
gigacalorie (Gcal)	4.187×10^{-3}	1	1.000×10^{-7}	3.968	1.163×10^{-3}
million tonnes of oil equivalent (Mtoe)	4.187×10^{4}	1.000×10^{7}	1	3.968×10^{7}	1.163×10^{4}
million British thermal units (MBtu)	1.055×10^{-3}	2.520×10^{-1}	2.520×10^{-8}	1	2.931×10^{-4}
gigawatt hour (GWh)	3.600	8.598×10^{2}	8.598×10^{-5}	3.412×10^{3}	1

Conversion factors for mass

To:	kg	t	lt	st	lb
From:	multiply by:				
kilogramme (kg)	1	1.000×10^{-3}	9.842×10^{-4}	1.102×10^{-3}	2.205
tonne (t)	1.000×10^{3}	1	9.842×10^{-1}	1.102	2.205×10^{3}
long ton (lt)	1.016×10^{3}	1.016	1	1.120	2.240×10^{3}
short ton (st)	9.072×10^{2}	9.072×10^{-1}	8.929×10^{-1}	1	2.000×10^{3}
pound (lb)	4.536×10^{-1}	4.536×10^{-4}	4.464×10^{-4}	5.000×10^{-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 U.S.)	1	8.327×10^{-1}	2.381×10^{-2}	1.337×10^{-1}	3.785	3.785×10^{-3}
U.K. gallon (gal U.K.)	1.201	1	2.859×10^{-2}	1.605×10^{-1}	4.546	4.546×10^{-3}
barrel (bbl)	4.200×10^{1}	3.497×10^{1}	1	5.615	1.590×10^{2}	1.590×10^{-1}
cubic foot (ft^3)	7.481	6.229	1.781×10^{-1}	1	2.832×10^{1}	2.832×10^{-2}
litre (l)	2.642×10^{-1}	2.200×10^{-1}	6.290×10^{-3}	3.531×10^{-2}	1	1.000×10^{-3}
cubic metre (m^3)	2.642×10^{2}	2.200×10^{2}	6.290	3.531×10^{1}	1.000×10^{3}	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)

Energy content

Coal

Coal has separate net calorific values for production, imports, exports, inputs to electricity/heat generation and coal used in coke ovens, blast furnaces and industry.

For electricity/heat generation, coal inputs to each type of plant (i.e. main activity electricity plant, autoproducer electricity plant, main activity CHP plant, autoproducer CHP plant, main activity heat plant, autoproducer heat plant) are converted to energy units using average factors calculated from the Annual Electricity Questionnaire. All other flows are converted using an average net calorific value.

Crude oil

Country-specific net calorific values (NCV) for production, imports and exports by country are used to calculate the balances. The average value is used to convert all the other flows to heat values.

Gases

World Energy Statistics expresses the following gases in terajoules, using their gross calorific value.

Gas data provided in joules should be converted as follows: Data in TJ / 41 868 = Data in Mtoe.

To calculate the net heat content of a gas from its gross heat content, multiply the gross heat content by the appropriate following factor.

Gas	Ratio NCV to GCV
Natural gas	0.9
Gas works gas	0.9
Coke oven gas	0.9
Blast furnace gas	1.0
Other recovered gases	1.0

Biofuels and waste

The heat content of primary solid biofuels, biogases, municipal waste and industrial waste, expressed in terajoules on a net calorific value basis, is presented in *World Energy Statistics*. The Secretariat does not receive information on volumes and other characteristics of these fuels.

Data in TJ / 41 868 = Data in Mtoe. Data for charcoal are converted from tonnes using the average net calorific values given in the electronic tables.

Unless country-specific information has been provided, data for biogasoline are converted from tonnes using 26 800 kJ/kg. Biodiesels and other liquid biofuels are assumed to have a net calorific value of 36 700 kJ/kg unless otherwise specified.

Oil products

For oil products, the IEA applies regional net calorific values (in conjunction with Eurostat for the European countries), except for the individual countries listed in the table at the end of this section.

Electricity

Figures for electricity production, trade, and final consumption are calculated using the energy content of the electricity. Electricity is converted as follows: Data in TWh x 0.086 = data in Mtoe.

Hydro-electricity production (excluding pumped storage) and electricity produced by other non-thermal means (wind, tide/wave/ocean, solar PV, etc.) are accounted for similarly. Gross electricity generation in TWh x 0.086 = primary energy equivalent in Mtoe.

The primary energy equivalent of nuclear electricity is calculated from the gross generation by assuming a 33% conversion efficiency. The calculation to be carried out is the following: gross electricity generation in TWh x 0.086 / 0.33 = primary energy equivalent in Mtoe.
In the case of electricity produced from geothermal heat, if the actual geothermal efficiency is not known, then the primary equivalent is calculated assuming an efficiency of 10%. The calculation to be carried out is

the following: gross electricity generation in TWh x 0.086 / 0.10 = primary energy equivalent in Mtoe.

For electricity produced from solar thermal heat, the primary equivalent is calculated assuming an efficiency of 33% unless the actual efficiency is known. The calculation to be carried out is the following: gross electricity generation in TWh x 0.086 / 0.33 = primary energy equivalent in Mtoe.

Heat

Information on heat is supplied in terajoules and is converted as follows: Data in TJ / 41 868 = Data in Mtoe.

In the case of heat produced in a geothermal plant, if the actual geothermal efficiency is not known, then the primary equivalent is calculated assuming an efficiency of 50%. The calculation to be carried out is the following: Heat production in TJ x 0.0000238 / 0.50 = primary energy equivalent in Mtoe.

For heat produced in a solar thermal plant, the primary equivalent is equal to the heat consumed. Data in TJ / 41 868 = data in Mtoe.

For direct use of geothermal and solar thermal heat, all the heat consumed is accounted for in production and consumption.

Examples

The following examples indicate how to calculate the net calorific content (in ktoe) of the quantities expressed in original units in *World Energy Statistics*.

From original units	To Mtoe (on a NCV basis)
Coking coal production (Poland) for 2016 in thousand tonnes	divide by 41 868 and then multiply by 29.606
Natural gas in terajoules (gross)	multiply by 2.38846 x 10^{-5} and then multiply by 0.9
Motor gasoline (Poland) in thousand tonnes	divide by 41 868 and then multiply by 44.000
Heat in terajoules (net)	multiply by 2.38846 x 10^{-5}

7. ABBREVIATIONS

Btu:	British thermal unit
GWh:	gigawatt hour
kcal:	kilocalorie
kg:	kilogramme
kJ:	kilojoule
Mt:	million tonnes
m^3:	cubic metre
t:	metric ton = tonne = 1,000 kg
TJ:	terajoule
toe:	tonne of oil equivalent = 10^7 kcal
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
pkm	passenger-kilometres
AfDB:	African Development Bank
EU-28:	European Union - 28
FAO:	Food and Agriculture Organisation of the United Nations
IEA:	International Energy Agency
IPCC:	Intergovernmental Panel on Climate Change
ISIC:	International Standard Industrial Classification
OECD:	Organisation for Economic Co-Operation and Development
OLADE:	Organización Latinoamericana de Energía
UN:	United Nations
UNIPEDE:	International Union of Producers and Distributors of Electrical Energy
c	confidential
e	estimated
..	not available
-	nil
x	not applicable