defra

2008

Guidelines to Defra's GHG Conversion Factors

Annexes updated April 2008

Key

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

Annex 1 - Fuel Conversion Factors

Last updated: Apr-08

Table 1

Converting fuel types to CO_2				Net CV Basis [5]			Gross CV Basis [6]	
Fuel Type	Amount used per year	Units	x	kg CO_2 per unit	Total kg CO_2	x	kg CO_2 per unit	Total kg CO_2
Electricity		See Annex 3					See Annex 3	
Natural Gas		kWh	x	0.206		x	0.185	
		therms	x	6.023		x	5.421	
Gas Oil		tonnes	x	3190		x	3190	
		kWh	x	0.265		x	0.252	
		litres	x	2.674		x	2.674	
Diesel		tonnes	x	3164		x	3164	
		kWh	x	0.263		x	0.250	
		litres	x	2.630		x	2.630	
Petrol		tonnes	x	3135		x	3135	
		kWh	x	0.252		x	0.240	
		litres	x	2.315		x	2.315	
Fuel Oil		tonnes	x	3223		x	3223	
		kWh	x	0.282		x	0.268	
Burning Oil[1]		tonnes	x	3150		x	3150	
		kWh	x	0.258		x	0.245	
		litres	x	2.518		x	2.518	
Industrial Coal [2]		tonnes	x	2457		x	2457	
		kWh	x	0.347		x	0.330	
Domestic Coal [3]		tonnes	x	2523		x	2523	
		kWh	x	0.313		x	0.298	
Wood Pellets [4]		tonnes	x	132		x	132	
		kWh	x	0.026		x	0.025	
Coking Coal		tonnes	x	2810		x	2810	
		kWh	x	0.349		x	0.332	
LPG		kWh	x	0.225		x	0.214	
		therms	x	6.608		x	6.277	
		litres	x	1.495		x	1.495	
Aviation Spirit		tonnes	x	3128		x	3128	
		kWh	x	0.250		x	0.238	
		litres	x	2.233		x	2.233	
Aviation Turbine Fuel [1]		tonnes	x	3150		x	3150	
		kWh	x	0.258		x	0.245	
		litres	x	2.518		x	2.518	
Other Petroleum Gas		tonnes	x	2894		x	2894	
		kWh	x	0.217		x	0.206	
Naphtha		tonnes	x	3131		x	3131	
		kWh	x	0.250		x	0.237	
Lubricants		tonnes	x	3171		x	3171	
		kWh	x	0.263		x	0.250	
Petroleum Coke		tonnes	x	3410		x	3410	
		kWh	x	0.361		x	0.343	
Refinery Miscellaneous		kWh	x	0.258		x	0.245	
		therms	x	7.562		x	7.184	
Total					0			0

Sources
UK Greenhouse Gas Inventory for 2006 (AEA Energy & Environment)
Digest of UK Energy Statistics (DTI)

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 UKETS.

3 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.

4 Wood pellets are used in domestic biomass heating systems. The emission factors are based on the factor provided in SAP2005, Table 12.

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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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. You can therefore calculate the total plant emissions from the fuel used with the standard conversion factors at Annex 1.

If, however, you export energy or heat to another business (or import from another business), you will need to split the emissions between the energy and heat before calculating the appropriate proportion of emissions which should be deducted from (or added to) your company total.

Because it is typically roughly twice as efficient to generate heat from fossil fuels as it is to generate electricity, you can attribute the emissions from the CHP plant 1:2 and calculate emissions per kWh of heat or electricity produced by the CHP plant using the appropriate formula below:

Emissions (in kgCO2) per kWh electricity = <u>twice total emissions (in kgCO_2)</u>
twice total electricity produced + total heat produced (in kWh)

Emissions (in kgCO2) per kWh heat = <u>total emissions (in kgCO_2)</u>
twice total electricity produced + total heat produced (in kWh)

Calculate emissions per kWh electricity			
Total emissions (kg CO_2)	Total electricity produced	Total heat produced	kg CO_2/kWh elecricity

Calculate emissions per kWh heat			
Total emissions (kg CO_2)	Total electricity produced	Total heat produced	kg CO_2/kWh heat

Annex 3 - Electricity Conversion Factors from 1990 to 2006

Last updated:	Apr-08

Table 2

Electricity conversion factors from 1990 to 2006			
UK Grid Electricity Year	Amount used per year, kWh	kg CO_2 per kWh	Total kg CO_2
1990		0.77000	
1991		0.75000	
1992		0.70000	
1993		0.62000	
1994		0.61000	
1995		0.58000	
1996		0.56487	
1997		0.52102	
1998		0.52276	
1999		0.49064	
2000		0.51946	
2001		0.53524	
2002		0.51879	
2003		0.53481	
2004		0.53478	
2005		0.53485	
2006		0.56185	
Type of electricity factor			
Grid Rolling Average[7]		0.53702	
Long-term marginal factor[8]		0.43000	
Electricity from CHP[9]		0.30400	
Renewables[10]		0	
Total			**0**

Sources: Based on UK Greenhouse Gas Inventory for 2006 (AEA Energy & Environment) according to the amount of CO_2 emitted from major power stations per unit of electricity consumed from the DTI's Digest of UK Energy Statistics (DUKES) 2007 Table 5.6

Notes: 7-10, See accompanying notes at:
http://www.defra.gov.uk/environment/business/envrp/conversion-factors.htm

Annex 4 - Typical Process Emissions

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There are six main greenhouse gases that are produced as a by-product by industry:

Carbon Dioxide CO2
Methane CH4
Nitrous oxide N2O
Perfluorocarbons PFC
Sulphur Hexafluoride SF6
Hydrofluorocarbons HFC

Below is a table that highlights the gases that are likely to be produced by a variety of the 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 3

Process related emissions[9]							
Process		Emission					
		CO_2	CH_4	N_2O	PFC	SF_6	HFC
Mineral Products	Cement Production	■					
	Lime Production	■					
	Limestone Use[10]	■					
	Soda Ash Production and Use	■					
	Fletton Brick Manufacture[11]	■	■				
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	■	■				

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

adapted for UK processes by netcen (now AEA Energy & Environment)

[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 - Conversion Factors for Greenhouse Gas Process Emissions (including emissions from refrigerants and air conditioning systems)

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Table 4

Factors for Process Emissions				
Emission	Amount Emitted per Year in tonnes	x	Conversion Factor	Total kg CO_2 equivalent
CO_2		x	1,000	
Methane		x	21,000	
Nitrous Oxide		x	310,000	
HFC - 125		x	2,800,000	
HFC - 134		x	1,000,000	
HFC - 134a		x	1,300,000	
HFC - 143		x	300,000	
HFC - 143a		x	3,800,000	
HFC - 152a		x	140,000	
HFC - 227ea		x	2,900,000	
HFC - 23		x	11,700,000	
HFC - 236fa		x	6,300,000	
HFC - 245ca		x	560,000	
HFC - 32		x	650,000	
HFC - 41		x	150,000	
HFC - 43 - I0mee		x	1,300,000	
Perfluorobutane		x	7,000,000	
Perfluoromethane		x	6,500,000	
Perfluoropropane		x	7,000,000	
Perfluoropentane		x	7,500,000	
Perfluorocyclobutane		x	8,700,000	
Perfluoroethane		x	9,200,000	
Perfluorohexane		x	7,400,000	
SF_6		x	23,900,000	
Total				**0**

Sources

The conversion factors in the table 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) but current UNFCCC Guidelines on Reporting and Review, adopted before the publication of the Third Assessment Report, require emission estimates to be based on the GWPs in the IPCC Second Assessment Report.

Notes

Not all refrigerants in use are classified as greenhouse gases for the purposes of the Climate Change Programme (e.g. CFCs, HCFCs). GWP values for refrigerant HFC 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 2800x0.44 + 3800x0.52 + 1300x0.04 = 3260).

Annex 6 - Passenger Transport Conversion Tables

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Table 5a

Standard road transport fuel conversion factors					
Fuel used	Total units used	Units	x	kg CO_2 per unit	Total kg CO_2
Petrol		litres		2.3154	
Diesel		litres		2.6304	
Compressed Natural Gas (CNG)		kg		2.7278	
Liquid Petroleum Gas (LPG)		litres		1.4951	
Total					**0**

Sources: UK Greenhouse Gas Inventory for 2006 (produced for Defra by AEA Energy & Environment)
Digest of UK Energy Statistics (DTI)
Carbon factors for fuels (UKPIA, 2004)

Notes: 1 imperial gallon (UK) = 4.546 litres

Table 6a

Passenger Road Transport Conversion Factors: Petrol Cars					
Size of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
Small petrol car, up to 1.4 litre engine		miles	x	0.2912	
		km	x	0.1809	
Medium petrol car, from 1.4 - 2.0 litres		miles	x	0.3442	
		km	x	0.2139	
Large petrol cars, above 2.0 litres		miles	x	0.4760	
		km	x	0.2958	
Average petrol car		miles	x	0.3332	
		km	x	0.2070	
Total for petrol cars					**0**

Table 6b

Passenger Road Transport Conversion Factors: Diesel Cars					
Size of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
Small diesel car, up to 1.7 litre or under		miles	x	0.2435	
		km	x	0.1513	
Medium diesel car, from 1.7 to 2.0 litre		miles	x	0.3027	
		km	x	0.1881	
Large diesel car, over 2.0 litre		miles	x	0.4153	
		km	x	0.2580	
Average diesel car		miles	x	0.3185	
		km	x	0.1979	
Total for diesel cars					**0**

Table 6c

Passenger Road Transport Conversion Factors: Alternative Fuel Cars					
Type of alternative fuel car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
Medium petrol hybrid car		miles	x	0.2031	
		km	x	0.1262	
Large petrol hybrid car		miles	x	0.3604	
		km	x	0.2240	
Medium LPG or CNG car		miles	x	0.3044	
		km	x	0.1892	
Large LPG or CNG car		miles	x	0.4174	
		km	x	0.2594	
Average LPG or CNG car		miles	x	0.3609	
		km	x	0.2243	
Total for alternative fuel cars					**0**

Annex 6 - Passenger Transport Conversion Tables

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Table 6d

Passenger Road Transport Conversion Factors: Cars (unknown fuel)					
Size of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
Average car (unknown fuel)		miles	x	0.3286	
		km	x	0.2042	
Total for average cars					**0**

Sources: Revised factors developed by AEA Energy & Environment and agreed with Department for Transport (2008)

Notes: These factors are estimated average values for the UK car fleet in 2007 travelling on average trips in the UK. They are calculated based on data from SMMT on new car CO_2 emissions from 1997 to 2007 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 accross 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 CO2 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 CO2 emissions relative to the emission factors for petrol cars from Table 6a. 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 5a. 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 5a factors.

Table 7a

Passenger Road Transport Conversion Factors: Petrol Cars by Market Segment					
Market segment of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
A. Mini		miles	x	0.2611	
		km	x	0.1622	
B. Supermini		miles	x	0.2842	
		km	x	0.1766	
C. Lower Medium		miles	x	0.3233	
		km	x	0.2009	
D. Upper Medium		miles	x	0.3517	
		km	x	0.2185	
E. Executive		miles	x	0.4269	
		km	x	0.2653	
F. Luxury		miles	x	0.5792	
		km	x	0.3599	
G. Sports		miles	x	0.4443	
		km	x	0.2761	
H. Duel Prupose 4x4		miles	x	0.4915	
		km	x	0.3054	
I. MPV		miles	x	0.3898	
		km	x	0.2422	
Total for petrol cars					**0**

Annex 6 - Passenger Transport Conversion Tables

Last updated: Apr-08

Table 7b

Passenger Road Transport Conversion Factors: Diesel Cars by Market Segment					
Market segment of car	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
A. Mini		miles	x	0.2184	
		km	x	0.1357	
B. Supermini		miles	x	0.2377	
		km	x	0.1477	
C. Lower Medium		miles	x	0.2779	
		km	x	0.1727	
D. Upper Medium		miles	x	0.3093	
		km	x	0.1922	
E. Executive		miles	x	0.3724	
		km	x	0.2314	
F. Luxury		miles	x	0.5052	
		km	x	0.3139	
G. Sports		miles	x	0.3876	
		km	x	0.2408	
H. Duel Prupose 4x4		miles	x	0.4288	
		km	x	0.2664	
I. MPV		miles	x	0.3412	
		km	x	0.2120	
Total for diesel cars					**0**

Sources: Factors developed by AEA Energy & Environment and agreed with Department for Transport (2008)

Notes: These factors are estimated average values for the UK car fleet in 2007 travelling on average trips in the UK. They are calculated based on data from SMMT on new car CO2 emissions from 1997 to 2007. The factors are estimates based on data on emissions by fuel/engine size combined with average emission factors by market segment (all fuels). 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 6a-6d). 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 6a and 6b 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 5a. 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 5a factors.

Table 8

Passenger Road Transport Conversion Factors: Vans (Light Commercial Vehicles)					
Type of van	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
Petrol van up to 1.25 tonne		miles	x	0.3611	
		km	x	0.2244	
Diesel van up to 3.5 tonne		miles	x	0.4371	
		km	x	0.2716	
LPG or CNG van up to 3.5 tonne		miles	x	0.4375	
		km	x	0.2718	
Average van up to 3.5 tonne		miles	x	0.4283	
		km	x	0.2661	
Total for vans					**0**

Sources: Factors developed by AEA Energy & Environment and agreed with Department for Transport (2008)

Notes: New 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. 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.

Annex 6 - Passenger Transport Conversion Tables

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Table 9

Passenger Road Transport Conversion Factors: Motorcycles					
Size of motorcycle	Total units travelled	Units	x	kg CO_2 per unit	Total kg CO_2
Small petrol motorbike (mopeds/scooters up to 125cc)		miles	x	0.1173	
		km	x	0.0729	
Medium petrol motorbike (125-500cc)		miles	x	0.1511	
		km	x	0.0939	
Large petrol motorbike (over 500cc)		miles	x	0.2069	
		km	x	0.1286	
Average petrol motorbike (unknown engine size)		miles	x	0.1704	
		km	x	0.1059	
Total for motorcycles					**0**

Sources: Factors developed by AEA Energy & Environment and agreed with Department for Transport (2007)

Notes: These factors are based on calculations of average emissions data by size category, based data reproduced from ACEM (European Motorcycle Manufacturers Association) – sourced from the European Commission's Joint Research Centre. The original data is available at:
http://www.acembike.org/motorcycles&society/pressreleases/MS3-Environment-LMercanti.pdf

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 5a factors.

Table 10

Taxi, Bus, Rail and Ferry Passenger Transport Conversion Factors					
Method of travel		Passenger kms travelled (pkm)	x	kg CO_2 per pkm	Total kg CO_2
Taxi [4]	Regular taxi		x	0.1593	
	Black cab		x	0.1720	
Bus	Local bus [5]		x	0.1158	
	London bus [6]		x	0.0818	
	Average bus		x	0.1073	
	Coach [7]		x	0.0290	
	Average bus and coach		x	0.0686	
Rail	National rail [8]		x	0.0602	
	International rail (Eurostar) [9]		x	0.0177	
	Light rail and tram [10]		x	0.0780	
	London Underground [11]		x	0.0650	
Ferry (Large RoPax) [12]	Passengers and Vehicles		x	0.1152	
Total					**0**

Sources: Department for Transport, Transport for London and AEA Energy & Environment, 2008

Notes

4 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).

5 The factor for local buses was calculated based on data publically available from the major bus service operators including Stagecoach, First Goup, Arriva, National Express, Go-Ahead and from Transport for London, supplemented in some cases by average bus occupancy factors from national statistics.

6 The London bus factor is from the Transport for London 2007 environmental report (p16) available at: http://www.tfl.gov.uk/assets/downloads/corporate/TfL-environment-report-2007.pdf

7 The emission factor for coach transport is the figure from the National Express Group's Corporate Responsibility Report, available at: http://www.nationalexpressgroup.com/nx/cr/cr_reports/csr2006/csr2006.pdf. 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.

8 The national rail factor refers to an average emission per passenger kilometre for diesel and electric trains in 2005. The calculation of the factor is based on the total electricity and diesel consumed by the railways in 2005/06 from the DfT National Modelling Framework Environment Module, and DfT transport statistics on the total number of passenger kilometres for 2005/06. The factor for conversion of units of diesel and electricity into CO_2 are based on the factors in Table 1 for diesel and the 2005 grid electricity factor in Table 2.

9 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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[10] 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 and the Croydon Tramlink. The factors for the Tyne and Wear and Manchester Metrolink tram and light rail systems were based on annual electricity consumption and passenger km data provided by the network operators in 2005 (referring to consumption in 2003/04) and a CO_2 emission factor for electricity generation on the national grid from the UK Greenhouse Gas Inventory. DLR and Croydon Tramlink figures are available in the Transport for London 2007 environmental report (p16) available at: http://www.tfl.gov.uk/assets/downloads/corporate/TfL-environment-report-2007.pdf

[11] The London Underground rail factor is from the Transport for London 2007 environmental report (p16) available at: http://www.tfl.gov.uk/assets/downloads/corporate/TfL-environment-report-2007.pdf

[12] The factor for RoPax ferries (Roll-on Roll-off ferries with additional passenger capacity) was provided by Best Foot Forward based on 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.

Table 11

Air Passenger Transport Conversion Factors

Method of travel		Passenger kms travelled (pkm)	x	kg CO_2 per pkm [13]	x	km uplift factor [14]	Total kg CO_2
Flight type [15]	*Cabin class [16]*						
Domestic	**Average**		x	0.1753	x	109%	
Short-haul international	**Average**		x	0.0983	x	109%	
	Economy class		x	0.0937	x	109%	
	Business class		x	0.1405	x	109%	
Long-haul international	**Average**		x	0.1106	x	109%	
	Economy class		x	0.0807	x	109%	
	Premium economy class		x	0.1291	x	109%	
	Business class		x	0.2340	x	109%	
	First class		x	0.3228	x	109%	
Total							**0**

Source: Developed by AEA Energy & Environment in discussion with the Department for Transport and the airline industry, 2008

Notes: 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.

[13] The emission factors refer to aviation's carbon dioxide emissions only. There is currently uncertainty over the 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.

[14] 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.

[15] 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 2006 (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 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.

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 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 routeing 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 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).

[16] 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.

Annex 6 - Passenger Transport Conversion Tables

Last updated:	Apr-08

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.

Annex 7 - Freight Transport Conversion Tables

Last updated:	Apr-08

Table 5b

Standard road transport fuel conversion factors					
Fuel used	Total units used	Units	x	kg CO_2 per unit	Total kg CO_2
Petrol		litres	x	2.3154	
Diesel		litres	x	2.6304	
Compressed Natural Gas (CNG)		kg	x	2.7278	
Liquid Petroleum Gas (LPG)		litres	x	1.4951	
Total					0

Sources: UK Greenhouse Gas Inventory for 2005 (produced for Defra by AEA Energy & Environment)
Digest of UK Energy Statistics (DTI)
Carbon factors for fuels (UKPIA, 2004)

Notes: 1 imperial gallon (UK) = 4.546 litres

Table 12a

Van/Light Commercial Vehicle Road Freight Mileage Conversion Factors: Vehicle km Basis					
Type of van	Gross Vehicle Weight (tonnes)	Total vehicle km travelled	x	kg CO_2 per vehicle km	Total kg CO_2
Petrol	up to 1.25t		x	0.224	
Diesel	up to 3.5t		x	0.272	
LPG or CNG	up to 3.5t		x	0.272	
Average	*up to 3.5t*		x	0.266	
Total					0

Table 12b

Van/Light Commercial Vehicle Road Freight Mileage Conversion Factors Based on UK Average Vehicle					
	Gross Vehicle Weight (tonnes)	Total tonne km travelled	x	kg CO_2 per tonne.km	Total kg CO_2
Petrol	up to 1.25t		x	0.449	
Diesel	up to 3.5t		x	0.272	
LPG or CNG	up to 3.5t		x	0.272	
Average	*up to 3.5t*		x	0.283	
Total					0

Sources: Factors developed by AEA Energy & Environment and agreed with Department for Transport (2008)

Notes: Emission factors for vans in tonne km were calculated from the emission factors per vehicle km provided in Table 8 and an average load factor of 50%. 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 13a

Diesel HGV Road Freight Mileage Conversion Factors: Vehicle km Basis							
	Gross Vehicle Weight (tonnes)	% weight laden		Total vehicle km travelled	x	kg CO_2 per vehicle km	Total kg CO_2
Rigid	>3.5-7.5t	0%			x	0.525	
		50%			x	0.571	
		100%			x	0.617	
		41%	*(UK average load)*		x	*0.563*	
Rigid	>3.5-7.5t	0%			x	0.525	
		50%			x	0.571	
		100%			x	0.617	
		41%	*(UK average load)*		x	*0.563*	
Rigid	>7.5-17t	0%			x	0.672	
		50%			x	0.768	
		100%			x	0.864	
		39%	*(UK average load)*		x	*0.747*	
Rigid	>17t	0%			x	0.778	
		50%			x	0.949	
		100%			x	1.119	
		56%	*(UK average load)*		x	*0.969*	
All rigids	***UK average***				x	***0.895***	
Articulated	>3.5-33t	0%			x	0.672	
		50%			x	0.840	
		100%			x	1.008	
		43%	*(UK average load)*		x	*0.817*	
Articulated	>33t	0%			x	0.667	
		50%			x	0.889	
		100%			x	1.111	
		59%	*(UK average load)*		x	*0.929*	
All artics	***UK average***				x	***0.917***	
ALL HGVs	***UK average***				x	***0.906***	

Annex 7 - Freight Transport Conversion Tables

Last updated: Apr-08

Sources: Revised factors developed by AEA Energy & Environment and agreed with Department for Transport (2007)

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.

The factors are based on road freight statistics from the Department for Transport (DfT, 2006), from a survey on the average miles per gallon and average loading factor for different sizes of rigid and artic HGVs in the fleet in 2005, 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 (2006) 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 10a. The correction was based on the current percent lading for different sizes of HGVs in the national fleet in 2005 given in Table 1.16 of DfT (2006).

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 (2006).

UK average factors for all rigid and articulated HGVs are also provided in Table 10a 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 (2006).

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 (2006). 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

Table 13b

Diesel HGV Road Freight Mileage Conversion Factors Based on UK Average Vehicle Loads: Tonne.km Basis

	Gross Vehicle Weight (tonnes)	Total tonne km travelled	x	kg CO_2 per tonne.km	Total kg CO_2
Rigid	>3.5-7.5t		x	0.591	
Rigid	>7.5-17t		x	0.336	
Rigid	>17t		x	0.187	
All rigids	***UK average***		x	**0.276**	
Articulated	>3.5-33t		x	0.163	
Articulated	>33t		x	0.082	
All articulateds	***UK average***		x	**0.086**	
ALL HGVs	***UK average***		x	**0.132**	

Sources: Revised factors developed by AEA Energy & Environment and agreed with Department for Transport (2007)

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 14. 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 13b 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 13a 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 (2006). Dividing the tonne.km by the vehicle.km figures gives the average tonnes freight lifted by each HGV class.

Tables 13a and 13b are provided as alternative methods for calculating CO_2 emissions from movement of freight by HGVs. The factors in g/vehicle.km (Table 13a) 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 13b 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.

Annex 7 - Freight Transport Conversion Tables

Last updated:	Apr-08

Table 14

Other Freight								
Mode	Detail		Total tonne km travelled	x	kg CO_2 per tonne.km	=		Total kg CO_2
Rail	Diesel			x	0.021			
Shipping	*Type*	*Vessel deadweight, tonnes*						
	Large RoPax Ferry	-			0.384			
	Small tanker	844		x	0.020			
	Large tanker	18,371		x	0.005			
	Very large tanker	100,000		x	0.004			
	Small bulk carrier	1,720		x	0.011			
	Large bulk carrier	14,201		x	0.007			
	Very large bulk carrier	70,000		x	0.006			
	Small container vessel	2,500		x	0.015			
	Large container vessel	20,000		x	0.013			
Mode	Detail		Total tonne km travelled	x	kg CO_2 per tonne.km	x	km uplift factor [17]	Total kg CO_2
Air	Domestic			x	1.898	x	109%	
	Short-haul international			x	1.316	x	109%	
	Long-haul international			x	0.606	x	109%	
Total								**0**

Sources: Revised factors developed by AEA Energy & Environment and agreed with Department for Transport (2008)

Notes:

Rail:

The value for rail freight is provisional and based on currently available information on fuel consumption and CO_2 emissions by diesel freight trains in the UK in 2005 produced by the UK Greenhouse Gas Inventory:

UK Greenhouse Gas Inventory for 2005 (produced for Defra by AEA Energy & Environment)

and

http://www.airquality.co.uk/archive/reports/cat07/0704261626_ukghgi-90-05_annexes_final.pdf

on the basis of average fuel consumption rates of diesel locomotives and estimated freight train km and DfT statistics on the total tonne.km rail freight moved in 2005:

Transport Statistics Great Britain (Table 4.1)

The factor can be expected to vary with rail traffic route, speed and train weight, but comprehensive, robust and reliable fuel consumption data are not currently available in the public domain. Freight trains are hauled by electric and diesel locomotives, but specific rail freight energy use data are not available nationally and the current factors assume haulage only by diesel locomotives.

Traffic-, route- and freight-specific factors are not currently available, but would present a more appropriate means of comparing modes (e.g. for bulk aggregates, intermodal, other types of freight)

The rail freight CO_2 factor will be reviewed and updated when data become available relevant to rail freight movement in the UK.

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 11 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 11 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).

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 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 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 incorporating 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.

Notes 13-15 from the passenger flights emission factors also apply to the air freight emission factors.