

Annex 8A.1 Prefixes, units and abbreviations, standard equivalents

Prefixes and multiplication factors

Multiplication Factor	Abbreviation	Prefix	Symbol
1 000 000 000 000 000	10^{15}	peta	P
1 000 000 000 000	10^{12}	tera	T
1 000 000 000	10^9	giga	G
1 000 000	10^6	mega	M
1 000	10^3	kilo	k
100	10^2	hecto	h
10	10^1	deca	da
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	μ

Units and abbreviations

cubic metre	m^3
hectare	ha
gram	g
tonne	t
Joule	J
degree Celsius	$^{\circ}\text{C}$
calorie	cal
year	yr
capita	cap
gallon	gal
dry matter	d.m.
kilogram	kg
pound	lb
atmosphere	atm
Pascal	Pa
hour	h
Watt	W

Units and abbreviations, and standard equivalents

1 tonne of oil equivalent (toe)	1 toe	1 x 10 ¹⁰ calories	1 x 10 ¹⁰ cal
1 ktoe		41.868 terajoules	41.868 TJ
1 short ton	1 sh t	0.9072 tonne	0.9072 t
1 tonne	1 t	1.1023 short tons	1.1023 sh t
1 tonne	1 t	1 megagram	1 Mg
1 kilotonne	1 kt	1 gigagram	1 Gg
1 megatonne	1 Mt	1 teragram	1 Tg
1 gigatonne	1 Gt	1 petagram	1 Pg
1 kilogram	1 kg	2.2046 pounds	2.2046 lb
1 hectare	1 ha	10 ⁴ squire meters	10 ⁴ m ²
1 calorie _{IT}	1 cal _{IT}	4.1868 Joules	4.1868 J
1 atmosphere	1 atm	101.325 kilopascal	101.325 kPa
1 gram	1 g	0.002205 pounds	0.00205 lb
1 pound	1 lb	453.6 gram	453.6 g
1 terajoule	1 TJ	2.78 x 10 ⁵ kiloWatt hour	2.78 x 10 ⁵ kWh
1 kilowatt hour	1 kWh	3.6 x 10 ⁶ Joules	3.6 x 10 ⁶ J

Formulae for chemical compounds

Chemical formula	Gas
CO ₂	Carbon dioxide
CH ₄	Methane
N ₂ O	Nitrous oxide
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF ₆	Sulphur hexafluoride
NF ₃	Nitrogen trifluoride
SF ₅ CF ₃	Trifluoromethyl sulphur pentafluoride
CFCs	Chlorofluorocarbons
CHF ₃	HFC-23
CH ₂ F ₂	HFC-32
CH ₃ F	HFC-41
CHF ₂ CF ₃	HFC-125
CHF ₂ CHF ₂	HFC-134
CH ₂ FCF ₃	HFC-134a
CHF ₂ CH ₂ F	HFC-143
CF ₃ CH ₃	HFC-143a
CH ₂ FCH ₂ F	HFC-152
CH ₃ CHF ₂	HFC-152a
CH ₃ CH ₂ F	HFC-161
CF ₃ CHFCF ₃	HFC-227ea
CH ₂ FCF ₂ CF ₃	HFC-236cb
CHF ₂ CHFCF ₃	HFC-236ea

Figure 1.1 shows the structure of activities and *source categories* within the energy sector. This structure is based on the coding and naming as defined in *the 1996 IPCC Guidelines and the Common Reporting Format (CRF)* used by the UNFCCC. The technical chapters of this Volume follow this source category structure.

1.3 METHODOLOGICAL APPROACHES

1.3.1 Emissions from fossil fuel combustion

There are three Tiers presented in the *2006 IPCC Guidelines* for estimating emissions from fossil fuel combustion. In addition a Reference Approach is presented. It can be used as an independent check of the sectoral approach and to produce a first-order estimate of national greenhouse gas emissions if only very limited resources and data structures are available to the inventory compiler.

The *2006 IPCC Guidelines* estimate carbon emissions in terms of the species which are emitted. During the combustion process, most carbon is immediately emitted as CO₂. However, some carbon is released as carbon monoxide (CO), methane (CH₄) or non-methane volatile organic compounds (NMVOCs). Most of the carbon emitted as these non-CO₂ species eventually oxidises to CO₂ in the atmosphere. This amount can be estimated from the emissions estimates of the non-CO₂ gases (See Volume 1, Chapter 7).

In the case of fuel combustion, the emissions of these non-CO₂ gases contain very small amounts of carbon compared to the CO₂ estimate and, at Tier 1, it is more accurate to base the CO₂ estimate on the total carbon in the fuel. This is because the total carbon in the fuel depends on the fuel alone, while the emissions of the non-CO₂ gases depend on many factors such as technologies, maintenance etc which, in general, are not well known. At higher tiers, the amount of carbon in these non-CO₂ gases can be accounted for.

Since CO₂ emissions are independent of combustion technology whilst CH₄ and N₂O emissions are strongly dependent on the technology, this chapter only provides default emission factors for CO₂ that are applicable to all combustion processes, both stationary and mobile. Default emission factors for the other gases are provided in subsequent chapters of this volume, since combustion technologies differ widely between source categories within the source sector “Combustion” and hence will vary between these subsectors.

1.3.1.1 TIERS

TIER 1

The Tier 1 method is fuel-based, since emissions from all sources of combustion can be estimated on the basis of the quantities of fuel combusted (usually from national energy statistics) and average emission factors. Tier 1 emission factors are available for all relevant direct greenhouse gases.

The quality of these emission factors differs between gases. For CO₂, emission factors mainly depend upon the carbon content of the fuel. Combustion conditions (combustion efficiency, carbon retained in slag and ashes etc.) are relatively unimportant. Therefore, CO₂ emissions can be estimated fairly accurately based on the total amount of fuels combusted and the averaged carbon content of the fuels.

However, emission factors for methane and nitrous oxide depend on the combustion technology and operating conditions and vary significantly, both between individual combustion installations and over time. Due to this variability, use of averaged emission factors for these gases, that must account for a large variability in technological conditions, will introduce relatively large uncertainties.

TIER 2

In the Tier 2 method for energy, emissions from combustion are estimated from similar fuel statistics, as used in the Tier 1 method, but country-specific emission factors are used in place of the Tier 1 defaults. Since available country-specific emission factors might differ for different specific fuels, combustion technologies or even individual plants, activity data could be further disaggregated to properly reflect such disaggregated sources. If these country-specific emission factors indeed are derived from detailed data on carbon contents in different batches of fuels used or from more detailed information on the combustion technologies applied in the country, the uncertainties of the estimate should decrease, and the trends over time can be better estimated.

If an inventory compiler has well documented measurements of the amount of carbon emitted in non-CO₂ gases or otherwise not oxidised, it can be taken into account in this tier in the country-specific emission factors. It is *good practice* to document how this has been done.

TABLE 1.1 DEFINITIONS OF FUEL TYPES USED IN THE 2006 IPCC GUIDELINES		
English Description	Comments	
LIQUID (Crude oil and petroleum products)		
Crude Oil	Crude oil is a mineral oil consisting of a mixture of hydrocarbons of natural origin, being yellow to black in colour, of variable density and viscosity. It also includes lease condensate (separator liquids) which are recovered from gaseous hydrocarbons in lease separation facilities.	
Orimulsion	A tar-like substance that occurs naturally in Venezuela. It can be burned directly or refined into light petroleum products.	
Natural Gas Liquids (NGLs)	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. They may also include small quantities of non-hydrocarbons.	
Gasoline	Motor Gasoline	This is light hydrocarbon oil for use in internal combustion engines such as motor vehicles, excluding aircraft. Motor gasoline is distilled between 35°C and 215°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).
	Aviation Gasoline	Aviation gasoline is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine, a freezing point of -60°C, and a distillation range usually within the limits of 30°C and 180°C.
	Jet Gasoline	This includes all light hydrocarbon oils for use in aviation turbine power units. They distil between 100°C and 250°C. It is obtained by blending kerosenes and gasoline or naphthas in such a way that the aromatic content does not exceed 25 percent 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.
Jet Kerosene	This is medium distillate used for aviation turbine power units. It has the same distillation characteristics and flash point as kerosene (between 150°C and 300°C but not generally above 250°C). In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA).	
Other Kerosene	Kerosene comprises refined petroleum distillate intermediate in volatility between gasoline and gas/diesel oil. It is a medium oil distilling between 150°C and 300°C.	
Shale Oil	A mineral oil extracted from oil shale.	
Gas/Diesel Oil	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°C and 380°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°C and 540°C and are used as petrochemical feedstocks.	
Residual Fuel Oil	This heading defines oils that make up the distillation residue. It comprises all residual fuel oils, including those obtained by blending. Its kinematic viscosity is above 0.1cm ² (10 cSt) at 80°C. The flash point is always above 50°C and the density is always more than 0.90 kg/l.	
Liquefied Petroleum Gases	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 ₃ H ₈) and butane (C ₄ H ₁₀) or a combination of the two. They are normally liquefied under pressure for transportation and storage.	

TABLE 1.1 (CONTINUED) DEFINITIONS OF FUEL TYPES USED IN THE 2006 IPCC GUIDELINES		
English Description	Comments	
LIQUID (Crude oil and petroleum products)		
Ethane	Ethane is a naturally gaseous straight-chain hydrocarbon (C ₂ H ₆). It is a colourless paraffinic gas which is extracted from natural gas and refinery gas streams.	
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 in the 30°C and 210°C distillation range or part of this range.	
Bitumen	Solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in colour, obtained as a residue in the distillation of crude oil, vacuum distillation of oil residues from atmospheric distillation. 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.	
Lubricants	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.	
Petroleum Coke	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 percent) 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.	
Refinery Feedstocks	A refinery feedstock is a product or a combination of products derived from crude oil and destined for further processing 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.	
Other Oil	Refinery Gas	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.
	Waxes	Saturated aliphatic hydrocarbons (with the general formula C _n H _{2n+2}). These waxes are residues extracted when dewaxing lubricant oils, and they have a crystalline structure with carbon number greater than 12. Their main characteristics are that they are colourless, odourless and translucent, with a melting point above 45°C.
	White Spirit & SBP	White spirit and SBP are refined distillate intermediates with a distillation in the naphtha/kerosene range. They are sub-divided as: i) Industrial Spirit (SBP): Light oils distilling between 30°C and 200°C, with a temperature difference between 5 percent volume and 90 percent volume distillation points, including losses, of not more than 60°C. In other words, SBP is a light oil of narrower cut than motor spirit. There are 7 or 8 grades of industrial spirit, depending on the position of the cut in the distillation range defined above. ii) White Spirit: Industrial spirit with a flash point above 30°C. The distillation range of white spirit is 135°C to 200°C.
	Other Petroleum Products	Includes the petroleum products not classified above, for example: tar, sulphur, and grease. This category also includes aromatics (e.g. BTX or benzene, toluene and xylene) and olefins (e.g. propylene) produced within refineries.

TABLE 1.1 (CONTINUED) DEFINITIONS OF FUEL TYPES USED IN THE 2006 IPCC GUIDELINES		
English Description	Comments	
SOLID (Coal and coal products)		
Anthracite	Anthracite is a high rank coal used for industrial and residential applications. It has generally less than 10 percent volatile matter and a high carbon content (about 90 percent 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	Coking coal refers to bituminous 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	Other bituminous coal is used for steam raising purposes and includes all bituminous coal that is not included under coking coal. It is characterized by higher volatile matter than anthracite (more than 10 percent) and lower carbon content (less than 90 percent 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	Non-agglomerating coals with a gross calorific value between 17 435 kJ/kg (4 165 kcal/kg) and 23 865 kJ/kg (5 700 kcal/kg) containing more than 31 percent volatile matter on a dry mineral matter free basis.	
Lignite	Lignite/brown coal 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 percent volatile matter on a dry mineral matter free basis.	
Oil Shale and Tar Sands	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 subjected to pyrolysis (a treatment that consists of heating the rock at high temperature). Tar sands refers to sand (or porous carbonate rocks) that are naturally mixed with a viscous form of heavy crude oil sometimes referred to as bitumen. Due to its high viscosity this oil cannot be recovered through conventional recovery methods.	
Brown Coal Briquettes	Brown coal briquettes (BKB) are composition fuels manufactured from lignite/brown coal, produced by briquetting under high pressure. These figures include dried lignite fines and dust.	
Patent Fuel	Patent fuel is a composition fuel manufactured from hard coal fines with the addition of a binding agent. The amount of patent fuel produced may, therefore, be slightly higher than the actual amount of coal consumed in the transformation process.	
Coke	Coke Oven Coke and Lignite Coke	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. Also included are semi-coke, a solid product obtained from the carbonisation of coal at a low temperature, lignite coke, semi-coke made from lignite/brown coal, coke breeze and foundry coke. Coke oven coke is also known as metallurgical coke.
	Gas Coke	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.
Coal Tar	The 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.	
Derived Gases	Gas Works Gas	Gas works gas covers all types of gases produced in public utility or private plants, whose main purpose is manufacture, transport and distribution of gas. It includes gas produced by carbonization (including gas produced by coke ovens and transferred to gas works gas), by total gasification with or without enrichment with oil products (LPG, residual fuel oil, etc.), and by reforming and simple mixing of gases and/or air. It excludes blended natural gas, which is usually distributed through the natural gas grid.
	Coke Oven Gas	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	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.
	Oxygen Steel Furnace Gas	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. The gas is also known as converter gas, LD gas or BOS gas.

TABLE 1.1 (CONTINUED) DEFINITIONS OF FUEL TYPES USED IN THE 2006 IPCC GUIDELINES		
English Description	Comments	
GAS (Natural Gas)		
Natural Gas	Natural gas should include blended natural gas (sometimes also referred to as Town Gas or City Gas), a high calorific value gas obtained as a blend of natural gas with other gases derived from other primary products, and usually distributed through the natural gas grid (eg coal seam methane). Blended natural gas should include substitute natural gas, a high calorific value gas, manufactured by chemical conversion of a hydrocarbon fossil fuel, where the main raw materials are: natural gas, coal, oil and oil shale.	
OTHER FOSSIL FUELS		
Municipal Wastes (non-biomass fraction)	Non-biomass fraction of municipal waste includes waste produced by households, industry, hospitals and the tertiary sector which are incinerated at specific installations and used for energy purposes. Only the fraction of the fuel that is non-biodegradable should be included here.	
Industrial Wastes	Industrial waste consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power and that are not reported as biomass.	
Waste Oils	Waste oils are used oils (e.g. waste lubricants) that are combusted for heat production.	
PEAT		
Peat ⁵	Combustible soft, porous or compressed, sedimentary deposit of plant origin including woody material with high water content (up to 90 percent in the raw state), easily cut, can contain harder pieces of light to dark brown colour. Peat used for non-energy purposes is not included.	
BIOMASS		
Solid Biofuels	Wood/Wood Waste	Wood and wood waste combusted directly for energy. This category also includes wood for charcoal production but not the actual production of charcoal (this would be double counting since charcoal is a secondary product).
	Sulphite Lyes (Black Liquor)	Sulphite lyes is an alkaline spent liquor from the digesters in the production of sulphate or soda pulp during the manufacture of paper where the energy content derives from the lignin removed from the wood pulp. This fuel in its concentrated form is usually 65-70 percent solid.
	Other Primary Solid Biomass	Other primary solid biomass includes plant matter used directly as fuel that is not already included in wood/wood waste or in sulphite lyes. Included are vegetal waste, animal materials/wastes and other solid biomass. This category includes non-wood inputs to charcoal production (e.g. coconut shells) but all other feedstocks for production of biofuels should be excluded.
	Charcoal	Charcoal combusted as energy covers the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material.

⁵ Although peat is not strictly speaking a fossil fuel, its greenhouse gas emission characteristics have been shown in life cycle studies to be comparable to that of fossil fuels (Nilsson and Nilsson, 2004; Uppenberg *et al.*, 2001; Savolainen *et al.*, 1994). Therefore, the CO₂ emissions from combustion of peat are included in the national emissions as for fossil fuels.

TABLE 1.1 (CONTINUED)
DEFINITIONS OF FUEL TYPES USED IN THE 2006 IPCC GUIDELINES

English Description		Comments
Liquid Biofuels	Biogasoline	Biogasoline should only contain that part of the fuel that relates to the quantities of biofuel and not to the total volume of liquids into which the biofuels are blended. This category includes bioethanol (ethanol produced from biomass and/or the biodegradable fraction of waste), biomethanol (methanol produced from biomass and/or the biodegradable fraction of waste), bioETBE (ethyl-tertio-butyl-ether produced on the basis of bioethanol: the percentage by volume of bioETBE that is calculated as biofuel is 47 percent) and bioMTBE (methyl-tertio-butyl-ether produced on the basis of biomethanol: the percentage by volume of bioMTBE that is calculated as biofuel is 36 percent).
	Biodiesels	Biodiesels should only contain that part of the fuel that relates to the quantities of biofuel and not to the total volume of liquids into which the biofuels are blended. This category includes biodiesel (a methyl-ester produced from vegetable or animal oil, of diesel quality), biodimethylether (dimethylether produced from biomass), fischer tropsh (fischer tropsh produced from biomass), cold pressed bio oil (oil produced from oil seed through mechanical processing only) and all other liquid biofuels which are added to, blended with or used straight as transport diesel.
	Other Liquid Biofuels	Other liquid biofuels not included in biogasoline or biodiesels.
Gas Biomass	Landfill Gas	Landfill gas is derived from the anaerobic fermentation of biomass and solid wastes in landfills and combusted to produce heat and/or power.
	Sludge Gas	Sludge gas is derived from the anaerobic fermentation of biomass and solid wastes from sewage and animal slurries and combusted to produce heat and/or power.
	Other Biogas	Other biogas not included in landfill gas or sludge gas.
Other non-fossil fuels	Municipal Wastes (biomass fraction)	Biomass fraction of municipal waste includes waste produced by households, industry, hospitals and the tertiary sector which are incinerated at specific installations and used for energy purposes. Only the fraction of the fuel that is biodegradable should be included here.

1.4.1.2 CONVERSION OF ENERGY UNITS

In energy statistics and other energy data compilations, production and consumption of solid, liquid and gaseous fuels are specified in physical units, e.g. in tonnes or cubic metres. To convert these data to common energy units, eg joules, requires calorific values. To convert tonnes to energy units, in this case terajoules, requires calorific values. These Guidelines use net calorific values (NCVs), expressed in SI units or multiples of SI units (for example TJ/Mg). Some statistical offices use gross calorific values (GCV). The difference between NCV and GCV is the latent heat of vaporisation of the water produced during combustion of the fuel. As a consequence for coal and oil, the NCV is about 5 percent less than the GCV. For most forms of natural and manufactured gas, the NCV is about 10 percent less. The Box 1.1 below provides an algorithm for the conversion if fuel characteristics (moisture, hydrogen and oxygen contents) are known. For common biomass fuels default conversion from NCV to GCV especially bark, wood and wood waste are derived in the Pulp and Paper Greenhouse Gas Calculation Tools available via the WRI/WBCSD Greenhouse Gas Protocol web site⁶.

If countries use GCV, they should identify them as such. For further explanations of this issue and how to convert from the one into the other, please consult the IEA's Energy Statistics Manual (OECD/IEA, 2004).

⁶ See page 9 of "Calculation Tools for Estimating Greenhouse Gas Emissions from Pulp and Paper Mills, Version 1.1, July 8, 2005" page 9 available at <http://www.ghgprotocol.org/includes/getTarget.asp?type=d&id=MTYwNjQ>

Box 1.1**CONVERSION BETWEEN GROSS AND NET CALORIFIC VALUES**

Units: MJ/kg - Megajoules per kilogram; 1 MJ/kg = 1 Gigajoule/tonne (GJ/tonne)

Gross CV (GCV) or 'higher heating value' (HHV) is the calorific value under laboratory conditions.

Net CV (NCV) or 'lower heating value' (LHV) is the useful calorific value in boiler plant. The difference is essentially the latent heat of the water vapour produced.

Conversions - Gross/Net (per ISO, for As Received* figures) in MJ/kg:

$$Net\ CV = Gross\ CV - 0.212H - 0.0245M - 0.008Y$$

where M is percent Moisture, H is percent Hydrogen, Y is percent Oxygen (from ultimate analysis which determines the amount of carbon, hydrogen, oxygen, nitrogen and sulphur) As Received (i.e. includes Total Moisture (TM)).

Source: World Coal Institute (<http://www.worldcoal.org/pages/content/index.asp?PageID=190>), which provides more details.

Default NCV values to convert from units of 10³ tonnes to units of terajoules are in Table 1.2. These values are based on a statistical analysis of three data sources:

1. **Annual greenhouse gas inventory submissions of Annex I Parties:** UNFCCC Annex-1 countries' national submissions in 2004 on 2002 emissions (Table-1A(b) of the CRF). This dataset contains Net Calorific Values (NCVs), Carbon Emission Factor (CEF) and Carbon Oxidation Factor (COF) for individual fuels for more than 33 Annex 1 countries.
2. **Emission Factor Database:** The IPCC Emission Factor Database (EFDB), version-1, as of December 2003 contains all default values included in the *1996 IPCC Guidelines* and additional data accepted by the EFDB editorial board. The EFDB contains country-specific data for NCV and CEF including developing countries.
3. **IEA Database:** International Energy Agency NCV database for all fuels, as of November 2004. The IEA database contains country-specific NCV data for many countries, including developing countries.

The statistical analysis performed on these datasets has been described in detail in a separate document (Kainou, 2005). The same data set was used to compile a table of default values and uncertainty ranges.

1.4.1.3 ACTIVITY DATA SOURCES

Fuel statistics collected by an officially recognised national body are usually the most appropriate and accessible activity data. In some countries, however, those charged with the task of compiling inventory information may not have ready access to the entire range of data available within their country and may wish to use data specially provided by their country to the international organisations.

There are currently two main sources of international energy statistics: the International Energy Agency (IEA), and the United Nations (UN). Both international organisations collect energy data from the national administrations of their member countries through systems of questionnaires. The data gathered are therefore "official" data. To avoid duplication of reporting, where countries are members of both organisations, the UN receives copies of the IEA questionnaires for the OECD member countries rather than requiring these countries to complete the UN questionnaires. When compiling its statistics of non-OECD member countries, the IEA, for certain countries, uses UN data to which it may add additional information obtained from the national administration, consultants or energy companies operating within the countries. Statistics for other countries are obtained directly from national sources. The number of countries covered by the IEA publications is fewer than that of the UN.⁷

⁷ Approximately 130 countries (of about 170 UN Member countries) are included in the IEA data, and represent about 98 per cent of worldwide energy consumption and nearly all energy production.

Fuel type English description		Net calorific value (TJ/Gg)	Lower	Upper
Crude Oil		42.3	40.1	44.8
Orimulsion		27.5	27.5	28.3
Natural Gas Liquids		44.2	40.9	46.9
Gasoline	Motor Gasoline	44.3	42.5	44.8
	Aviation Gasoline	44.3	42.5	44.8
	Jet Gasoline	44.3	42.5	44.8
Jet Kerosene		44.1	42.0	45.0
Other Kerosene		43.8	42.4	45.2
Shale Oil		38.1	32.1	45.2
Gas/Diesel Oil		43.0	41.4	43.3
Residual Fuel Oil		40.4	39.8	41.7
Liquefied Petroleum Gases		47.3	44.8	52.2
Ethane		46.4	44.9	48.8
Naphtha		44.5	41.8	46.5
Bitumen		40.2	33.5	41.2
Lubricants		40.2	33.5	42.3
Petroleum Coke		32.5	29.7	41.9
Refinery Feedstocks		43.0	36.3	46.4
Other Oil	Refinery Gas ²	49.5	47.5	50.6
	Paraffin Waxes	40.2	33.7	48.2
	White Spirit and SBP	40.2	33.7	48.2
	Other Petroleum Products	40.2	33.7	48.2
Anthracite		26.7	21.6	32.2
Coking Coal		28.2	24.0	31.0
Other Bituminous Coal		25.8	19.9	30.5
Sub-Bituminous Coal		18.9	11.5	26.0
Lignite		11.9	5.50	21.6
Oil Shale and Tar Sands		8.9	7.1	11.1
Brown Coal Briquettes		20.7	15.1	32.0
Patent Fuel		20.7	15.1	32.0
Coke	Coke Oven Coke and Lignite Coke	28.2	25.1	30.2
	Gas Coke	28.2	25.1	30.2
Coal Tar ³		28.0	14.1	55.0
Derived Gases	Gas Works Gas ⁴	38.7	19.6	77.0
	Coke Oven Gas ⁵	38.7	19.6	77.0
	Blast Furnace Gas ⁶	2.47	1.20	5.00
	Oxygen Steel Furnace Gas ⁷	7.06	3.80	15.0
Natural Gas		48.0	46.5	50.4
Municipal Wastes (non-biomass fraction)		10	7	18
Industrial Wastes		NA	NA	NA
Waste Oil ⁸		40.2	20.3	80.0
Peat		9.76	7.80	12.5

Fuel type English description		Net calorific value (TJ/Gg)	Lower	Upper
Solid Biofuels	Wood/Wood Waste ⁹	15.6	7.90	31.0
	Sulphite lyes (black liquor) ¹⁰	11.8	5.90	23.0
	Other Primary Solid Biomass ¹¹	11.6	5.90	23.0
	Charcoal ¹²	29.5	14.9	58.0
Liquid Biofuels	Biogasoline ¹³	27.0	13.6	54.0
	Biodiesels ¹⁴	27.0	13.6	54.0
	Other Liquid Biofuels ¹⁵	27.4	13.8	54.0
Gas Biomass	Landfill Gas ¹⁶	50.4	25.4	100
	Sludge Gas ¹⁷	50.4	25.4	100
	Other Biogas ¹⁸	50.4	25.4	100
Other non-fossil fuels	Municipal Wastes (biomass fraction)	11.6	6.80	18.0
Notes:				
¹ The lower and upper limits of the 95 percent confidence intervals, assuming lognormal distributions, fitted to a dataset, based on national inventory reports, IEA data and available national data. A more detailed description is given in section 1.5.				
² Japanese data; uncertainty range: expert judgement				
³ EFDB; uncertainty range: expert judgement				
⁴ Coke Oven Gas; uncertainty range: expert judgement				
⁵⁻⁷ Japan and UK small number data; uncertainty range: expert judgement				
⁸ For waste oils the values of "Lubricants" are taken				
⁹ EFDB; uncertainty range: expert judgement				
¹⁰ Japanese data ; uncertainty range: expert judgement				
¹¹ Solid Biomass; uncertainty range: expert judgement				
¹² EFDB; uncertainty range: expert judgement				
¹³⁻¹⁴ Ethanol theoretical number; uncertainty range: expert judgement;				
¹⁵ Liquid Biomass; uncertainty range: expert judgement				
¹⁶⁻¹⁸ Methane theoretical number uncertainty range: expert judgement;				

In general, the IEA and UN data for a country can be obtained free of charge by that country's national inventory agencies by contacting stats@iea.org or energy_stat@un.org.

Two types of fuels deserve special attention:

Biomass:

Biomass data are generally more uncertain than other data in national energy statistics. A large fraction of the biomass, used for energy, may be part of the informal economy, and the trade in these type of fuels (fuel wood, agricultural residues, dung cakes, etc.) is frequently not registered in the national energy statistics and balances.

The AFOLU Volume 4 Chapter 4 (Forest Land) provides an alternative method to estimate activity data for fuel wood use.

Where data from energy statistics and AFOLU statistics are both available, the inventory compiler should take care to avoid any double counting, and should indicate how data from both sources have been integrated to obtain the best possible estimate of fuel wood use in the country. CO₂ emissions from biomass combustion are not included in national totals, but are recorded as an information item for cross-checking purposes as well as avoiding double counting. Note that peat is not treated as biomass in these guidelines, therefore CO₂ emissions from peat are estimated.

Waste:

Waste incineration may occur in installations where the combustion heat is used as energy in other processes. In such cases, this waste must be treated as a fuel and the emissions should be reported in the energy sector. When waste is incinerated without using the combustion heat as energy, emissions should be reported under waste incineration. Methodologies in both cases are provided in Volume 5 Chapter 5. CO₂ emissions from combustion

of biomass in waste used for energy are not included in national totals, but are recorded as an information item for cross-checking purposes.

1.4.1.4 TIME SERIES CONSISTENCY

Many countries have long time series of energy statistics that can be used to derive time series of energy sector greenhouse gas emissions. However, in many cases statistical practices (including definitions of fuels, of fuel use by sectors) will have changed over time and recalculations of the energy data in the latest set of definitions is not always feasible. In compiling time series of emissions from fuel combustion, these changes might give rise to time series inconsistencies, which should be dealt with using the methods provided in Time Series Consistency Chapter 5 of Volume 1 of the *2006 IPCC Guidelines*.

1.4.2 Emission factors

1.4.2.1 CO₂ EMISSION FACTORS

Combustion processes are optimized to derive the maximum amount of energy per unit of fuel consumed, hence delivering the maximum amount of CO₂. Efficient fuel combustion ensures oxidation of the maximum amount of carbon available in the fuel. CO₂ emission factors for fuel combustion are therefore relatively insensitive to the combustion process itself and hence are primarily dependent only on the carbon content of the fuel.

The carbon content may vary considerably both among and within primary fuel types on a per mass or per volume basis:

- For natural gas, the carbon content depends on the composition of the gas which, in its delivered state, is primarily methane, but can include small quantities of ethane, propane, butane, and heavier hydrocarbons. Natural gas flared at the production site will usually contain far larger amounts of non-methane hydrocarbons. The carbon content will be correspondingly different.
- Carbon content per unit of energy is usually less for light refined products such as gasoline than for heavier products such as residual fuel oil.
- For coal, carbon emissions per tonne vary considerably depending on the coal's composition of carbon, hydrogen, sulphur, ash, oxygen, and nitrogen.

By converting to energy units this variability is reduced.

A small part of the fuel carbon entering the combustion process escapes oxidation. This fraction is usually small (99 to 100 percent of the carbon is oxidized) and so the default emission factors in Table 1.4 are derived on the assumption of 100 percent oxidation. For some fuels, this fraction may in practice not be negligible and where representative country-specific values, based on measurements are available, they should be used. In other words: the fraction of carbon oxidised is assumed to be 1 in deriving default CO₂ emission factors.

Table 1.3 gives carbon contents of fuels from which emission factors on a full molecular weight basis can be calculated (Table 1.4). These emission factors are default values that are suggested only if country-specific factors are not available. More detailed and up-to-date emission factors may be available at the IPCC EFDB.

Note that CO₂ emissions from biomass fuels are not included in the national total but are reported as an information item. Net emissions or removals of CO₂ are estimated in the AFOLU sector and take account of these emissions. Note that peat is treated as a fossil fuel and not a biofuel and emissions from its combustion are therefore included in the national total.

The data presented in Table 1.3 is used to calculate default emission factors for each fuel on a per energy basis. If activity data are available on a per mass basis, a similar approach can be applied to these activity data directly. Obviously the carbon content then should be known on a per mass basis.

TABLE 1.3
DEFAULT VALUES OF CARBON CONTENT

Fuel type English description	Default carbon content ¹ (kg/GJ)	Lower	Upper
Crude Oil	20.0	19.4	20.6
Orimulsion	21.0	18.9	23.3
Natural Gas Liquids	17.5	15.9	19.2
Motor Gasoline	18.9	18.4	19.9
Aviation Gasoline	19.1	18.4	19.9
Jet Gasoline	19.1	18.4	19.9
Jet Kerosene	19.5	19	20.3
Other Kerosene	19.6	19.3	20.1
Shale Oil	20.0	18.5	21.6
Gas/Diesel Oil	20.2	19.8	20.4
Residual Fuel Oil	21.1	20.6	21.5
Liquefied Petroleum Gases	17.2	16.8	17.9
Ethane	16.8	15.4	18.7
Naphtha	20.0	18.9	20.8
Bitumen	22.0	19.9	24.5
Lubricants	20.0	19.6	20.5
Petroleum Coke	26.6	22.6	31.3
Refinery Feedstocks	20.0	18.8	20.9
Refinery Gas ²	15.7	13.3	19.0
Paraffin Waxes	20.0	19.7	20.3
White Spirit & SBP	20.0	19.7	20.3
Other Petroleum Products	20.0	19.7	20.3
Anthracite	26.8	25.8	27.5
Coking Coal	25.8	23.8	27.6
Other Bituminous Coal	25.8	24.4	27.2
Sub-Bituminous Coal	26.2	25.3	27.3
Lignite	27.6	24.8	31.3
Oil Shale and Tar Sands	29.1	24.6	34
Brown Coal Briquettes	26.6	23.8	29.6
Patent Fuel	26.6	23.8	29.6
Coke Oven Coke and Lignite Coke	29.2	26.1	32.4
Gas Coke	29.2	26.1	32.4
Coal Tar ³	22.0	18.6	26.0
Gas Works Gas ⁴	12.1	10.3	15.0
Coke Oven Gas ⁵	12.1	10.3	15.0
Blast Furnace Gas ⁶	70.8	59.7	84.0
Oxygen Steel Furnace Gas ⁷	49.6	39.5	55.0
Natural Gas	15.3	14.8	15.9

TABLE 1.3 (CONTINUED)
DEFAULT VALUES OF CARBON CONTENT

Fuel type English description	Default carbon content¹ (kg/GJ)	Lower	Upper
Municipal Wastes (non-biomass fraction) ⁸	25.0	20.0	33.0
Industrial Wastes	39.0	30.0	50.0
Waste Oils ⁹	20.0	19.7	20.3
Peat	28.9	28.4	29.5
Wood/Wood Waste ¹⁰	30.5	25.9	36.0
Sulphite lyes (black liquor) ¹¹	26.0	22.0	30.0
Other Primary Solid Biomass ¹²	27.3	23.1	32.0
Charcoal ¹³	30.5	25.9	36.0
Biogasoline ¹⁴	19.3	16.3	23.0
Biodiesels ¹⁵	19.3	16.3	23.0
Other Liquid Biofuels ¹⁶	21.7	18.3	26.0
Landfill Gas ¹⁷	14.9	12.6	18.0
Sludge Gas ¹⁸	14.9	12.6	18.0
Other Biogas ¹⁹	14.9	12.6	18.0
Municipal Wastes (biomass fraction) ²⁰	27.3	23.1	32.0

Notes:

¹ The lower and upper limits of the 95 percent confidence intervals, assuming lognormal distributions, fitted to a dataset, based on national inventory reports, IEA data and available national data. A more detailed description is given in section 1.5

² Japanese data; uncertainty range: expert judgement;

³ EFDB; uncertainty range: expert judgement

⁴ Coke Oven Gas; uncertainty range: expert judgement

⁵ Japan & UK small number data; uncertainty range: expert judgement

⁶ 7. Japan & UK small number data; uncertainty range: expert judgement

⁸ Solid Biomass; uncertainty range: expert judgement

⁹ Lubricants ; uncertainty range: expert judgement

¹⁰ EFDB; uncertainty range: expert judgement

¹¹ Japanese data; uncertainty range: expert judgement

¹² Solid Biomass; uncertainty range: expert judgement

¹³ EFDB; uncertainty range: expert judgement

¹⁴ Ethanol theoretical number; uncertainty range: expert judgement

¹⁵ Ethanol theoretical number; uncertainty range: expert judgement

¹⁶ Liquid Biomass; uncertainty range: expert judgement

¹⁷⁻¹⁹ Methane theoretical number; uncertainty range: expert judgement

²⁰ Solid Biomass; uncertainty range: expert judgement

TABLE 1.4
DEFAULT CO₂ EMISSION FACTORS FOR COMBUSTION ¹

Fuel type English description	Default carbon content (kg/GJ)	Default carbon oxidation factor	Effective CO ₂ emission factor (kg/TJ) ²			
			Default value ³	95% confidence interval		
				Lower	Upper	
	A	B	$C=A*B*44/12*1000$			
Crude Oil	20.0	1	73 300	71 100	75 500	
Orimulsion	21.0	1	77 000	69 300	85 400	
Natural Gas Liquids	17.5	1	64 200	58 300	70 400	
Gasoline	Motor Gasoline	18.9	1	69 300	67 500	73 000
	Aviation Gasoline	19.1	1	70 000	67 500	73 000
	Jet Gasoline	19.1	1	70 000	67 500	73 000
Jet Kerosene	19.5	1	71 500	69 700	74 400	
Other Kerosene	19.6	1	71 900	70 800	73 700	
Shale Oil	20.0	1	73 300	67 800	79 200	
Gas/Diesel Oil	20.2	1	74 100	72 600	74 800	
Residual Fuel Oil	21.1	1	77 400	75 500	78 800	
Liquefied Petroleum Gases	17.2	1	63 100	61 600	65 600	
Ethane	16.8	1	61 600	56 500	68 600	
Naphtha	20.0	1	73 300	69 300	76 300	
Bitumen	22.0	1	80 700	73 000	89 900	
Lubricants	20.0	1	73 300	71 900	75 200	
Petroleum Coke	26.6	1	97 500	82 900	115 000	
Refinery Feedstocks	20.0	1	73 300	68 900	76 600	
Other Oil	Refinery Gas	15.7	1	57 600	48 200	69 000
	Paraffin Waxes	20.0	1	73 300	72 200	74 400
	White Spirit & SBP	20.0	1	73 300	72 200	74 400
Other Petroleum Products	20.0	1	73 300	72 200	74 400	
Anthracite	26.8	1	98 300	94 600	101 000	
Coking Coal	25.8	1	94 600	87 300	101 000	
Other Bituminous Coal	25.8	1	94 600	89 500	99 700	
Sub-Bituminous Coal	26.2	1	96 100	92 800	100 000	
Lignite	27.6	1	101 000	90 900	115 000	
Oil Shale and Tar Sands	29.1	1	107 000	90 200	125 000	
Brown Coal Briquettes	26.6	1	97 500	87 300	109 000	
Patent Fuel	26.6	1	97 500	87 300	109 000	
Coke	Coke oven coke and lignite Coke	29.2	1	107 000	95 700	119 000
	Gas Coke	29.2	1	107 000	95 700	119 000
Coal Tar	22.0	1	80 700	68 200	95 300	
Derived Gases	Gas Works Gas	12.1	1	44 400	37 300	54 100
	Coke Oven Gas	12.1	1	44 400	37 300	54 100
	Blast Furnace Gas ⁴	70.8	1	260 000	219 000	308 000
	Oxygen Steel Furnace Gas ⁵	49.6	1	182 000	145 000	202 000

TABLE 1.4 (CONTINUED)
DEFAULT CO₂ EMISSION FACTORS FOR COMBUSTION ¹

Fuel type English description	Default carbon content (kg/GJ)	Default carbon oxidation Factor	Effective CO ₂ emission factor (kg/TJ) ²			
			Default value	95% confidence interval		
				Lower	Upper	
	A	B	$C=A*B*44/12*1000$			
Natural Gas	15.3	1	56 100	54 300	58 300	
Municipal Wastes (non-biomass fraction)	25.0	1	91 700	73 300	121 000	
Industrial Wastes	39.0	1	143 000	110 000	183 000	
Waste Oil	20.0	1	73 300	72 200	74 400	
Peat	28.9	1	106 000	100 000	108 000	
Solid Biofuels	Wood/Wood Waste	30.5	1	112 000	95 000	132 000
	Sulphite lyes (black liquor) ⁵	26.0	1	95 300	80 700	110 000
	Other Primary Solid Biomass	27.3	1	100 000	84 700	117 000
	Charcoal	30.5	1	112 000	95 000	132 000
Liquid Biofuels	Biogasoline	19.3	1	70 800	59 800	84 300
	Biodiesels	19.3	1	70 800	59 800	84 300
	Other Liquid Biofuels	21.7	1	79 600	67 100	95 300
Gas biomass	Landfill Gas	14.9	1	54 600	46 200	66 000
	Sludge Gas	14.9	1	54 600	46 200	66 000
	Other Biogas	14.9	1	54 600	46 200	66 000
Other non-fossil fuels	Municipal Wastes (biomass fraction)	27.3	1	100 000	84 700	117 000

Notes:

¹ The lower and upper limits of the 95 percent confidence intervals, assuming lognormal distributions, fitted to a dataset, based on national inventory reports, IEA data and available national data. A more detailed description is given in section 1.5

² TJ = 1000GJ

³ The emission factor values for BFG includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas.

⁴ The emission factor values for OSF includes carbon dioxide originally contained in this gas as well as that formed due to combustion of this gas

⁵ Includes the biomass-derived CO₂ emitted from the black liquor combustion unit and the biomass-derived CO₂ emitted from the kraft mill lime kiln.

1.4.2.2 OTHER GREENHOUSE GASES

Emission factors for non-CO₂ gases from fuel combustion are strongly dependent on the technology used. Since the set of technologies, applied in each sector varies considerably, so do the emission factors. Therefore it is not useful to provide default emission factors for these gases on the basis of fuels only. Tier 1 default emission factors are therefore provided in the subsequent chapters for each subsector separately.

1.4.2.3 INDIRECT GREENHOUSE GASES

This volume will not present guidance on the estimation of emissions of indirect greenhouse gases. For information on these gases, the user is referred to guidance provided under other conventions (see also section 1.3.1.3 Relation to other inventory approaches). Default methods for estimating these emissions are provided in the EMEP/CORINAIR Guidebook. Chapter 7 of Volume 1 provides full details on how to link to this information.