2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting

Produced by AEA for the Department of Energy and Climate Change (DECC)
and the Department of Environment, Food and Rural Affairs (Defra)

Key

light blue	=	Data entry field
purple	=	Fixed factors used in calculations
yellow	=	Calculation results

Introduction

Last updated: Jun-09

General Introduction

What are Greenhouse Gas Conversion Factors?

Greenhouse Gases can be measured by recording emissions at source by continuous emissions monitoring **or** by estimating the amount emitted using activity data (such as the amount of fuel used) and applying relevant conversion factors (e.g. calorific values, emission factors, oxidation factors).

These conversion factors allow organisations and individuals to calculate greenhouse gas (GHG) emissions from a range of activities, including energy use, water consumption, waste disposal, recycling and transport activities. For instance, a conversion factor can be used to calculate the amount of greenhouse gases emitted as a result of burning a particular quantity of oil in a heating boiler.

These conversion factors will enable you to convert activity data (e.g. litres of fuel used, number of miles driven, tonnes of waste sent to landfill) into kilograms of carbon dioxide equivalent (CO_2eq). Carbon dioxide equivalent is a universal unit of measurement used to indicate the global warming potential of one unit of carbon dioxide. It is used to evaluate the releasing of different greenhouse gases against a common basis.

What are the major changes and updates from the June 2008 version?

Major changes and updates from the June 2008 version are as follows:

i. In previous versions of the conversion factors, emissions factors have only been provided for CO_2. The 2009 update provides emissions factors for the non-CO_2 greenhouse gases methane ($CH_{4)}$ and nitrous oxide (N_2O) as well, based upon the emission factors used in UK Greenhouse Gas Inventory (GHGI). Values for CH_4 and N_2O are presented as CO_2 equivalents (CO_2eq) using Global Warming Potential (GWP) factors (GWP for CH_4 = 21, GWP for N_2O = 310), consistent with reporting under the Kyoto Protocol and the second assessment report of the Intergovernmental Panel on Climate Change (IPCC).

ii. Lifecycle emissions factors for water, waste, biofuels and biomass have been added. These emission factors include both direct and indirect emissions. For example in the case of biofuels, these emission factors incorporate emissions associated with the production and transportation of the fuel, as well as the direct emissions from fuel combustion. **As a result, these emission factors are different from all other emissions factors in the annexes which only account for direct emissions.**

iii. Global Warming Potentials for greenhouse gases not covered by the Kyoto Protocol have been added.

iv. Emission factors for air conditioning and refrigeration have been added.

v. International electricity emission factors have been added

vi. A supporting methodological paper to explain how all of the emission factors have been derived has been produced. This methodological paper can be found here: http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Who should use these factors?

These factors are publicly available for use by organisations and individuals within the UK. We **do not recommend** that they are used by organisations or individuals overseas as the emission factors are specific to the UK and many will vary to a very significant degree for other countries. For example, the electricity emission factors are based on the UK grid average mix of different types of generation and average factors for transport are based the composition of the UK fleet and UK-specific occupancy/loading factors where relevant.

What should I use these factors for?

These conversion factors should be used to measure and report GHG emissions for:

1. Your organisation's **corporate carbon footprint** - Organisations that wish to calculate their corporate carbon footprint should refer to Defra's website for guidance on how to measure and report GHG emissions in a clear and consistent manner. The Conversion factors assist organisations in doing this. **Please note, by the 1st of October, 2009, Defra will issue guidance on how UK organisations should measure and report their GHG emissions under the Climate Change Act. Defra will consult on this guidance over summer 2009:** (http://www.defra.gov.uk/environment/business/reporting/index.htm)

2. Your personal carbon footprint - Individuals who wish to calculate their carbon footprint from their day-to-day activity may be interested in the Government's Act on CO2 carbon calculator, (http://actonco2.direct.gov.uk/index.html?fullscreen=yes).

3. Other reasons such as project planning and emission reductions projects.

What should I not use the factors for?

These factors are not for use with mandatory or legal reporting.

For reporting emissions under the EU Emissions Trading Scheme, please refer to:
http://www.defra.gov.uk/environment/climatechange/trading/eu/index.htm

For reporting emissions under Climate Change Agreements, please refer to:
http://www.defra.gov.uk/environment/climatechange/uk/business/cca/index.htm

For reporting emissions under the new Carbon Reduction Commitment (CRC), please refer to:
http://www.defra.gov.uk/environment/climatechange/uk/business/crc/index.htm

Policymakers in National, Regional and Local Government should consult the document *Greenhouse Gas Policy Evaluation and Appraisal in Government Departments.*

Do I need to update all my calculations using the new conversion factors each year?

Only in certain cases will you need to update previous calculations due to the release of the annual update to the GHG conversion factors. The conversion factors provided in these annexes provide broadly two types of data:

(a) **Emission factors provide in a time-series (e.g. Annex 3 - Electricity Factors):** These **should** be updated for historical reporting with each annual update - i.e. you should recalculate emissions from previous years using the latest time-series dataset. This is because there can be revisions to earlier emission factor data due to improvements in the calculation methodology or UK GHG inventory datasets they are based upon.

(b) **Other emission factors:** The other factors provided in the annexes are figures produced generally for the *most recent year available* . In the majority of cases this is 2 years behind the update year (i.e. based on 2007 data for the current 2009 update)[2]. A company **should not** generally recalculate their emissions for all previous years using the newer factors. The most recent factors should only be applied for reporting on years up to 2 years prior to the most recent dataset.

In most cases (except for natural gas, and perhaps bioenergy due to changing sources) the fuel emission factors in general are unlikely to vary very significantly between different years. However, specific transport factors generally *do* change on an annual basis and the new factors should only be used for the most relevant/recent year of reporting. Earlier versions of the conversion factors from previous updates may therefore be used for older data as necessary/appropriate.

In summary, you should **only** recalculate previous year's emissions using the new factors in the following cases:

A. When calculating emissions from use of electricity (or when using any other time series emission factors). In this case the updated emission factor time series should be checked to see if they have changed for relevant previous years and time series data updated as necessary in reporting.

B. When recalculating emissions for a year consistent with the data basis of the new update. For example, if you are now reporting emissions for 2008-9, you should also recalculate the 2007-8 emissions using the 2009 update data, as these are for the most part based on 2007 datasets. Figures reported for 2006 should use emission factors from the 2008 update, which are mostly based on 2006 data.

Which Conversion Factors should I use?

- To calculate emissions from the use of Fuels, see Annex 1
- To calculate emissions from Combined Heat and Power (CHP), see Annex 2
- To calculate emissions from the use of Electricity, see Annex 3
- To understand which industrial processes lead to GHG emissions, see Annex 4
- To convert greenhouse gases into carbon dioxide equivalents, see Annex 5
- To calculate emissions associated with Passenger Transport, see Annex 6
- To calculate emissions associated with Freight Transport, see Annex 7
- To calculate emissions from the use of Refrigeration and Air Conditioning Equipment, see Annex 8
- To calculate life-cycle emissions from the use of Water, Biomass and Biofuels, and from Waste Disposal, see Annex 9
- To calculate emissions from the use of Overseas Electricity, see Annex 10
- For the typical Calorific Values and Densities of UK Fuels, see Annex 11
- To convert between common units of energy, volume, mass and distance, see Annex 12

Units

All emissions factors are given in units of kg (kilograms) of carbon dioxide (CO_2) equivalent. GHG emissions are sometimes quoted in figures of mass of *Carbon equivalent*, rather than *Carbon Dioxide equivalent*. To convert carbon equivalents into carbon dioxide equivalents (CO_2eq), multiply by 44/12.

To convert emissions of greenhouse gases to carbon dioxide equivalent units, see **Annex 5**. For other unit conversions see **Annexes 11** and **12**.

Missing factors and additional guidance

If you require GHG conversion factors that you cannot find here, or this guidance is unclear, or you have additional questions, please send us an email at environmental.reporting@defra.gsi.gov.uk. We cannot undertake to provide all the conversion factors.

Useful links:

The Carbon Trust also provides information about carbon footprinting for companies available at www.carbontrust.co.uk/footprinting.

The Carbon Trust has developed a carbon footprint calculator for organisations, which uses the factors contained in this document. Visit http://www.carbontrust.co.uk/carboncalculator.

The Publicly Available Specification (PAS): 2050 provides a method for measuring the lifecycle greenhouse gas emissions from goods and services. It is available at http://www.bsigroup.com/en/Standards-and-Publications/Industry-Sectors/Energy/PAS-2050/

Annex 1 - Converting from fuel use to carbon dioxide equivalent emissions

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How to use this Annex

1) Identify the amount of fuel used
2) Identify the units. Are you measuring fuel use in terms of mass, volume or energy?
3) If you are measuring fuel use in terms of *energy* is your unit of measurement *net energy* or *gross energy?* (In the event that this is unclear you should contact your fuel supplier).
4) Identify the appropriate conversion factor that matches the unit you are using. If you cannot find a factor for that unit, **Annex 12** gives guidance on converting between different units of mass, volume, length and energy.
5) Multiply the amount of fuel used by the conversion factor to get total emissions in kilograms of carbon dioxide equivalent (kg CO_2eq). The excel spreadsheet calculates this automatically following your entry of the amount of fuel used into the appropriate box.

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here: http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Two tables are presented here, the first provides emission factors on a Net CV basis and the second on a Gross CV basis. Emission factors per unit mass or volume are identical in these two tables. However values on an energy basis are different - emission factors on a Net CV basis are higher (see definition of Gross CV and Net CV in *italics* below). **It is important to use the correct emission factor**, otherwise emissions calculations will over- or under-estimate the results. If you are making calculations based on energy use, you must check (e.g. with your fuel supplier) whether these values were calculated on a Gross CV or Net CV basis and use the appropriate factor. It is most usual for Natural Gas consumption figures quoted in kWh by suppliers to be calculated (from the volume of gas used) on a Gross CV basis - see Transco website: http://www.transco.co.uk/services/cvalue/cvinfo.htm.

Gross CV or higher heating value (HHV) is the CV under laboratory conditions. Net CV or 'lower heating value (LHV) is the useful calorific value in typical real world conditions (e.g. boiler plant). The difference is essentially the latent heat of the water vapour produced (which can be recovered in laboratory conditions).

Table 1a

Converting fuel types on a Net CV Basis [5]				CO_2			CH_4			N_2O			Total GHG	
Fuel Type	Amount used per year	Units	x	kg CO_2 per unit	Total kg CO_2	x	kg CO_2eq per unit	Total kg CO_2eq	x	kg CO_2eq per unit	Total kg CO_2eq	x	kg CO_2eq per unit	Total kg CO_2eq
Aviation Spirit		tonnes	x	3127.7		x	30.4		x	31.0		x	3189.1	
		kWh	x	0.25023		x	0.00243		x	0.00248		x	0.25514	
		litres	x	2.2261		x	0.0216		x	0.0221		x	2.2698	
Aviation Turbine Fuel [1]		tonnes	x	3149.7		x	1.6		x	31.0		x	3182.3	
		kWh	x	0.25837		x	0.00013		x	0.00254		x	0.26104	
		litres	x	2.5278		x	0.0013		x	0.0249		x	2.5540	
Biofuels	See Annex 8						See Annex 8			See Annex 8			See Annex 8	
Burning Oil [1]		tonnes	x	3149.7		x	6.7		x	8.6		x	3164.9	
		kWh	x	0.25847		x	0.00055		x	0.00071		x	0.25972	
		litres	x	2.5319		x	0.0054		x	0.0069		x	2.5442	
Coal (industrial) [2]		tonnes	x	2301.0		x	0.1		x	36.9		x	2338.1	
		kWh	x	0.32415		x	0.00002		x	0.00520		x	0.32937	
Coal (electricity generation) [3]		tonnes	x	2256.5		x	0.4		x	19.5		x	2276.4	
		kWh	x	0.32637		x	0.00006		x	0.00282		x	0.32925	
Coal (domestic) [4]		tonnes	x	2506.3		x	329.7		x	37.8		x	2873.8	
		kWh	x	0.31139		x	0.04096		x	0.00470		x	0.35705	
Coking Coal		tonnes	x	2931.5		x	26.9		x	70.6		x	3029.1	
		kWh	x	0.36423		x	0.00335		x	0.00877		x	0.37635	
Diesel		tonnes	x	3164.3		x	2.3		x	34.0		x	3200.6	
		kWh	x	0.26328		x	0.00019		x	0.00283		x	0.26630	
		litres	x	2.6391		x	0.0019		x	0.0283		x	2.6694	
Electricity	See Annex 3						See Annex 3			See Annex 3			0	
Fuel Oil		tonnes	x	3215.9		x	2.4		x	11.2		x	3229.5	
		kWh	x	0.27927		x	0.00021		x	0.00097		x	0.28045	
Gas Oil		tonnes	x	3190.0		x	3.3		x	305.1		x	3498.4	
		kWh	x	0.26542		x	0.00027		x	0.02539		x	0.29108	
		litres	x	2.7619		x	0.0028		x	0.2642		x	3.0289	
LPG		kWh	x	0.22546		x	0.00009		x	0.00017		x	0.22572	
		therms	x	6.6077		x	0.0026		x	0.0049		x	6.6153	
		litres	x	1.4951		x	0.0006		x	0.0011		x	1.4968	
Lubricants		tonnes	x	3171.1		x	1.9		x	8.5		x	3181.5	
		kWh	x	0.27537		x	0.00017		x	0.00074		x	0.27628	
Naphtha		tonnes	x	3131.3		x	2.9		x	8.0		x	3142.2	
		kWh	x	0.24989		x	0.00023		x	0.00064		x	0.25076	
Natural Gas		kWh	x	0.20374		x	0.00031		x	0.00012		x	0.20417	
		cubic metre	x	2.0091		x	0.0030		x	0.0012		x	2.0133	
		therms	x	5.9712		x	0.0090		x	0.0036		x	5.9837	
Other Petroleum Gas		tonnes	x	2894.0		x	3.6		x	66.5		x	2964.2	
		kWh	x	0.21651		x	0.00027		x	0.00497		x	0.22175	
Petrol		tonnes	x	3135.0		x	6.4		x	30.7		x	3172.1	
		kWh	x	0.25238		x	0.00052		x	0.00247		x	0.25537	
		litres	x	2.3035		x	0.0047		x	0.0226		x	2.3307	
Petroleum Coke		tonnes	x	3422.7		x	2.2		x	74.7		x	3499.7	
		kWh	x	0.36301		x	0.00024		x	0.00792		x	0.37117	
Refinery Miscellaneous		kWh	x	0.25693		x	0.00025		x	0.00070		x	0.25789	
		therms	x	7.5300		x	0.0074		x	0.0206		x	7.5580	
Wood	See Annex 8						See Annex 8			See Annex 8			See Annex 8	
Total					**0**			**0**			**0**			**0**

Annex 1 - Converting from fuel use to carbon dioxide equivalent emissions

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Table 1b

Converting fuel types on a Gross CV Basis [6]			CO_2			CH_4		N_2O		Total GHG	
Fuel Type	Amount used per year	Units	x	kg CO_2 per unit	Total kg CO_2	x	kg CO_2eq per unit	Total kg CO_2eq	x	kg CO_2eq per unit	Total kg CO_2eq	x	kg CO_2eq per unit	Total kg CO_2eq
Aviation Spirit		tonnes	x	3127.7		x	30.4		x	31.0		x	3189.1	
		kWh	x	0.23771		x	0.00231		x	0.00236		x	0.24238	
		litres	x	2.2261		x	0.0216		x	0.0221		x	2.2698	
Aviation Turbine Fuel [1]		tonnes	x	3149.7		x	1.6		x	31.0		x	3182.3	
		kWh	x	0.24545		x	0.00013		x	0.00242		x	0.24799	
		litres	x	2.5278		x	0.0013		x	0.0249		x	2.5540	
Biofuels	See Annex 8						See Annex 8			See Annex 8			See Annex 8	
Burning Oil [1]		tonnes	x	3149.7		x	6.7		x	8.6		x	3164.9	
		kWh	x	0.24555		x	0.00052		x	0.00067		x	0.24674	
		litres	x	2.5319		x	0.0054		x	0.0069		x	2.5442	
Coal (industrial) [2]		tonnes	x	2301.0		x	0.1		x	36.9		x	2338.1	
		kWh	x	0.30794		x	0.00002		x	0.00494		x	0.31290	
Coal (electricity generation) [3]		tonnes	x	2256.5		x	26.9		x	70.6		x	2354.0	
		kWh	x	0.31005		x	0.00318		x	0.00833		x	0.32157	
Coal (domestic) [4]		tonnes	x	2506.3		x	329.7		x	37.8		x	2873.8	
		kWh	x	0.29582		x	0.03892		x	0.00447		x	0.33920	
Coking Coal		tonnes	x	2931.5		x	26.9		x	70.6		x	3029.1	
		kWh	x	0.34601		x	0.00318		x	0.00833		x	0.35753	
Diesel		tonnes	x	3164.3		x	2.3		x	34.0		x	3200.6	
		kWh	x	0.25012		x	0.00018		x	0.00268		x	0.25298	
		litres	x	2.6391		x	0.0019		x	0.0283		x	2.6694	
Electricity	See Annex 3						See Annex 3			See Annex 3			See Annex 3	
Fuel Oil		tonnes	x	3215.9		x	2.4		x	11.2		x	3229.5	
		kWh	x	0.26530		x	0.00020		x	0.00092		x	0.26643	
Gas Oil		tonnes	x	3190.0		x	3.3		x	305.1		x	3498.4	
		kWh	x	0.25215		x	0.00026		x	0.02412		x	0.27652	
		litres	x	2.7619		x	0.0028		x	0.2642		x	3.0289	
LPG		kWh	x	0.21419		x	0.00009		x	0.00016		x	0.21444	
		therms	x	6.2773		x	0.0025		x	0.0047		x	6.2846	
		litres	x	1.4951		x	0.0006		x	0.0011		x	1.4968	
Lubricants		tonnes	x	3171.1		x	1.9		x	8.5		x	3181.5	
		kWh	x	0.26161		x	0.00016		x	0.00070		x	0.26246	
Naphtha		tonnes	x	3131.3		x	2.9		x	8.0		x	3142.2	
		kWh	x	0.23740		x	0.00022		x	0.00061		x	0.23822	
Natural Gas		kWh	x	0.18358		x	0.00028		x	0.00011		x	0.18396	
		cubic metre	x	2.0091		x	0.0030		x	0.0012		x	2.0133	
		therms	x	5.3801		x	0.0081		x	0.0033		x	5.3914	
Other Petroleum Gas		tonnes	x	2894.0		x	3.6		x	66.5		x	2964.2	
		kWh	x	0.20568		x	0.00026		x	0.00472		x	0.21066	
Petrol		tonnes	x	3135.0		x	6.4		x	30.7		x	3172.1	
		kWh	x	0.23976		x	0.00049		x	0.00235		x	0.24260	
		litres	x	2.3035		x	0.0047		x	0.0226		x	2.3307	
Petroleum Coke		tonnes	x	3422.7		x	2.2		x	74.7		x	3499.7	
		kWh	x	0.34486		x	0.00023		x	0.00753		x	0.35261	
Refinery Miscellaneous		kWh	x	0.24444		x	0.00024		x	0.00067		x	0.24535	
		therms	x	7.1640		x	0.0070		x	0.0196		x	7.1906	
Wood	See Annex 8						See Annex 8			See Annex 8			See Annex 8	
Total					**0**			**0**			**0**			**0**

Sources

UK Greenhouse Gas Inventory for 2007 (AEA)
Digest of UK Energy Statistics 2008 (BERR), available at:
http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.h

Notes

[1] Burning oil is also known as kerosene or paraffin used for heating systems. Aviation Turbine fuel is a similar kerosene fuel specifically refined to a higher quality for aviation.

[2] Average emission factor for coal used in sources other than power stations and domestic, i.e. industry sources including collieries, Iron & Steel, Autogeneration, Cement production, Lime production, Other industry, Miscellaneous, Public Sector, Stationary combustion - railways and Agriculture. Users who wish to use coal factors for types of coal used in specific industry applications should use the factors given in the UK ETS.

[3] This emission factor should only be used for coal supplied for electricity generation (power stations. Coal supplied for domestic or industrial purposes have different emission factors.

[4] This emission factor should only be used for coal supplied for domestic purposes. Coal supplied to power stations or for industrial purposes have different emission factors.

[5] Emission factors calculated on a Net Calorific Value basis.

[6] Emission factors calculated on a Gross Calorific Value basis

Annex 2 - Combined Heat and Power - Imports and Exports

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How to use this Annex

If you use all the output of a Combined Heat and Power (CHP) plant to meet the energy needs of your business (i.e. you are not exporting any of the electricity or heat for others to use), there is no need for you to attribute the emissions from the CHP plant between the electricity and heat output in your reporting. This is because you are in this case responsible for the full emissions resulting from the fuel used for CHP. You can calculate the total CHP plant emissions from the fuel used with the standard conversion factors at Annex 1.

If the *heat user* and the *electricity user* are different individuals/installations, carbon dioxide emissions should be calculated as per Annex 1 (i.e. calculate fuel consumption then apply the appropriate conversion factor for that fuel) and then divided between the *heat user* and the *electricity user*.

It is typically roughly twice as efficient to generate heat from fossil fuels as it is to generate electricity. Therefore you can attribute the greenhouse gas emissions from the CHP plant in the ratio 1:2 respectively per kWh of heat and electricity generated. Emissions per kWh of heat or electricity produced by the CHP plant may be calculated in this way using the appropriate formula below:

$$\text{Emissions (in kg}CO_2\text{eq) per kWh electricity} = \frac{\text{twice total emissions (in kg}CO_2\text{eq)}}{\text{twice total electricity produced + total heat produced (in kWh)}}$$

$$\text{Emissions (in kgCO2eq) per kWh heat} = \frac{\text{total emissions (in kg}CO_2\text{eq)}}{\text{twice total electricity produced + total heat produced (in kWh)}}$$

Table 2a

Calculate emissions per kWh electricity			
Total emissions (kg CO_2eq)	Total electricity produced	Total heat produced	kg CO_2eq/kWh electricity

Table 2b

Calculate emissions per kWh heat			
Total emissions (kg CO_2eq)	Total electricity produced	Total heat produced	kgCO_2eq/kWh heat

I buy my electricity from a producer/plant that I know is CHP. Which factor should I use?

If you purchase electricity from a CHP plant, the appropriate emissions factor for electricity use is given in **Annex 3**, under *Electricity* from CHP.

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here: http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Annex 3 - Converting from purchased electricity use to carbon dioxide equivalent emissions

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How to use this Annex

To calculate emissions of carbon dioxide associated with use of UK grid *electricity*:

1) Identify the amount electricity used, in units of kWh;

2) Multiply this value by the conversion factor for UK grid rolling average electricity use.

How are the factors calculated?

The electricity conversion factors given represent the average carbon dioxide emission from the UK national grid per kWh of electricity used at the point of final consumption (i.e. transmission and distribution losses are included). These factors include only carbon dioxide, methane and nitrous oxide emissions at UK power stations and do not include emissions resulting from production and delivery of fuel to these power stations (i.e. from gas rigs, refineries and collieries, etc).

This factor changes from year to year, as the fuel mix consumed in UK power stations changes. Because these annual changes can be large (the factor depends very heavily on the relative prices of coal and natural gas), and to assist companies with year to year comparability, the factor presented is the *average* of the grid Conversion factor over the last 5 years. This factor is updated annually.

I generate my electricity onsite. How do I calculate emissions from this?

Government is currently consulting on how organisations should account for emissions from the generation of onsite renewable energy as part of our public consultation on 'Guidance on how to measure and report your greenhouse gas emissions'. The consultation package is available on the Defra website at:
http://www.defra.gov.uk/corporate/consult/greenhouse-gas/index.htm

These guidelines will be re-issued following publication of our guidance by the 1st of October 2009

How should I report the carbon emissions from my use of green tariffs?

Government is currently consulting on how organisations should account for emissions from the purchase of green tariffs as part of our public consultation on 'Guidance on how to measure and report your greenhouse gas emissions'. The consultation package is available on the Defra website at:
http://www.defra.gov.uk/corporate/consult/greenhouse-gas/index.htm

These guidelines will be re-issued following publication of our guidance by the 1st of October 2009

Do I need to update all my calculations using the new conversion factors each year?

Emission factors for electricity are provided in time-series (e.g. for grid electricity) and **should** be updated for historical reporting with the annual update. This is because there can be revisions for earlier data due to the improvements in the calculation methodology or UK GHG inventory datasets they are based upon. Please refer to the general introduction for further details.

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here:
http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Annex 3 - Converting from purchased electricity use to carbon dioxide equivalent emissions

Table 3

Electricity factors from 1990 to 2007:	CO_2	CH_4	N_2O	Total GHG
UK Grid Electricity Year	kg CO_2 per kWh	kg CO_2eq per kWh	kg CO_2eq per kWh	kg CO_2eq per kWh
1990	0.77000	0.00027	0.00522	0.77549
1991	0.75000	0.00026	0.00509	0.75535
1992	0.70000	0.00024	0.00475	0.70499
1993	0.62000	0.00021	0.00421	0.62442
1994	0.61000	0.00021	0.00414	0.61435
1995	0.58000	0.00020	0.00394	0.58414
1996	0.56845	0.00020	0.00386	0.57250
1997	0.52448	0.00019	0.00331	0.52798
1998	0.52592	0.00020	0.00332	0.52944
1999	0.49345	0.00020	0.00285	0.49650
2000	0.52368	0.00021	0.00315	0.52704
2001	0.54110	0.00022	0.00336	0.54469
2002	0.52306	0.00022	0.00315	0.52642
2003	0.53859	0.00022	0.00336	0.54218
2004	0.53945	0.00022	0.00326	0.54293
2005	0.52665	0.00024	0.00333	0.53022
2006	0.55502	0.00024	0.00366	0.55892
2007	0.54303	0.00025	0.00339	0.54667
Electricity from CHP [2]				
2005	0.29369	0.00252	0.00014	0.29636
2006	0.30400	0.00284	0.00017	0.30700
2007	0.27300	0.00266	0.00016	0.27582
Other electricity factor				
Renewables [3]	0	0	0	0
Total				

Grid Rolling Average [1]:	CO_2		CH_4		N_2O		Total GHG	
Amount used per year, kWh	kg CO_2 per kWh	Total kg CO_2	kg CO_2eq per kWh	Total kg CO_2eq	kg CO_2eq per kWh	Total kg CO_2eq	kg CO_2eq per kWh	Total kg CO_2eq
	0.77000		0.00027		0.00522		0.77549	
	0.76000		0.00026		0.00516		0.76542	
	0.74000		0.00025		0.00502		0.74528	
	0.71000		0.00024		0.00482		0.71506	
	0.69000		0.00024		0.00468		0.69492	
	0.65200		0.00022		0.00442		0.65665	
	0.61569		0.00021		0.00418		0.62008	
	0.58059		0.00020		0.00389		0.58468	
	0.56177		0.00020		0.00371		0.56568	
	0.53846		0.00020		0.00345		0.54211	
	0.52720		0.00020		0.00330		0.53069	
	0.52173		0.00020		0.00320		0.52513	
	0.52144		0.00021		0.00317		0.52482	
	0.52398		0.00021		0.00317		0.52737	
	0.53318		0.00022		0.00326		0.53665	
	0.53377		0.00022		0.00329		0.53729	
	0.53655		0.00023		0.00335		0.54013	
	0.54055		0.00023		0.00340		0.54418	
	0.30400		0.00261		0.00015		0.30676	
	0.30400		0.00284		0.00017		0.30700	
	0.29800		0.00290		0.00017		0.30107	
	0		0		0		0	
		0		**0**		**0**		**0**

Sources

Based on UK Greenhouse Gas Inventory for 2007 (AEA) according to the amount of CO_2, CH_4 and N_2O emitted from major power stations per unit of electricity consumed from the BERR's Digest of UK Energy Statistics (DUKES) 2008 Table 5.6, available at:
http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html

Notes

[1] The electricity conversion factors given represent the average carbon dioxide emission from the UK national grid per kWh of electricity used at the point of final consumption (i.e. transmission and distribution losses are included). These factors include only direct carbon dioxide, methane and nitrous oxide emissions at UK power stations and do not include emissions resulting from production and delivery of fuel to these power stations (i.e. from gas rigs, refineries and collieries, etc.).

This factor changes from year to year, as the fuel mix consumed in UK power stations changes. Because these annual changes can be large (the factor depends very heavily on the relative prices of coal and natural gas), and to assist companies with year to year comparability, the factor presented is the grid rolling average of the grid conversion factor over the previous 5 years. This factor is updated annually.

[2] The conversion factor for electricity from CHP may be used only for the percentage of the electricity sourced from your supplier that has been produced from CHP meeting the *'Good Quality CHP'* criterion of the CHPQA programme. If you use all the output of a Combined Heat and Power plant to meet the energy needs of your business, you need not attribute the emissions from the plant between the energy and heat output - please refer to Annex 2 for this calculation. Otherwise the regular electricity emission factor should be applied. Emission factors include grid losses.

[3] Government is currently consulting on how organisations should account for the generation of onsite renewable energy and emissions from the purchase of green tariffs as part of our public consultation on 'Guidance on how to measure and report your greenhouse gas emissions'. The consultation package is available on the Defra website at:

http://www.defra.gov.uk/corporate/consult/greenhouse-gas/index.htm

Annex 4 - Typical Process Emissions

Last updated:	Jun-09

How to use this Annex

The Kyoto protocol seeks to reduce emissions of the following six greenhouse gases.

Carbon Dioxide CO_2
Methane CH_4
Nitrous oxide N_2O
Perfluorocarbons PFC
Sulphur Hexafluoride SF_6
Hydrofluorocarbons HFC

Below is a table that highlights the gases that are likely to be produced by a variety of th industries in the UK that are most likely to have a significant impact on climate change. The dark areas represent the gases that are likely to be produced.

Table 4

Process related emissions [1]							
Process		Emission					
		CO_2	CH_4	N_2O	PFC	SF_6	HFC
Mineral Products	Cement Production	■					
	Lime Production	■					
	Limestone Use [2]	■					
	Soda Ash Production and Use	■					
	Fletton Brick Manufacture [3]	■	■				
Chemical Industry	Ammonia	■	■				
	Nitric Acid			■			
	Adpic Acid			■			
	Urea			■			
	Carbides	■	■				
	Caprolactam			■			
	Petrochemicals		■				
Metal Production	Iron, Steel and Ferroalloys	■	■				
	Aluminium	■			■		
	Magnesium					■	■
	Other Metals	■					
Energy Industry	Coal mining		■				
	Solid fuel transformation	■					
	Oil production	■	■				
	Gas production and distribution	■	■				
	Venting and flaring from oil/gas production	■	■				
Other	Production of Halocarbons				■		■
	Use of Halocarbons and SF_6				■	■	■
	Organic waste management	■	■				

If you have identified process emissions of greenhouse gases other than those covered in this Annex these may be converted to carbon dioxide equivalents by using the factors provided in **Annex 5**.

Sources

Greenhouse Gas Inventory Reference Manual, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997)

adapted for UK processes by AEA

Notes

[1] These process related emissions refer to the types of processes that are used specifically in the UK. Process emissions might be slightly different for processes operated in other countries.

[2] For use of limestone in Flue Gas Desulphurisation (FGD) and processes such as those in the glass industry. Not all uses of limestone release CO_2.

[3] This is specific to Fletton brick manufacture at the mineral processing stage, a process that uses clay with high organic content. Other types of brick manufacturing in the UK do not release Greenhouse Gases during the processing stage.

Annex 5 - Emission Factors for converting Greenhouse Gas Emissions into Carbon Dioxide Equivalents (including emissions from refrigerants and air conditioning systems)

Last updated:	Jun-09

How to use this Annex

Global Warming Potentials (GWPs) are used to compare the impact of the emission of equivalent masses of different GHGs relative to carbon dioxide. For example, it is estimated that the emission of 1 kilogram of methane will have the same warming impact[1] as 21 kilograms of carbon dioxide. Therefore the GWP of methane is 21. The GWP of carbon dioxide is, by definition, 1

The conversion factors in **Table 5a** incorporate (GWP) values relevant to reporting under UNFCCC, as published by the IPCC in its Second Assessment Report, *Climate Change 1995. The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. (Eds. J. T Houghton et al, 1996)*.

Revised GWP values have since been published by the IPCC in the Fourth Assessment Report (2007) but current UNFCCC Guidelines on Reporting and Review, adopted before the publication of the Fourth Assessment Report, require emission estimates to be based on the GWPs in the IPCC Second Assessment Report. A second table, **Table 5b**, includes other greenhouse gases not listed in the Kyoto protocol or covered by reporting under UNFCCC. These GWP conversion factors have been taken from the IPCC's Fourth Assessment Report (2007).

CFCs and HCFCs

Not all refrigerants in use are classified as greenhouse gases for the purposes of the UNFCCC and Kyoto Protocol (e.g. CFCs, HCFCs). These gases are controlled under the Montreal Protocol and as such GWP values are listed in **Table 5b**

Mixed/Blended gases

GWP values for refrigerant blends should be calculated on the basis of the percentage blend composition (e.g. the GWP for R404a that comprises is 44% HFC125, 52% HFC143a and 4% HFC134a is [2800 x 0.44] + [3800 x 0.52] + [1300 x 0.04] = 3260). A limited selection of common blends is presented in Tables 5a and 5b.

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here: http://www.defra.gov.uk/environment/business/reporting/conversion-factors/htm

Table 5a

Factors for Process Emissions - Greenhouse Gases Listed in the Kyoto Protocol							
Emission	Chemical formula	Amount Emitted per Year in tonnes	x	Conversion Factor (GWP)	x	Unit conversion tonnes to kg	Total kg CO_2 equivalent
Carbon Dioxide	CO_2		x	1	x	1,000	
Methane	CH_4		x	21	x	1,000	
Nitrous Oxide	N_2O		x	310	x	1,000	
HFC-23	CHF_3		x	11,700	x	1,000	
HFC-32	CH_2F_2		x	650	x	1,000	
HFC-41	CH_3F		x	150	x	1,000	
HFC-125	CHF_2CF_3		x	2,800	x	1,000	
HFC-134	CHF_2CHF_2		x	1,000	x	1,000	
HFC-134a	CH_2FCF_3		x	1,300	x	1,000	
HFC-143	CH_3CF_3		x	300	x	1,000	
HFC-143a	CH_3CHF_2		x	3,800	x	1,000	
HFC-152a	CF_3CHFCF_3		x	140	x	1,000	
HFC-227ea	$CF_3CH_2CF_3$		x	2,900	x	1,000	
HFC-236fa	$CHF_2CH_2CF_3$		x	6,300	x	1,000	
HFC-245fa	$CH_3CF_2CH_2CF_3$		x	560	x	1,000	
HFC-43-I0mee	$CF_3CHFCHFCF_2CF_3$		x	1,300	x	1,000	
Perfluoromethane (PFC-14)	CF_4		x	6,500	x	1,000	
Perfluoroethane (PFC-116)	C_2F_6		x	9,200	x	1,000	
Perfluoropropane (PFC-218)	C_3F_8		x	7,000	x	1,000	
Perfluorocyclobutane (PFC-318)	$c\text{-}C_4F_8$		x	8,700	x	1,000	
Perfluorobutane (PFC-3-1-10)	C_4F_{10}		x	7,000	x	1,000	
Perfluoropentane (PFC-4-1-12)	C_5F_{12}		x	7,500	x	1,000	
Perfluorohexane (PFC-5-1-14)	C_6F_{14}		x	7,400	x	1,000	
Sulphur hexafluoride	SF_6		x	23,900	x	1,000	
Blends							
R404A	52:44:4 blend of HFC-143a, -125 and -134a		x	3,260	x	1,000	
R407C	23:25:52 blend of HFC-32, -125 and -134a		x	1,526	x	1,000	
R408A	47:7:46 blend HCFC-22, HFC-125 and HFC-143a		x	2,795	x	1,000	
R410A	50:50 blend of HFC-32 and -125		x	1,725	x	1,000	
R507	50:50 blend of HFC-125 and HFC-143a		x	3,300	x	1,000	
R508B	46:54 blend of HFC-23 and PFC-116		x	10,350	x	1,000	
Total							**0**

[1] Over the period of one century. The length of time a GWP is referenced to is important. 100 year GWPs were adopted for use under the UNFCCC and Kyoto

Annex 5 - Emission Factors for converting Greenhouse Gas Emissions into Carbon Dioxide Equivalents (including emissions from refrigerants and air conditioning systems)

Last updated:	Jun-09

Table 5b

Factors for Process Emissions - Other Greenhouse Gases (e.g. other refrigerants)							
Emission		Amount Emitted per Year in tonnes	x	Conversion Factor (GWP)	x	Unit conversion tonnes to kg	Total kg CO_2 equivalent
Substances controlled by the Montreal Protocol							
CFC-11/R11 = Trichlorofluoromethane	CCl_3F		x	4,750	x	1,000	
CFC-12/R12 = Dichlorodifluoromethane	CCl_2F_2		x	10,900	x	1,000	
CFC-13	$CClF_3$		x	14,400	x	1,000	
CFC-113	CCl_2FCClF_2		x	6,130	x	1,000	
CFC-114	$CClF_2CClF_2$		x	10,000	x	1,000	
CFC-115	$CClF_2CF_3$		x	7,370	x	1,000	
Halon-1211	$CBrClF_2$		x	1,890	x	1,000	
Halon-1301	$CBrF_3$		x	7,140	x	1,000	
Halon-2402	$CBrF_2CBrF_2$		x	1,640	x	1,000	
Carbon tetrachloride	CCl_4		x	1,400	x	1,000	
Methyl bromide	CH_3Br		x	5	x	1,000	
Methyl chloroform	CH_3CCl_3		x	146	x	1,000	
HCFC-22/R22 = Chlorodifluoromethane	$CHClF_2$		x	1,810	x	1,000	
HCFC-123	$CHCl_2CF_3$		x	77	x	1,000	
HCFC-124	$CHClFCF_3$		x	609	x	1,000	
HCFC-141b	CH_3CCl_2F		x	725	x	1,000	
HCFC-142b	CH_3CClF_2		x	2,310	x	1,000	
HCFC-225ca	$CHCl_2CF_2CF_3$		x	122	x	1,000	
HCFC-225cb	$CHClFCF_2CClF_2$		x	595	x	1,000	
Other Perfluorinated compounds							
Nitrogen trifluoride	NF_3		x	17,200	x	1,000	
PFC-4-1-12	C_5F_{12}		x	9,160	x	1,000	
PFC-9-1-18	$C_{10}F_{18}$		x	7,500	x	1,000	
trifluoromethyl sulphur pentafluoride	SF_5CF_3		x	17,700	x	1,000	
Fluorinated ethers							
HFE-125	CHF_2OCF_3		x	14,900	x	1,000	
HFE-134	CHF_2OCHF_2		x	6,320	x	1,000	
HFE-143a	CH_3OCF_3		x	756	x	1,000	
HCFE-235da2	$CHF_2OCHClCF_3$		x	350	x	1,000	
HFE-245cb2	$CH_3OCF_2CHF_2$		x	708	x	1,000	
HFE-245fa2	$CHF_2OCH_2CF_3$		x	659	x	1,000	
HFE-254cb2	$CH_3OCF_2CHF_2$		x	359	x	1,000	
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$		x	575	x	1,000	
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$		x	580	x	1,000	
HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$		x	110	x	1,000	
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$		x	297	x	1,000	
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$		x	59	x	1,000	
HFE-43-10pccc124 (H-Galden1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$		x	1,870	x	1,000	
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$		x	2,800	x	1,000	
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$		x	1,500	x	1,000	
Others							
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$		x	10,300	x	1,000	
Dimethylether	CH_3OCH_3		x	1	x	1,000	
Methylene chloride	CH_2Cl_2		x	8.7	x	1,000	
Methyl chloride	CH_3Cl		x	13	x	1,000	
R290 = Propane	C_3H_8		x	3.3	x	1,000	
R600A = Isobutane	C_4H_{10}		x	0.001	x	1,000	
Blends							
R406A	55:41:4 blend of HCFC-22, HCFC-142b and R600A		x	1,943	x	1,000	
R409A	60:25:15 blend of HCFC-22, HCFC-124 and HCFC-142b		x	1,585	x	1,000	
R502	48.8:51.2 blend of HCFC-22 and CFC-115		x	4,657	x	1,000	
Total							**0**

Sources

The conversion factors in Table 4a above incorporate global warming potential (GWP) values published by the IPCC in its Second Assessment Report (Climate Change 1995. The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. (Eds. J.T Houghton et al). Published for the Intergovernmental Panel on Climate Change by Cambridge University Press 1996). Revised GWP values have since been published by the IPCC in the Third Assessment Report (2001) and Fourth Assessment Report (2007) but current UNFCCC Guidelines on Reporting and Review, adopted before the publication of the Third and Fourth Assessment Report, require emission estimates to be based on the GWPs in the IPCC Second Assessment Report.

The conversion factors in Table 5b above incorporate (GWP) values published by the IPCC in its Fourth Assessment Report (Working Group I Report "The Physical Science Basis", 2007, available at: http://www.ipcc.ch/ipccreports/ar4-wg1.htm).

Notes

Not all refrigerants in use are classified as greenhouse gases for the purposes of the Climate Change Programme (e.g. CFCs, HCFCs, other substances listed in Table 5b). GWP values for refrigerant HFC blends should be calculated on the basis of the percentage blend composition. For example, the GWP for R404A that comprises is 44% HFC125, 52% HFC143a and 4% HFC134a is 2800 x 0.44 + 3800 x 0.52 + 1300 x 0.04 = 3260. Similarly R407C is a blend of 23% of R32, 25% of R125 and 52% of R134a = 650 x 0.23 + 2800 x 0.25 + 1300 x 0.52 = 1526. Information on blends is based largely on information from the UK Institute of Refrigeration website: http://www.ior.org.uk/index.php

Annex 6 - Passenger Transport Conversion Tables

Last updated:	Jun-09

How to use this Annex

Emissions can be calculated *either* from fuel use (see Table 6a), which is the most accurate method of calculation, or estimated from *distance* travelled using UK average emission factors for different modes of transport (other Tables 6b - 6j). For public transport (Tables 6k and 6l) emissions are presented per passenger, rather than per vehicle. Therefore enter *passenger kilometres travelled* to calculate emissions (e.g. if one person travels 500km, then *passenger kilometres travelled* are 500. If three people travel the same distance *passenger kilometres travelled* are 1500).

Simply multiply activity (either fuel used, kilometres travelled or passenger kilometres travelled) by the appropriate conversion factor. An excel spreadsheet is provided for ease of use.

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here:
http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Table 6a

Standard Road Transport Fuel Conversion Factors				CO_2		CH_4		N_2O		Total GHG	
Fuel used	Total units used	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Petrol		litres		2.3035		0.0047		0.0226		2.3307	
Diesel		litres		2.6391		0.0019		0.0283		2.6694	
Compressed Natural Gas (CNG)		kg		2.7278		0.0042		0.0016		2.7336	
Liquid Petroleum Gas (LPG)		litres		1.4951		0.0006		0.0011		1.4968	
Total					**0**		**0**		**0**		**0**

Sources
UK Greenhouse Gas Inventory for 2007 (AEA)
Digest of UK Energy Statistics 2008 (BERR), available at:
http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html
Carbon factors for fuels (UKPIA, 2004)

Notes
1 imperial gallon (UK) = 4.546 litres

Annex 6 - Passenger Transport Conversion Tables

Last updated:	Jun-09

Table 6b

Passenger Road Transport Conversion Factors: Petrol Cars				CO_2		CH_4		N_2O		Total GHG	
Size of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Small petrol car, up to 1.4 litre engine		miles	x	0.2894		0.0005		0.0030		0.2929	
		km	x	0.1798		0.0003		0.0018		0.1820	
Medium petrol car, from 1.4 - 2.0 litres		miles	x	0.3425		0.0005		0.0030		0.3459	
		km	x	0.2128		0.0003		0.0018		0.2149	
Large petrol cars, above 2.0 litres		miles	x	0.4756		0.0005		0.0030		0.4790	
		km	x	0.2955		0.0003		0.0018		0.2976	
Average petrol car		miles	x	0.3310		0.0005		0.0030		0.3344	
		km	x	0.2057		0.0003		0.0018		0.2078	
Total for petrol cars					0		0		0		0

Table 6c

Passenger Road Transport Conversion Factors: Diesel Cars				CO_2		CH_4		N_2O		Total GHG	
Size of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Small diesel car, up to 1.7 litre or under		miles	x	0.2429		0.0001		0.0028		0.2459	
		km	x	0.1510		0.0001		0.0017		0.1528	
Medium diesel car, from 1.7 to 2.0 litre		miles	x	0.3019		0.0001		0.0028		0.3048	
		km	x	0.1876		0.0001		0.0017		0.1894	
Large diesel car, over 2.0 litre		miles	x	0.4117		0.0001		0.0028		0.4146	
		km	x	0.2558		0.0001		0.0017		0.2576	
Average diesel car		miles	x	0.3163		0.0001		0.0028		0.3192	
		km	x	0.1965		0.0001		0.0017		0.1983	
Total for diesel cars					0		0		0		0

Table 6d

Passenger Road Transport Conversion Factors: Alternative Fuel Cars				CO_2		CH_4		N_2O		Total GHG	
Type of alternative fuel car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Medium petrol hybrid car		miles	x	0.2031		0.0003		0.0030		0.2063	
		km	x	0.1262		0.0002		0.0018		0.1282	
Large petrol hybrid car		miles	x	0.3604		0.0003		0.0030		0.3637	
		km	x	0.2240		0.0002		0.0018		0.2260	
Medium LPG or CNG car		miles	x	0.2997		0.0005		0.0030		0.3031	
		km	x	0.1862		0.0003		0.0018		0.1883	
Large LPG or CNG car		miles	x	0.4161		0.0005		0.0030		0.4195	
		km	x	0.2586		0.0003		0.0018		0.2607	
Average LPG or CNG car		miles	x	0.3579		0.0005		0.0030		0.3613	
		km	x	0.2224		0.0003		0.0018		0.2245	
Total for alternative fuel cars					0		0		0		0

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Table 6e

Passenger Road Transport Conversion Factors: Cars (unknown fuel)				CO_2		CH_4		N_2O		Total GHG	
Size of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Average car (unknown fuel)		miles	x	0.3264		0.0004		0.0029		0.3297	
		km	x	0.2028		0.0002		0.0018		0.2049	
Total for average cars					**0**		**0**		**0**		**0**

Sources: Revised factors developed by AEA and agreed with Department for Transport (2009)

Notes: These factors are estimated average values for the UK car fleet in 2008 travelling on average trips in the UK. They are calculated based on data from SMMT on new car CO_2 emissions from 1997 to 2008 combined with factors from TRL as functions of average speed of vehicle derived from test data under real world testing cycles and an uplift of 15% agreed with DfT to take into account further real-world driving effects on emissions relative to test-cycle based data. Further work is ongoing to understand this figure in more detail and revise it if necessary in the future.

The hybrid car factors are calculated based on data new car CO_2 emissions averaged across the main 4 hybrid vehicles currently available on the market and an uplift of 15% agreed with DfT to take into account real-world driving effects on emissions relative to test-cycle based data.

According to the Energy Savings Trust (EST), LPG and CNG cars results in 10-15% reduction in CO_2 relative to petrol cars, similar to diesel vehicles. New factors for LPG and CNG cars were calculated based on an average 12.5% reduction in CO_2 emissions relative to the emission factors for petrol cars from Table 6b. Due to the significant size and weight of the LPG and CNG fuel tanks only medium and large sized vehicles are available.

Real world effects not covered in regular test cycles include use of accessories (air con, lights, heaters, etc), vehicle payload (only driver +25kg is considered in tests, no passengers or further luggage), poor maintenance (tyre under inflation, maladjusted tracking, etc), gradients (tests effectively assume a level road), weather, harsher driving style, etc.

More accurate calculation of emissions can be made using the actual fuel consumed, where available, and the emission factors in Table 6a. Alternatively if a figure for a specific car's fuel consumption (e.g. in miles per gallon, mpg) is known, then the CO_2 can be calculated from the total mileage and the Table 6a factors.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

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Table 6f

Passenger Road Transport Conversion Factors: Petrol Cars by Market Segment				CO_2		CH_4		N_2O		Total GHG	
Market segment of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
A. Mini		miles	x	0.2642		0.0005		0.0030		0.2677	
		km	x	0.1642		0.0003		0.0018		0.1663	
B. Supermini		miles	x	0.2797		0.0005		0.0030		0.2832	
		km	x	0.1738		0.0003		0.0018		0.1760	
C. Lower Medium		miles	x	0.3273		0.0005		0.0030		0.3307	
		km	x	0.2034		0.0003		0.0018		0.2055	
D. Upper Medium		miles	x	0.3710		0.0005		0.0030		0.3744	
		km	x	0.2305		0.0003		0.0018		0.2326	
E. Executive		miles	x	0.4404		0.0005		0.0030		0.4439	
		km	x	0.2737		0.0003		0.0018		0.2758	
F. Luxury		miles	x	0.5589		0.0005		0.0030		0.5623	
		km	x	0.3473		0.0003		0.0018		0.3494	
G. Sports		miles	x	0.4110		0.0005		0.0030		0.4144	
		km	x	0.2554		0.0003		0.0018		0.2575	
H. Duel Purpose 4x4		miles	x	0.4683		0.0005		0.0030		0.4717	
		km	x	0.2910		0.0003		0.0018		0.2931	
I. MPV		miles	x	0.3836		0.0005		0.0030		0.3870	
		km	x	0.2384		0.0003		0.0018		0.2405	
Total for petrol cars					**0**		**0**		**0**		**0**

Table 6g

Passenger Road Transport Conversion Factors: Diesel Cars by Market Segment				CO_2		CH_4		N_2O		Total GHG	
Market segment of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
A. Mini		miles	x	0.1585		0.0001		0.0028		0.1615	
		km	x	0.0985		0.0001		0.0017		0.1003	
B. Supermini		miles	x	0.2362		0.0001		0.0028		0.2391	
		km	x	0.1468		0.0001		0.0017		0.1486	
C. Lower Medium		miles	x	0.2699		0.0001		0.0028		0.2729	
		km	x	0.1677		0.0001		0.0017		0.1696	
D. Upper Medium		miles	x	0.2935		0.0001		0.0028		0.2964	
		km	x	0.1824		0.0001		0.0017		0.1842	
E. Executive		miles	x	0.3499		0.0001		0.0028		0.3528	
		km	x	0.2174		0.0001		0.0017		0.2192	
F. Luxury		miles	x	0.4094		0.0001		0.0028		0.4124	
		km	x	0.2544		0.0001		0.0017		0.2562	
G. Sports		miles	x	0.3015		0.0001		0.0028		0.3044	
		km	x	0.1873		0.0001		0.0017		0.1891	
H. Duel Purpose 4x4		miles	x	0.4418		0.0001		0.0028		0.4447	
		km	x	0.2745		0.0001		0.0017		0.2763	
I. MPV		miles	x	0.3383		0.0001		0.0028		0.3412	
		km	x	0.2102		0.0001		0.0017		0.2120	
Total for diesel cars					**0**		**0**		**0**		**0**

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Table 6h

Passenger Road Transport Conversion Factors: Cars (unknown fuel) by Market Segment				CO_2		CH_4		N_2O		Total GHG	
Market segment of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
A. Mini		miles	x	0.2637		0.0005		0.0029		0.2671	
		km	x	0.1639		0.0003		0.0018		0.1660	
B. Supermini		miles	x	0.2756		0.0005		0.0029		0.2790	
		km	x	0.1712		0.0003		0.0018		0.1733	
C. Lower Medium		miles	x	0.3114		0.0004		0.0029		0.3148	
		km	x	0.1935		0.0003		0.0018		0.1956	
D. Upper Medium		miles	x	0.3395		0.0004		0.0029		0.3428	
		km	x	0.2110		0.0002		0.0018		0.2130	
E. Executive		miles	x	0.4039		0.0003		0.0029		0.4071	
		km	x	0.2510		0.0002		0.0018		0.2529	
F. Luxury		miles	x	0.5273		0.0003		0.0029		0.5305	
		km	x	0.3276		0.0002		0.0018		0.3296	
G. Sports		miles	x	0.4094		0.0003		0.0029		0.4126	
		km	x	0.2544		0.0002		0.0018		0.2564	
H. Duel Purpose 4x4		miles	x	0.4530		0.0003		0.0029		0.4562	
		km	x	0.2815		0.0002		0.0018		0.2835	
I. MPV		miles	x	0.3606		0.0004		0.0029		0.3638	
		km	x	0.2240		0.0002		0.0018		0.2261	
Total for cars (unknown fuel)					**0**		**0**		**0**		**0**

Sources: Factors developed by AEA and agreed with Department for Transport (2009)

Notes: The market segment categories are the standard segments as defined by SMMT (UK Society of Motor Manufacturers and Traders). These factors are estimated average values for the UK car fleet in 2008 travelling on average trips in the UK. They are calculated based on data from SMMT on new car CO2 emissions from 1997 to 2008 by SMMT. An uplift of 15% agreed with DfT to take into account further real-world driving effects on emissions relative to test-cycle based data (as under Tables 6b-6e). Further work is ongoing to understand this figure in more detail and revise it if necessary in the future.

There is a substantial variation in emission factors across market classes due to significant variations in engine size and vehicle weight. The Department for Transport consider the emission factors by fuel and engine size to often be a closer match to actual emissions. It is preferable to use the emission factors by engine size provided in Tables 6b and 6c over the market class based factors where possible.

More accurate calculation of emissions can be made using the actual fuel consumed, where available, and the emission factors in Table 6a. Alternatively if a figure for a specific car's fuel consumption (e.g. in miles per gallon, mpg) is known, then the CO_2 can be calculated from the total mileage and the Table 6a factors.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

Annex 6 - Passenger Transport Conversion Tables

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Table 6i

Passenger Road Transport Conversion Factors: Vans (Light Commercial Vehicles)				CO_2		CH_4		N_2O		Total GHG	
Type of van	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Petrol van up to 1.25 tonne		miles	x	0.3611		0.0005		0.0057		0.3673	
		km	x	0.2244		0.0003		0.0035		0.2282	
Diesel van (Class I), up to 1.305 tonne		miles	x	0.2589		0.0001		0.0017		0.2607	
		km	x	0.1609		0.0000		0.0011		0.1620	
Diesel van (Class II), 1.305 to 1.74 tonne		miles	x	0.3620		0.0001		0.0024		0.3644	
		km	x	0.2249		0.0000		0.0015		0.2265	
Diesel van (Class III), 1.74 to 3.5 tonne		miles	x	0.4817		0.0001		0.0032		0.4850	
		km	x	0.2993		0.0000		0.0020		0.3014	
Diesel van up to 3.5 tonne		miles	x	0.4371		0.0001		0.0029		0.4401	
		km	x	0.2716		0.0000		0.0018		0.2735	
LPG or CNG van up to 3.5 tonne		miles	x	0.4375		0.0005		0.0057		0.4437	
		km	x	0.2718		0.0003		0.0035		0.2757	
Average van up to 3.5 tonne		miles	x	0.4291		0.0001		0.0032		0.4324	
		km	x	0.2666		0.0001		0.0020		0.2687	
Total for vans					0		0		0		0

Sources: Factors developed by AEA and agreed with Department for Transport (2009)

Notes: Emission factors for light good vehicles (vans up to 3.5 tonnes) were calculated based on revisions to the diesel emission factors used in the National Atmospheric Emissions Inventory (NAEI) proposed to DfT by AEA (2005). These test cycle based emission factors were then uplifted by 15% to represent 'real-world' emissions, consistent with the approach used for cars agreed with DfT. New factors for Class I - Class III Diesel vans were calculated based on a summary of MVRIS reported CO2 data broken down by van class from analysis of the revised database by AEA as part of work on a 'Light Goods Vehicle – CO2 Emissions Study' for DfT (2009). Emission factors for petrol vehicles were calculated from the relative emissions and vkm of petrol and diesel LGVs in the NAEI. Emission factors for LPG and CNG vans were estimated to be similar to diesel vehicles, as indicated by EST for cars. The average van emission factor was calculated on the basis of the relative NAEI vehicle km for petrol and diesel LGVs for 2005.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

Table 6j

Passenger Road Transport Conversion Factors: Motorcycles				CO_2		CH_4		N_2O		Total GHG	
Size of motorcycle	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Small petrol motorbike (mopeds/scooters up to 125cc)		miles	x	0.1368		0.0030		0.0009		0.1407	
		km	x	0.0850		0.0018		0.0006		0.0874	
Medium petrol motorbike (125-500cc)		miles	x	0.1660		0.0031		0.0010		0.1701	
		km	x	0.1032		0.0019		0.0006		0.1057	
Large petrol motorbike (over 500cc)		miles	x	0.2209		0.0031		0.0010		0.2249	
		km	x	0.1372		0.0019		0.0006		0.1398	
Average petrol motorbike (unknown engine size)		miles	x	0.1868		0.0030		0.0010		0.1908	
		km	x	0.1161		0.0019		0.0006		0.1186	
Total for motorcycles					0		0		0		0

Sources: Factors developed by AEA and agreed with Department for Transport (2009)

Notes: These factors are based on calculations of average emissions data by size category, based data provided by Clear (http://www.clear-offset.com/) of almost 1200 datapoints, over 300 different bikes from 50-1500cc, and from 25 manufacturers from a mix of magazine road test reports and user reported data.

More accurate calculation of emissions can be made using the actual fuel consumed, where available, and the emission factors in Table 5a. Alternatively if a figure for a specific motorbike's fuel consumption (e.g. in miles per gallon, mpg) is known, then the CO_2 can be calculated from the total mileage and the Table 6a factors.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

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Table 6k

Taxi, Bus, Rail and Ferry Passenger Transport Conversion Factors				CO_2		CH_4		N_2O		Total GHG	
Method of travel		Vehicle kms travelled (vkm)	x	kg CO_2 per vkm	Total kg CO_2	kg CO_2eq per vkm	Total kg CO_2eq	kg CO_2eq per vkm	Total kg CO_2eq	kg CO_2eq per vkm	Total kg CO_2eq
Taxi [1]	Regular taxi		x	0.2217		0.0001		0.0017		0.2235	
	Black cab		x	0.2558		0.0001		0.0017		0.2576	
Method of travel		Passenger kms travelled (pkm)	x	kg CO_2 per pkm	Total kg CO_2	kg CO_2eq per pkm	Total kg CO_2eq	kg CO_2eq per pkm	Total kg CO_2eq	kg CO_2eq per pkm	Total kg CO_2eq
Taxi [1]	Regular taxi		x	0.1583		0.0001		0.0012		0.1596	
	Black cab		x	0.1705		0.0001		0.0012		0.1717	
Bus	Local bus [2]		x	0.1104		0.0001		0.0010		0.1115	
	London bus [3]		x	0.0830		0.0001		0.0007		0.0838	
	Average bus		x	0.1035		0.0001		0.0010		0.1046	
	Coach [4]		x	0.0300		0.0000		0.0006		0.0306	
	Average bus and coach		x	0.0682		0.0001		0.0008		0.0691	
Rail	National rail [5]		x	0.0577		0.0001		0.0033		0.0611	
	International rail (Eurostar) [6]		x	0.0177		0.0000		0.0001		0.0178	
	Light rail and tram [7]		x	0.0834		0.0000		0.0005		0.0840	
	London Underground [8]		x	0.0780		0.0000		0.0005		0.0786	
Ferry (Large RoPax) [9]	Foot passengers		x	0.0191		0.0000		0.0001		0.0193	
	Car passengers		x	0.1322		0.0000		0.0010		0.1332	
	Average (all passengers)		x	0.1152		0.0000		0.0009		0.1161	
Total					**0**		**0**		**0**		**0**

Sources: Department for Transport, Transport for London and AEA (2009)

Notes

[1] New emission factors for taxis were estimated on the basis of an average of the emission factors of medium and large cars from Table 6c and occupancy of 1.4 (CfIT, 2002). The emission factors for black cabs are based on the large car emission factor (consistent with the VCA dataset for London Taxis International vehicles) and an average passenger occupancy of 1.5 (average 2.5 people per cab from LTI website, 2008).

[2] The factor for local buses was calculated based on data publically available from the major bus service operators including Stagecoach, First Group, Arriva, National Express, Go-Ahead and from Transport for London, supplemented in some cases by average bus occupancy factors from national statistics.
The DfT is currently considering changing the methodology used to calculate local bus CO_2 emissions in future years. This approach will make use of actual fuel consumption data submitted by bus operators to the DfT as part of their Bus Service Operators Grant (BSOG) claims.

[3] The London bus factor is from the Transport for London 2008 environmental report available at: http://www.tfl.gov.uk/assets/downloads/corporate/environment-report-2008.pdf and http://www.tfl.gov.uk/assets/downloads/corporate/environment-report-2008-data-tables.pdf

[4] The emission factor for coach transport is the figure from the National Express Group's Corporate Responsibility Report, available at: http://www.nationalexpressgroup.com/nx1/corporate/environment/climate/. National Express are responsible for the majority of long-distance coach services in the UK, so this figure is expected to be broadly representative of the overall average.

[5] The national rail factor refers to an average emission per passenger kilometre for diesel and electric trains in 2007. The calculation of the factor is based on the total electricity and diesel consumed by the railways in 2007/08 from the DfT National Modelling Framework Environment Module, and DfT transport statistics on the total number of passenger kilometres for 2007/08. Emission factors for freight rail are provided in Annex 7, Table 7f.

[6] The emission factor for international rail is based on an average of the figures provided on the Eurostar website for the London-Brussels and London-Paris Eurostar routes, available at: http://www.eurostar.com/UK/uk/leisure/travel_information/before_you_go/Green_Eurostar.jsp

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[7] The light rail and tram factors were based on an average of factors for the Docklands Light Rail (DLR) service, the Manchester Metrolink, Tyne and Wear Metro, Glasgow Underground, Supertram, Midland Metro and the Croydon Tramlink. The factors for the Tyne and Wear, Glasgow, Midland, Supertram and Manchester tram and light rail systems were based on annual electricity consumption and passenger km data provided by the network operators in 2008 (referring mostly to consumption in 2007/08) and a CO_2 emission factor for grid rolling average electricity from Table 2. DLR and Croydon Tramlink figures were recalculated using the updated 2007 grid rolling average from those available in the Transport for London 2008 environmental report available at: http://www.tfl.gov.uk/assets/downloads/corporate/environment-report-2008.pdf and http://www.tfl.gov.uk/assets/downloads/corporate/environment-report-2008-data-tables.pdf

[8] The London Underground rail factor is recalculated using the updated 2007 grid rolling average from figures in the Transport for London 2007 environmental report available at: http://www.tfl.gov.uk/assets/downloads/corporate/environment-report-2008.pdf and http://www.tfl.gov.uk/assets/downloads/corporate/environment-report-2008-data-tables.pdf

[9] The factors for RoPax ferries (Roll-on Roll-off ferries with additional passenger capacity) are based on data provided by Best Foot Forward from work for the Passenger Shipping Association (PSA) carried out in 2007/8. The calculated figure is based on ferry service operator provided data on fuel consumption and passengers transported, but does not include any data for passenger only ferry services, which would be expected to have significantly higher emission factors per passenger km.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

Table 6l

Air Passenger Transport Conversion Factors							CO_2		CH_4		N_2O		Total GHG	
Method of travel		Passenger kms travelled (pkm)	x	km uplift factor [12]	x	kg CO_2 per pkm [13]	Total kg CO_2		kg CO_2eq per pkm	Total kg CO_2eq	kg CO_2eq per pkm	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Flight type [10]	*Cabin class* [11]													
Domestic	**Average**		x	109%	x	0.1710			0.00013		0.0017		0.1728	
Short-haul international	**Average**		x	109%	x	0.0983			0.00001		0.0010		0.0992	
	Economy class		x	109%	x	0.0937			0.00001		0.0009		0.0946	
	Business class		x	109%	x	0.1405			0.00001		0.0014		0.1419	
Long-haul international	**Average**		x	109%	x	0.1122			0.00001		0.0011		0.1133	
	Economy class		x	109%	x	0.0819			0.00000		0.0008		0.0827	
	Premium economy class		x	109%	x	0.1311			0.00001		0.0013		0.1324	
	Business class		x	109%	x	0.2375			0.00001		0.0023		0.2399	
	First class		x	109%	x	0.3276			0.00002		0.0032		0.3309	
Total							**0**			**0**		**0**		**0**

Source Notes: Developed by AEA (2009) using the methodology developed in discussion with the Department for Transport and the airline industry, 2008.
These emissions factors are intended to be an aggregate representation of the typical emissions per passenger km from illustrative types of aircraft for the 3 types of air services. Actual emissions will vary significantly according to the type of aircraft in use, the load, cabin class, specific conditions of the flight route, etc.

[10] The emission factors refer to aviation's direct carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions only. There is currently uncertainty over the other non-CO2 climate change effects of aviation (including water vapour, contrails, NOx etc) which may indicatively be accounted for by applying a multiplier. The appropriate factor to apply is subject to uncertainty but was estimated by the IPCC in 1999 to be in the range 2-4, with current best scientific evidence suggesting a factor of 1.9.
If used, this factor would be applied to the emissions factors set out here.

[11] The 9% uplift factor comes from the IPCC Aviation and the global Atmosphere 8.2.2.3 , which states that 9-10% should be added to take into account non-direct routes (i.e. not along the straight line great circle distances between destinations) and delays/circling. Airline industry representatives have indicated that the percentage uplift for short-haul flights will be higher and for long-haul flights will be lower, however specific data is not currently available to provide separate factors. This is under investigation for future versions of these guidelines.

[12] The emissions factors are based on typical aircraft fuel burn over illustrative trip distances listed in the EMEP/CORINAIR Emissions Inventory Guidebook (EIG 2007) – available at the EEA website at: http://reports.eea.europa.eu/EMEPCORINAIR5/en/B851vs2.4.pdf and http://reports.eea.europa.eu/EMEPCORINAIR5/en/B851_annex.zip. This information is combined with data from the Civil Aviation Authority (CAA) on average aircraft seating capacity, loading factors, and annual passenger-km and aircraft-km for 2007 (most recent full-year data available). The provisional evidence to date suggests an uplift in the region of 10-12% to climb/cruise/descent factors derived by the CORINAIR approach is appropriate in order to ensure consistency with estimated UK aviation emissions as reported in line with the UN Framework on Climate Change, covering UK domestic flights and departing international flights.

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These emissions are based on bunker fuel consumption and are closely related to fuel on departing flights. This uplift is therefore based on comparisons of national aviation fuel consumption from this reported inventory, with detailed bottom up calculations in DfT modelling along with the similar NAEI approach, which both use detailed UK activity data (by aircraft and route) from CAA, and the CORINAIR fuel consumption approach. Therefore for this version of the Defra CO_2 emission factors an uplift of 10% is applied to the emissions from the Cruise, Climb and Decent of the aircraft based on provisional evidence. The CORINAIR uplift is in addition to the assumption that Great Circle Distances are increased by 9% to allow for sub-optimal routing and stacking at airports during periods of heavy congestion. It should be noted that work will continue to determine a more robust reconciliation and this will be accounted for in future versions of these factors.

The long haul estimate is based on a flight length from the Guidebook of 6482 km, short haul 1108km and domestic 463km. Actual flight distances do however vary significantly, as demonstrated in the examples in the following tables. Domestic flights are between UK airports, short haul international flights are typically to Europe (up to 3700km distance), and long haul international flights are typically to non-European destinations (or all other international flights over 3700km distance).

[13] The indicative emissions factors by passenger seating class have been produced to allow passengers to build an understanding of how emissions per passenger km are affected by load factors and seat configurations. This is in response to feedback on the previous version of the Act on CO_2 calculator.

Emission factors by passenger seating class were developed on the basis of detailed analysis of the seating configurations of 24 aircraft model variants from 16 major airlines providing services within/to/from the UK. Indicative emission factors were calculated via the relative area on the aircraft occupied by different seating classes compared to an economy class equivalent per passenger. Figures are only indicative averages and will vary considerably between different specific airline and aircraft configurations.

These indicative factors will be updated as further evidence comes to light on how these factors could more accurately be estimated. There are several ways in which these factors could be estimated, which will be kept under review.

Illustrative long haul flight distances

From London to:		
Area	***Airport***	***Distance (km)***
North Africa	Abu Simbel/Sharm El Sheikh, Egypt	3300
Southern Africa	Johannesburg/Pretoria, South Africa	9000
Middle East	Dubai, UAE	5500
North America	New York (JFK), USA	5600
North America	Los Angeles California, USA	8900
South America	Sao Paulo, Brazil	9400
Indian sub-continent	Bombay/Mumbai, India	7200
Far East	Hong Kong	9700
Australasia	Sydney, Australia	17000

Source Distances based on International Passenger Survey (Office for National Statistics) calculations using airport geographic information.

Illustrative short haul flight distances

From London to:		
Area	***Airport***	***Distance (km)***
Europe	Amsterdam, Netherlands	400
Europe	Prague (Ruzyne), Czech Rep	1000
Europe	Malaga, Spain	1700
Europe	Athens, Greece	1500

Source Distances based on International Passenger Survey (Office for National Statistics) calculations using airport geographic information.

New emission factors for CH_4 and N_2O are based on the UK Greenhouse Gas Inventory for 2007 (AEA)

Annex 7 - Freight Transport Conversion Tables

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How to use this Annex

If you know how much of a particular fuel type is consumed, emissions can be calculated using **Table 7a**. This is the most accurate way to calculate emissions.

Table 7b gives emissions for distance travelled for vans and small trucks

Table 7c gives emissions *per tonne freight carried* for vans and small trucks. Emission factors for vans in tonne km were calculated from the emission factors per vehicle km provided in Table 6i (Annex 6) and an average load factor of 40%. The average cargo capacity was taken to be 0.5 tonnes for vans up to 1.25 tonnes gross vehicle weight, and 2 tonnes for vans up to 3.5 tonnes gross vehicle weight.

Table 7d gives emissions *per vehicle kilometre travelled* for a range of HGV sizes with a range of different loads. Use this table if you know the distance the *vehicle* has travelled. If you do not know the load capacity of your vehicle, apply the *UK average load* which is given for a range of vehicle classes.

Table 7e gives emissions *per tonne kilometre travelled* for a range of HGV sizes with a range of different loads. Use this table if you know the distance the *freight* has travelled and what the mass (in tonnes) of the freight was.

Table 7f gives emissions factors for *tonne kilometres* of freight for *shipping, rail*, and *air freight*

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here:
http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Table 7a

Standard Road Transport Fuel Conversion Factors				CO_2		CH_4		N_2O		Total GHG	
Fuel used	Total units used	Units	x	kg CO_2 per unit	Total kg CO_2	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq	kg CO_2eq per unit	Total kg CO_2eq
Petrol		litres	x	2.3035		0.0047		0.0226		2.3307	
Diesel		litres	x	2.6391		0.0019		0.0283		2.6694	
Compressed Natural Gas (CNG)		kg	x	2.7278		0.0042		0.0016		2.7336	
Liquid Petroleum Gas (LPG)		litres	x	1.4951		0.0006		0.0011		1.4968	
Total					**0**		**0**		**0**		**0**

Sources
UK Greenhouse Gas Inventory for 2007 (AEA)
Digest of UK Energy Statistics 2008 (BERR), available at: http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html
Carbon factors for fuels (UKPIA, 2004)

Notes
1 imperial gallon (UK) = 4.546 litres

Annex 7 - Freight Transport Conversion Tables

Last updated: Jun-09

Table 7b

Van/Light Commercial Vehicle Road Freight Conversion Factors: Vehicle km Basis				CO_2		CH_4		N_2O		Total GHG	
Type of van	Gross Vehicle Weight (tonnes)	Total vehicle km travelled	x	kg CO_2 per vehicle km	Total kg CO_2	kg CO_2eq per vehicle km	Total kg CO_2eq	kg CO_2eq per vehicle km	Total kg CO_2eq	kg CO_2eq per vehicle km	Total kg CO_2eq
Petrol	up to 1.25t		x	0.2244		0.0003		0.0035		0.2282	
Diesel (Class I)	up to 1.305t		x	0.1609		0.0000		0.0011		0.1620	
Diesel (Class II)	1.305t to 1.74t		x	0.2249		0.0000		0.0015		0.2265	
Diesel (Class III)	1.74t to 3.5t		x	0.2993		0.0000		0.0020		0.3014	
Diesel (average)	*up to 3.5t*		*x*	*0.2716*		*0.0000*		*0.0018*		*0.2735*	
LPG or CNG	up to 3.5t		x	0.2718		0.0003		0.0035		0.2757	
Average	*up to 3.5t*		*x*	*0.2666*		*0.0001*		*0.0020*		*0.2687*	
Total					**0**		**0**		**0**		**0**

Table 7c

Van/Light Commercial Vehicle Road Freight Conversion Factors (UK Average Vehicle Loads): Tonne.km Basis				CO_2		CH_4		N_2O		Total GHG	
	Gross Vehicle Weight (tonnes)	Total tonne km travelled	x	kg CO_2 per tonne.km	Total kg CO_2	kg CO_2eq per tonne.km	Total kg CO_2eq	kg CO_2eq per tonne.km	Total kg CO_2eq	kg CO_2eq per tonne.km	Total kg CO_2eq
Petrol	up to 1.25t		x	0.9286		0.0014		0.0145		0.9445	
Diesel (Class I)	up to 1.305t		x	0.6657		0.0002		0.0044		0.6703	
Diesel (Class II)	1.305t to 1.74t		x	0.5584		0.0001		0.0037		0.5623	
Diesel (Class III)	1.74t to 3.5t		x	0.3716		0.0001		0.0025		0.3741	
Diesel (average)	*up to 3.5t*		*x*	*0.3372*		*0.0001*		*0.0022*		*0.3395*	
LPG or CNG	up to 3.5t		x	0.3375		0.0004		0.0044		0.3423	
Average	*up to 3.5t*		*x*	*0.4001*		*0.0002*		*0.0035*		*0.4038*	
Total					**0**		**0**		**0**		**0**

Sources: Factors developed by AEA and agreed with Department for Transport (2009)

Notes: Emission factors for vans in tonne km were calculated from the emission factors per vehicle km provided in Table 6i and an average load factor of 40% (estimated on the basis of DfT statistics for Vans for 2005). The average cargo capacity was taken to be 0.6 tonnes for petrol vans up to 1.25 tonnes gross vehicle weight and diesel Class I vans, 1 tonne for Class II diesel vans and 2 tonnes for vans up to 3.5 tonnes gross vehicle weight.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

Annex 7 - Freight Transport Conversion Tables

Last updated: Jun-09

Table 7d

Diesel HGV Road Freight Conversion Factors: Vehicle km Basis						CO_2		CH_4		N_2O		Total GHG	
	Gross Vehicle Weight (tonnes)	% weight laden		Total vehicle km travelled	x	kg CO_2 per vehicle km	Total kg CO_2	kg CO_2eq per vehicle km	Total kg CO_2eq	kg CO_2eq per vehicle km	Total kg CO_2eq	kg CO_2eq per vehicle km	Total kg CO_2eq
Rigid	>3.5-7.5t	0%			x	0.5088		0.0003		0.0059		0.5150	
		50%			x	0.5530		0.0003		0.0059		0.5592	
		100%			x	0.5973		0.0003		0.0059		0.6035	
		40%	*(UK average load)*		*x*	*0.5442*		*0.0003*		*0.0059*		*0.5504*	
Rigid	>7.5-17t	0%			x	0.6578		0.0003		0.0079		0.6660	
		50%			x	0.7518		0.0003		0.0079		0.7600	
		100%			x	0.8457		0.0003		0.0079		0.8539	
		37%	*(UK average load)*		*x*	*0.7273*		*0.0003*		*0.0079*		*0.7355*	
Rigid	>17t	0%			x	0.7513		0.0003		0.0101		0.7617	
		50%			x	0.9162		0.0003		0.0101		0.9267	
		100%			x	1.0811		0.0003		0.0101		1.0916	
		55%	*(UK average load)*		*x*	*0.9336*		*0.0003*		*0.0101*		*0.9441*	
All rigids	***UK average***	***53%***			***x***	***0.7931***		***0.0003***		***0.0086***		***0.8020***	
Articulated	>3.5-33t	0%			x	0.6894		0.0015		0.0091		0.7001	
		50%			x	0.8618		0.0015		0.0091		0.8724	
		100%			x	1.0342		0.0015		0.0091		1.0448	
		43%	*(UK average load)*		*x*	*0.8377*		*0.0015*		*0.0091*		*0.8483*	
Articulated	>33t	0%			x	0.6741		0.0015		0.0102		0.6858	
		50%			x	0.8988		0.0015		0.0102		0.9105	
		100%			x	1.1235		0.0015		0.0102		1.1352	
		60%	*(UK average load)*		*x*	*0.9437*		0.0015		0.0102		*0.9555*	
All artics	***UK average***	***59%***			***x***	***0.9319***		***0.0015***		***0.0101***		***0.9435***	
ALL HGVs	***UK average***	***56%***			***x***	***0.8575***		***0.0009***		***0.0093***		***0.8678***	
Total							**0**		**0**		**0**		**0**

Sources: Revised factors developed by AEA and agreed with Department for Transport (2009)

Notes: Factors are provided in kgCO_2/vehicle.km for 3 different gross vehicle weight ranges of rigid-axled HGVs and 2 different gross vehicle weight ranges of articulated HGVs. A vehicle km is the distance travelled by the HGV.

The % weight laden refers to the extent to which the vehicle is loaded to its maximum carrying capacity. A 0% weight laden HGV means the vehicle is travelling carrying no loads. 100% weight laden means the vehicle is travelling with loads bringing the vehicle to its maximum carrying capacity.

Factors are based on road freight statistics from the Department for Transport (DfT, 2008), from a survey on the average miles per gallon and average loading factor for different sizes of rigid and artic HGVs in the 2007 fleet, combined with test data from the European ARTEMIS project showing how fuel efficiency, and hence CO_2 emissions, varies with vehicle load.

The miles per gallon figures in Table 1.9 of DfT (2008) were converted into CO_2 factors using the diesel fuel conversion factors. Then using the ARTEMIS data, these were corrected to CO_2 factors corresponding to 0%, 50% and 100% loading in Table 7d. The correction was based on the current percent lading for different sizes of HGVs in the national fleet in 2007 given in Table 1.16 of DfT (2008).

As well as CO_2 factors for 0, 50 and 100% loading, CO_2 factors are shown for the average loading of each weight class of HGV in the UK fleet in 2005. These should be used as default values if the user does not know the loading factor to use and are based on the actual laden factors and mpg figures from tables 1.16 and 1.9 in DfT (2008).

UK average factors for all rigid and articulated HGVs are also provided in Table 7d if the user requires aggregate factors for these main classes of HGVs, perhaps because the weight class of the HGV is not known. Again, these factors represent averages for the UK HGV fleet in 2005. These are derived directly from the average mpg values for all rigid and articulated HGVs in Table 1.9 of DfT (2008).

At a more aggregated level still are factors for all HGVs representing the average mpg for all rigid and articulated HGV classes in Table 1.9 of DfT (2008). This factor should be used if the user has no knowledge of or requirement for different classes of HGV and may be suitable for analysis of HGV CO_2 emissions in, for example, inter-modal freight transport comparisons.

Reference: Transport Statistics Bulletin: Road Freight Statistics 2005, DfT SB (06) 27, June 2006
http://www.dft.gov.uk/162259/162469/221412/221522/222944/coll_roadfreightstatistics2005in/rfs05comp.pdf
New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

Annex 7 - Freight Transport Conversion Tables

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Table 7e

Diesel HGV Road Freight Conversion Factors (UK Average Vehicle Loads): Tonne.km Basis						CO_2		CH_4		N_2O		Total GHG	
	Gross Vehicle Weight (tonnes)	% weight laden	UK average tonnes goods carried per vehicle	Total tonne km travelled	x	kg CO_2 per tonne.km	Total kg CO_2	kg CO_2eq per tonne.km	Total kg CO_2eq	kg CO_2eq per tonne.km	Total kg CO_2eq	kg CO_2eq per tonne.km	Total kg CO_2eq
Rigid	>3.5-7.5t	40%	0.81		x	0.6712		0.0004		0.0073		0.6788	
Rigid	>7.5-17t	37%	2.31		x	0.3152		0.0001		0.0034		0.3187	
Rigid	>17t	55%	5.25		x	0.1780		0.0001		0.0019		0.1800	
All rigids	***UK average***	***53%***	***3.42***		***x***	***0.2317***		***0.0001***		***0.0025***		***0.2343***	
Articulated	>3.5-33t	43%	6.00		x	0.1396		0.0003		0.0015		0.1414	
Articulated	>33t	60%	11.46		x	0.0824		0.0001		0.0009		0.0834	
All articulateds	***UK average***	***59%***	***10.97***		***x***	***0.0849***		***0.0001***		***0.0009***		***0.0860***	
ALL HGVs	***UK average***	***56%***	***7.23***		***x***	***0.1186***		***0.0001***		***0.0017***		***0.1204***	
Total							**0**		**0**		**0**		**0**

Sources: Revised factors developed by AEA and agreed with Department for Transport (2009)

Notes: The user may want to use factors in kgCO_2/tonne.km for calculating the emissions due to transporting a given weight of freight a given distance for comparison with other modes of freight transport, e.g. for comparing road *vs* rail using tonne.km factors for other modes in Table 7f. A tonne.km is the distance travelled multiplied by the weight of freight carried by the HGV. So, for example, an HGV carrying 5 tonnes freight over 100 km has a tonne.km value of 500 tonne.km. As different users may require CO2 factors for HGVs in different levels of detail of HGV type, factors are provided in kgCO_2/tonne.km for: 3 different gross vehicle weight ranges of rigid-axled HGVs (most amount of detail possible) and 2 different gross vehicle weight ranges of articulated HGVs; fleet averaged factors for all types of rigids and articulated HGVs; factor averaged for all types of HGVs (least amount of detail).

The gCO_2/tonne.km factors in Table 7e have been calculated on the basis that a lorry will run empty for part of the time in the overall transporting of the freight. Thus the user does not need to double the distance of their freight tonne km for parts of a trip done empty loaded, as this has already been considered in the calculations. The distance should refer to the overall distance that the goods are moved.

The factors are derived from the 2005 fleet average kgCO_2 per vehicle km factors in Table 7d and the average tonne freight per vehicle lifted by each HGV weight class. The average tonne freight lifted figures are derived from the tonne.km and vehicle.km figures given for each class of HGV in Tables 1.12 and 1.13, respectively, in DfT (2008). Dividing the tonne.km by the vehicle.km figures gives the average tonnes freight lifted by each HGV class.

Tables 7d and 7e are provided as alternative methods for calculating CO_2 emissions from movement of freight by HGVs. The factors in g/vehicle.km (Table 7d) are sufficient (and with the ability to take into account different loading factors are preferential) for an operator who simply wants to calculate and compare CO_2 emissions for different ways of transporting goods around by optimising freight logistics. Factors in Table 7e may be better to use when comparing road freight with other modes for transporting a given weight of freight a given distance. To avoid double-counting, it is important that calculations **DO NOT USE BOTH** methods.

New emission factors for CH_4 and N_2O are based on UK Greenhouse Gas Inventory default values for 2007 (AEA)

Annex 7 - Freight Transport Conversion Tables

Last updated: Jun-09

Table 7f

Other Freight Mileage Conversion Factors: Tonne.km Basis							CO_2		CH_4		N_2O		Total GHG	
Mode	Detail		Total tonne km travelled			x	kg CO_2 per tonne.km	Total kg CO_2	kg CO_2eq per tonne.km	Total kg CO_2eq	kg CO_2eq per tonne.km	Total kg CO_2eq	kg CO_2eq per tonne.km	Total kg CO_2eq
Rail	Diesel					x	0.0285		0.0001		0.0033		0.0319	
Shipping	*Type*	*Vessel deadweight, tonnes*												
	Large RoPax Ferry	-					0.3843		0.0001		0.0030		0.3875	
	Small tanker	844				x	0.0200		0.0000		0.0002		0.0202	
	Large tanker	18,371				x	0.0050		0.0000		0.0000		0.0050	
	Very large tanker	100,000				x	0.0040		0.0000		0.0000		0.0040	
	Small bulk carrier	1,720				x	0.0110		0.0000		0.0001		0.0111	
	Large bulk carrier	14,201				x	0.0070		0.0000		0.0001		0.0071	
	Very large bulk carrier	70,000				x	0.0060		0.0000		0.0000		0.0060	
	Small container vessel	2,500				x	0.0150		0.0000		0.0001		0.0151	
	Large container vessel	20,000				x	0.0130		0.0000		0.0001		0.0131	
Mode	Detail		Total tonne km travelled	x	km uplift factor [1]	x	kg CO_2 per tonne.km	Total kg CO_2	kg CO_2eq per tonne.km	Total kg CO_2	kg CO_2eq per tonne.km	Total kg CO_2	kg CO_2eq per tonne.km	Total kg CO_2
Air	Domestic			x	109%	x	1.916		0.0014		0.0189		1.9362	
	Short-haul international			x	109%	x	1.404		0.0001		0.0138		1.4183	
	Long-haul international			x	109%	x	0.595		0.0000		0.0059		0.6008	
Total								0		0		0		0

Sources: Revised factors developed by AEA and agreed with Department for Transport (2009)

Notes

Rail:

The CO2 value for rail freight is based on currently available information on CO_2 emissions by diesel freight trains in the UK in 2007 produced by ORR (Office of the Rail Regulator) and is available at:

http://www.rail-reg.gov.uk/upload/pdf/rolling-c9-environ.pdf

The rail freight CH_4 and N_2O factors are based on those used in the UK Greenhouse Gas Inventory for diesel rail for 2007.

Shipping:

The freight CO_2 emission factor for RoPax Ferries was derived from data provided by Best Foot Forward based on work for the Passenger Shipping Association (PSA) carried out in 2007/8. The calculated figure assumes an average HGV load factor of 13.6 tonnes, based on information in Table 2.6 of Road Transport Statistics 2005 (from the Department for Transport). RoPax Ferries are Roll-on Roll-off ferries that carry both road vehicles and their passengers as well as having additional passenger-only capacity.

Factors for the other representative ships are derived from information in the EMEP-CORINAIR Handbook (2003) and a report by Entec (2002). This included fuel consumption rates for engine power and speed while cruising at sea associated with different vessels. The factors refer to kgCO_2 per deadweight tonne km. Deadweight tonnage is the weight of the cargo etc which when added to the weight of the ship's structure and equipment, will bring the vessel down to its designated waterline. This implies the factors are based on a fully loaded vessel. Because the ship's engines are propelling the weight of the ship itself which is a significant proportion of the overall weight of the vessel and its cargo, reducing the cargo load from the deadweight tonnage will not lead to a proportionate reduction in the amount of fuel required to move the vessel a given distance. For example, decreasing the cargo load to half the ship's deadweight will not reduce the ship's fuel consumption by a half.

As a consequence, the factors expressed in kgCO_2/tonne.km freight will be higher than the figures in Table 6k for ships that are only partially loaded (i.e. loaded to less than the vessel's deadweight tonnage). Figures on the typical loading factors for different vessels are not currently available in the public domain. The CO_2 factors will be reviewed and updated when the loading factors become available to provide factors that are more representative of vessel movements from UK ports. Meanwhile, the factors in Table 6k should be regarded as lower limits.

References:

EMEP/CORINAIR (2007), Atmospheric Emission Inventory Guidebook, 5th Edition.

Entec (2002), Quantification of emissions from ships associated with ship movements between ports in the European Community, Report for European Commission, DG ENV. Belgium; Main Contributors Chris Whall, Karen Archer, Layla Twigger, Neil Thurston, David Ockwell, Alun McIntyre, Alistair Ritchie (Entec) and David Cooper (IVL).

New emission factors for CH_4 and N_2O are based on the UK Greenhouse Gas Inventory for 2007 (AEA)

Annex 7 - Freight Transport Conversion Tables

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Air:

Freight is transported by two types of aircraft - dedicated cargo aircraft which carry freight only, and passenger aircraft which carry both passengers and their luggage, as well as freight. Statistics from the CAA for 2007 suggest a large proportion of long haul air freight is transported on passenger aircraft. While it is possible to estimate freight CO_2 factors per tonne.km for dedicated cargo aircraft in much the same way as the passenger.km factors for passengers, it is more difficult to generate freight CO_2 factors for aircraft that are also carrying passengers without double-counting.

The allocation of aircraft CO_2 emissions between passengers and freight on these aircraft is complex and for the purposes of these emission factors the allocation is carried out by treating freight carried on cargo or passenger services as equivalent. This is done by assuming the incorporation of the lost cargo capacity of passenger aircraft relative cargo-only equivalents into the passenger weighting. It is assumed this difference in freight cargo capacity is due to passenger-service specific equipment (such as seating, galley, toilets, food) and air frame modifications. The reference aircraft used in this calculation is the Boeing 747, as the freight configuration equivalent is used for over 90% of long-haul dedicated cargo transport from the UK.

[1] The 9% uplift factor comes from the IPCC Aviation and the global Atmosphere 8.2.2.3 , which states that 9-10% should be added to take into account non-direct routes (i.e. not along the straight line great circle distances between destinations) and delays/circling. Airline industry representatives have indicated that the percentage uplift for short-haul flights will be higher and for long-haul flights will be lower, however specific data is not currently available to provide separate factors. This is under investigation for future versions of these guidelines.

Notes 10-12 from the passenger flights emission factors (Annex 6) also apply to the air freight emission factors.
New emission factors for CH_4 and N_2O are based on the UK Greenhouse Gas Inventory for 2007 (AEA)

Annex 8 - Direct GHG Emissions from Use of Refrigeration and Air Conditioning Equipment

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How to use this Annex

There are two methods presented here for the estimation of emissions from the use of refrigeration and air conditioning equipment. For smaller users the simple **A. Screening Method** will likely be the easiest way to calculate their emissions. For some larger users of refrigerant and they should have the information necessary to perform a more accurate estimation using a **B. Simplified Material Balance Method**.

A. Screening Method

This Screening Method will help organisations to estimate emissions from refrigeration and air conditioning based on the type of equipment used and emissions factors. This approach requires relatively little actual data collection however there is a high degree of uncertainty with these emission factors. Therefore if emissions from this equipment are determined to be significant when compared to your organisation's other emissions sources, then you should apply a better estimation method (e.g. a Material Balance Method). **Please note, there are extensive regulatory requirements governing the operation of stationary equipment using fluorinated greenhouse gases, including record keeping requirements for stationary refrigeration and air-conditioning equipment, heat pumps and fire protection equipment with a charge of 3kg or more. Guidance is available at** http://defraweb/environment/air-atmos/fgas/index.htm

To complete these tables you will need to:

1) **Carry out an inventory of equipment to find out:**
(i) the number and types of each refrigeration unit;
(ii) the type of refrigerant used (e.g. HFC 134a, R404a, R407a, R407b, R407c, R410A, etc);
(iii) the total charge capacity of each piece of equipment;
(iv) the time in years used during the reporting period (e.g. 0.5 if used only during half of the reporting period then disposed)

Once you know the refrigerant type, please refer to **Annex 5** to identify its Global Warming Potential (GWP). Alternatively, defaults are currently filled out automatically from selected refrigerants in the Excel spreadsheet. For further guidance on typical charge capacity, please refer to **Table 8d**.

2) **Determine installation emissions**: Identify any new equipment that was installed during the reporting period and was charged (filled) on-site. Emissions from equipment that was charged at the manufacturer are not the responsibility of your organisation. For each new piece of equipment charged **on-site** use **Table 8a** to estimate emissions.

3) **Determine operating emissions**: This step estimates losses from equipment leaks and service losses over the life of the equipment. For all pieces of equipment, use **Table 8b** to estimate emissions. You will need to determine the length of time (in years) that each piece of equipment has be used.

4) **Determine disposal emissions**: Identify any pieces of equipment that were disposed of **on-site** during the reporting period. Emissions from equipment that was sent offsite for third party recycling, reclamation or disposal are not the responsibility of your organisation. For each piece disposed equipment, use **Table 8c** to estimate emissions.

5) **Calculate total emissions**: Add the emissions from each piece of equipment for each of emission - installation, operation and disposal - to get total emissions. Calculate separate totals for each type of refrigerant used.

Information on refrigerant type and kilograms (kg) of charge capacity can be sourced from:
(a) *Air conditioning chillers* and *modular units*: visual readings on the equipment, equipment manuals or maintenance records;
(b) *Refrigeration units*: visual readings on the equipment

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here:
http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Table 8a

Emissions from Installation of Refrigeration and Air-conditioning Equipment

Type of Equipment	Number of Units	x	Equipment Charge Capacity (kg)	x	Installation Emission Factor	x			Refrigerant type (select from list from Annex 5)	Global Warming Potential (GWP)	x	Total kg CO_2 equivalent
Domestic Refrigeration		x		x	1.0%	x					x	
Stand-alone Commercial Applications		x		x	1.5%	x					x	
Medium & Large Commercial Applications		x		x	2.0%	x					x	
Transport Refrigeration		x		x	1.0%	x					x	
Industrial Refrigeration (inc. food processing and cold storage)		x		x	1.0%	x					x	
Chillers		x		x	1.0%	x					x	
Residential and Commercial A/C including Heat Pumps		x		x	1.0%	x					x	
Mobile Air Conditioning		x		x	1.0%	x					x	
Total												**0**

Annex 8 - Direct GHG Emissions from Use of Refrigeration and Air Conditioning Equipment

Last updated:	Jun-09

Table 8b

Emissions from operation of Refrigeration and Air-conditioning Equipment

Type of Equipment	Number of Units	x	Equipment Charge Capacity (kg)	x	Time used during reporting period (years)	x	Annual Leak Rate	x	Refrigerant type (select from list from Annex 5)	Global Warming Potential (GWP)	x	Total kg CO_2 equivalent
Domestic Refrigeration		x		x		x	0.3%	x			x	
Stand-alone Commercial Applications		x		x		x	2.0%	x			x	
Medium & Large Commercial Applications		x		x		x	11.0%	x			x	
Transport Refrigeration		x		x		x	8.0%	x			x	
Industrial Refrigeration (inc. food processing and cold storage)		x		x		x	8.0%	x			x	
Chillers		x		x		x	3.0%	x			x	
Residential and Commercial A/C including Heat Pumps		x		x		x	8.5%	x			x	
Mobile Air Conditioning		x		x		x	7.5%	x			x	
Total												**0**

Table 8c

Emissions from Disposal of Refrigeration and Air-conditioning Equipment

Refrigerant Type	Number of Units	x	Equipment Charge Capacity (kg)	x	Capacity remaining at disposal (%)	x	Refrigerant recovered (%)	x	Refrigerant type (select from list from Annex 5)	Global Warming Potential (GWP)	x	Total kg CO_2 equivalent
Domestic Refrigeration		x		x	80%	x	99.0%	x			x	
Stand-alone Commercial Applications		x		x	80%	x	94.5%	x			x	
Medium & Large Commercial Applications		x		x	100%	x	95.0%	x			x	
Transport Refrigeration		x		x	50%	x	94.0%	x			x	
Industrial Refrigeration (inc. food processing and cold storage)		x		x	100%	x	95.0%	x			x	
Chillers		x		x	100%	x	95.0%	x			x	
Residential and Commercial A/C including Heat Pumps		x		x	80%	x	95.0%	x			x	
Mobile Air Conditioning		x		x	50%	x	88.0%	x			x	
Total												**0**

Table 8d

Typical Charge Capacity for Equipment

Type of Equipment	Typical Range in Charge Capacity (kg)
Domestic Refrigeration	0.05 - 0.5
Stand-alone Commercial Applications	0.2 - 6
Medium & Large Commercial Applications	50 - 2,000
Transport Refrigeration	3 to 8
Industrial Refrigeration (inc. food processing and cold storage)	10 - 10,000
Chillers	10 - 2,000
Residential and Commercial A/C including Heat Pumps	0.5 - 100
Mobile Air Conditioning	0.5 - 1.5

Sources

UK Greenhouse Gas Inventory for 2007 (AEA)
2006 IPCC Guidelines for National Greenhouse Inventories (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_7_Ch7_ODS_Substitutes.pdf)
US EPA Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance - Direct HFC and PFC Emissions from use of Refrigeration and Air Conditioning Equipment (see: http://www.epa.gov/stateply/documents/resources/mfgrfg.pdf)

Annex 8 - Direct GHG Emissions from Use of Refrigeration and Air Conditioning Equipment

Last updated:	Jun-09

B. Simplified Material Balance Method

This is a simplified material balance method. This will enable more accurate estimation of refrigerant leakage than the Screening Method (Table 8a - d).
To complete Table 8e, you will need to:

1) Calculate installation emissions.
This step is only necessary if your organisation installed any new equipment during the reporting period that was not pre-charged by the equipment supplier. Emissions are calculated by taking the difference between the amount of refrigerant used to charge the equipment and the total capacity of the equipment. The difference is assumed to be released into the environment.

2) Determine equipment servicing emissions
Equipment servicing emissions result from the refrigerant that is used to service operating equipment. It is assumed that the servicing refrigerant is replacing the same amount that was lost to the environment.

3) Calculate disposal emissions
This step is only necessary if your organisation disposed of equipment during the reporting period. Emissions are calculated by taking the difference between the total capacity of the equipment disposed and the amount of refrigerant recovered. The difference is assumed to be released to the environment.

4) Calculate emissions
Emissions are calculated by summing the results of the first three steps.

This approach should be used for **each type of refrigerant and blend**.

This method requires the following information:

a) Refrigerant used to fill new equipment (set to 0 if the equipment has been pre-charged by the manufacturer);
b) Refrigerant used to fill equipment retrofitted to use this refrigerant (set to 0 if the equipment has been pre-charged by the manufacturer);
c) Total full capacity of new equipment using this refrigerant (set to 0 if the equipment has been pre-charged by the manufacturer);
d) Total full capacity of equipment that is retrofitted to use this refrigerant (set to 0 if the equipment has been pre-charged by the manufacturer);
e) Refrigerant used to service equipment;
f) Total full capacity of retiring equipment;
g) Total full capacity of equipment that is retrofitted away from this refrigerant to a different refrigerant;
h) Refrigerant recovered from retiring equipment;
i) Refrigerant recovered from equipment that is retrofitted away from this refrigerant to a different refrigerant.

Table 8e **Estimating Refrigerant Emissions with Simplified Material Balance Method**

	Purchases of refrigerant used to charge new equipment (kg)	-	Total full capacity of the new equipment (kg)	+	Quantity of refrigerant used to service equipment (kg)	+	Total full capacity of retiring equipment (kg)	-	Refrigerant recovered from retiring equipment (kg)	x	Refrigerant type (select from list from Annex 5)	Global Warming Potential (GWP)	=	Total kg CO_2 equivalent
Refrigerant 1		-		+		+		-		x			=	
Refrigerant 2		-		+		+		-		x			=	
Refrigerant 3		-		+		+		-		x			=	
Refrigerant 4		-		+		+		-		x			=	
Refrigerant 5		-		+		+		-		x			=	
Refrigerant 6		-		+		+		-		x			=	
Refrigerant 7		-		+		+		-		x			=	
Refrigerant 8		-		+		+		-		x			=	
Refrigerant 9		-		+		+		-		x			=	
Refrigerant 10		-		+		+		-		x			=	
Total														**0**

Sources
2006 IPCC Guidelines for National Greenhouse Inventories (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_7_Ch7_ODS_Substitutes.pdf)
US EPA Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance - Direct HFC and PFC Emissions from use of Refrigeration and Air Conditioning Equipment (see: http://www.epa.gov/stateply/documents/resources/mfgrfg.pdf)

Annex 9 - Other UK Conversion Factor Tables

Last updated:	Jun-09

Unlike the emission factors provided in other Annexes, the emission factors presented in *this* Annex incorporate emissions from the full life-cycle and include net CO_2, CH_4 and N_2O emissions. They are therefore not directly comparable with the other emission factors in other Annexes, which only include direct emissions.

How to use this Annex

Table 9a provides life-cycle conversion factors for water, biofuels and biomass:

1) Identify the amount of substance used

2) Identify the units. Are you measuring your fuel use in terms of mass, volume or energy?

3) Convert to the appropriate unit of volume or mass for the table:

(i) If you cannot find a factor for that unit, Annex 12 gives guidance on converting between different units of mass, volume, length and energy.

(ii) If you measuring fuel use in terms of energy is your unit of measurement net energy or gross energy (in the event that this is unclear you should contact your fuel supplier)? Annex 11 gives typical/average net/gross calorific values and the densities

4) Multiply the amount of fuel used by the conversion factor to get total emissions in kilograms of carbon dioxide equivalent (kg CO_2eq). The excel spreadsheet does this automatically following your entry of the amount of fuel used into the appropriate box.

Please note that these emission factors **do not** enable you to calculate direct emissions of carbon dioxide for the combustion of biomass and biofuels. Further updates to these Guidelines will seek to address this issue.

Table 9b provides life-cycle conversion factors for waste disposal:

To complete this table, you will need to:

1) **Check for existing data**. Data on waste arisings will be contained in waste transfer/consignment notes or receipts provided for individual waste transfers. All waste producers are legally required to retain these notes for a specified period. These may identify the quantity of waste arising and the company collecting the waste.

Has your organisation carried out a waste audit recently? This may provide further useful information, such as the composition of mixed waste sent for proposal.

2) **Speak to your waste contractor(s)**. Your waste contractor will be able to advise you to which location your wastes have subsequently been delivered (i.e. landfill site, recycling operation, compositing, or energy recovery facility).

Depending on the level of information that your waste contractor can provide, you will need to carry out step 3.

Annex 9 - Other UK Conversion Factor Tables

Last updated:	Jun-09

3) **Carry out a waste audit**

If you do not have detailed waste data from your waste contractors, you should carry out a waste inventory to determine:

(i) The total waste sent to landfill, recycled or composted. This can be done through sampling your waste in order to approximate total waste for each different waste treatment method

(ii) The waste composition (in tonnes) for each waste treatment method. This can be done through sampling, sorting, and weighing your waste to determine its percentage composition in tonnes. **If you choose to do this, please wear the appropriate protective clothing and do not attempt to sample any hazardous, toxic or radioactive waste**.

4) **Enter the data in the table**. Enter the weight (in tonnes) for each waste fraction (e.g. paper and card, textiles, etc) in the appropriate cell. The total net kgCO_2eq emissions for each waste treatment method will be automatically calculated.

For further assistance, please see Envirowise Guide GG414 Measuring to manage: the key to reducing waste costs, available free of charge from the Envirowise website.

Key information:

The **tonnes of waste prevented column** should be used if you want to determine the reduction in emissions associated with reduced procurement of materials.

Are these factors directly comparable to those in the other annexes?

No. The emission factors provided in this annex are for net life-cycle emissions of GHG resulting from water supply, water treatment, use of biofuels and biomass and from waste disposal. Because they encompass the whole life-cycle (i.e. direct and indirect emissions) these emission factors are **not directly comparable** with those from other annexes, which **only** include emissions from the point of use (generation for electricity).

Work is still being carried out looking to better understand indirect/life-cycle emissions, which may allow expansion to include the indirect emissions component to other annexes in the future.

How were these factors calculated?

For further explanation on how these emission factors have been derived, please refer to the GHG conversion factor methodology paper available here: http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Annex 9 - Other UK Conversion Factor Tables

Last updated:	Jun-09

Table 9a

Life-Cycle Conversion Factors for water, biofuels and biomass				Total Net CO_2eq	
Fuel used	Total units used	Units	x	kg CO_2eq per unit	Total kg CO_2eq
Water supply		million litres	x	276	
		cubic metres	x	0.2760	
Water treatment		million litres	x	693	
		cubic metres	x	0.6930	
Biodiesel (ME) [1]		litres	x	2.8605	
Biodiesel (HVO) [2]		litres	x	2.9652	
Bioethanol		litres	x	1.8045	
BioETBE (refinery)		litres	x	2.3087	
BioETBE (non-refinery)		litres	x	2.3087	
Biomethane		kg	x	3.0380	
Wood Pellets [3]		tonnes	x	121.5	
Total					**0**

Sources Water UK Sustainability Indicators 2007/08, available at:
http://www.water.org.uk/home/policy/reports/sustainability/sustainability-indicators-2007-08
Renewable Fuels Agency (2009)

Notes Emissions factors for biofuels are RFA calculation defaults where the source/production pathway of the biofuel is unknown. Detailed factors by source/supplier are provided and updated regularly in the RFA Quarterly Reports, available on the RFA's website at:
http://www.renewablefuelsagency.org/reportsandpublications/rtforeports.cfm

[1] Biodiesel (ME) = Biodiesel (Methyl Ester), biodiesel produced from oils using conventional esterification processes.

[2] Biodiesel (HVO) = Biodiesel (Hydrotreated Vegetable Oil), biodiesel produced from vegetable oils using hydroprocessing.

[3] Wood pellets are used in domestic biomass heating systems. The emission factors are based on the factor of 0.025 kgCO_2/kWh provided in SAP2005, Table 12.

Annex 9 - Other UK Conversion Factor Tables

Last updated:	Jun-09

Table 9b

Life-Cycle Conversion Factors for Waste Disposal								
Waste fraction	Net kg CO_2eq emitted per tonne of waste treated [4]							kg CO_2eq emitted per tonne waste prevented (saving from embodied fossil energy) [5]
	Recycling		Energy from waste			Composting	Landfill	
	Closed Loop	Open Loop	Power only moving grate	CHP moving grate	Anaerobic Digestion			
Paper and Card	-713		**-500**		-121	57	**550**	**-950**
Kitchen/food waste			-89		**500**	**30**	**365**	-2,428
Garden/plant waste			-121		**500**	57	**210**	-89
Other organic	44		-271		-330	34	230	
Wood	**250**		**-700**	**-640**		**250**	**930**	-256
Textiles	**-3,800**		**600**	**1,089**			**300**	-19,294
Plastic (dense)	**-1,500**		**1,800**				**40**	**-3,100**
Plastic (film)	**-1,000**		**1,800**				**35**	**-2,500**
Ferrous metal	**-1,300**		-786				10	**-3,100**
Non-ferrous metal	**-9,000**		23				10	**-11,000**
Silt/soil	16		35				10	-4
Aggregate materials	**-4**		35				10	**-8**
Misc combustibles	58		242				305	-102
Glass	**-315**	**0**	**5**	**5**			10	**-840**
Estimated impact of other materials (municipal and C&I)	-259		97		-13	7	81	-2,860
Waste fraction	Tonnes of waste treated							Tonnes of waste prevented
	Recycling		Energy from waste			Composting	Landfill	
	Closed Loop	Open Loop	Power only moving grate	CHP moving grate	Anaerobic Digestion			
Paper and Card								
Kitchen/food waste								
Garden/plant waste								
Other organic								
Wood								
Textiles								
Plastic (dense)								
Plastic (film)								
Ferrous metal								
Non-ferrous metal								
Silt/soil								
Aggregate materials								
Misc combustibles								
Glass								
Estimated impact of other materials (municipal and C&I)								
Total Net kgCO_2eq emissions by category	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Grand Total Net kgCO_2eq emissions								**0**

Sources Defra Waste Strategy, Table A.28: Emission factors for waste treatment processes (kg carbon dioxide equivalents/tonne of waste processed)
http://www.defra.gov.uk/environment/waste/strategy/strategy07/pdf/waste07-annex-a.pdf
Updated figures in **BOLD** provided by WRAP, 2009.

Annex 9 - Other UK Conversion Factor Tables

Last updated:	Jun-09

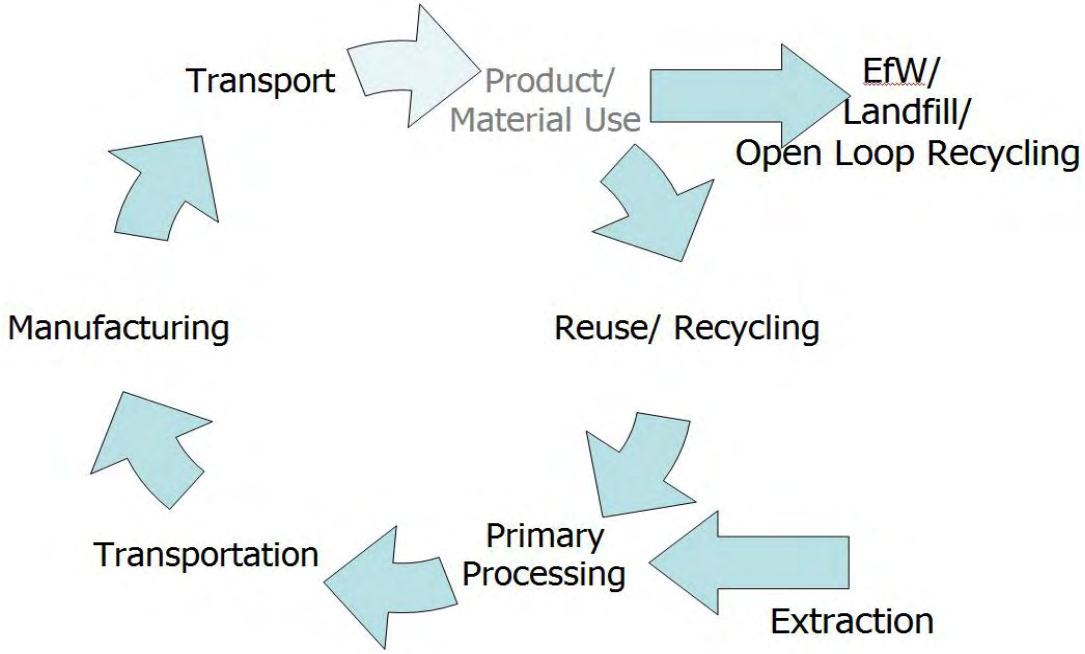
Notes

The data summarised in the table covers the life cycle stages highlighted below. It excludes use of the product as this will be variable. For example, plastic may be used as automotive parts or as drinks packaging amongst other things. If it is used as drinks packaging it will require filling. As it is not known what the final use of the material is, this section of the life cycle is excluded for all materials. For some products forming is also excluded. Metals may be made into various products by different methods, excluded from these figures.

[4] Impact of other treatments as in pRIA – http://www.defra.gov.uk/corporate/consult/wastestratreview/partialRIA.pdf – p.58.

[5] The waste prevention figure for textiles currently does not account for the split of material types on the UK market. Improvements will be made to this figure in future updates More information on WRAP can be found at: http://www.wrap.org.uk/

Life Cycle Stages Covered:



Annex 10 - International Electricity Emission Factors

Last updated: Jun-09

The factors presented in the two tables below are a timeseries of combined electricity and heat CO_2 emission factors per kWh **GENERATED** (Table 10a, i.e. before losses in transmission/distribution) and per kWh **CONSUMED** (Table 10b, i.e. for the final consumer, including transmission/distribution losses).

How to use this Annex

To calculate emissions of carbon dioxide associated with *use of overseas grid electricity*:

1) Identify the amount electricity used, in units of kWh, for the relevant country.

2) Multiply this value by the conversion factor for the country or grid rolling average electricity use. You should use emission factors from **Table 10b** for electricity consumed from the national/local electricity grid for consistency with those provided for the UK in **Annex 3**.

3) Repeat the process for other countries and sum the totals.

The country I am looking for is not included, where can I find information?

We have provided emission factors for all EU member states and the major UK trading partners. Additional emission factors for other countries not included in this list can be found at the GHG Protocol website, though it should be noted the figures supplied there **do not** include losses from transmission and distribution of heat and electricity.

Data source

Emission factor data is from International Energy Agency (IEA) Data Services, 2006 and 2008 for "CO_2 Emissions per kWh Electricity and Heat Generated" and mainly sourced from the GHG Protocol website.

Data on losses in distribution of electricity and heat is calculated from 2006 country energy balances available at the IEA website.

How were these factors calculated?

For further explanation on how these emission factors have derived, please refer to the GHG conversion factor methodology paper available here:
http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

Table 10a

Overseas Electricity/Heat Conversion Factors from 1990 to 2006: kgCO_2 per kWh electricity and heat GENERATED*																			% Total GWh		% Distribution Losses	
Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006 5-yr rolling average	Electricity	Heat	Electricity	Heat
European Union																						
Austria	0.2447	0.2519	0.2088	0.1937	0.2070	0.2140	0.2296	0.2278	0.2078	0.1950	0.1833	0.1940	0.1944	0.2360	0.2300	0.2249	0.2140	0.2199	80.4%	19.6%	5.7%	8.0%
Belgium	0.3485	0.3423	0.3317	0.3460	0.3656	0.3582	0.3399	0.3110	0.3154	0.2784	0.2849	0.2719	0.2664	0.2736	0.2685	0.2680	0.2600	0.2673	93.4%	6.6%	4.9%	7.8%
Bulgaria			0.4760	0.4825	0.4566	0.4296	0.4184	0.4749	0.4806	0.4456	0.4307	0.4634	0.4329	0.4703	0.4706	0.4480	0.4480	0.4540	74.9%	25.1%	16.0%	13.0%
Cyprus			0.8315	0.8321	0.8359	0.8264	0.8368	0.8455	0.8475	0.8608	0.8419	0.7812	0.7597	0.8372	0.7764	0.7923	0.7580	0.7847	100.0%	0.0%	3.9%	0.0%
Czech Republic	0.5993	0.5902	0.5867	0.5822	0.5857	0.5848	0.5814	0.5616	0.5693	0.5593	0.5675	0.5600	0.5461	0.5019	0.5035	0.5156	0.5270	0.5188	68.1%	31.9%	8.3%	16.8%
Denmark	0.4762	0.5061	0.4697	0.4566	0.4699	0.4300	0.4669	0.4215	0.3897	0.3633	0.3393	0.3359	0.3320	0.3572	0.3082	0.2836	0.3410	0.3244	50.6%	49.4%	4.4%	20.1%
Estonia			0.6487	0.6199	0.6188	0.6890	0.6791	0.6797	0.7196	0.7065	0.6972	0.6854	0.6722	0.7233	0.7009	0.6649	0.6400	0.6803	57.8%	42.2%	15.5%	13.3%
Finland	0.2304	0.2350	0.2074	0.2324	0.2687	0.2498	0.2897	0.2678	0.2123	0.2116	0.2110	0.2395	0.2529	0.2929	0.2546	0.1936	0.2420	0.2472	60.9%	39.1%	3.5%	6.7%
France	0.1099	0.1245	0.0995	0.0691	0.0698	0.0770	0.0780	0.0719	0.0974	0.0864	0.0827	0.0708	0.0763	0.0804	0.0781	0.0909	0.0850	0.0821	91.7%	8.3%	7.0%	0.0%
Germany	0.5714	0.5837	0.5527	0.5499	0.5477	0.5325	0.5249	0.5175	0.5083	0.4946	0.4959	0.5062	0.5184	0.4379	0.4357	0.3492	0.4040	0.4290	63.6%	36.4%	5.4%	7.8%
Greece	0.9912	0.9408	0.9585	0.9336	0.8841	0.8723	0.8282	0.8690	0.8602	0.8216	0.8136	0.8323	0.8152	0.7739	0.7772	0.7765	0.7250	0.7736	99.1%	0.9%	9.9%	0.0%
Hungary	0.4693	0.4603	0.4853	0.4587	0.4419	0.4457	0.4331	0.4313	0.4273	0.4144	0.4118	0.3948	0.3916	0.4209	0.3895	0.3387	0.3440	0.3769	66.9%	33.1%	10.9%	0.0%
Ireland	0.7500	0.7533	0.7595	0.7366	0.7292	0.7287	0.7279	0.7196	0.7152	0.6978	0.6392	0.6751	0.6371	0.5974	0.5715	0.5842	0.5350	0.5850	100.0%	0.0%	7.9%	0.0%
Italy	0.5739	0.5490	0.5356	0.5252	0.5165	0.5467	0.5253	0.5151	0.5161	0.4980	0.5038	0.4852	0.5090	0.5248	0.4106	0.4054	0.4040	0.4508	85.0%	15.0%	6.4%	0.0%
Latvia			0.2763	0.2688	0.2504	0.2381	0.2625	0.2182	0.1973	0.2168	0.2002	0.1897	0.1881	0.1829	0.1665	0.1620	0.1670	0.1733	36.2%	63.8%	12.7%	16.7%
Lithuania			0.1858	0.1859	0.2151	0.1727	0.1731	0.1654	0.1722	0.1765	0.1578	0.1437	0.1198	0.1123	0.1102	0.1296	0.1390	0.1222	51.6%	48.4%	13.3%	16.4%
Luxembourg	2.5884	2.4703	2.4837	2.4643	2.1074	1.3400	1.1929	0.8100	0.2489	0.2577	0.2551	0.2399	0.3288	0.3302	0.3338	0.3278	0.3260	0.3293	85.4%	14.6%	1.7%	0.0%
Malta			1.0235	1.3916	1.1640	0.9617	0.9789	0.9416	0.9365	0.9086	0.8678	1.0282	0.8195	0.8138	0.9016	0.8919	0.8340	0.8522	100.0%	0.0%	11.6%	0.0%
Netherlands	0.6022	0.5838	0.5709	0.5745	0.5382	0.5294	0.5007	0.4992	0.4694	0.4675	0.4468	0.4624	0.4586	0.4671	0.4399	0.3867	0.3940	0.4293	67.9%	32.1%	4.1%	17.0%
Poland	0.6563	0.6507	0.6526	0.6403	0.6432	0.6752	0.6646	0.6669	0.6643	0.6651	0.6716	0.6604	0.6624	0.6623	0.6650	0.6589	0.6590	0.6615	62.4%	37.6%	12.8%	0.0%
Portugal	0.5173	0.5224	0.6219	0.5459	0.4970	0.5696	0.4291	0.4667	0.4642	0.5393	0.4801	0.4425	0.5127	0.4139	0.4523	0.4982	0.4160	0.4586	92.4%	7.6%	8.3%	0.0%
Romania			0.4096	0.3844	0.4561	0.4405	0.4443	0.3853	0.3513	0.3599	0.3954	0.4122	0.4124	0.4512	0.4183	0.3941	0.4290	0.4210	62.6%	37.4%	13.0%	22.0%
Slovak Republic	0.3785	0.3887	0.3603	0.4125	0.3607	0.3698	0.3627	0.3789	0.3512	0.3487	0.2668	0.2488	0.2239	0.2555	0.2473	0.2321	0.2230	0.2364	68.3%	31.7%	6.9%	12.9%
Slovenia			0.3662	0.3732	0.3345	0.3371	0.3175	0.3870	0.3937	0.3670	0.3313	0.3410	0.3719	0.3673	0.3366	0.3283	0.3320	0.3472	84.4%	15.6%	7.0%	16.9%
Spain	0.4279	0.4237	0.4817	0.4192	0.4166	0.4566	0.3587	0.3919	0.3806	0.4448	0.4296	0.3833	0.4371	0.3810	0.3826	0.3943	0.3500	0.3890	100.0%	0.0%	9.7%	0.0%
Sweden	0.0480	0.0581	0.0508	0.0520	0.0558	0.0500	0.0733	0.0503	0.0544	0.0481	0.0421	0.0432	0.0520	0.0595	0.0512	0.0445	0.0440	0.0502	75.9%	24.1%	8.2%	3.5%
European Union - 27			**0.4431**	**0.4217**	**0.4205**	**0.4190**	**0.4092**	**0.3986**	**0.3932**	**0.3837**	**0.3808**	**0.3780**	**0.3838**	**0.3767**	**0.3623**	**0.3409**	**0.3540**	**0.3635**	**78.1%**	**21.9%**	**7.4%**	**7.7%**

Annex 10 - International Electricity Emission Factors

Last updated: Jun-09

Table 10a - continued

Overseas Electricity/Heat Conversion Factors from 1990 to 2006: kgCO_2 per kWh electricity and heat GENERATED*

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006 5-yr rolling average	% Total GWh: Electricity	% Total GWh: Heat	% Distribution Losses: Electricity	% Distribution Losses: Heat
Other countries																						
Australia	0.8111	0.8143	0.8211	0.8058	0.7821	0.7758	0.8233	0.8655	0.8799	0.8720	0.8647	0.8449	0.8922	0.8717	0.8438	0.8733	0.9210	0.8804	100.0%	0.0%	7.6%	0.0%
Brazil			0.0608	0.0553	0.0510	0.0552	0.0570	0.0620	0.0622	0.0825	0.0879	0.1039	0.0856	0.0792	0.0852	0.0842	0.0810	0.0830	99.7%	0.3%	15.6%	0.0%
Canada	0.1950	0.1873	0.1961	0.1751	0.1718	0.1766	0.1706	0.1897	0.2160	0.2070	0.2166	0.2260	0.2134	0.2248	0.2066	0.1987	0.1840	0.2055	98.5%	1.5%	8.2%	0.0%
China, People's Republic of			0.7943	0.7939	0.7679	0.8029	0.8206	0.8042	0.8232	0.7978	0.7649	0.7399	0.7485	0.7761	0.8056	0.7879	0.7880	0.7812	79.7%	20.3%	7.8%	1.4%
Chinese Taipei			0.4899	0.5056	0.5035	0.5144	0.5211	0.5505	0.5596	0.5797	0.6038	0.6158	0.6057	0.6327	0.6277	0.6317	0.6590	0.6314	100.0%	0.0%	3.7%	0.0%
Croatia			0.3251	0.3279	0.2499	0.2726	0.2536	0.2983	0.3233	0.3032	0.2993	0.3097	0.3538	0.3768	0.2978	0.3113	0.3180	0.3315	77.1%	22.9%	12.9%	13.5%
Egypt			0.5296	0.5032	0.4665	0.4433	0.4327	0.4422	0.4675	0.4545	0.4118	0.3810	0.4367	0.4325	0.4731	0.4714	0.4700	0.4567	100.0%	0.0%	16.4%	0.0%
Gibraltar			0.7774	0.7771	0.7551	0.7696	0.7556	0.7766	0.7696	0.7696	0.7635	0.7574	0.7637	0.7581	0.7696	0.7431	0.7300	0.7529	100.0%	0.0%	0.0%	0.0%
Hong Kong (China)			0.8191	0.8604	0.8710	0.8524	0.8296	0.7239	0.7401	0.7150	0.7108	0.7189	0.7240	0.7937	0.8294	0.8098	0.8550	0.8024	100.0%	0.0%	10.9%	0.0%
Iceland	0.0005	0.0005	0.0005	0.0008	0.0008	0.0016	0.0012	0.0011	0.0029	0.0038	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0010	0.0007	77.1%	22.9%	4.7%	10.4%
India			0.8890	0.9112	0.8757	0.9258	0.9706	0.9426	0.9214	0.9191	0.9385	0.9341	0.9190	0.9031	0.9420	0.9434	0.9440	0.9303	100.0%	0.0%	26.8%	0.0%
Indonesia			0.6393	0.7561	0.6416	0.5819	0.6382	0.6755	0.6506	0.6765	0.6428	0.7393	0.7135	0.7752	0.7504	0.7707	0.6770	0.7374	100.0%	0.0%	12.3%	0.0%
Israel			0.8204	0.8224	0.8209	0.8213	0.8271	0.8218	0.7657	0.7673	0.7609	0.7728	0.8228	0.8176	0.8075	0.7675	0.7740	0.7979	100.0%	0.0%	2.9%	0.0%
Japan	0.4305	0.4210	0.4269	0.4086	0.4261	0.4082	0.4056	0.3912	0.3791	0.3949	0.3986	0.3997	0.4197	0.4415	0.4248	0.4285	0.4180	0.4265	99.3%	0.7%	4.9%	0.0%
Korea, Republic of	0.5123	0.5504	0.5779	0.5593	0.5431	0.5315	0.5281	0.5497	0.4944	0.4792	0.5011	0.5019	0.4251	0.4453	0.4440	0.4182	0.5330	0.4531	87.9%	12.1%	3.7%	1.9%
Malaysia			0.6233	0.6044	0.5563	0.5564	0.5591	0.4661	0.5394	0.5277	0.5167	0.5407	0.5911	0.5255	0.5312	0.5570	0.6550	0.5720	100.0%	0.0%	4.3%	0.0%
Mexico	0.5355	0.5348	0.5095	0.5099	0.5611	0.5068	0.5062	0.5219	0.5716	0.5612	0.5662	0.5685	0.5581	0.5599	0.5223	0.5155	0.5410	0.5394	100.0%	0.0%	17.6%	0.0%
New Zealand	0.1280	0.1303	0.1741	0.1387	0.1155	0.1117	0.1393	0.2130	0.2140	0.2376	0.2303	0.2758	0.2468	0.2900	0.2407	0.2754	0.3090	0.2724	99.7%	0.3%	7.6%	0.0%
Norway	0.0034	0.0045	0.0039	0.0042	0.0052	0.0045	0.0063	0.0055	0.0055	0.0060	0.0041	0.0058	0.0053	0.0083	0.0070	0.0055	0.0070	0.0066	97.5%	2.5%	8.1%	16.1%
Pakistan			0.3932	0.3842	0.3911	0.4049	0.4426	0.4537	0.4114	0.4678	0.4794	0.4628	0.4425	0.3700	0.3967	0.3796	0.4130	0.4004	100.0%	0.0%	25.2%	0.0%
Philippines			0.4834	0.4790	0.5188	0.5086	0.5140	0.5699	0.5914	0.5009	0.4981	0.5299	0.4822	0.4602	0.4570	0.4951	0.4350	0.4659	100.0%	0.0%	13.1%	0.0%
Russian Federation			0.3084	0.2913	0.2962	0.2919	0.3420	0.3284	0.3265	0.3271	0.3209	0.3216	0.3268	0.3294	0.3249	0.3380	0.3290	0.3296	36.9%	63.1%	14.8%	2.6%
Saudi Arabia			0.8329	0.8377	0.8157	0.8151	0.8020	0.8087	0.8149	0.8116	0.8098	0.7782	0.7513	0.7395	0.7595	0.7476	0.7550	0.7506	100.0%	0.0%	7.8%	0.0%
Singapore			0.8412	1.0040	0.9765	0.9384	0.8798	0.7692	0.7742	0.6560	0.6637	0.6346	0.5950	0.5737	0.5562	0.5439	0.5360	0.5610	100.0%	0.0%	5.5%	0.0%
South Africa			0.8553	0.8805	0.8636	0.8781	0.8607	0.8695	0.9275	0.8897	0.8930	0.8289	0.8194	0.8452	0.8655	0.8484	0.8690	0.8495	100.0%	0.0%	7.2%	0.0%
Switzerland	0.0218	0.0244	0.0278	0.0207	0.0198	0.0219	0.0255	0.0227	0.0277	0.0220	0.0221	0.0214	0.0218	0.0226	0.0237	0.0262	0.0260	0.0241	92.5%	7.5%	6.8%	7.5%
Thailand			0.6463	0.6301	0.6234	0.6061	0.6254	0.6337	0.6082	0.5961	0.5641	0.5624	0.5385	0.5279	0.5379	0.5313	0.5110	0.5293	100.0%	0.0%	8.0%	0.0%
Turkey	0.5840	0.5933	0.5938	0.5242	0.5727	0.5325	0.5385	0.5506	0.5584	0.5772	0.5259	0.5505	0.4785	0.4483	0.4270	0.4328	0.4380	0.4449	94.2%	5.8%	15.7%	0.0%
Ukraine			0.3667	0.3836	0.3548	0.3643	0.3310	0.3210	0.3294	0.3365	0.3443	0.3273	0.3227	0.3786	0.3127	0.3143	0.3440	0.3345	52.5%	47.5%	15.6%	25.2%
United States			0.5882	0.5903	0.5872	0.5710	0.5801	0.6039	0.6045	0.5961	0.5861	0.6023	0.5748	0.5748	0.5754	0.5729	0.5590	0.5714	98.4%	1.6%	6.6%	18.0%
Africa			**0.6786**	**0.6899**	**0.6822**	**0.6871**	**0.6711**	**0.6788**	**0.7100**	**0.6799**	**0.6670**	**0.6221**	**0.6228**	**0.6366**	**0.6508**	**0.6427**	**0.6450**	**0.6396**	**99.9%**	**0.1%**	**12.0%**	**0.0%**
Latin America			**0.1921**	**0.1832**	**0.1780**	**0.1820**	**0.1868**	**0.1929**	**0.2008**	**0.2039**	**0.1958**	**0.2057**	**0.1975**	**0.1932**	**0.2029**	**0.1970**	**0.1940**	**0.1969**	**99.9%**	**0.1%**	**16.7%**	**0.0%**
Middle-East			**0.7163**	**0.7222**	**0.7256**	**0.7279**	**0.7205**	**0.7189**	**0.7051**	**0.7089**	**0.7056**	**0.7056**	**0.6918**	**0.6873**	**0.6966**	**0.6901**	**0.6700**	**0.6872**	**100.0%**	**0.0%**	**14.0%**	**0.0%**
Non-OECD Europe			**0.4792**	**0.4680**	**0.4798**	**0.4834**	**0.4705**	**0.4805**	**0.4770**	**0.4494**	**0.4737**	**0.4871**	**0.4853**	**0.5126**	**0.4893**	**0.4786**	**0.4990**	**0.4930**	**74.7%**	**25.3%**	**15.7%**	**15.4%**

Source: Emission factor data is from International Energy Agency Data Services, 2006 and 2008 for "CO2 Emissions per kWh Electricity and Heat Generated" and mainly sourced from the GHG Protocol website http://www.ghgprotocol.org/calculation-tools

Data on the proportion of electricity and heat (for 2006) is sourced from the IEA website at: http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Electricity/Heat

Data on losses in distribution of electricity and heat is calculated from 2006 country energy balances available at the IEA website at: http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances

Notes: Electricity emissions factors for electricity and heat generated - **excludes** losses from the transmission and distribution grid.
If you cannot find an emission factor for a particular country, please refer to the larger list available on the GHG Protocol website at the link above.

Annex 10 - International Electricity Emission Factors

Last updated: Jun-09

Table 10b

Overseas Electricity/Heat Conversion Factors from 1990 to 2006: kgCO_2 per kWh electricity and heat CONSUMED**																			% Total GWh		% Distribution Losses	
Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006 5-yr rolling average	Electricity	Heat	Electricity	Heat
European Union																						
Austria	0.2608	0.2685	0.2225	0.2063	0.2206	0.2280	0.2447	0.2427	0.2214	0.2077	0.1953	0.2067	0.2071	0.2514	0.2450	0.2396	0.2280	0.2342	79.5%	20.5%	5.7%	8.0%
Belgium	0.3672	0.3606	0.3495	0.3647	0.3853	0.3774	0.3582	0.3277	0.3324	0.2934	0.3002	0.2866	0.2808	0.2883	0.2830	0.2824	0.2740	0.2817	94.2%	5.8%	4.9%	7.8%
Bulgaria			0.5605	0.5690	0.5384	0.5066	0.4935	0.5601	0.5668	0.5255	0.5080	0.5465	0.5106	0.5546	0.5550	0.5284	0.5284	0.5354	70.2%	29.8%	16.0%	13.0%
Cyprus			0.8657	0.8663	0.8702	0.8603	0.8712	0.8802	0.8823	0.8961	0.8765	0.8133	0.7909	0.8715	0.8083	0.8249	0.7891	0.8169	100.0%	0.0%	3.9%	0.0%
Czech Republic	0.6751	0.6650	0.6609	0.6544	0.6584	0.6574	0.6535	0.6313	0.6399	0.6287	0.6379	0.6295	0.6138	0.5641	0.5660	0.5795	0.5924	0.5832	65.7%	34.3%	8.3%	16.8%
Denmark	0.5384	0.5722	0.5310	0.5198	0.5349	0.4896	0.5315	0.4799	0.4437	0.4136	0.3862	0.3824	0.3779	0.4066	0.3508	0.3228	0.3882	0.3693	54.5%	45.5%	4.4%	20.1%
Estonia			0.7577	0.7257	0.7244	0.8065	0.7949	0.7957	0.8424	0.8271	0.8161	0.8024	0.7869	0.8467	0.8205	0.7784	0.7492	0.7963	48.6%	51.4%	15.5%	13.3%
Finland	0.2416	0.2464	0.2175	0.2441	0.2822	0.2623	0.3043	0.2812	0.2230	0.2223	0.2216	0.2516	0.2656	0.3077	0.2674	0.2033	0.2542	0.2596	65.9%	34.1%	3.5%	6.7%
France	0.1173	0.1328	0.1061	0.0739	0.0746	0.0823	0.0834	0.0768	0.1041	0.0923	0.0884	0.0756	0.0815	0.0859	0.0835	0.0971	0.0908	0.0878	89.0%	11.0%	7.0%	0.0%
Germany	0.6099	0.6230	0.5899	0.5866	0.5843	0.5680	0.5599	0.5520	0.5422	0.5276	0.5290	0.5400	0.5530	0.4671	0.4647	0.3725	0.4309	0.4576	61.3%	38.7%	5.4%	7.8%
Greece	1.0988	1.0429	1.0626	1.0351	0.9802	0.9671	0.9183	0.9634	0.9537	0.9109	0.9020	0.9228	0.9038	0.8580	0.8617	0.8609	0.8038	0.8576	98.9%	1.1%	9.9%	0.0%
Hungary	0.5067	0.4970	0.5240	0.4946	0.4765	0.4807	0.4671	0.4651	0.4608	0.4469	0.4441	0.4258	0.4223	0.4539	0.4201	0.3653	0.3710	0.4065	68.0%	32.0%	10.9%	0.0%
Ireland	0.8144	0.8181	0.8248	0.7999	0.7919	0.7914	0.7905	0.7815	0.7767	0.7578	0.6942	0.7331	0.6919	0.6487	0.6207	0.6344	0.5810	0.6353	100.0%	0.0%	7.9%	0.0%
Italy	0.6070	0.5806	0.5664	0.5555	0.5463	0.5783	0.5556	0.5448	0.5458	0.5267	0.5328	0.5132	0.5384	0.5551	0.4343	0.4288	0.4273	0.4768	84.9%	15.1%	6.4%	0.0%
Latvia			0.3248	0.3173	0.2956	0.2811	0.3099	0.2575	0.2330	0.2560	0.2364	0.2239	0.2221	0.2159	0.1966	0.1913	0.1971	0.2046	45.2%	54.8%	12.7%	16.7%
Lithuania			0.2188	0.2182	0.2525	0.2027	0.2032	0.1941	0.2022	0.2071	0.1852	0.1687	0.1406	0.1318	0.1294	0.1521	0.1632	0.1434	43.1%	56.9%	13.3%	16.4%
Luxembourg	2.6277	2.5078	2.5215	2.5000	2.1379	1.3594	1.2102	0.8218	0.2525	0.2614	0.2588	0.2434	0.3335	0.3350	0.3386	0.3325	0.3307	0.3341	89.7%	10.3%	1.7%	0.0%
Malta			1.1575	1.5739	1.3164	1.0877	1.1071	1.0649	1.0592	1.0276	0.9815	1.1629	0.9268	0.9203	1.0196	1.0087	0.9432	0.9637	100.0%	0.0%	11.6%	0.0%
Netherlands	0.6498	0.6300	0.6161	0.6262	0.5866	0.5771	0.5458	0.5442	0.5117	0.5096	0.4870	0.5041	0.4999	0.5092	0.4795	0.4215	0.4295	0.4679	75.1%	24.9%	4.1%	17.0%
Poland	0.7058	0.6997	0.7017	0.6958	0.6989	0.7338	0.7222	0.7247	0.7219	0.7228	0.7298	0.7176	0.7198	0.7197	0.7226	0.7160	0.7161	0.7188	54.7%	45.3%	12.8%	0.0%
Portugal	0.5604	0.5659	0.6738	0.5915	0.5385	0.6172	0.4649	0.5056	0.5029	0.5843	0.5201	0.4794	0.5554	0.4484	0.4900	0.5398	0.4507	0.4969	92.4%	7.6%	8.3%	0.0%
Romania			0.4905	0.4596	0.5454	0.5266	0.5312	0.4607	0.4200	0.4303	0.4728	0.4928	0.4931	0.5395	0.5001	0.4712	0.5129	0.5034	61.2%	38.8%	13.0%	22.0%
Slovak Republic	0.4152	0.4264	0.3952	0.4522	0.3954	0.4055	0.3977	0.4154	0.3850	0.3823	0.2925	0.2727	0.2454	0.2801	0.2711	0.2544	0.2445	0.2591	67.4%	32.6%	6.9%	12.9%
Slovenia			0.4001	0.4079	0.3657	0.3685	0.3471	0.4231	0.4304	0.4012	0.3622	0.3728	0.4066	0.4015	0.3680	0.3589	0.3629	0.3796	84.8%	15.2%	7.0%	16.9%
Spain	0.4738	0.4692	0.5333	0.4642	0.4612	0.5056	0.3972	0.4339	0.4214	0.4924	0.4756	0.4243	0.4840	0.4218	0.4236	0.4366	0.3875	0.4307	100.0%	0.0%	9.7%	0.0%
Sweden	0.0516	0.0625	0.0546	0.0560	0.0601	0.0538	0.0789	0.0541	0.0585	0.0517	0.0453	0.0465	0.0560	0.0641	0.0551	0.0479	0.0474	0.0541	72.9%	27.1%	8.2%	3.5%
European Union - 27			**0.4790**	**0.4559**	**0.4546**	**0.4530**	**0.4423**	**0.4309**	**0.4250**	**0.4148**	**0.4117**	**0.4086**	**0.4148**	**0.4072**	**0.3916**	**0.3685**	**0.3827**	**0.3930**	**77.0%**	**23.0%**	**7.4%**	**7.7%**

Annex 10 - International Electricity Emission Factors

Last updated: Jun-09

Table 10b - continued

Overseas Electricity/Heat Conversion Factors from 1990 to 2006: kgCO_2 per kWh electricity and heat CONSUMED**

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2006 5-yr rolling average	% Total GWh Electricity	% Total GWh Heat	% Distribution Losses Electricity	% Distribution Losses Heat
Other countries																						
Australia	0.8776	0.8810	0.8883	0.8719	0.8461	0.8394	0.8908	0.9364	0.9520	0.9435	0.9356	0.9141	0.9653	0.9431	0.9129	0.9449	0.9965	0.9525	100.0%	0.0%	7.6%	0.0%
Brazil			0.0721	0.0655	0.0605	0.0653	0.0675	0.0734	0.0737	0.0977	0.1042	0.1230	0.1014	0.0938	0.1010	0.0997	0.0959	0.0984	100.0%	0.0%	15.6%	0.0%
Canada	0.2121	0.2037	0.2133	0.1905	0.1869	0.1922	0.1857	0.2064	0.2351	0.2253	0.2358	0.2460	0.2322	0.2447	0.2248	0.2162	0.2002	0.2236	98.2%	1.8%	8.2%	0.0%
China, People's Republic of			0.8496	0.8491	0.8213	0.8587	0.8777	0.8602	0.8804	0.8534	0.8181	0.7914	0.8006	0.8301	0.8617	0.8427	0.8428	0.8356	79.8%	20.2%	7.8%	1.4%
Chinese Taipei			0.5086	0.5250	0.5228	0.5341	0.5410	0.5716	0.5811	0.6020	0.6269	0.6394	0.6289	0.6570	0.6518	0.6559	0.6842	0.6556	100.0%	0.0%	3.7%	0.0%
Croatia			0.3737	0.3769	0.2873	0.3135	0.2915	0.3430	0.3717	0.3486	0.3441	0.3560	0.4068	0.4332	0.3423	0.3579	0.3656	0.3812	82.8%	17.2%	12.9%	13.5%
Egypt			0.6337	0.6020	0.5581	0.5303	0.5177	0.5291	0.5593	0.5438	0.4927	0.4558	0.5225	0.5174	0.5661	0.5640	0.5623	0.5465	100.0%	0.0%	16.4%	0.0%
Gibraltar			0.7774	0.7771	0.7551	0.7696	0.7556	0.7766	0.7696	0.7696	0.7635	0.7574	0.7637	0.7581	0.7696	0.7431	0.7300	0.7529	100.0%	0.0%	0.0%	0.0%
Hong Kong (China)			0.9194	0.9658	0.9778	0.9568	0.9312	0.8126	0.8307	0.8026	0.7979	0.8070	0.8128	0.8909	0.9311	0.9090	0.9598	0.9007	100.0%	0.0%	10.9%	0.0%
Iceland	0.0006	0.0005	0.0005	0.0009	0.0009	0.0017	0.0013	0.0012	0.0031	0.0040	0.0007	0.0006	0.0007	0.0007	0.0007	0.0007	0.0011	0.0008	77.2%	22.8%	4.7%	10.4%
India			1.2141	1.2445	1.1959	1.2644	1.3256	1.2873	1.2583	1.2553	1.2817	1.2757	1.2551	1.2334	1.2865	1.2884	1.2893	1.2705	100.0%	0.0%	26.8%	0.0%
Indonesia			0.7290	0.8623	0.7317	0.6636	0.7278	0.7703	0.7419	0.7715	0.7330	0.8431	0.8137	0.8841	0.8557	0.8789	0.7720	0.8409	100.0%	0.0%	12.3%	0.0%
Israel			0.8451	0.8472	0.8456	0.8460	0.8520	0.8465	0.7887	0.7903	0.7838	0.7961	0.8475	0.8422	0.8317	0.7906	0.7973	0.8219	100.0%	0.0%	2.9%	0.0%
Japan	0.4524	0.4424	0.4486	0.4294	0.4478	0.4290	0.4262	0.4111	0.3984	0.4150	0.4188	0.4201	0.4410	0.4640	0.4464	0.4504	0.4393	0.4482	99.3%	0.7%	4.9%	0.0%
Korea, Republic of	0.5307	0.5703	0.5987	0.5795	0.5627	0.5507	0.5472	0.5695	0.5122	0.4965	0.5192	0.5200	0.4405	0.4614	0.4600	0.4333	0.5523	0.4695	87.2%	12.8%	3.7%	1.9%
Malaysia			0.6514	0.6316	0.5814	0.5815	0.5843	0.4871	0.5637	0.5515	0.5400	0.5651	0.6178	0.5492	0.5552	0.5821	0.6845	0.5978	100.0%	0.0%	4.3%	0.0%
Mexico	0.6501	0.6493	0.6186	0.6191	0.6813	0.6154	0.6145	0.6336	0.6940	0.6813	0.6874	0.6902	0.6776	0.6798	0.6342	0.6258	0.6568	0.6548	100.0%	0.0%	17.6%	0.0%
New Zealand	0.1385	0.1410	0.1883	0.1501	0.1249	0.1208	0.1506	0.2303	0.2315	0.2570	0.2491	0.2983	0.2669	0.3136	0.2603	0.2979	0.3342	0.2946	100.0%	0.0%	7.6%	0.0%
Norway	0.0037	0.0050	0.0042	0.0046	0.0056	0.0049	0.0069	0.0060	0.0060	0.0066	0.0044	0.0064	0.0058	0.0091	0.0076	0.0060	0.0076	0.0072	97.9%	2.1%	8.1%	16.1%
Pakistan			0.5256	0.5136	0.5229	0.5412	0.5916	0.6065	0.5499	0.6253	0.6409	0.6187	0.5916	0.4946	0.5303	0.5074	0.5521	0.5352	100.0%	0.0%	25.2%	0.0%
Philippines			0.5562	0.5512	0.5969	0.5852	0.5914	0.6558	0.6804	0.5764	0.5731	0.6097	0.5548	0.5295	0.5258	0.5697	0.5005	0.5361	100.0%	0.0%	13.1%	0.0%
Russian Federation			0.3298	0.3137	0.3189	0.3143	0.3682	0.3536	0.3515	0.3522	0.3455	0.3462	0.3518	0.3546	0.3498	0.3638	0.3542	0.3548	31.7%	68.3%	14.8%	2.6%
Saudi Arabia			0.9035	0.9086	0.8848	0.8841	0.8699	0.8772	0.8839	0.8803	0.8784	0.8442	0.8149	0.8021	0.8238	0.8109	0.8189	0.8141	100.0%	0.0%	7.8%	0.0%
Singapore			0.8897	1.0620	1.0329	0.9926	0.9306	0.8136	0.8189	0.6939	0.7020	0.6712	0.6293	0.6069	0.5883	0.5753	0.5670	0.5934	100.0%	0.0%	5.5%	0.0%
South Africa			0.9212	0.9483	0.9301	0.9458	0.9270	0.9365	0.9989	0.9583	0.9618	0.8928	0.8826	0.9103	0.9322	0.9137	0.9360	0.9150	100.0%	0.0%	7.2%	0.0%
Switzerland	0.0234	0.0262	0.0298	0.0222	0.0212	0.0235	0.0274	0.0243	0.0298	0.0236	0.0237	0.0230	0.0234	0.0243	0.0254	0.0282	0.0279	0.0258	92.8%	7.2%	6.8%	7.5%
Thailand			0.7028	0.6852	0.6779	0.6591	0.6801	0.6891	0.6613	0.6482	0.6134	0.6116	0.5855	0.5740	0.5850	0.5778	0.5557	0.5756	100.0%	0.0%	8.0%	0.0%
Turkey	0.6840	0.6949	0.6956	0.6156	0.6725	0.6253	0.6323	0.6465	0.6557	0.6778	0.6175	0.6465	0.5619	0.5265	0.5015	0.5083	0.5143	0.5225	92.9%	7.1%	15.7%	0.0%
Ukraine			0.4606	0.4802	0.4441	0.4561	0.4143	0.4018	0.4124	0.4213	0.4311	0.4097	0.4040	0.4740	0.3915	0.3935	0.4307	0.4187	49.9%	50.1%	15.6%	25.2%
United States			0.6308	0.6334	0.6302	0.6127	0.6225	0.6481	0.6488	0.6397	0.6290	0.6463	0.6169	0.6168	0.6176	0.6149	0.5999	0.6132	99.0%	1.0%	6.6%	18.0%
Africa			**0.7716**	**0.7844**	**0.7756**	**0.7811**	**0.7629**	**0.7716**	**0.8071**	**0.7729**	**0.7583**	**0.7072**	**0.7080**	**0.7238**	**0.7399**	**0.7307**	**0.7333**	**0.7271**	**100.0%**	**0.0%**	**12.0%**	**0.0%**
Latin America			**0.2306**	**0.2198**	**0.2136**	**0.2183**	**0.2241**	**0.2314**	**0.2409**	**0.2446**	**0.2349**	**0.2468**	**0.2369**	**0.2318**	**0.2435**	**0.2363**	**0.2327**	**0.2362**	**100.0%**	**0.0%**	**16.7%**	**0.0%**
Middle-East			**0.8332**	**0.8401**	**0.8440**	**0.8466**	**0.8380**	**0.8362**	**0.8201**	**0.8246**	**0.8207**	**0.8207**	**0.8047**	**0.7994**	**0.8103**	**0.8027**	**0.7793**	**0.7993**	**100.0%**	**0.0%**	**14.0%**	**0.0%**
Non-OECD Europe			**0.5678**	**0.5546**	**0.5685**	**0.5729**	**0.5575**	**0.5693**	**0.5652**	**0.5325**	**0.5614**	**0.5772**	**0.5750**	**0.6074**	**0.5799**	**0.5671**	**0.5913**	**0.5841**	**73.5%**	**26.5%**	**15.7%**	**15.4%**

Source

Emission factor data is from International Energy Agency Data Services, 2006 and 2008 for "CO2 Emissions per kWh Electricity and Heat Generated" and mainly sourced from the GHG Protocol website http://www.ghgprotocol.org/calculation-tools

Data on the proportion of electricity and heat (for 2006) is sourced from the IEA website at: http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Electricity/Heat

Data on losses in distribution of electricity and heat is calculated from 2006 country energy balances available at the IEA website at: http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances

Notes

Electricity emissions factors for electricity and heat generated - **includes** losses from the transmission and distribution grid.

If you cannot find an emission factor for a particular country, please refer to the larger list available on the GHG Protocol website at the link above.

Emission factors per kWh energy consumed are calculated using % distribution losses for 2006.

Annex 11 - Fuel Properties

Last updated:	Jun-09

How to use this Annex

This annex can be used to help you convert between common units of energy, together with the unit conversions provided in **Annex 12**. In this Annex the typical/average UK calorific values and densities of the most common fuels has been provided.

Table 11

Fuel properties	Net CV	Gross CV	Density	Density	Net CV	Gross CV
	GJ/tonne	GJ/tonne	kg/m^3	litres/tonne	kWh/kg	kWh/kg
Commonly Used Fossil Fuels						
Aviation Spirit	45.00	47.37	711.7	1405	12.50	13.16
Aviation Turbine Fuel	43.89	46.20	802.6	1246	12.19	12.83
Burning Oil[1]	43.87	46.18	803.9	1244	12.19	12.83
Coal (domestic)[2]	28.98	30.50	850.0	1176	8.05	8.47
Coal (electricity generation)[3]	24.89	26.20			6.91	7.28
Coal (industrial)[4]	25.56	26.90			7.10	7.47
Coking Coal	28.98	30.50			8.05	8.47
Diesel	43.27	45.54	834.0	1199	12.02	12.65
Fuel Oil	41.46	43.64	986.2	1014	11.52	12.12
Gas Oil	43.27	45.54	865.8	1155	12.02	12.65
LPG	46.98	49.45	508.1	1968	13.05	13.74
Naphtha	45.11	47.48	689.7	1450	12.53	13.19
Natural Gas	47.59	52.82	0.7459	1340651	13.22	14.67
Petrol	44.72	47.07	734.8	1361	12.42	13.08
Other Fuels						
Biodiesel (ME)[5]	37.20	41.04	890.0	1124	10.33	11.40
Biodiesel (BtL or HVO)[6]	44.00	46.32	780.0	1282	12.22	12.87
Bioethanol[7]	26.80	29.25	794.0	1259	7.44	8.13
BioETBE[8]	36.30	39.62	750.0	1333	10.08	11.01
Biogas[9]	30.00	33.30	0.9626	1038840	8.33	9.25
Biomethane[10]	49.00	54.39	0.7263	1376907	13.61	15.11
CNG[11]	25.56	26.90	175.0	5714	7.10	7.47
Wood Pellets[12]	16.62	17.50	1538.5	650	4.62	4.86
Methane	50.00	55.50	0.7170	1394700	13.89	15.42
Carbon Dioxide	0.00	0.00	1.9800	505051	0.00	0.00

Sources

Data for Commonly Used Fossil Fuels was sourced from the Digest of UK Energy Statistics 2008 (BERR), available at: http://www.berr.gov.uk/whatwedo/energy/statistics/publications/dukes/page45537.html
Figures for CNG and biofuels are predominantly based on data from JRC/EUCAR/CONCAWE EU Well-to-Wheels study, 2007 update. Available at: http://ies.jrc.ec.europa.eu/WTW.html

Notes

[1] Burning oil is also known as kerosene or paraffin used for heating systems. Aviation Turbine fuel is a similar kerosene fuel specifically refined to a higher quality for aviation.

[2] Factors should only be used for coal supplied for domestic purposes. Coal supplied to power stations or for industrial purposes have different emission factors.

[3] Factors should only be used for coal supplied for electricity generation (power stations). Coal supplied for domestic or industrial purposes have different emission factors.

[4] For coal used in sources other than power stations and domestic, i.e. industry sources including collieries, Iron & Steel, Autogeneration, Cement production, Lime production, Other industry, Miscellaneous, Public Sector, Stationary combustion - railways and agriculture. Users who wish to use coal factors for types of coal used in specific industry applications should use the factors given in the UK ETS.

[5] Biodiesel ME (Methyl Ester) is the conventionally produced biodiesel type (also known as 1st generation biodiesel).

[6] Biodiesel, BtL (Biomass-to-Liquid) is an advanced biodiesel fuel not yet in significant commercial production (also known as 2nd generation biodiesel). Biodiesel HVO (Hydrotreated Vegetable Oil) is a new type of biodiesel, similar in properties to BtL biodiesel fuel, only recently becoming available.

[7] Bioethanol is a biofuel commonly used in petrol engined vehicles, usually in a low % blend with conventional petrol.

[8] BioETBE is a biofuel that can be used in petrol engined vehicles in a low % blend with conventional petrol, usually as a replacement for conventional octane enhancers.

[9] Figures are indicative for uncompressed biogas assuming an assumed content of 60% methane and 40% of mainly carbon dioxide (with small quantities of nitrogen, oxygen, hydrogen and hydrogen disulphide). Note: the relative proportions can vary significantly depending on the source of the biogas, e.g. landfill gas, sewage gas, anaerobic digestion of biomass, etc. This will affect all physical properties.

[10] Figures are for uncompressed biomethane (of suitable purity for transport applications) comprising an average of 98% methane and 2% carbon dioxide. Biomethane can be produced by upgrading biogas through removal of the majority of the carbon dioxide and other impurities.

[11] CNG (Compressed Natural Gas) is an alternative transport fuel, typically at 200 bar pressure.

[12] Based on average information on wood pellets sourced from the BIOMASS Energy Centre (BEC), which is owned and managed by the UK Forestry Commission, via Forest Research, its research agency. Fuel property data on a range of other wood and other heating fuels is available at: http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,20041&_dad=portal&_schema=PORTAL

Annex 12 - Unit Conversions

Last updated:	Jun-09

How to use this Annex

This Annex can be used to help you convert between common units of energy, volume, mass or distance.

Table 12a provides conversions from common units of **Energy**

Table 12b provides conversions from common units of **Volume**

Table 12c provides conversions from common units of **Weight/Mass**

Table 12d provides conversions from common units of **Length/Distance**

If this annex does not have the conversion factor you are looking for, a more complete list of conversions is available here: http://www.onlineconversion.com/

Common unit abbreviations:
kilo (k) = 1,000 or 10^3
mega (M) = 1,000,000 or 10^6
giga (G) = 1,000,000,000 or 10^9
tera (T) = 1,000,000,000,000 or 10^{12}
peta (P) = 1,000,000,000,000,000 or 10^{15}

Table 12a **Energy**

From/To - multiply by	GJ	kWh	therm	toe	kcal
Gigajoule, GJ	1	277.78	9.47817	0.02388	238,903
Kilowatthour, kWh	0.0036	1	0.03412	0.00009	860.05
Therm	0.10551	29.307	1	0.00252	25,206
Tonne oil equivalent, toe	41.868	11,630	396.83	1	10,002,389
Kilocalorie, kcal	0.000004186	0.0011627	0.000039674	0.000000100	1

Table 12b **Volume**

From/To - multiply by	L	m^3	cu ft	Imp. gallon	US gallon	Bbl (US,P)
Litres, L	1	0.001	0.03531	0.21997	0.26417	0.0062898
Cubic metres, m^3	1000	1	35.315	219.97	264.17	6.2898
Cubic feet, cu ft	28.317	0.02832	1	6.2288	7.48052	0.17811
Imperial gallon	4.5461	0.00455	0.16054	1	1.20095	0.028594
US gallon	3.7854	0.0037854	0.13368	0.83267	1	0.023810
Barrel (US, petroleum), bbl	158.99	0.15899	5.6146	34.972	42	1

Table 12c **Weight/Mass**

From/To - multiply by	kg	tonne	ton (UK)	ton (US)	lb
Kilogram, kg	1	0.001	0.00098	0.00110	2.20462
tonne, t (metric ton)	1000	1	0.98421	1.10231	2204.62368
ton (UK, long ton)	1016.04642	1.01605	1	1.12000	2240
ton (US, short ton)	907.18	0.90718	0.89286	1	2000
Pound, lb	0.45359	0.00045359	0.00044643	0.00050	1

Table 12d **Length/Distance**

From/To - multiply by	m	ft	mi	km	nmi
Metre, m	1	3.2808	0.00062137	0.001	0.00053996
Feet, ft	0.30480	1	0.000	0.0003048	0.00016458
Miles, mi	1609.34	5280	1	1.60934	0.86898
Kilometres, km	1000	3280.8	0.62137	1	0.53996
Nautical miles, nmi or NM	1852	6076.1	1.15078	1.852	1

From/To - multiply by	m	ft	in	cm	yd
Metre, m	1	3.28084	39.37008	100	1.09361
Feet, ft	0.30480	1	12	30.48000	0.33333
Inch, in	0.02540	0.08333	1	2.54000	0.02778
Centimetres, cm	0.01	0.03281	0.39370	1	0.01094
Yard, yd	0.91440	3	36	91.44000	1