



Department
of Energy &
Climate Change

2014 Government GHG Conversion Factors for Company Reporting:

Methodology Paper for Emission Factors
FINAL

October 2014

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1. General Introduction

- 1.1. 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, etc.).
- 1.2. 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.
- 1.3. The 2014 Government Greenhouse Gas (GHG) Conversion Factors for Company Reporting¹ (hereafter the 2014 GHG Conversion Factors) represent the current official set of government emissions factors. These factors are also used in a number of different policies. This paper outlines the methodology used to update and expand the emission factors for the 2014 GHG Conversion Factors. The new factors are presented at the end of each of the relevant following sections.
- 1.4. Values for the non-carbon dioxide (CO₂) greenhouse gases, methane (CH₄) and nitrous oxide (N₂O), are presented as CO₂ equivalents (CO₂e) using Global Warming Potential (GWP) factors from the Intergovernmental Panel on Climate Change (IPCC)'s second assessment report (GWP for CH₄ = 21, GWP for N₂O = 310), consistent with reporting under the Kyoto Protocol. It should be noted here that the second assessment report by the IPCC is still used for the GHG Conversion Factors as this remains the report which is accepted for use in national GHG reporting under the Kyoto Protocol. Although the IPCC have prepared newer versions since, the methods have not yet been officially accepted for use under the Kyoto Protocol. This is therefore also the basis upon which all emissions are calculated under the UK GHG inventory, which is the basis of many of the conversion factors and with which this work should be consistent with.
- 1.5. The factors for 2014 GHG Conversion Factors will be set for the next year, and will continue to be reviewed and updated on an annual basis.
- 1.6. In order to further improve the usefulness of the GHG Conversion Factors and the guidance and other information provided alongside them, Defra commissioned a piece of work to consult on the format and content of the GHG Conversion Factors in September 2012. This work has culminated in a revised set of reporting tables and guidance, which will be provided via a new online tool². In this new format a number of the previous 'Annexes' for the GHG Conversion Factors have been moved instead to

¹ Previously known as the 'Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting'

² Available at: <http://www.ukconversionfactorscarbonsmart.co.uk>

Defra's new guidance on company reporting³, including former Annex 2, Annex 4, Annex 8 and Annex 13. In addition, in the new structure the remaining information previously provided is distributed across a number of similar tables grouped for better consistency with the GHG Protocol Reporting categories.

- 1.7. The purpose of this report is to provide the methodological approach, the key data sources and the assumptions used to define the emission factors provided in the 2013 GHG Conversion Factors. The report aims to expand and compliment the information already provided in the data tables themselves. However, it is not intended to be an exhaustively detailed explanation of every calculation performed (this is not practical/possible). Nor is it intended to provide guidance on the practicalities of reporting for organisations. Rather, the intention is to provide an overview with key information so that the basis of the emissions factors provided can be better understood and assessed.
- 1.8. Further information about the 2014 GHG Conversion Factors together with previous methodology papers is available from Defra's website at: <https://www.gov.uk/measuring-and-reporting-environmental-impacts-guidance-for-businesses>

Overview of changes since the previous update

- 1.9. Major changes and updates in terms of methodological approach from the 2013 version are summarised below. All other updates are essentially revisions of the previous year's data based on new/improved data using existing calculation methodologies (i.e. using a similar methodological approach as for the 2013 update)::
 - a. *Fuels*: Emission factors are now provided for domestically sourced/home produced coal that is only used in UK power generation (to complement the existing emission factor for coal from all sources). This emission factor has been added on the request of HMRC to allow for differentiation for emissions calculations using home produced coal only.
 - b. For LPG and natural gas, emission factors are now presented also on a per tonne fuel consumed basis, to complement existing factors.
 - c. *Passenger Cars*: In recent years the difference between the real-world performance of new cars compared to that stated by manufacturers reporting CO₂ emissions has been increasing according to a range of sources. The methodology used to estimate UK passenger cars' average CO₂ conversion factors has therefore been updated in the 2014 GHG Conversion Factors to include an accounting for this gradual change over time. The 2014 GHG Conversion Factors are therefore not directly comparable with those from 2013 or other previous versions. Therefore, whilst the overall average for reported factors and the averages for reported factors for some vehicle sizes / market segments have continued to reduce, the conversion factors for certain vehicle types/classifications have gone up this year.
 - d. *Aviation methodology change*: There has been a significant change in the source data and methodological basis for the aviation emission factors calculations in the 2014 update. Changes for the direct emission factors this year been based on fuel consumption for different aircraft types calculated using the EUROCONTROL small

³ Available at: <https://www.gov.uk/measuring-and-reporting-environmental-impacts-guidance-for-businesses>

emitters tool⁴, which has been produced for reporting under the European Emissions Trading Scheme (ETS). This change (discussed and agreed with experts from the Department for Transport) has resulted in significant changes to the emission factors for the 2014 update.

- e. *Heavy Goods Vehicles (HGVs)*: There have been two changes made to HGV conversion factors in the 2014 update to improve the accuracy of reporting. Firstly, new conversion factors by 0%, 50% and 100% vehicle laden weight have been added for all rigid HGVs, all artic HGVs and all HGVs from 2014. Secondly, the methodology for estimating conversion factors from refrigerated / temperature controlled HGVs has been modified in 2014 to improve the accuracy of reporting where users do not already have the specific fuel consumption available from their vehicles.
- f. *Taxi methodology change*: Previous year's methodologies have used large diesel passenger cars as proxy factors for taxis. This year data from testing using real-world taxi drive cycles provided by Transport for London has been used to calculate more accurate emission factors for the 2014 update. The emission factors for black cabs and taxis have therefore increased significantly this year as a result.
- g. *Bioenergy methodology changes*: There have been two changes made to bioenergy (specifically biomass) conversion factors in the 2014 update to improve the accuracy of reporting. Firstly, there has been an addition of methane (CH₄) and nitrous oxide (N₂O) emissions into the direct (Scope 1) conversion factors from bioenergy combustion (based on UK GHG Inventory emission factors). Also there has been a modification of the WTT-bioenergy conversion factors (Scope 3). The WTT biomass and biogas factors have been updated with new data sourced from two carbon calculators, produced by Ofgem. For more details please see the relevant section within this report.

Further details on many of these changes are provided in the introduction to the 2014 GHG Conversion Factors tables themselves, and in the relevant sections of this report.

- 1.10. Additional information is also provided in Appendix 3 of this report on major changes to the values of specific emission factors (i.e. +/-10% since the 2013 GHG Conversion Factors). Some of these changes are due to the methodological adjustments outlined above and in the later sections of this methodology paper, whilst others are due to changes in the underlying source datasets.
- 1.11. Detailed guidance on how the emission factors provided should be used is contained in the introduction to the 2014 GHG Conversion Factors themselves. This guidance must be referred to before using the emission factors and provides important context for the description of the methodologies presented in this report and in the table footnotes.

Structure of this methodology paper

- 1.12. The following Sections 1 to 12 provide methodological summary for the data tables contained in the Government GHG Conversion Factors for Company Reporting (GCF). For easier identification/navigation of this document, the major Section headings contain references grouped in a consistent way to the new GHG Conversion Factors format.

⁴ The EUROCONTROL small emitters tool is available at: <https://www.eurocontrol.int/articles/small-emitters-tool>

Area covered	Location in this document
Fuel Emission Factors	see Section 2
UK Electricity, Heat and Steam Factors	see Section 3
Refrigerant and Process Factors	see Section 4
Passenger Land Transport Factors	see Sections 5
Freight Land Transport Factors	see Sections 6
Sea Transport Factors	see Section 7
Air Transport Factors	see Section 8
Bioenergy and Water Factors	see Section 9
Overseas Electricity Factors	see Section 10
Material Use and Waste Disposal	see Section 11
Fuel Properties	see Section 12
Unit Conversions	N/A *

*This report does not provide any methodological description for unit conversions, since these are for standard units, provided as simple supplementary information or guidance.

Table 1: Summary Structure of this Methodology Paper

2. Fuel Emission Factors

Summary of changes since the previous update

- 2.1. The only methodological change since the previous update is that additional emission factors are now provided for domestically sourced/home produced coal that is only used in UK power generation. This emission factor has been added on the request of HMRC to allow for differentiation for emissions calculations using home produced coal only.

Direct Emissions

- 2.2. All the fuel conversion factors for direct emissions presented in the 2014 GHG Conversion Factors are based on the default emission factors used in the UK GHG Inventory (GHGI) for 2011 (managed by Ricardo-AEA)⁵.
- 2.3. The CO₂ emissions factors are based on the same ones used in the UK GHGI and are essentially independent of application (assuming full combustion). However, emissions of CH₄ and N₂O can vary to some degree for the same fuel depending on the particular use (e.g. emission factors for gas oil used in rail, shipping, non-road mobile machinery or different scales/types of stationary combustion plants can all be different). The figures for Fuels the 2014 GHG Conversion Factors for fuels are based on an activity-weighted average of all the different CH₄ and N₂O emission factors from the GHGI.
- 2.4. The standard emission factors from the GHGI have been converted into different energy and volume units using information on Gross and Net Calorific Values (CV) from DECC's Digest of UK Energy Statistics (DUKES) 2013⁶.
- 2.5. Four tables are presented in the 2014 GHG Conversion Factors, the first of which provides emission factors by unit mass, and the second by unit volume. The final two tables provide emission factors for energy on a Gross and Net CV basis respectively. Emission factors on a Net CV basis are higher (see definition of Gross CV and Net CV in the footnote below⁷).
- 2.6. It is important to use the correct emission factor; otherwise emissions calculations will over- or under-estimate the results. When making calculations based on energy use, it is important to 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. Natural Gas consumption figures quoted in kWh by suppliers in the UK are generally calculated (from the volume of gas used) on a Gross CV basis⁸. Therefore the emission factor for energy

⁵ UK Greenhouse Gas Inventory for 2011 (Ricardo-AEA), available at: <http://naei.defra.gov.uk>

⁶ Available at: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/digest-of-uk-energy-statistics-dukes>

⁷ 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).

⁸ See information available on Transco website: <http://www.transco.co.uk/services/cvalue/cvinfo.htm>

consumption on a Gross CV basis should be used by default for calculation of emissions from Natural Gas in kWh, unless your supplier specifically states they have used Net CV basis in their calculations instead.

Indirect/WTT Emissions from Fuels

- 2.7. These fuel lifecycle emissions (also sometimes referred to as 'Well-To-Tank' or simply WTT emissions usually in the context of transport fuels) are the emissions 'upstream' from the point of use of the fuel resulting from the transport, refining, purification or conversion of primary fuels to fuels for direct use by end-users and the distribution of these fuels. They are classed as Scope 3 according to the GHG Protocol.
- 2.8. In the absence of specific UK-based set of fuel lifecycle emissions factors information from JEC Well-To-Wheels (2013) were used as a basis for the factors in the 2014 GHG Conversion Factors⁹. This is the preeminent European study carried out in this area that covers a wide variety of fuels. This report is an update of the version used in the derivation of the 2013 GHG Conversion Factors, and the values for a number of fuels changed in the new report version (e.g. petrol and diesel fuels), which was used first in the 2013 update and has been used again as the basis for the 2014 GHG Conversion Factors. The coverage of the JEC WTW (2013) work includes:
- Refined conventional road transport fuels: petrol and diesel;
 - Alternative road transport fuels: LPG, CNG and LNG;
 - Other fuels/energy carriers: coal, natural gas, naphtha, heating oil and (EU) electricity
- 2.9. For fuels covered by the 2014 GHG Conversion Factors where no fuel lifecycle emission factor was available in JEC WTW (2013), these were estimated based on similar fuels, according to the assumptions in Table 3.
- 2.10. The final combined emission factors (in kgCO₂e/GJ, Net CV basis) are presented in Table 3. These include indirect/WTT emissions of CO₂, N₂O and CH₄ and were converted into other units of energy (e.g. kWh, Therms) and to units of volume and mass using the default Fuel Properties and Unit Conversion factors also provided in the 2014 GHG Conversion Factors alongside the emission factor data tables.
- 2.11. The methodology for calculating the indirect/WTT emission factors for natural gas and CNG has been updated for the 2014 update to account for the increasing share of UK gas supplied via imports of LNG (which have a higher WTT emission factor than conventionally sourced natural gas) in recent years. Table 2 provides a summary of the information on UK imports of LNG and their significance compared to other sources of natural gas used in the UK grid. These figures have been used to calculate the revised figures for Natural Gas and CNG WTT emission factors provided in Table 3 below.
- 2.12. Emission factors are also calculated for diesel supplied at public and commercial refuelling stations, factoring in the biodiesel supplied in the UK as a proportion of the total supply of diesel and biodiesel (2.52% by unit volume, 2.09% by unit energy – see

⁹ "Well-to-Wheels Analysis of Future Automotive Fuels and Powertrains in the European Context" Version 4, July 2013. Report EUR 26028 EN – 2013. <http://iet.jrc.ec.europa.eu/about-jec/>

Table 4). These estimates have been made based on DECC's Quarterly Energy Statistics for Renewables¹⁰.

2.13. Emission factors are also calculated for petrol supplied at public and commercial refuelling stations, factoring in the bioethanol supplied in the UK as a proportion of the total supply of petrol and bioethanol (=4.73% by unit volume, 3.13% by unit energy – see Table 4). These estimates have also been made based on DECC's Quarterly Energy Statistics for Renewables.

	LNG % of total natural gas imports ⁽²⁾	Net Imports as % total UK supply of natural gas ⁽¹⁾	LNG Imports as % total UK supply of natural gas
2007	4.6%	20.3%	1.41%
2008	2.3%	26.1%	0.82%
2009	24.7%	31.6%	10.97%
2010	35.1%	37.8%	18.64%
2011	46.8%	44.3%	29.92%
2012	27.6%	47.1%	17.28%

Source: DUKES 2013, (1) Table 4.1 - Commodity balances and (2) Table 4.5 - Natural gas imports and exports.

Table 2: Imports of LNG into the UK as a share of imports and net total natural gas supply

Fuel	Indirect/WTT EF (kgCO ₂ e/GJ, Net CV basis)	Source of Indirect/WTT Emission Factor	Assumptions
Aviation Spirit	13.76	Estimate	Similar to petrol
Aviation Turbine Fuel ¹	14.93	Estimate	= Kerosene fuel, estimate based on average of petrol and diesel factors
Burning Oil ¹	14.93	Estimate	= Kerosene, as above
CNG (excl. LNG imports) ²	8.70	JEC WTW (2013)	CNG from natural gas EU mix
CNG	11.78	JEC WTW (2013)	Factors in UK % share LNG imports ⁸
Coal (domestic) ³	14.77	JEC WTW (2013)	Emission factor for coal
Coal (electricity generation) ⁴	14.77	JEC WTW (2013)	Emission factor for coal
Coal (industrial) ⁵	14.77	JEC WTW (2013)	Emission factor for coal
Coal (electricity generation – home imports) ⁶	14.77	JEC WTW (2013)	Emission factor for coal
Coking Coal	14.77	Estimate	Assume same as factor for coal
Diesel	16.10	JEC WTW (2013)	

¹⁰ DECC's Renewable Energy Statistics, 2014 – Energy Trends, Quarterly tables – data used here released March 2014; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295362/ET_March_2014.PDF

Fuel	Indirect/WTT EF (kgCO ₂ e/GJ, Net CV basis)	Source of Indirect/WTT Emission Factor	Assumptions
Fuel Oil ⁷	14.93	Estimate	Assume same as factor for kerosene
Gas Oil ⁸	16.10	Estimate	Assume same as factor for diesel
LPG	8.04	JEC WTW (2013)	
LNG ⁹	21.05	JEC WTW (2013)	
Lubricants	9.54	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Naphtha	14.10	JEC WTW (2013)	
Natural Gas (excl. LNG imports)	5.66	JEC WTW (2013)	Natural gas EU mix
Natural Gas	7.66	JEC WTW (2013)	Factors in UK % share LNG imports ⁸
Other Petroleum Gas	6.80	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Petrol	13.76	JEC WTW (2013)	
Petroleum Coke	12.07	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Recycled fuel oil	9.54	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Refinery Miscellaneous	8.78	Estimate	Based on LPG figure, scaled relative to direct emissions ratio

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) CNG = Compressed Natural Gas is usually stored at 200 bar in the UK for use as an alternative transport fuel.
- (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) 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.
- (5) 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.
- (6) This emission factor should only be used for domestically coal supplied for electricity generation (UK power stations only). Coal supplied for domestic or industrial purposes have different emission factors.
- (7) Fuel oil is used for stationary power generation. Also use this emission factor for similar marine fuel oils.
- (8) Gas oil is used for stationary power generation and 'diesel' rail in the UK. Also use this emission factor for similar marine diesel oil and marine gas oil fuels.
- (9) LNG = Liquefied Natural Gas, usually shipped into the UK by tankers. LNG is usually used within the UK gas grid, however it can also be used as an alternative transport fuel.

Table 3: Basis of the indirect/WTT emissions factors for different fuels

	Total Sales, millions of litres		Biofuel % Total Sales		
	Biofuel	Conventional Fuel	per unit mass	per unit volume	per unit energy
Diesel/Biodiesel	657.2	25,440.1	2.28%	2.52%	2.09%
Petrol/Bioethanol	818.4	16,488.2	5.12%	4.73%	3.13%

Source: DECC's Renewable Energy Statistics, 2014 – Energy Trends, Quarterly tables – data used here released in March 2014; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295362/ET_March_2014.PDF

Table 4: Liquid biofuels for transport consumption: 4th quarter 2012 – 3rd quarter 2013

3. UK Electricity, Heat and Steam Emission Factors

Summary of changes since the previous update

- 3.1. There have been no methodological changes and additions since the previous 2013 update.
- 3.2. From 2013 onwards the emission factors per unit of electricity consumed were no longer provided, since these were being previously misused. Equivalent emission factors can still be calculated separately by adding the corresponding figures for electricity generated and for transmission and distribution losses together.
- 3.3. A detailed summary of the methodology used to calculate individual electricity emission factors is provided in the following subsections.

Direct Emissions from UK Grid Electricity

- 3.4. The electricity conversion factors given represent the average CO₂ emission from the UK national grid per kWh of electricity generated (Scope 2 of the GHG Protocol and separately for electricity transmission and distribution losses (Scope 3 of the GHG Protocol). The calculations also factor in net imports of electricity via the interconnectors with Ireland and France. These factors include only direct CO₂, CH₄ and N₂O emissions at UK power stations and from autogenerators (for the first time in the 2013 GHG Conversion Factors), plus those from the proportion of imported electricity. They do not include emissions resulting from production and delivery of fuel to these power stations (i.e. from gas rigs, refineries and collieries, etc.).
- 3.5. This factor changes from year to year as the fuel mix consumed in UK power stations (and autogenerators) changes, and as the proportion of net imported electricity also changes. These annual changes can be large as the factor depends very heavily on the relative prices of coal and natural gas as well as fluctuations in peak demand and renewables. Therefore to assist companies with year to year comparability, in previous years the factor presented was the 'Grid Rolling Average' of the grid conversion factor over the previous 5 years. However from 2013 a decision was made to switch to the actual in-year (i.e. non-rolling average) emission factors, and only these have been provided since then, and should be used in all reporting from this point onwards. One of the key reasons for the change was to provide an emission factor that was as close as possible to the actual year of reporting as possible. More information on the significance of this was provided in the 2013 methodology paper. However, one of the results was that it will require a baseline/reference year adjustment for those companies reporting in years before this point. Further information on this is also provided within the 2013 and 2014 GHG Conversion Factors.
- 3.6. The UK electricity conversion factors provided in the 2014 GHG Conversion Factors are based on emissions from sector 1A1a (power stations) and 1A2f (autogenerators) in the

UK Greenhouse Gas Inventory (GHGI) for 2011 (Ricardo-AEA) according to the amount of CO₂, CH₄ and N₂O emitted per unit of electricity consumed (from DUKES 2012)¹¹.

- 3.7. The UK is a net importer of electricity from the interconnector with France, and a net exporter of electricity to Ireland according to DUKES (2012). For the 2014 GHG Conversion Factors net electricity imports were calculated from DUKES (2012) Table 5.1.2 (Electricity supply, availability and consumption 1970 to 2011).
- 3.8. The electricity emission factor for France (from the Overseas Electricity emissions factors tables) – including losses – is used to account for the net import of electricity, as it will also have gone through the French distribution system. Note that this method effectively reduces the UK’s electricity emission factors as the electricity emission factor for France is lower than that for the UK. This is largely due to the fact that France’s electricity generation is much less carbon-intensive than that of the UK.
- 3.9. The source data and calculated emissions factors are summarised in the following Table 5, Table 6 and Table 7. Time series source data and emission factors that were fixed/locked from the 2013 update onwards have been highlighted in light grey. The tables provide the data and emission factors against the relevant data year. Table 5 also provides a comparison of how the data year reads across to the GHG conversion factors update / reporting year to which the data and emission factors are applied, which is two years ahead of the data year. For example, the most recent emission factor for the 2014 GHG Conversion Factors is based on a data year of 2012. A full timeseries of data using the most recently available GHGI and DUKES datasets for all years is also provided in Appendix 2 of this report. This is provided for purposes **other than company reporting**, where a fully consistent data timeseries is desirable, e.g. for policy impact analysis.

Data Year	Applied to Reporting Year*	Electricity Generation (1) GWh	Total Grid Losses (2) %	UK electricity generation emissions (3), ktonne		
				CO ₂	CH ₄	N ₂ O
1990	1992	290,666	8.08%	204,614	2.671	5.409
1991	1993	293,743	8.27%	201,213	2.499	5.342
1992	1994	291,692	7.55%	189,327	2.426	5.024
1993	1995	294,935	7.17%	172,927	2.496	4.265
1994	1996	299,889	9.57%	168,551	2.658	4.061
1995	1997	310,333	9.07%	165,700	2.781	3.902
1996	1998	324,724	8.40%	164,875	2.812	3.612
1997	1999	324,412	7.79%	152,439	2.754	3.103

¹¹ DUKES (2012): <http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx>

Data Year	Applied to Reporting Year*	Electricity Generation (1) GWh	Total Grid Losses (2) %	UK electricity generation emissions (3), ktonne		
				CO ₂	CH ₄	N ₂ O
1998	2000	335,035	8.40%	157,171	2.978	3.199
1999	2001	340,218	8.25%	149,036	3.037	2.772
2000	2002	349,263	8.38%	160,927	3.254	3.108
2001	2003	358,185	8.56%	171,470	3.504	3.422
2002	2004	360,496	8.26%	166,751	3.490	3.223
2003	2005	370,639	8.47%	177,044	3.686	3.536
2004	2006	367,883	8.71%	175,963	3.654	3.414
2005	2007	370,977	7.25%	175,086	3.904	3.550
2006	2008	368,314	7.21%	184,517	4.003	3.893
2007	2009	365,252	7.34%	181,256	4.150	3.614
2008	2010	356,887	7.45%	176,418	4.444	3.380
2009	2011	343,418	7.87%	155,261	4.450	2.913
2010	2012	348,812	7.32%	160,385	4.647	3.028
2011	2013	330,128	7.88%	148,153	4.611	3.039
2012*	2014	320,470	8.04%	161,903	5.258	3.934

Notes:

- (1) Based upon calculated total for centralised electricity generation (GWh supplied) from DUKES (2012) / DUKES (2013) Table 5.6 Electricity fuel use, generation and supply for 1990-2012 / 2013 respectively. The total is consistent with UNFCCC emissions reporting categories 1A1a+1A2f includes (according to Table 5.6 categories) GWh supplied (gross) from all thermal sources from 'Major power producers' plus Hydro-natural flow; plus GWh supplied from thermal renewables + coal and gas thermal sources, hydro-natural flow and other non-thermal sources from 'Other generators'.
- (2) Based upon calculated net grid losses from data in DUKES (2012, 2013) Table 5.1.2 (long term trends, only available online).
- (3) Emissions from UK centralised power generation (including Crown Dependencies only) listed under UNFCC reporting category 1A1a and autogeneration - exported to grid (UK Only) listed under UNFCC reporting category 1A2f from the UK Greenhouse Gas Inventory for 2011 (Ricardo-AEA, 2013) for data years 1990-2011 and for the GHGI for 2012 (Ricardo-AEA, 2014) for the 2012 data year.

* Corrected data, 22 October 2014.

Table 5: Base electricity generation emissions data

2014 Government GHG Conversion Factors for Company Reporting:
Methodology Paper for Emission Factors

Data Year	Emission Factor, kgCO ₂ e / kWh												% Net Electricity Imports	Imported Electricity EF
	For electricity GENERATED (supplied to the grid)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)					
	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total		
1990	0.70395	0.00019	0.00577	0.70991	0.05061	0.00001	0.00042	0.05104	0.7658	0.00021	0.00628	0.77229	3.85%	0.113
1991	0.685	0.00018	0.00564	0.69081	0.04318	0.00001	0.00033	0.04352	0.74675	0.00019	0.00615	0.75309	5.18%	0.1279
1992	0.64907	0.00017	0.00534	0.65458	0.05678	0.00002	0.00042	0.05722	0.70205	0.00019	0.00578	0.70801	5.29%	0.10097
1993	0.58632	0.00018	0.00448	0.59098	0.05101	0.00002	0.00037	0.0514	0.6316	0.00019	0.00483	0.63662	5.25%	0.06828
1994	0.56204	0.00019	0.0042	0.56643	0.04471	0.00002	0.0003	0.04502	0.62154	0.00021	0.00464	0.62639	5.22%	0.06899
1995	0.53394	0.00019	0.0039	0.53803	0.03813	0.00001	0.00024	0.03839	0.58721	0.00021	0.00429	0.5917	4.97%	0.0783
1996	0.50774	0.00018	0.00345	0.51137	0.04182	0.00002	0.00026	0.0421	0.55432	0.0002	0.00376	0.55828	4.80%	0.08212
1997	0.46989	0.00018	0.00297	0.47304	0.03816	0.00002	0.00022	0.0384	0.50961	0.00019	0.00322	0.51302	4.76%	0.07552
1998	0.46912	0.00019	0.00296	0.47226	0.04084	0.00002	0.00024	0.04111	0.51211	0.0002	0.00323	0.51555	3.51%	0.10497
1999	0.43806	0.00019	0.00253	0.44077	0.04375	0.00002	0.00027	0.04404	0.47745	0.0002	0.00275	0.48041	3.94%	0.09039
2000	0.46076	0.0002	0.00276	0.46372	0.04083	0.00002	0.00024	0.04109	0.50293	0.00021	0.00301	0.50616	3.82%	0.08117
2001	0.47872	0.00021	0.00296	0.48189	0.04398	0.00002	0.00027	0.04427	0.52354	0.00022	0.00324	0.52701	2.78%	0.0655
2002	0.46256	0.0002	0.00277	0.46554	0.04487	0.00002	0.00027	0.04516	0.50418	0.00022	0.00302	0.50742	2.24%	0.07114
2003	0.47767	0.00021	0.00296	0.48084	0.03621	0.00002	0.00023	0.03646	0.52187	0.00023	0.00323	0.52533	0.57%	0.07478
2004	0.47831	0.00021	0.00288	0.4814	0.03831	0.00002	0.00025	0.03857	0.52395	0.00023	0.00315	0.52733	1.97%	0.07244
2005	0.47196	0.00022	0.00297	0.47515	0.03884	0.00002	0.00024	0.0391	0.50883	0.00024	0.0032	0.51226	2.16%	0.08482
2006	0.50098	0.00023	0.00328	0.50448	0.03883	0.00002	0.00023	0.03908	0.53993	0.00025	0.00353	0.54371	1.97%	0.07754
2007	0.49625	0.00024	0.00307	0.49956	0.03838	0.00002	0.00022	0.03863	0.53555	0.00026	0.00331	0.53911	1.37%	0.08121
2008	0.49433	0.00026	0.00294	0.49752	0.03611	0.00002	0.00021	0.03634	0.53414	0.00028	0.00317	0.53759	2.91%	0.07784
2009	0.45211	0.00027	0.00263	0.45501	0.03783	0.00002	0.00024	0.03809	0.49074	0.0003	0.00285	0.49389	0.80%	0.08403
2010	0.4598	0.00028	0.00269	0.46277	0.05061	0.00001	0.00042	0.05104	0.49613	0.0003	0.0029	0.49933	0.73%	0.0851
2011	0.44877	0.00029	0.00285	0.45192	0.04318	0.00001	0.00033	0.04352	0.48715	0.00032	0.0031	0.49056	1.76%	0.0851
2012	0.5052	0.00034	0.00381	0.50935	0.04418	0.00003	0.00033	0.04454	0.54938	0.00037	0.00414	0.55389	3.40%	0.06522

Notes: Timeseries data in light grey is locked/fixed for the purposes of company reporting and has not been updated be updated in the database in the 2014 update.

Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) / (1 - %Electricity Total Grid LOSSES)

Emission Factor (Electricity LOSSES) = Emission Factor (Electricity CONSUMED) - Emission Factor (Electricity GENERATED)

⇒ Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) + Emission Factor (Electricity LOSSES),

Table 6: Base electricity generation emission factors (excluding imported electricity)

Data Year	Emission Factor, kgCO ₂ e / kWh												% Net Electricity Imports	Imported Electricity EF kgCO ₂ e / kWh
	For electricity GENERATED (supplied to the grid, plus imports)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)					
	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total		
1990	0.6812	0.00019	0.00558	0.68697	0.05985	0.00002	0.00049	0.06036	0.74106	0.0002	0.00607	0.74733	3.85%	0.113
1991	0.65616	0.00017	0.0054	0.66174	0.05915	0.00002	0.00049	0.05966	0.71532	0.00019	0.00589	0.72139	5.18%	0.1279
1992	0.62005	0.00017	0.0051	0.62532	0.05061	0.00001	0.00042	0.05104	0.67066	0.00018	0.00552	0.67636	5.29%	0.10097
1993	0.55913	0.00017	0.00428	0.56358	0.04318	0.00001	0.00033	0.04352	0.60232	0.00018	0.00461	0.6071	5.25%	0.06828
1994	0.53633	0.00018	0.00401	0.54051	0.05678	0.00002	0.00042	0.05722	0.59311	0.0002	0.00443	0.59773	5.22%	0.06899
1995	0.5113	0.00018	0.00373	0.51521	0.05101	0.00002	0.00037	0.0514	0.56231	0.0002	0.0041	0.56661	4.97%	0.0783
1996	0.48731	0.00017	0.00331	0.4908	0.04471	0.00002	0.0003	0.04502	0.53202	0.00019	0.00361	0.53582	4.80%	0.08212
1997	0.45112	0.00017	0.00285	0.45414	0.03813	0.00001	0.00024	0.03839	0.48925	0.00019	0.00309	0.49253	4.76%	0.07552
1998	0.45633	0.00018	0.00288	0.45939	0.04182	0.00002	0.00026	0.0421	0.49816	0.0002	0.00314	0.5015	3.51%	0.10497
1999	0.42438	0.00018	0.00245	0.427	0.03816	0.00002	0.00022	0.0384	0.46254	0.0002	0.00267	0.46541	3.94%	0.09039
2000	0.44628	0.00019	0.00267	0.44914	0.04084	0.00002	0.00024	0.04111	0.48712	0.00021	0.00292	0.49024	3.82%	0.08117
2001	0.46725	0.0002	0.00289	0.47034	0.04375	0.00002	0.00027	0.04404	0.511	0.00022	0.00316	0.51438	2.78%	0.0655
2002	0.45378	0.0002	0.00272	0.4567	0.04083	0.00002	0.00024	0.04109	0.49461	0.00022	0.00296	0.49779	2.24%	0.07114
2003	0.47537	0.00021	0.00294	0.47853	0.04398	0.00002	0.00027	0.04427	0.51936	0.00023	0.00322	0.5228	0.57%	0.07478
2004	0.47033	0.00021	0.00283	0.47337	0.04487	0.00002	0.00027	0.04516	0.51521	0.00022	0.0031	0.51853	1.97%	0.07244
2005	0.46359	0.00022	0.00291	0.46673	0.03621	0.00002	0.00023	0.03646	0.49981	0.00023	0.00314	0.50318	2.16%	0.08482

Data Year	Emission Factor, kgCO ₂ e / kWh												% Net Electricity Imports	Imported Electricity EF kgCO ₂ e / kWh
	For electricity GENERATED (supplied to the grid, plus imports)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)					
	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total		
2006	0.49263	0.00022	0.00322	0.49608	0.03831	0.00002	0.00025	0.03857	0.53094	0.00024	0.00347	0.53465	1.97%	0.07754
2007	0.49054	0.00024	0.00303	0.49381	0.03884	0.00002	0.00024	0.0391	0.52939	0.00025	0.00327	0.53291	1.37%	0.08121
2008	0.48219	0.00026	0.00286	0.48531	0.03883	0.00002	0.00023	0.03908	0.52102	0.00028	0.00309	0.52439	2.91%	0.07784
2009	0.44917	0.00027	0.00261	0.45205	0.03838	0.00002	0.00022	0.03863	0.48755	0.00029	0.00284	0.49068	0.80%	0.08403
2010	0.45706	0.00028	0.00267	0.46002	0.03611	0.00002	0.00021	0.03634	0.49317	0.0003	0.00289	0.49636	0.73%	0.0851
2011	0.44238	0.00029	0.00281	0.44548	0.03783	0.00002	0.00024	0.03809	0.4802	0.00031	0.00305	0.48357	1.76%	0.0851
2012	0.49023	0.00033	0.00369	0.49426	0.04287	0.00003	0.00032	0.04322	0.5331	0.00036	0.00402	0.53748	3.40%	0.06522

Notes: Timeseries data in light grey is locked/fixed for the purposes of company reporting and has not been updated be updated in the database in the 2014 update.

Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) / (1 - %Electricity Total Grid LOSSES)

Emission Factor (Electricity LOSSES) = Emission Factor (Electricity CONSUMED) - Emission Factor (Electricity GENERATED)

⇒ Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) + Emission Factor (Electricity LOSSES)

Table 7: Base electricity generation emissions factors (including imported electricity)

Indirect/WTT Emissions from UK Grid Electricity

- 3.10. In addition to the GHG emissions resulting directly from the generation of electricity, there are also indirect/WTT emissions resulting from the production, transport and distribution of the fuels used in electricity generation (i.e. indirect/WTT / fuel lifecycle emissions as included in the Fuels WTT tables). The average fuel lifecycle emissions per unit of electricity generated will be a result of the mix of different sources of fuel / primary energy used in electricity generation.
- 3.11. Average indirect/WTT emission factors for electricity have been calculated using the corresponding fuels indirect/WTT emission factors and data on the total fuel consumption by type of generation from Table 5.6, DUKES, 2012. The data used in these calculations are presented in Table 8, Table 9 and Table 10, together with the final indirect/WTT emission factors for electricity. As for the direct emission factors presented in the previous section, earlier years are based on data reported in previous versions of DUKES and following the new convention set from 2013, historic timeseries factors/data have not been updated. The relevant time series source data and emission factors that were fixed/locked from the 2013 update onwards have therefore been highlighted in light grey and are unchanged since the last update.

Data Year	Fuel Consumed in Electricity Generation, GWh					
	Coal	Fuel Oil	Natural Gas	Other thermal (excl. renewables)	Other generation	Total
1990 to 1995	N/A	N/A	N/A	N/A	N/A	N/A
1996	390,938	45,955	201,929	16,066	243,574	898,462
1997	336,614	25,253	251,787	16,066	257,272	886,992
1998	347,696	17,793	267,731	16,046	268,184	917,450
1999	296,706	17,920	315,548	16,187	256,159	902,520
2000	333,429	18,023	324,560	15,743	228,045	919,800
2001	367,569	16,545	312,518	12,053	249,422	958,107
2002	344,552	14,977	329,442	12,343	244,609	945,923
2003	378,463	13,867	323,926	17,703	241,638	975,597
2004	364,158	12,792	340,228	16,132	228,000	961,309
2005	378,846	15,171	331,658	21,877	233,705	981,257
2006	418,018	16,665	311,408	18,038	224,863	988,991
2007	382,857	13,491	355,878	14,613	189,813	956,652
2008	348,450	18,393	376,810	13,074	167,638	924,366
2009	286,820	17,597	359,303	11,551	213,450	888,721
2010	297,290	13,705	373,586	9,322	202,893	896,796
2011	302,729	10,514	307,265	8,913	232,146	861,567
2012	399,253	9,076	214,146	12,926	230,227	865,628

Source: For the latest 2012 data year, Table 5.6, Digest of UK Energy Statistics (DUKES) 2013 (DECC, 2013), available at: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/digest-of-uk-energy-statistics-dukes>. Earlier years are based on data reported in previous versions of DUKES and following the new convention set from 2013, historic timeseries factors/data have not been updated.

Table 8: Fuel Consumed in electricity generation (GWh), by year

Data Year	Fuel Consumed in Electricity Generation, % Total					
	Coal	Fuel Oil	Natural Gas	Other thermal (excl. renewables)	Other generation	Total
1990	43.50%	5.10%	22.50%	1.80%	27.10%	100.00%
1991	38.00%	2.80%	28.40%	1.80%	29.00%	100.00%
1992	37.90%	1.90%	29.20%	1.70%	29.20%	100.00%
1993	32.90%	2.00%	35.00%	1.80%	28.40%	100.00%
1994	36.30%	2.00%	35.30%	1.70%	24.80%	100.00%
1995	38.40%	1.70%	32.60%	1.30%	26.00%	100.00%
1996	36.40%	1.60%	34.80%	1.30%	25.90%	100.00%
1997	38.80%	1.40%	33.20%	1.80%	24.80%	100.00%
1998	37.90%	1.30%	35.40%	1.70%	23.70%	100.00%
1999	38.60%	1.50%	33.80%	2.20%	23.80%	100.00%
2000	42.30%	1.70%	31.50%	1.80%	22.70%	100.00%
2001	40.00%	1.40%	37.20%	1.50%	19.80%	100.00%
2002	37.70%	2.00%	40.80%	1.40%	18.10%	100.00%
2003	32.30%	2.00%	40.40%	1.30%	24.00%	100.00%
2004	33.20%	1.50%	41.70%	1.00%	22.60%	100.00%
2005	35.10%	1.20%	35.70%	1.00%	26.90%	100.00%
2006	46.10%	1.00%	24.70%	1.50%	26.60%	100.00%
2007	43.50%	5.10%	22.50%	1.80%	27.10%	100.00%
2008	38.00%	2.80%	28.40%	1.80%	29.00%	100.00%
2009	37.90%	1.90%	29.20%	1.70%	29.20%	100.00%
2010	32.90%	2.00%	35.00%	1.80%	28.40%	100.00%
2011	36.30%	2.00%	35.30%	1.70%	24.80%	100.00%
2012*	46.12%	1.05%	24.74%	1.49%	26.60%	100.00%

Notes: Calculated from figures in Table 8. * Corrected data, 22 October 2014.

Table 9: Fuel consumed in electricity generation as a % of the Total, by year

Data Year	Indirect/WTT Emissions as % Direct CO ₂ Emissions, by fuel							
	Coal	Fuel Oil	Natural Gas	Other thermal (excl. renewables)	Other generation	Weighted Average	Direct CO ₂	Calc Indirect /WTT CO ₂ e
1990	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.6812	0.10012
1991	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.65616	0.09644
1992	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.62005	0.09113
1993	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.55913	0.08218
1994	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.53633	0.07883
1995	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.5113	0.07515
1996	16.50%	18.90%	10.40%	12.50%	14.70%	14.70%	0.48731	0.07162
1997	16.50%	18.90%	10.40%	12.50%	14.10%	14.10%	0.45112	0.06345
1998	16.50%	18.90%	10.40%	12.50%	14.00%	14.00%	0.45633	0.06372
1999	16.50%	18.90%	10.40%	12.50%	13.50%	13.50%	0.42438	0.0573
2000	16.50%	18.90%	10.40%	12.50%	13.60%	13.60%	0.44628	0.06079
2001	16.50%	18.90%	10.40%	12.50%	13.80%	13.80%	0.46725	0.06452
2002	16.50%	18.90%	10.40%	12.50%	13.60%	13.60%	0.45378	0.06184
2003	16.50%	18.90%	10.40%	12.50%	13.80%	13.80%	0.47537	0.06545
2004	16.50%	18.90%	10.40%	12.50%	13.60%	13.60%	0.47033	0.06413
2005	16.50%	18.90%	10.40%	12.50%	13.70%	13.70%	0.46359	0.06368
2006	16.50%	18.90%	10.40%	12.50%	14.00%	14.00%	0.49263	0.06888
2007	16.50%	18.90%	10.40%	12.50%	13.60%	13.60%	0.49054	0.06694
2008	16.50%	18.90%	10.40%	12.50%	13.50%	13.50%	0.48219	0.06492
2009	16.50%	18.90%	12.40%	12.50%	14.30%	14.30%	0.44917	0.06423
2010	16.50%	18.90%	13.90%	12.50%	15.10%	15.10%	0.45706	0.069
2011	16.50%	18.90%	15.30%	12.50%	15.90%	15.90%	0.44238	0.07033
2012	16.40%	18.80%	13.45%	12.59%	15.35%	15.35%	0.49023	0.07527

Notes: Indirect/WTT emissions as % direct CO₂ emissions is based on information for specific fuels. Weighted average is calculated from the figures for fuels from both Table 9 and Table 10.

Table 10: Indirect/WTT emissions share for fuels used for electricity generation and the calculated average indirect/WTT emission factor, by year

Emission Factors for the Supply of Purchased Heat or Steam

3.12. Updated time-series emission factors for the supply of purchased heat or steam have been provided for the 2014 GHG Conversion Factors. These conversion factors represent the average emission from the heat and steam supplied by the UK CHPQA (Combined Heat and Power Quality Assurance) scheme¹² operators for a given year. This factor changes from year to year, as the fuel mix consumed changes and is therefore to be updated annually. No statistics are available that would allow the calculation of UK national average emission factors for the supply of heat and steam from non-CHP operations.

3.13. CHP (Combined Heat and Power) simultaneously produces both heat and electricity, and there are a number of conventions used to allocate emissions between these products. At the extremes, emissions could be allocated wholly to heat or wholly to electricity, or in various proportions in-between. The following sections outline the methodology (including the basis, key sources and assumptions) utilised to develop the heat and steam emission factors for the 2014 GHG Conversion Factors.

Fuel allocation to electricity from CHP

3.14. To determine the amount of fuel attributed to CHP heat (qualifying heat output, or 'QHO'), it is necessary to apportion the total fuel to the CHP scheme to the separate heat and electricity outputs. This then enables the fuel, and therefore emissions, associated with the qualifying heat output to be determined. There are three possible methodologies for apportioning fuel to heat and power, which include:

- i. **Method 1:** 1/3 : 2/3 Method (DUKES)
- ii. **Method 2:** Boiler Displacement Method
- iii. **Method 3:** Power Station Displacement Method

The basis of each method is described in the following sub-sections.

Method 1: 1/3 : 2/3 Method (DUKES)

3.15. Under the UK's Climate Change Agreements¹³ (CCAs), this method which is used to apportion fuel use to heat and power assumes that twice as many units of fuel are required to generate each unit of electricity than are required to generate each unit of heat. This follows from the observation that the efficiency of the generation of electricity (at electricity only generating plant) varies from as little as 25% to 50%, while the efficiency of the generation of heat in fired boilers ranges from 50% to about 90%.

¹² See <http://chpqa.decc.gov.uk/>

¹³ Climate Change Agreements (CCAs) are agreements between UK energy intensive industries and UK Government, whereby industry undertakes to make challenging, but achievable, improvements in energy efficiency in exchange for a reduction in the Climate Change Levy (CCL).

3.16. Mathematically, Method 1 can be represented as follows:

$$\text{Heat Energy} = \left(\frac{\text{Total Fuel Input}}{(2 \times \text{Electricity Output}) + \text{Heat Output}} \right) \times \text{Heat Output}$$

$$\text{Electricity Energy} = \left(\frac{2 \times \text{Total Fuel Input}}{(2 \times \text{Electricity Output}) + \text{Heat Output}} \right) \times \text{Electricity Output}$$

Where:

- 'Total Fuel Input' is the total fuel to the prime mover.
- 'Heat Output' is the useful heat generated by the prime mover.
- 'Electricity Output' is the electricity (or the electrical equivalent of mechanical power) generated by the prime mover.
- 'Heat Energy' is the fuel to the prime mover apportioned to the heat generated.
- 'Electricity Energy' is the fuel to the prime mover apportioned to the electricity generated.

3.17. This method is used only in the UK for accounting for primary energy inputs to CHP where the CHP generated heat and electricity is used within a facility with a CCA.

Method 2: Boiler Displacement Method

3.18. Under this convention it is assumed that the heat generated by the CHP displaces heat raised by a boiler with an efficiency of 81% on a GCV basis (90% NCV basis¹⁴), but that the boiler uses the same fuel mix as the actual fuel mix to the CHP to determine the CO₂ emissions.

3.19. Mathematically, Method 2 can be represented as follows:

$$\text{Heat Energy} = \left(\frac{\text{Heat Output}}{0.81} \right)$$

Where: the *Heat Energy* and *Heat Output* are as defined for Method 1, above.

3.20. This method has wider understanding within the European Union and has the advantage that it would be compatible with other allocation methodologies for heat.

3.21. Carbon emission factors for Heat and Electricity are calculated according to this method as follows:

CO₂ emission from Fuel for Boiler

$$= \left(\frac{QHO}{0.81} \right) * \text{FuelmixCO2Factor}$$

CHP Heat EF = CO₂ emission from Fuel for Boiler / QHO

$$= \left(\frac{\text{FuelMixCO2Factor}}{0.81} \right)$$

¹⁴ Annex II, EU Decision (2011/877/EU) establishing harmonised efficiency reference values for separate production of electricity and heat.

CO₂ emission from Fuel for Electricity

$$= \left\{ TFI - \left(\frac{QHO}{0.81} \right) \right\} * FuelMixCO_2 factor$$

3- CHP Electricity EF

$$= \left\{ \left\{ TFI - \left(\frac{QHO}{0.81} \right) \right\} * FuelMixCO_2 factor \right\} / TPO$$

Where: the QHO is the (Qualifying) Heat Output; EF = emission factor.

Method 3: Power Station Displacement Method

3.22. Under this convention it is assumed that the electricity generated by the CHP displaces electricity generated by conventional power only plant with an agreed efficiency (using the UK's fossil fuel fired power stations annual efficiencies, taken into consideration the transmission and distribution losses). This establishes the fuel for electricity and the balance of the fuel to the prime mover is then assumed to be for the generation of heat.

3.23. Mathematically, Method 3 can be represented by:

$$Heat Energy = Total Fuel Input - \left(\frac{Electricity Output}{Power.Stations.Efficiency} \right)$$

Where: Heat Energy, Total Fuel Input and Electricity Output are defined for Method 1, above.

3.24. This method raises the question of which power generation efficiency to use. For comparison in this analysis we have used the power generation efficiency of gas fired power stations, which has been taken to be 47.7% on a GCV basis¹⁵.

3.25. Carbon emission factors for Heat and Electricity are calculated according to this method as follows::

CO₂ emission from Fuel for Boiler

$$= \left\{ TFI - \left(\frac{Electricity Output}{0.477} \right) \right\} * FuelMixCO_2 factor$$

CHP Heat emission factor = CO₂ emission from Fuel for Boiler / QHO

CO₂ emission from Fuel for Electricity

$$= \left(\frac{TPO}{0.477} \right) * FuelMixCO_2 factor$$

CHP Electricity Emission factor

$$= \left(\frac{FuelMixCO_2 Factor}{0.477} \right)$$

Calculation of CO₂ Emissions Factor for CHP Fuel Input, FuelMixCO₂factor

3.26. The value *FuelMixCO₂factor* referred to above is the carbon emissions factor per unit fuel input to a CHP scheme. This factor is determined using fuel input data provided by

¹⁵ Digest of UK Energy Statistics (DUKES) 2013, Chapter 5, Table 5.10. Thermal Efficiency for CCGT Power Stations in 2012

CHP scheme operators to the CHP Quality Assurance (CHPQA) programme, which is held in confidence.

The value for *FuelMixCO₂factor* is determined using the following expression:

$$FuelMixCO_2factor = \frac{\sum(Fuel\ Input \times Fuel\ CO_2\ Emissions\ Factor)}{TFI}$$

Where:

- *FuelMixCO₂factor* is the composite emissions factor (in tCO₂/MWh thermal fuel input) for a scheme
- *Fuel Input* is the fuel input (in MWh thermal) for a single fuel supplied to the prime mover
- *Fuel CO₂ Emissions factor* is the CO₂ emissions factor (in tCO₂/MWh_{th}) for the fuel considered.
- *TFI* is total fuel input (in MWh thermal) for all fuels supplied to the prime mover

3.27. Fuel inputs and emissions factors are evaluated on a Gross Calorific Value (Higher Heating Value) basis. The following Table 11 provides the individual fuel types considered and their associated emissions factors, consistent with other reporting under the CHP QA scheme.

Fuel	CO ₂ Emissions Factor (kgCO ₂ /kWh _{th})
Biomass (e.g. woodchips, chicken litter)	-
Biodiesel	0.002
Blast furnace gas	1.048
Coal and lignite	0.313
Coke oven gas	0.154
Domestic refuse (raw)*	0.16
Ethane	0.184
Fuel oil	0.269
Gas oil	0.272
Hydrogen	-
Methane	0.184
Mixed refinery gases	0.246
Natural gas	0.184
Other Biogas (e.g. gasified woodchips)	-
Other gaseous waste	0.184
Other liquid waste	0.261
Other solid waste	0.354
Refuse-derived Fuels (RDF)*	0.16
Sewage gas	-
Unknown process gas	0.184
Waste exhaust heat from high temperature processes	-
Waste heat from exothermic chemical reactions	-
Wood Fuels (woodchips, logs, wood pellets etc.)	-

Sources: Defra/DECC GHG Conversion Factors for Company Reporting (2012 update) and National Atmospheric Emissions Inventory (NAEI).

* Corrected data, 1 October 2014.

Table 11: Fuel types and associated emissions factors used in determination of FuelMixCO₂factor

3.28. The 1/3 : 2/3 method was utilised in deriving the new heat/steam emission factors provided in the Heat and Steam tables of the 2014 GHG Conversion Factors, for consistency with DUKES. However, results are provided for comparison according to all three methods in Table 12.

3.29. As for the electricity emission factors, the relevant time series source data and emission factors that were fixed/locked from the 2013 update onwards have been highlighted in light grey and are unchanged since the last update. Also similarly to electricity, the GHG conversion factors update / reporting year to which the data and emission factors are applied is two years ahead of the data year. For example, the most recent emission factor for the 2014 GHG Conversion Factors is based on the data year of 2012 in the table.

Data Year	KgCO ₂ /kWh supplied heat/steam			KgCO ₂ /kWh supplied power		
	Method 1 (DUKES: 2/3rd - 1/3rd)	Method 2 (Boiler displaced)	Method 3 (Power displaced)	Method 1 (DUKES: 2/3rd - 1/3rd)	Method 2 (Boiler displaced)	Method 3 (Power displaced)
2001	0.23770	0.26342	0.05903	0.22703	0.19519	0.44825
2002	0.22970	0.25361	0.07100	0.23765	0.20842	0.43157
2003	0.23393	0.26230	0.04925	0.23378	0.20112	0.44635
2004	0.22750	0.25638	0.05380	0.24085	0.20836	0.43627
2005	0.22105	0.24803	0.05115	0.23931	0.21029	0.42207
2006	0.23072	0.25544	0.06223	0.25681	0.23071	0.43468
2007	0.23118	0.25492	0.04048	0.24446	0.22089	0.43379
2008	0.22441	0.24731	0.04062	0.23564	0.21257	0.42084
2009	0.22196	0.24548	0.04567	0.24019	0.21650	0.41773
2010	0.21859	0.24163	0.05447	0.24125	0.21739	0.41118
2011	0.21518	0.23876	0.05898	0.24351	0.21894	0.40629
2012*	0.20539	0.23419	0.04379	0.21689	0.18452	0.39852

Notes: * Corrected data, 1 October 2014.

Table 12: Comparison of calculated Electricity and Heat/Steam CO₂ emission factors for the 3 different allocation method

Calculation of Non-CO₂ and Indirect/WTT Emissions Factor for Heat and Steam

3.30. CH₄ and N₂O emissions have been estimated relative to the CO₂ emissions, based upon activity weighted average values for each CHP fuel used (using relevant average fuel emission factors from the NAEI).

3.31. Indirect/WTT GHG emission factors have been estimated relative to the CO₂ emissions, based upon activity weighted average indirect/WTT GHG emission factor values for each CHP fuel used. Where fuels are not included in the set of indirect/WTT GHG emission factors provided in the 2014 GHG Conversion Factors, the value for the closest/most similar alternative fuel was utilised instead.

- 3.32. The complete final emission factors for supplied heat or steam utilised are presented in the 'Heat and Steam' tables of the 2014 GHG Conversion Factors, and are counted as Scope 2 emissions under the GHG Protocol.
- 3.33. For district heating systems, where the location of use of the heat is some distance from the point of production, there are distribution energy losses. These losses are typically around 5%, which need to be factored into the calculation of overall GHG emissions where relevant and are counted as Scope 3 emissions under the GHG Protocol (similar to the treatment of transmission and distribution losses for electricity).

4. Refrigerant and Process Emission Factors

Summary of changes since the previous update

- 4.1. No changes have been made to these data tables for the 2014 GHG Conversion Factors.

Global Warming Potentials of Greenhouse Gases

Greenhouse Gases Listed in the Kyoto Protocol

- 4.2. The conversion factors in the Refrigerant tables 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) that is required to be used in inventory reporting.
- 4.3. *Mixed/Blended gases*: GWP values for refrigerant blends are 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 $[2800 \times 0.44] + [3800 \times 0.52] + [1300 \times 0.04] = 3260$). A limited selection of common blends is presented in the Refrigerant tables.

Other Greenhouse Gases

- 4.4. 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. Some tables the Refrigerant section 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).
- 4.5. *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 also listed in the provided tables.

5. Passenger Land Transport Emission Factors

Summary of changes since the previous update

- 5.1. The only methodological change since the previous 2103 update involves a revision to the 'real-world' uplift applied to official passenger car CO₂ data (from type approval), following an investigation into this area. Previously an uplift factor of +15% over NEDC based gCO₂/km factors was agreed with DfT in 2007 to take into account the combined 'real-world' effects on fuel consumption not already taken into account in the previous factors. However, some recent studies have presented evidence that the differential is widening for new cars (particularly for the most efficient models). In particular, new evidence collated by ICCT (2013)¹⁶ states the necessary uplift may need to be as high as 27% for 2012 model year vehicles. With this new information it was decided to apply a varying 'real world' uplift over time as opposed to the flat 15% used previously.
- 5.2. All other factors have also been updated with more recent data for the latest 2014 GHG Conversion Factors.

Direct Emissions from Passenger Cars

Emission Factors for Petrol and Diesel Passenger Cars by Engine Size

- 5.3. SMMT (Society for Motor Manufacturers and Traders)¹⁷ provides numbers of registrations and averages of the NEDC¹⁸ gCO₂/km figures for new vehicles registered from 1998 to 2013¹⁹. The dataset represents a good indication of the relative NEDC gCO₂/km by size category. Table 13 presents the 1998-2013 average CO₂ emission factors and number of vehicle registrations.
- 5.4. For the 2014 GHG Conversion Factors update, the SMMT data have been used in conjunction with DfT's ANPR (Automatic Number Plate Recognition) data to weight the emission factors to account for the age and activity distribution of the UK vehicle fleet in 2012.
- 5.5. The ANPR data have been collected annually (since 2007) over 256 sites in the UK on different road types (urban and rural major/minor roads, and motorways) and regions.

¹⁶ 'FROM LABORATORY TO ROAD - A comparison of official and 'real-world' fuel consumption and CO₂ values for cars in Europe and the United States' a report by the ICCT, May 2013. Available at: <http://www.theicct.org/laboratory-road>

¹⁷ SMMT is the Society of Motor Manufacturers and Traders that represents the UK auto industry. <http://www.smmt.co.uk/>

¹⁸ NEDC = New European Driving Cycle, which is used in the type approval of new passenger cars.

¹⁹ The SMMT gCO₂/km dataset for 1997 represented around 70% of total registrations, which rose to about 99% by 2000 and essentially all vehicles thereafter.

Measurements are made at each site on one weekday (8am-2pm and 3pm-9pm) and one half weekend day (either 8am-2pm or 3pm-9pm) each year in June and are currently available for 2007, 2008, 2009, 2010 and 2011. There are approximately 1.4-1.7 million observations recorded from all the sites each year, and they cover various vehicle and road characteristics such as fuel type, age of vehicle, engine sizes, vehicle weight and road types.

5.6. Data for the UK car fleet were extracted from the 2011 ANPR dataset and categorised according to their engine size, fuel type and year of registration. The 2014 GHG Conversion Factors' emission factors for petrol and diesel passenger cars were subsequently calculated based upon the equation below:

$$2014 \text{ update } gCO_2/km = \Sigma \left(gCO_2/km_{yr \text{ reg}} \times \frac{ANPR_{yr \text{ reg}}}{ANPR_{total \ 2011}} \right)$$

Vehicle Type	Engine size	Size label	gCO ₂ per km	Total no. of registrations	% Total
Petrol car	< 1.4 l	Small	137.0	11,662,848	48%
	1.4 - 2.0 l	Medium	174.3	10,608,076	44%
	> 2.0 l	Large	255.9	1,827,019	8%
Average petrol car			167.7	24,097,943	100%
Diesel car	<1.7 l	Small	118.2	3,275,124	27%
	1.7 - 2.0 l	Medium	147.7	6,250,076	51%
	> 2.0 l	Large	192.0	2,623,627	22%
Average diesel car			153.5	12,148,827	100%

Table 13: Average CO₂ emission factors and total registrations by engine size for 1998 to 2013 (based on data sourced from SMMT)

5.7. A limitation of the NEDC (New European Driving Cycle – used in vehicle type approval) is that it takes no account of further 'real-world' effects that can have a significant impact on fuel consumption. These 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, more aggressive/harsher driving style, etc. It is therefore desirable to uplift NEDC based data to bring it closer to anticipated 'real-world' vehicle performance.

5.8. As stated at the beginning of the section, an uplift factor of **+15% over NEDC based gCO₂/km** factors agreed previously with DfT in 2007 to take into account the combined 'real-world' effects on fuel consumption has been replaced this year to take into account new evidence. The uplift applied now varies over time to align with work performed by

ICCT (2013)²⁰, illustrated in Figure 1 alongside the source data / chart reproduced from the ICCT (2013) report.

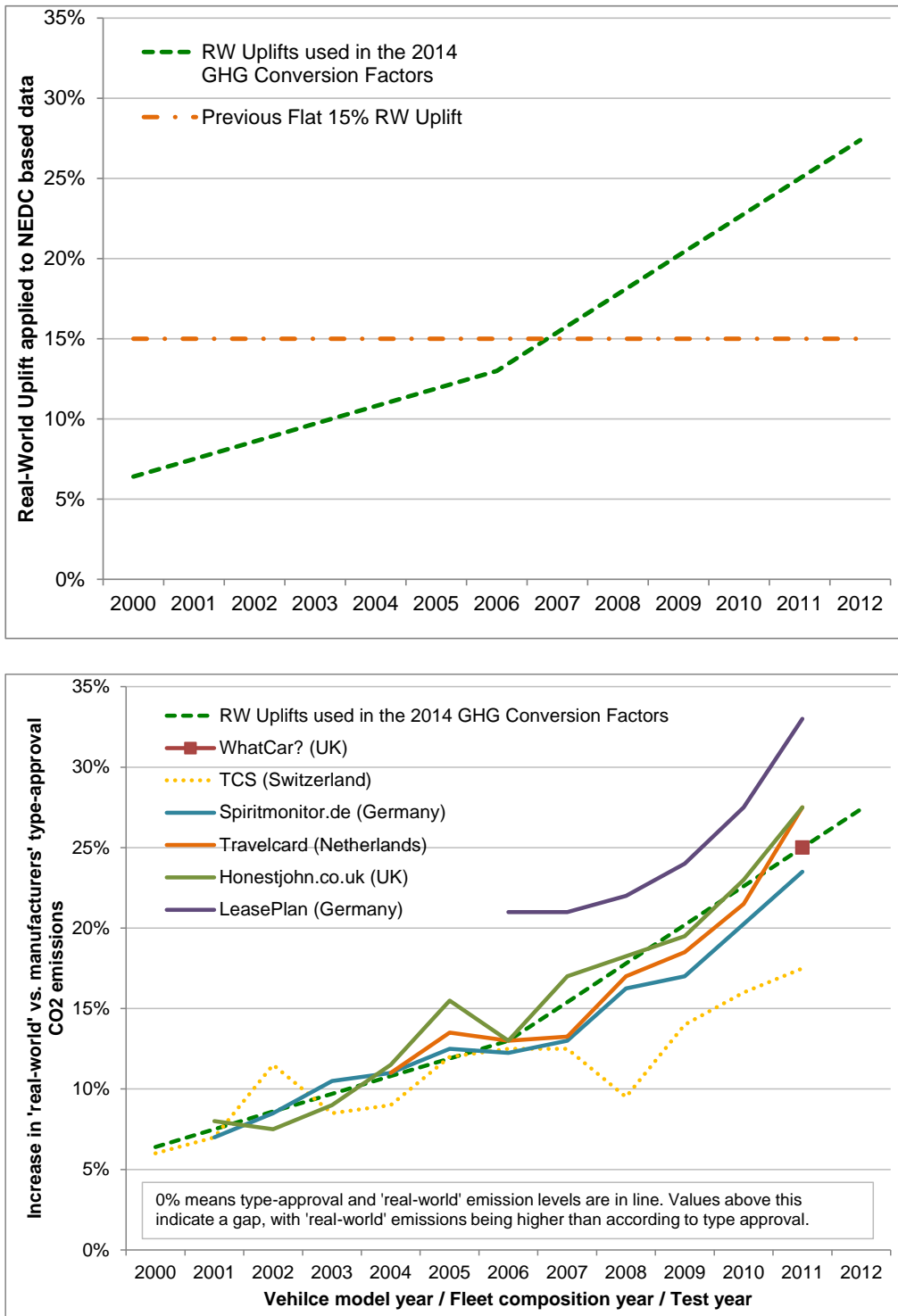


Figure 1: Updated 'Real world' uplift values based on ICCT (2013)

²⁰ 'FROM LABORATORY TO ROAD - A comparison of official and 'real-world' fuel consumption and CO₂ values for cars in Europe and the United States' a report by the ICCT, May 2013. Available at:

<http://www.theicct.org/laboratory-road>

- 5.9. The above uplifts have been applied to the ANPR weighted SMMT gCO₂/km to give the *New 'Real-World'* 2014 GHG Conversion Factors, to take into account the 'real-world' impacts on fuel consumption not captured by drive cycles such as the NEDC in type-approval.
- 5.10. Figures for the aggregated average emission factors by engine type and fuel type (as well as the overall average) were calculated based on weighting by the relative mileage of the different categories. This calculation utilised data from the UK GHG Inventory on the relative % total mileage by petrol and diesel cars. Overall for petrol and diesel, this split in total annual mileage was 57.5% petrol and 42.5% diesel, and can be compared to the respective total registrations of the different vehicle types for 1998-2013, which were 66.5% petrol and 33.5% diesel.
- 5.11. Emission factors for CH₄ and N₂O have been updated for all vehicle classes and are based on the emission factors from the UK GHG Inventory. Note that when compared with the 2013 update, changes in the CH₄ and N₂O emission factors have arisen as a result of updates to the NAEI methodology. ANPR data and Regional Vehicle Licensing Statistics (DVLA) were used to define the petrol and diesel car mix by road type and by Devolved Administrations²¹.
- 5.12. The final 2014 emission factors for petrol and diesel passenger cars by engine size are presented in the 'passenger vehicles' and 'business travel- land' tables of the 2014 GHG Conversion Factors.
- 5.13. Due to the change in methodology in this section and subsequent revision of the 'real world' uplift, the 2014 GHG Conversion Factors are not directly comparable with those from previous versions of the greenhouse gas conversion factors. Therefore, whilst the overall factors and the factors for some vehicle sizes / market segments have continued to reduce, the conversion factors for certain vehicle types/classifications have gone up this year.

Hybrid, LPG and CNG Passenger Cars

- 5.14. The methodology used in the 2014 update for medium and large hybrid petrol/diesel electric cars is similar to that in the 2011 - 2013 updates, having received numbers of registrations and averages of the NEDC²² gCO₂/km figures from SMMT for new hybrid vehicles registered in 2013.
- 5.15. Due to the significant size and weight of the LPG and CNG fuel tanks it is assumed only medium and large sized vehicles will be available. In the 2014 GHG Conversion Factors, CO₂ emission factors for CNG and LPG medium and large cars are derived by multiplying the equivalent petrol EF by the ratio of CNG (and LPG) to petrol EFs on a unit energy basis. For example, for a Medium car run on CNG:

$$gCO_2/km_{CNG\ Medium\ car} = gCO_2/km_{Petrol\ Medium\ car} \times \frac{gCO_2/kWh_{CNG}}{gCO_2/kWh_{Petrol}}$$

²¹ For improvements in the 2010 inventory, see the report and annexes 'UK Greenhouse Gas Inventory, 1990 to 2010: Annual Report for submission under the Framework Convention on Climate Change', available from <http://naei.defra.gov.uk/reports.php>

²² NEDC = New European Driving Cycle, which is used in the type approval of new passenger cars.

5.16. For the 2014 GHG Conversion Factors, the emission factors for CH₄ and N₂O were updated, but the methodology remains unchanged. These are based on the emission factors from the UK GHG Inventory (produced by Ricardo-AEA) and are presented together with an overall total emission factors in the 'passenger vehicles' and 'business travel- land' tables of the 2014 GHG Conversion Factors.

Emission Factors by Passenger Car Market Segments

5.17. For the 2014 GHG Conversion Factors, the market classification split (according to SMMT classifications) was derived using detailed SMMT data on new car registrations between 1998 and 2013 split by fuel²³, presented in Table 14, and again combining this with information extracted from the 2011 ANPR dataset. These data were then uplifted to take into account 'real-world' impacts, consistent with the methodology used to derive the car engine size emission factors. The supplementary market segment based emission factors for passenger cars are presented in the 'passenger vehicles' and 'business travel- land' tables of the 2014 GHG Conversion Factors.

5.18. Emission factors for CH₄ and N₂O were also updated for all car classes. These figures are based on the emission factors from the UK GHG Inventory. The factors are presented together with the overall total emission factors in the tables of the 2014 GHG Conversion Factors.

²³ This data was provided by EST and is based on detailed data sourced from SMMT on new car registrations.

Fuel Type	Market Segment	Example Model	1998-2012		
			gCO ₂ /km	# registrations	% Total
Diesel	A. Mini	Smart Fortwo	89.1	9296	0.08%
	B. Super Mini	VW Polo	119.2	1484070	12%
	C. Lower Medium	Ford Focus	135.6	3708068	30.5%
	D. Upper Medium	Toyota Avensis	150.7	3150404	25.9%
	E. Executive	BMW 5-Series	170.7	972650	8%
	F. Luxury Saloon	Bentley Continental GT	204.9	57339	0.47%
	G. Specialist Sports	Mercedes SLK	140.8	68834	0.57%
	H. Dual Purpose	Land Rover Discovery	211.3	1717490	14.0%
	I. Multi Purpose	Renault Espace	168.3	980677	8%
	All	Total	153.9	12148828	100%
Petrol	A. Mini	Smart Fortwo	128.3	676371	2.8%
	B. Super Mini	VW Polo	143.7	10397591	43%
	C. Lower Medium	Ford Focus	171.5	6762372	28%
	D. Upper Medium	Toyota Avensis	197.8	3102272	12.8%
	E. Executive	BMW 5-Series	231.9	770583	3.2%
	F. Luxury Saloon	Bentley Continental GT	297.7	116973	0.5%
	G. Specialist Sports	Mercedes SLK	217.6	872233	3.6%
	H. Dual Purpose	Land Rover Discovery	244.3	744075	3.08%
	I. Multi Purpose	Renault Espace	192.4	716113	2.9%
	All	Total	168.9	24158583	100%
Unknown Fuel (Diesel + Petrol)	A. Mini	Smart Fortwo	127.8	685667	1.9%
	B. Super Mini	VW Polo	140.74	11881661	32.7%
	C. Lower Medium	Ford Focus	158.8	10470440	28.8%
	D. Upper Medium	Toyota Avensis	174.1	6252676	17.2%
	E. Executive	BMW 5-Series	197.8	1743233	4.8%
	F. Luxury Saloon	Bentley Continental GT	267.2	174312	0.5%
	G. Specialist Sports	Mercedes SLK	212	941067	2.6%
	H. Dual Purpose	Land Rover Discovery	221.3	2461565	6.8%
	I. Multi Purpose	Renault Espace	178.5	1696790	4.7%
	All	Total	163.9	36307411	100%

Table 14: Average car CO₂ emission factors and total registrations by market segment for 1998 to 2013 (based on data sourced from SMMT)

Direct Emissions from Taxis

- 5.19. The emission factors for black cabs and taxis have been revised for the 2014 update.
- 5.20. The new emission factors for black cabs based on data provided by Transport for London (TfL) on the testing of emissions from black cabs using real-world London Taxi cycles, and an average **passenger** occupancy of 1.5 (average 2.5 people per cab, including the driver, from LTI, 2007). This revised methodology accounts for the significantly different operational cycle of black cabs/taxis in the real world when compared to their NEDC (official type-approval) values, which significantly increases the emission factor (by ~40% vs NEDC).
- 5.21. The new emission factors (per passenger km) for taxis were estimated on the basis of the average type-approval CO₂ factors for of medium and large cars uplifted by the (40%) difference between the type-approval figures and real-world taxi cycle emission factors for the vehicles tested by TfL, plus an assumed average passenger occupancy of 1.4 (CfIT, 2002²⁴).
- 5.22. Since the 2013 update, emission factors per passenger km for taxis and black cabs are presented in the 'business travel- land' tables of the GHG Conversion Factors. The base emission factors per vehicle km are also presented in the 'business travel- land' tables of the 2014 GHG Conversion Factors.
- 5.23. Emission factors for CH₄ and N₂O have been updated for all taxis for the 2014 update. These figures are, as before, based on the emission factors for diesel cars from the UK GHG Inventory and are presented together with overall total emission factors in the tables of the 2014 GHG Conversion Factors.
- 5.24. It should be noted that the current emission factors for taxis still don't take into account emissions spent from "cruising" for fares. Currently robust data sources do not exist that could inform such an "empty running" factor. If suitably robust sources are identified in the future, the methodology for taxis may be revisited and revised in a future update to account for this.

Direct Emissions from Vans

- 5.25. Average emission factors by fuel for light good vehicles (N1 vehicles, vans up to 3.5 tonnes gross vehicle weight) by size class (I, II or III), presented in Table 15 (and in the "delivery vehicles" section of the 2014 GHG Conversion Factors), have been updated for the this year's update. The data set used to allocate different vehicles to each class is based on reference weight (approximately equivalent to kerb weight plus 60kg) in the MVRIS data set. The assumed split of petrol van stock between size classes uses the split of registrations from this dataset.
- 5.26. These test cycle based emission factors are uplifted by 15% to represent 'real-world' emissions, consistent with the previous approach used for cars, and agreed with DfT in the absence of a similar time-series dataset of 'real-world' vs type-approval emissions from vans (see earlier section on passenger cars). Emission factors for petrol and

²⁴ Obtaining the best value for public Subsidy of the bus industry, a report by L.E.K. Consulting LLP for the UK Commission for Integrated Transport, 14 March 2002. Appendix 10.5.1: Methodology for settlements with <25k population. Available at:

<http://webarchive.nationalarchives.gov.uk/20110304132839/http://cfit.independent.gov.uk/pubs/2002/psbi/lek/index.htm>

diesel LGVs are based upon emission factors and vehicle km from the NAEI for 2012. In the 2014 GHG Conversion Factors, CO₂ emission factors for CNG and LPG vans are calculated using the same methodology as for passenger cars. The average van emission factor is calculated on the basis of the relative NAEI vehicle km for petrol and diesel LGVs for 2012, as presented in Table 15.

5.27. Emission factors for CH₄ and N₂O were also updated for all van classes, based on the emission factors from the UK GHG Inventory. N₂O emissions are assumed to scale relative to vehicle class/CO₂ emissions for diesel vans.

Van fuel	Van size	Direct gCO ₂ e per km				vkm	Capacity
		CO ₂	CH ₄	N ₂ O	Total		
Petrol (Class I)	Up to 1.305 tonne	193.0	0.2	0.8	194.0	38.4%	0.64
Petrol (Class II)	1.305 to 1.740 tonne	211.2	0.2	0.8	212.2	48.6%	0.72
Petrol (Class III)	Over 1.740 tonne	255.7	0.2	1.8	257.7	13.0%	1.29
Petrol (average)	Up to 3.5 tonne	210.0	0.2	0.9	211.1	100.0%	0.76
Diesel (Class I)	Up to 1.305 tonne	152.3	0.1	1.1	153.5	6.2%	0.64
Diesel (Class II)	1.305 to 1.740 tonne	225.3	0.1	1.6	227.0	25.7%	0.98
Diesel (Class III)	Over 1.740 tonne	266.9	0.1	1.9	268.8	68.1%	1.29
Diesel (average)	Up to 3.5 tonne	249.1	0.1	1.8	250.9	100.0%	1.17
LPG	Up to 3.5 tonne	261.6	0.5	2.0	264.1		1.17
CNG	Up to 3.5 tonne	236.7	1.0	2.0	239.7		1.17
Average		247.2	0.1	1.7	249.0		1.15

Table 15: New emission factors for vans for the 2014 GHG Conversion Factors

Direct Emissions from Buses

5.28. The 2014 update uses data from DfT from the Bus Service Operators Grant (BSOG) in combination with DfT bus activity statistics (vehicle km, passenger km) to estimate emission factors for local buses. DfT holds very accurate data on the total amount of money provided to bus service operators under the scheme, which provides a fixed amount of financial support per unit of fuel consumed. Therefore the total amount of fuel consumed (and hence CO₂ emissions) can be calculated from this, which when combined with DfT statistics on total vehicle km and passenger km allows the calculation of emission factors.

5.29. Emission factors for coach services were based on figures from National Express, who provide the majority of scheduled coach services in the UK.

5.30. Emission factors for CH₄ and N₂O are based on the emission factors from the UK GHG Inventory. These factors are also presented together with an overall total factor in Table 16.

5.31. Table 16 gives a summary of the 2014 updated emission factors and average passenger occupancy. It should also be noted that fuel consumption and emission factors for individual operators and services will vary significantly depending on the local conditions, the specific vehicles used and on the typical occupancy achieved.

Bus type	Average passenger occupancy	gCO ₂ e per passenger km			
		CO ₂	CH ₄	N ₂ O	Total
Local bus	9.5	108.5	0.09	0.90	109.5
Local London bus	16.8	80.8	0.05	0.55	81.4
Average local bus	10.8	100.7	0.08	0.80	101.6
Coach	16.2*	28.7	0.05	0.57	29.3

Notes: Average load factors/passenger occupancy provided by DfT Statistics Division.

* Combined figure from DfT for non-local buses and coaches combined. Actual occupancy for coaches alone is likely to be significantly higher.

Table 16: Emission factors for buses for the 2014 GHG Conversion Factors

Direct Emissions from Motorcycles

5.32. Data from type approval is not currently readily available for motorbikes and CO₂ emission measurements were only mandatory in motorcycle type approval from 2005.

5.33. For the practical purposes of the GHG Conversion Factors, emission factors for motorcycles are split into 3 categories:

- a. Small motorbikes (mopeds/scooters up to 125cc),
- b. Medium motorbikes (125-500cc), and
- c. Large motorbikes (over 500cc)

5.34. For the 2009 update the emission factors were calculated based on a large dataset kindly provided by Clear (2008)²⁵. This dataset was more comprehensive compared to the one previously used, containing almost 1200 data points (over 300 different bikes from 50-1500cc and from 25 manufacturers) from a mix of magazine road test reports and user reported data compared to only 42 data points in the previous dataset. A summary is presented in Table 17, with the corresponding complete emission factors developed for motorcycles are presented in the 'passenger vehicles' tables of the 2014 GHG Conversion Factors. The total average has been calculated weighted by the relative number of registrations of each category in 2008 according to DfT statistics from CMS (2008)²⁶. In the absence of new information the methodology and dataset are unchanged for the 2014 GHG Conversion Factors.

5.35. These emission factors are based predominantly upon data derived from real-world riding conditions (rather than the test-cycle based data) and therefore likely to be more representative of typical in-use performance. The average difference between the factors based on real-world observed fuel consumption and figures based upon test-

²⁵ Dataset of motorcycle fuel consumption compiled by Clear (<http://www.clear-offset.com/>) for the development of its motorcycle CO₂ model used in its carbon offsetting products.

²⁶ "Compendium of Motorcycling Statistics: 2008", available at: <http://webarchive.nationalarchives.gov.uk/+/dft.gov.uk/pgr/statistics/datatablespublications/vehicles/motorcycling/motorcyclingstats2008.html>

cycle data from ACEM²⁷ (+9%) is smaller than the corresponding differential used to uplift cars test cycle data to real-world equivalents (+15%).

5.36. Emission factors for CH₄ and N₂O were updated for the 2014 GHG Conversion Factors based on the emission factors from the 2011 UK GHG Inventory (Ricardo-AEA, 2014). These factors are also presented together with overall total emission factors in the tables of the 2014 GHG Conversion Factors.

CC Range	Model Count	Number	Av. gCO ₂ /km	Av. MPG
Up to 125cc	24	58	85.0	76.2
125cc to 200cc	3	13	77.8	83.3
200cc to 300cc	16	57	93.1	69.6
300cc to 400cc	8	22	112.5	57.6
400cc to 500cc	9	37	122.0	53.1
500cc to 600cc	24	105	139.2	46.5
600cc to 700cc	19	72	125.9	51.5
700cc to 800cc	21	86	133.4	48.6
800cc to 900cc	21	83	127.1	51.0
900cc to 1000cc	35	138	154.1	42.0
1000cc to 1100cc	14	57	135.6	47.8
1100cc to 1200cc	23	96	136.9	47.3
1200cc to 1300cc	9	32	136.6	47.4
1300cc to 1400cc	3	13	128.7	50.4
1400cc to 1500cc	61	256	132.2	49.0
1500cc to 1600cc	4	13	170.7	38.0
1600cc to 1700cc	5	21	145.7	44.5
1700cc to 1800cc	3	15	161.0	40.3
1800cc to 1900cc	0	0		
1900cc to 2000cc	0	0		
2000cc to 2100cc	1	5	140.9	46.0
<125cc	24	58	85.0	76.2
126-500cc	36	129	103.2	62.8
>500cc	243	992	137.2	47.2
Total	303	1179	116.7	55.5

Note: Summary data based data provided by Clear (<http://www.clear-offset.com/>) from a mix of magazine road test reports and user reported data.

Table 17: Summary dataset on CO₂ emissions from motorcycles based on detailed data provided by Clear (2008)

²⁷ The European Motorcycle Manufacturers Association

Direct Emissions from Passenger Rail

5.37. Emission factors for passenger rail services have been updated and provided in the “Business travel – land” section of the 2014 GHG Conversion Factors. These include updates to the national rail, international rail (Eurostar), light rail schemes and the London Underground. Emission factors for CH₄ and N₂O emissions were also updated in the 2014 GHG Conversion Factors. These factors are based on the assumptions outlined in the following paragraphs.

International Rail (Eurostar)

5.38. The international rail factor is based on a passenger-km weighted average of the emission factors for all of the Eurostar routes. These are London-Brussels, London-Paris, London-Marne Le Vallee (Disney), London-Avignon and the ski train from London-Bourg St Maurice. The emission factors were provided by Eurostar for the 2014 update, together with information on the basis of the electricity figures used in their calculation.

5.39. The methodology applied in calculating the Eurostar emission factors currently uses 3 key pieces of information:

- d. Total electricity use by Eurostar trains on the UK and France/Belgium track sections;
- e. Total passenger numbers (and therefore calculated passenger km) on all Eurostar services;
- f. Emission factors for electricity (in kgCO₂ per kWh) for the UK and France/Belgium journey sections. These are based on the UK grid average electricity from the GHG Conversion Factors and the France/Belgium grid averages.

5.40. The new figure from Eurostar is 12.02 gCO₂/pkm, and is consistent with Ricardo-AEA's previous methodology for calculating emissions for the GHG Conversion Factors. Eurostar's previously published figure (from 2010) is 7.71 gCO₂/pkm differs from the figure quoted in the 2010-2013 GHG Conversion Factors as it was calculated using the individual conversion factors as specified by each electricity supplier across each network section upon which they operate, rather than the grid average. For further information please visit: <http://www.eurostar4agents.com/treadlightly/greener.html>

5.41. CH₄ and N₂O emission factors have been estimated from the corresponding emission factors for electricity generation, proportional to the CO₂ emission factors.

National Rail

5.42. The national rail factor refers to an average emission per passenger kilometre for diesel and electric trains in 2012-13. The factor is sourced from information from the Office of the Rail Regulator's National rail trends for 2012-13 (ORR, 2013)²⁸. This has been calculated based on total electricity and diesel consumed by the railways for the year (sourced from ATOC), and the total number of passenger kilometres (from National Rail Trends).

5.43. CH₄ and N₂O emission factors have been estimated from the corresponding emissions factors for electricity generation and diesel rail (from the UK GHG Inventory), proportional to the CO₂ emission factors. The emission factors were calculated based

²⁸ Available from the ORR's website at: <http://www.rail-reg.gov.uk/server/show/nav.2026>

on the relative passenger km proportions of diesel and electric rail provided by DfT for 2006-7 (since no newer datasets have been made available by DfT).

Light Rail

- 5.44. The light rail factors were based on an average of factors for a range of UK tram and light rail systems, as detailed in Table 18.
- 5.45. Figures for the DLR, London Overground and Croydon Tramlink for 2011/12 based on figures kindly provided by Transport for London, adjusted to the new 2012 grid electricity CO₂ emission factor.
- 5.46. The factors for Midland Metro, Tyne and Wear Metro, the Manchester Metrolink and Supertram were based on annual passenger km data from DfT's Light rail and tram statistics²⁹ and the new 2012 grid electricity CO₂ emission factor.
- 5.47. The factor for the Glasgow Underground was provided by the network based on annual electricity consumption and passenger km data provided by the network operators for 2005/6 and the new 2012 grid electricity CO₂ emission factor, for consistency.
- 5.48. The average emission factor was estimated based on the relative passenger km of the four different rail systems (see Table 18).
- 5.49. CH₄ and N₂O emission factors have been estimated from the corresponding emissions factors for electricity generation, proportional to the CO₂ emission factors.

	Type	Electricity use kWh/pkm	gCO ₂ e per passenger km				Million pkm	
			CO ₂	CH ₄	N ₂ O	Total		
DLR (Docklands Light Rail)	Light Rail	0.1208	64.4	0.043	0.486	64.9	524	
Glasgow Underground	Light Rail	0.1643	87.6	0.059	0.660	88.3	40	
Midland Metro	Light Rail	0.1353	72.1	0.049	0.544	72.7	50	
Tyne & Wear Metro	Light Rail	0.2053	109.5	0.074	0.825	110.4	299	
London Overground	Light Rail	0.0791	42.2	0.028	0.318	42.5	780	
Croydon Tramlink	Tram	0.0646	34.4	0.023	0.260	34.7	156	
Manchester Metrolink	Tram	0.0787	41.9	0.028	0.316	42.3	262	
Nottingham Express Transit	Tram	No data						
Supertram	Tram	0.3500	186.6	0.126	1.407	188.1	93	
Average*		0.1194	63.6	0.043	0.480	64.2	2206	

Notes: * Weighted by relative passenger km

Table 18: GHG emission factors, electricity consumption and passenger km for different tram and light rail services

²⁹ DfT Light rail and tram statistics, <http://www.dft.gov.uk/statistics/series/light-rail-and-tram/>

London Underground

- 5.50. The London Underground rail factor was provided from Transport for London corrected to the 2012 grid electricity CO₂ emission factor.
- 5.51. CH₄ and N₂O emission factors have been estimated from the corresponding emissions factors for electricity generation, proportional to the CO₂ emission factors.

Indirect/WTT Emissions from Passenger Land Transport

Cars, Vans, Motorcycles, Taxis, Buses and Ferries

- 5.52.** Indirect/WTT emissions factors (EFs) for cars, vans, motorcycles, taxis, buses and ferries include only emissions resulting from the fuel lifecycle (i.e. production and distribution of the relevant transport fuel). These indirect/WTT emission factors were derived using simple ratios of the direct CO₂ EFs and the indirect/WTT EFs for the relevant fuels from the “Fuels” section and the corresponding direct CO₂ EFs for vehicle types using these fuels in the “Passenger vehicles”, “Business travel – land” and “Business travel – air” sections of the new tables format used in the 2014 GHG Conversion Factors.

Rail

- 5.53. Indirect/WTT EFs for international rail (Eurostar), light rail and the London Underground were derived using a simple ratio of the direct CO₂ EFs and the indirect/WTT EFs for grid electricity from the “UK Electricity” section and the corresponding direct CO₂ EFs for vehicle types using these fuels in the “passenger vehicles”, “Business travel – land” and “Business travel – air” sections of the new tables format used in the 2014 GHG Conversion Factors..
- 5.54. The EFs for national rail services are based on a mixture of emissions from diesel and electric rail. Indirect/WTT EFs were therefore calculated from corresponding estimates for diesel and electric rail combined using relative passenger km proportions of diesel and electric rail provided by DfT for 2006-7 (no newer similar dataset is available).

6. Freight Land Transport Emission Factors

Summary of changes since the previous update

6.1. There have been two changes made to HGV conversion factors in the 2014 update of the GHG Conversion factors to improve the accuracy of reporting. The new factors for the 2014 GHG Conversion Factors now include :

- g. New conversion factors by 0%, 50% and 100% vehicle laden weight have been added for all rigid HGVs, all artic HGVs and all HGVs from this year.
- h. The methodology for estimating conversion factors from refrigerated / temperature controlled HGVs has been modified to improve the accuracy of reporting where users do not already have the specific fuel consumption available from their vehicles.

6.2. All other factors have been updated with more recent data in the latest 2014 GHG Conversion Factors.

Direct Emissions from Heavy Goods Vehicles (HGVs)

6.3. A revised set of CO₂ conversion factors for road freight has been derived for different sizes of rigid and articulated HGVs with different load factors, using the same methodology as used in the 2008-13 GHG Conversion Factors. The new factors for the 2014 GHG Conversion Factors are presented in sections “Delivery Vehicles” and “Freighting Goods”.

6.4. The factors are based on road freight statistics from the Department for Transport (DfT, 2011)³⁰ for Great Britain (GB), from a survey on different sizes of rigid and articulated HGVs in the fleet in 2011. The statistics on fuel consumption figures (in miles per gallon) have been estimated by DfT from the survey data. For the GHG Conversion Factors these are combined with test data from the European ARTEMIS project showing how fuel efficiency, and hence CO₂ emissions, varies with vehicle load.

6.5. The miles per gallon (MPG) figures in Table RFS0141 of DfT (2011) are converted to gCO₂ per km factors using the standard fuel conversion factor for diesel in the 2014 GHG Conversion Factors tables. Table RFS0117 of DfT (2011) shows the percent loading factors are on average between 40-60% in the UK HGV fleet. Figures from the ARTEMIS project show that the effect of load becomes proportionately greater for heavier classes of HGVs. In other words, the relative difference in fuel consumption between running an HGV completely empty or fully laden is greater for a large >33t HGV than it is for a small <7.5t HGV. From analysis of the ARTEMIS data, it was possible to derive the figures in Table 19 showing the change in CO₂ emissions for a vehicle completely empty (0% load) or fully laden (100% load) on a weight basis compared with the emissions at half-load (50% load). The data show the effect of load is symmetrical and largely independent of the HGVs Euro emission classification and type of drive

³⁰ “Transport Statistics Bulletin: Road Freight Statistics 2011, (DfT, 2011). Available at: <http://www.dft.gov.uk/statistics/releases/tsgb-2011-freight/>

cycle. So, for example, a >17t rigid HGV emits 18% more CO₂ per kilometre when fully laden and 18% less CO₂ per kilometre when empty relative to emissions at half-load.

- 6.6. The previous factors are also included for refrigerated/temperature-controlled HGVs included a 20% increase in fuel consumption to the standard “all diesel” factors. This accounts for the typical additional energy needed to power refrigeration equipment in such vehicles over similar non-refrigerated alternatives³¹. The methodology for estimating conversion factors from refrigerated / temperature controlled HGVs has been modified to improve the accuracy of reporting where users do not already have the specific fuel consumption available from their vehicles. New uplifts of 19.2% and 16.2% are now applied to rigid and arctic refrigerated/temperature-controlled HGVs respectively. Finally, the refrigerated/temperature-controlled average factors now have a revised 17.7% uplift applied. These updates are based on average data for different sizes of refrigerated HGV from Tassou et al (2009)³².
- 6.7. As previously stated, new conversion factors by 0%, 50% and 100% vehicle laden weight have been added for all rigid HGVs, all artic HGVs and all HGVs from this year, calculated on a similar basis.

	Gross Vehicle Weight (GVW)	% change in CO ₂ emissions
Rigid	<7.5t	± 8%
	7.5-17t	± 12.5%
	>17 t	± 18%
Articulated	<33t	± 20%
	>33t	± 25%

Source: EU-ARTEMIS project

Table 19: Change in CO₂ emissions caused by +/- 50% change in load from average loading factor of 50%

6.8. Using these loading factors, the CO₂ factors derived from the DfT survey’s MPG data, each corresponding to different average states of HGV loading, were corrected to derive the 50% laden CO₂ factor shown for each class of HGV for the final factors presented in sections “Delivery vehicles” and “Freighting goods” of the 2014 GHG Conversion Factors.

6.9. The loading factors in Table 19 were then used to derive corresponding CO₂ factors for 0% and 100% loadings in the above sections. Because the effect of vehicle loading on

³¹ ‘Reduction and Testing of Greenhouse Gas (GHG) Emissions from Heavy Duty Vehicles – Lot 1: Strategy’, a report for EC DG CLIMA by AEA Technology plc and Ricardo, February 2011. Available at: http://ec.europa.eu/clima/policies/transport/vehicles/docs/ec_hdv_ghg_strategy_en.pdf

³² *Food transport refrigeration – Approaches to reduce energy consumption and environmental impacts of road transport*, by S.A. Tassou, G. De-Lille, and Y.T. Ge. Applied Thermal Engineering, Volume 29, Issues 8–9, June 2009, Pages 1467–1477. Available at: <http://www.sciencedirect.com/science/article/pii/S135943110800286X>

CO₂ emissions is linear with load (according to the ARTEMIS data), then these factors can be linearly interpolated if a more precise figure on vehicle load is known. For example, an HGV running at 75% load would have a CO₂ factor halfway between the values for 50% and 100% laden factors.

- 6.10. It might be surprising to see that the CO₂ factor for a >17t rigid HGV is greater than for a >33t articulated HGV. However, these factors merely reflect the estimated MPG figures from DfT statistics that consistently show worse mpg fuel efficiency, on average, for large rigid HGVs than large articulated HGVs once the relative degree of loading is taken into account. This is likely to be a result of the usage pattern for different types of HGVs where large rigid HGVs may spend more time travelling at lower, more congested urban speeds, operating at lower fuel efficiency than articulated HGVs which spend more time travelling under higher speed, free-flowing traffic conditions on motorways where fuel efficiency is closer to optimum. Under the drive cycle conditions more typically experienced by large articulated HGVs, the CO₂ factors for large rigid HGVs may be lower than indicated in “Delivery vehicles” and “Freighting goods” of the 2014 GHG Conversion Factors. Thus the factors in “Delivery vehicles” and “Freighting goods”, linked to the DfT (2009) statistics on MPG (estimated by DfT from the survey data) reflect each HGV class’s typical usage pattern on the GB road network.
- 6.11. UK average factors for all rigid and articulated HGVs are also provided in sections “Delivery vehicles” and “Freighting goods” of the 2014 GHG Conversion Factors 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 GB HGV fleet in 2011. These are derived directly from the mpg values for rigid and articulated HGVs in Table RFS0141 of DfT (2011).
- 6.12. At a more aggregated level still are factors for all HGVs representing the average mpg for all rigid and articulated HGV classes in Table RFS0141 of DfT (2011). 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 CO₂ emissions in, for example, inter-modal freight transport comparisons.
- 6.13. The conversion factors provided in “Delivery vehicles” of the 2014 GHG Conversion Factors are in distance units, that is to say, they enable CO₂ emissions to be calculated just from the distance travelled by the HGV in km multiplied by the appropriate conversion factor for the type of HGV and, if known, the extent of loading.
- 6.14. For comparison with other freight transport modes (e.g. road vs. rail), the user may require CO₂ factors in tonne km (tkm) units. The “Freighting goods” section of the 2014 GHG Conversion Factors also provides such factors for each weight class of rigid and articulated HGV, for all rigids and all artics and aggregated for all HGVs. These are derived from the 2009 fleet average gCO₂ per vehicle km factors in “Delivery vehicles”. Previous year’s updates only included factors for the UK average laden weight for each HGV class in tonne km (tkm). The average tonne freight lifted figures are derived from the tkm and vehicle km (vkm) figures given for each class of HGV in Tables RFS0119 and RFS0109, respectively (DfT, 2011). Dividing the tkm by the vkm figures gives the average tonnes freight lifted by each HGV class. For example a rigid HGV, >3.5-7.5t has an average load of 46%. In the 2014 GHG Conversion Factors, this has been expanded to include factors in tonne km (tkm) for all loads, (0%, 50%, 100% and average).
- 6.15. A tonne km (tkm) 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 tkm value of 500 tkm. The CO₂ emissions are calculated from these factors by multiplying

the number of tkm the user has for the distance and weight of the goods being moved by the CO₂ conversion factor in “Freighting goods” of the 2014 GHG Conversion Factors for the relevant HGV class.

6.16. Emission factors for CH₄ and N₂O have been updated for all HGV classes. These are based on the emission factors from the 2011 UK GHG Inventory. CH₄ and N₂O emissions are assumed to scale relative to vehicle class/CO₂ emissions for HGVs. These factors are presented with an overall total factor in sections “Delivery vehicles” and “Freighting goods” of the 2014 GHG Conversion Factors.

Direct Emissions from Light Goods Vehicles (LGVs)

6.17. Emission factors for light good vehicles (vans up to 3.5 tonnes), were calculated based on the emission factors per vehicle-km in the earlier section on passenger transport.

6.18. The typical / average capacities and average payloads agreed with DfT that are used in the calculation of van emission factors per tonne km are presented in Table 20. These are based on quantitative assessment of the van database used by Ricardo-AEA in a variety of policy assessments for DfT.

Van fuel	Van size	Vkm % split	Av. Capacity tonnes	Av. Payload tonnes
Petrol (Class I)	Up to 1.305 tonne	38.4%	0.64	0.24
Petrol (Class II)	1.305 to 1.740 tonne	48.6%	0.72	0.26
Petrol (Class III)	Over 1.740 tonne	13.0%	1.29	0.53
Petrol (average)	Up to 3.5 tonne	100.0%	0.76	0.31
Diesel (Class I)	Up to 1.305 tonne	6.2%	0.64	0.24
Diesel (Class II)	1.305 to 1.740 tonne	25.7%	0.98	0.36
Diesel (Class III)	Over 1.740 tonne	68.1%	1.29	0.53
Diesel (average)	Up to 3.5 tonne	100.0%	1.17	0.47
LPG (average)	Up to 3.5 tonne		1.17	0.47
CNG (average)	Up to 3.5 tonne		1.17	0.47
Average			1.15	0.46

Table 20: Typical van freight capacities and estimated average payload

6.19. The average load factors assumed for different vehicle types used to calculate the average payloads in Table 20 are summarised in Table 21, on the basis of DfT statistics from a survey of company owned vans.

Average van loading	Utilisation of vehicle volume capacity				
	0-25%	26-50%	51-75%	76-100%	Total
<i>Mid-point for van loading ranges</i>	12.5%	37.5%	62.5%	87.5%	
Proportion of vehicles in the loading range					
Up to 1.8 tonnes	45%	25%	18%	12%	100%
1.8 – 3.5 tonnes	36%	28%	21%	15%	100%
All LGVs	38%	27%	21%	14%	100%
Estimated weighted average % loading					
Up to 1.8 tonnes					36.8%
1.8 – 3.5 tonnes					41.3%
All LGVs					40.3%

Notes: Based on information from Table 24, TSG/UW, 2008³³

Table 21: Utilisation of vehicle capacity by company-owned LGVs: annual average 2003 – 2005 (proportion of total vehicle kilometres travelled)

6.20. Emission factors for CH₄ and N₂O have been updated for all van classes in the 2014 GHG Conversion Factors. These are based on the emission factors from the UK GHG Inventory. N₂O emissions are assumed to scale relative to vehicle class/CO₂ emissions for diesel vans.

6.21. Emission factors per tonne km are calculated from the average load factors for the different weight classes in combination with the average freight capacities of the different vans in Table 20 and the earlier emission factors per vehicle-km in the “Delivery vehicles” and “Freighting goods” sections of the 2014 GHG Conversion Factors.

³³ TSG/UW, 2008. “Using official data sources to analyse the light goods vehicle fleet and operations in Britain” a report by Transport Studies Group, University of Westminster, London, November 2008. Available at: [http://www.greenlogistics.org/SiteResources/61debf21-2b93-4082-ab15-84787ab75d26_LGV%20activity%20report%20\(final\)%20November%202008.pdf](http://www.greenlogistics.org/SiteResources/61debf21-2b93-4082-ab15-84787ab75d26_LGV%20activity%20report%20(final)%20November%202008.pdf)

Direct Emissions from Rail Freight

- 6.22. Data from Table 9.1 of the Office of the Rail Regulator's National Rail Trends Yearbook for 2011-12 (ORR, 2012)³⁴ has been used to update the rail freight emission factors for the 2014 GHG Conversion Factors. This factor is presented in "Freighting goods" in the 2014 GHG Conversion Factors. There have been no further updates to the methodology in the 2014 update.
- 6.23. The factor can be expected to vary with rail traffic route, speed and train weight. Freight trains are hauled by electric and diesel locomotives, but the vast majority of freight is carried by diesel rail and correspondingly CO₂ emissions from diesel rail freight are over 93% of the total for 2012-13 (ORR, 2013).
- 6.24. 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).
- 6.25. The rail freight CO₂ factor will be reviewed and updated if data become available relevant to rail freight movement in the UK.
- 6.26. CH₄ and N₂O emission factors have been estimated from the corresponding emissions for diesel rail from the UK GHG Inventory, proportional to the CO₂ emissions. The emission factors were calculated based on the relative passenger km proportions of diesel and electric rail provided by DfT for 2006-7 in the absence of more suitable tonne km data for freight.

Indirect/WTT Emissions from Freight Land Transport

Vans and HGVs

- 6.27. Indirect/WTT emission factors (EFs) for vans and HGVs include only emissions resulting from the fuel lifecycle (i.e. production and distribution of the relevant transport fuel). These indirect/WTT emission factors were derived using simple ratios of the direct CO₂ EFs and the indirect/WTT EFs for the relevant fuels and the corresponding direct CO₂ EFs for vehicle types using these fuels.

Rail

- 6.28. The EFs for freight rail services are based on a mixture of emissions from diesel and electric rail. Indirect/WTT EFs were therefore calculated in a similar way to the other freight transport modes, except from combining indirect/WTT EFs for diesel and electricity into a weighted average for freight rail using relative CO₂ emissions from traction energy for diesel and electric freight rail provided from ORR (2013)³⁵.

³⁴ Available from the ORR's website at: <http://www.rail-reg.gov.uk/server/show/nav.2026>

³⁵ Available from the ORR's website at: <http://www.rail-reg.gov.uk/server/show/nav.2026>

7. Sea Transport Emission Factors

Direct Emissions from RoPax Ferry Passenger Transport

- 7.1. Based on information from the Best Foot Forward (BFF) work for the Passenger Shipping Association (PSA) (BFF, 2007)³⁶. No new methodology or updated dataset has been identified for the 2014 GHG Conversion Factors.
- 7.2. The BFF study analysed data for mixed passenger and vehicle ferries (RoPax ferries) on UK routes supplied by PSA members. Data provided by the PSA operators included information by operating route on: the route/total distance, total passenger numbers, total car numbers, total freight units, total fuel consumptions.
- 7.3. From the information provided by the operators, figures for passenger km, tonne km and CO₂ emissions were calculated. CO₂ emissions from ferry fuels were allocated between passengers and freight on the basis of tonnages transported, taking into account freight, vehicles and passengers. Some of the assumptions included in the analysis are presented in the following table.

Assumption	Weight, tonnes	Source
Average passenger car weight	1.250	MCA, 2007 ³⁷
Average weight of passenger + luggage, total	0.100	MCA, 2007 ³⁷
Average Freight Unit*, total	22.173	BFF, 2007 ³⁸
Average Freight Load (per freight unit)*, tonnes	13.624	RFS 2005, 2006 ³⁹

Notes: Freight unit includes weight of the vehicle/container as well as the weight of the actual freight load

Table 22: Assumptions used in the calculation of ferry emission factors

- 7.4. CO₂ emissions are allocated to passengers based on the weight of passengers + luggage + cars relative to the total weight of freight including freight vehicles/containers. For the data supplied by the 11 (out of 17) PSA operators this equated to just under 12% of the total emissions of the ferry operations. The emission factor for passengers was calculated from this figure and the total number of passenger km, and is presented in the “Business travel – sea” section of the 2014 GHG Conversion Factors. A further split has

³⁶ BFF, 2007. “Carbon emissions of mixed passenger and vehicle ferries on UK and domestic routes”, Prepared by Best Foot Forward for the Passenger Shipping Association (PSA), November 2007.

³⁷ Maritime and Coastguard Agency, Marine Guidance Note MGN 347 (M), available at: <http://www.dft.gov.uk/mca/mcga07-home/shipsandcargoes/mcga-shipsregsandguidance/marinenotices/mcga-mnotice.htm?textobjid=82A572A99504695B>

³⁸ This is based on a survey of actual freight weights at 6 ferry ports. Where operator-specific freight weights were available these were used instead of the average figure.

³⁹ Average of tonnes per load to/from UK derived from Table 2.6 of Road Freight Statistics 2005, Department for Transport, 2006.

been provided between foot-only passengers and passengers with cars in the 2014 GHG Conversion Factors, again on a weight allocation basis.

- 7.5. It is important to note that this emission factor is relevant only for ferries carrying passengers and freight and that emission factors for passenger only ferries are likely to be significantly higher. No suitable dataset has yet been identified to enable the production of a ferry emission factor for passenger-only services (which were excluded from the BFF, 2007 work).
- 7.6. CH₄ and N₂O emission factors have been estimated from the corresponding emissions for shipping from the 2012 UK GHG Inventory, proportional to the CO₂ emissions.

Direct Emissions from RoPax Ferry Freight Transport

- 7.7. Based on information from the Best Foot Forward (BFF) work for the Passenger Shipping Association (PSA). No new methodology or updated dataset has been identified for the 2014 GHG Conversion Factors.
- 7.8. The BFF study analysed data for mixed passenger and vehicle ferries (RoPax ferries) on UK routes supplied by PSA members. Data provided by the PSA operators included information by operating route on: the route/total distance, total passenger numbers, total car numbers, total freight units, total fuel consumptions.
- 7.9. From the information provided by the operators, figures for passenger km, tonne km and CO₂ emissions were calculated. CO₂ emissions from ferry fuels were allocated between passengers and freight on the basis of tonnages transported, taking into account freight, vehicles and passengers. Some of the assumptions included in the analysis are presented in the following Table 23.

Assumption	Weight, tonnes	Source
Average passenger car weight	1.250	MCA, 2007 ⁴⁰
Average weight of passenger + luggage, total	0.100	MCA, 2007 ⁴⁰
Average Freight Unit*, total	22.173	BFF, 2007 ⁴¹
Average Freight Load (per freight unit)*, tonnes	13.624	RFS 2005, 2006 ⁴²

Notes: Freight unit includes weight of the vehicle/container as well as the weight of the actual freight load

Table 23: Assumptions used in the calculation of ferry emission factors

- 7.10. CO₂ emissions are allocated to freight based on the weight of freight (including freight vehicles/containers) relative to the total weight passengers + luggage + cars. For the data supplied by the 11 (out of 17) PSA operators this equated to just over 88% of the

⁴⁰ Maritime and Coastguard Agency, Marine Guidance Note MGN 347 (M), available at: <http://www.dft.gov.uk/mca/mcga07-home/shipsandcargoes/mcga-shipsregsandguidance/marinenotices/mcga-mnotice.htm?textobjid=82A572A99504695B>

⁴¹ This is based on a survey of actual freight weights at 6 ferry ports. Where operator-specific freight weights were available these were used instead of the average figure.

⁴² Average of tonnes per load to/from UK derived from Table 2.6 of Road Freight Statistics 2005, Department for Transport, 2006.

total emissions of the ferry operations. The emission factor for freight was calculated from this figure and the total number of tonne km (excluding the weight of the freight vehicle/container), and is presented in “Freighting goods” in the 2014 GHG Conversion Factors tables.

7.11. CH₄ and N₂O emission factors have been estimated from the corresponding emissions for shipping from the UK GHG Inventory for 2011, proportional to the CO₂ emissions.

Direct Emissions from Other Marine Freight Transport

7.12. The methodology/source of the emissions factors for other marine freight transport was entirely updated for the 2010 GHG Conversion Factors, with the exception of RoPax ferries, with this methodology unchanged for the 2014 update.

7.13. CO₂ emission factors for the other representative ships (apart from RoPax ferries discussed above) are now based on information from Table 9-1 of the IMO (2009)⁴³ report on GHG emissions from ships. The figures in “Freighting goods” of the 2014 GHG Conversion Factors represent international average data (i.e. including vessel characteristics and typical loading factors), as UK-specific datasets are not available.

7.14. CH₄ and N₂O emission factors have been estimated from the corresponding emissions for shipping from the UK GHG Inventory for 2012, proportional to the CO₂ emissions.

Indirect/WTT Emissions from Sea Transport

7.15. Indirect/WTT emissions factors (EFs) for ferries and ships include only emissions resulting from the fuel lifecycle (i.e. production and distribution of the relevant transport fuel). These indirect/WTT emission factors were derived using simple ratios of the direct CO₂ EFs and the indirect/WTT EFs for the relevant fuels and the corresponding direct CO₂ EFs for ferries and ships using these fuels.

⁴³ “Prevention of Air Pollution from Ships, Second IMO GHG Study 2009. Update of the 2000 IMO GHG Study, Final report covering Phase 1 and Phase 2”, Table 9-1 – Estimates of CO₂ efficiency for cargo ships, International Maritime Organisation, 2009. Available at:

http://www.imo.org/blast/blastDataHelper.asp?data_id=26046&filename=4-7.pdf

8. Air Transport Emission Factors

Summary of changes since the previous update

- 8.1. There has been a significant change in the source data and methodological basis for the aviation emission factors calculations in the 2014 update. Changes for the direct emission factors in the 2014 GHG Conversion Factors have this year been based on fuel consumption for different aircraft types calculated using the EUROCONTROL small emitters tool⁴⁴, which has been produced for reporting under the European Emissions Trading Scheme (ETS). This change (discussed and agreed with experts from the Department for Transport) has resulted in significant changes to the emission factors for the 2014 update.
- 8.2. No other changes to the structure of the air transport emission factors has been made this year, however additional information is provided in the sections below on the uncertainty in the radiative forcing (RF) uplift applied to the emission factors provided from 2013 onwards.

Passenger Air Transport Direct CO₂ Emission Factors

- 8.3. There have been no changes in the methodology used to derive the passenger air transport emission factors for the 2014 GHG Conversion Factors.
- 8.4. The 2014 update of the average factors (presented at the end of this section) have been calculated in a similar basic methodology as previously, but instead of using the aircraft specific fuel consumption/emission factors from AEIG (2006)⁴⁵, a more recent source - the EUROCONTROL small emitters tool - has been used. The principal advantages of this new source are that:
- The tool is based on a methodology designed to estimate the fuel burn for an entire flight, is updated on a regular basis in order to improve when possible its accuracy, and has been validated using actual fuel consumption data from airlines operating in Europe.
 - The tool covers a wider range of aircraft than the previous source, including many newer (and more efficient) aircraft increasingly used in flights to/from the UK. It also includes more variants in aircraft families.
 - The tool is approved for use for flights falling under the EU ETS via the Commission Regulation (EU) No. 606/2010.
- 8.5. A full summary of the expanded representative aircraft selection and the main assumptions influencing the emission factor calculation is presented in Table 24. Key features of the calculation methodology, data and assumptions include:

⁴⁴ The EUROCONTROL small emitters tool is available at: <https://www.eurocontrol.int/articles/small-emitters-tool>

⁴⁵ EMEP/CORINAIR Atmospheric Emissions Inventory Guidebook (2006), available at the EEA website at: <http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009>

- a. A wide variety of representative aircraft have been used to calculate emission factors for domestic, short- and long-haul flights;
- b. Average seating capacities, load factors and proportions of passenger km by the different aircraft types (subsequently aggregated to totals for domestic, short- and long-haul flights) have all been calculated from detailed UK Civil Aviation Authority (CAA, 2012) statistics for UK registered airlines for the year 2012 (the most recent complete dataset available at the time of calculation), split by aircraft and route type (Domestic, European Economic Area, other International) ⁴⁶;
- c. Freight transported on passenger services has also been taken into account (with the approach taken summarised in the following section). Accounting for freight makes a significant difference to long-haul factors.

8.6. New and high-profile efficient aircraft such as the Airbus A380-800 and Boeing 787-800 Dreamliner are not currently included in Table 24 as

- a. Currently they do not account for a significant share of pkm to/from the UK (and have only been introduced into CAA statistics from year 2013);
- b. A more significant volume of observed data is needed to enable their inclusion in the EUROCONTROL small emitters tool (currently absent).

8.7. Allocating flights into short- and long-haul: Domestic flights are those that start and end in the United Kingdom, which are simple to categorise. However, allocating flights into short- and long-haul is more complicated. In earlier versions of the GHG Conversion Factors it was suggested at a crude level to assign all flights <3700km to short haul and all >3700km to long-haul (on the basis of the maximum range of a Boeing 737). However, this approach was relatively simplistic, difficult to apply without detailed flight distance calculations, and was not completely consistent with CAA statistical dataset used to define the emission factors. The current preferred definition is to assume that all flights to 'Europe' (or those of similar distance, up to a 3,700km maximum) are short-haul, and those that are to non-European destinations (or for flights over 3,700km) should be counted as long-haul. Some examples of such 'long-haul' flights have been provided in the following Table 25 below (as previously provided within the 2012 Annexes in the old format). The methodology/basis has been unchanged for 2013 and 2014, and it is up to users of the GHG Conversion Factors to use their best judgement on which category to allocate particular flights into.

	Av. No. Seats	Av. Load Factor	Proportion of passenger km	EF, kgCO ₂ /vkm	Av. flight length, km
Domestic Flights					
Airbus A319	150	76.2%	43%	14.9	461
Airbus A320-100/200	166	73.8%	15%	16.1	467

⁴⁶ This dataset was provided by DfT for the purposes of the Conversion Factors calculations, and provides a breakdown by both aircraft and route type, which is unavailable in publically available sources, e.g. Annual Airline Statistics available from the CAA's website at:

<http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&pageid=1&sqlid=1>

	Av. No. Seats	Av. Load Factor	Proportion of passenger km	EF, kgCO ₂ /vkm	Av. flight length, km
Airbus A321	187	75.9%	6%	17.4	500
Boeing 737-300	59	59.4%	2%	16.5	400
Boeing 737-400	149	67.3%	6%	16.1	429
Bombardier Dash 8 Q400	78	60.4%	17%	7.0	348
Embraer ERJ175	88	64.5%	3%	9.1	573
Embraer ERJ190	98	63.3%	3%	13.2	474
Embraer ERJ195	118	62.3%	6%	13.2	474
Total	136	70.8%	100%	12.5	359
Short-haul Flights					
Airbus A319	151	85.2%	36%	11.7	991
Airbus A320-100/200	169	84.6%	22%	11.8	1,347
Airbus A321	207	86.8%	9%	12.9	1,681
Boeing 737-300	148	85.3%	5%	11.4	1,470
Boeing 737-400	143	79.8%	2%	12.5	1,136
Boeing 737-800	189	91.4%	7%	10.9	2,147
Boeing 757-200	204	91.4%	15%	15.0	1,860
Boeing 767-300ER/F	269	82.8%	4%	20.7	1,964
Total	175	86.4	100%	12.3	1,194
Long-haul Flights					
Airbus A320-100/200	168	83.9%	4%	10.7	2,664
Airbus A321	177	76.3%	2%	12.1	2,865
Airbus A330-200	309	87.3%	3%	21.5	5,298
Airbus A340-600	308	77.3%	10%	24.3	7,236
Boeing 747-400	339	82.1%	41%	37.7	7,347
Boeing 757-200	220	91.8%	5%	14.2	3,217
Boeing 767-300ER/F	202	84.6%	9%	19.3	5,291
Boeing 777-200ER	243	79.9%	21%	25.3	6,260
Boeing 777-300ER	297	82.4%	4%	29.7	8,319
Total	284	82.0%	100%	26.7	5,075

Notes: Figures on seats, load factors, % tkm and av. flight length have been calculated from 2012 CAA statistics for UK registered airlines for the different aircraft types. Figures of kgCO₂/vkm were calculated using the average flight lengths in the EUROCONTROL small emitters tool.

Table 24: Assumptions used in the calculation of revised average CO₂ emission factors for passenger flights for 2014

Area	Destination Airport	Distance, km
Short-haul		
Europe	Amsterdam, Netherlands	400
Europe	Prague (Ruzyne), Czech Rep	1,000
Europe	Malaga, Spain	1,700
Europe	Athens, Greece	1,500
Average (CAA statistics)		1,194
Long-haul		
North Africa	Abu Simbel/Sharm El Sheikh, Egypt	3,300
Southern Africa	Johannesburg/Pretoria, South Africa	9,000
Middle East	Dubai, UAE	5,500
North America	New York (JFK), USA	5,600
North America	Los Angeles California, USA	8,900
South America	Sao Paulo, Brazil	9,400
Indian sub-continent	Bombay/Mumbai, India	7,200
Far East	Hong Kong	9,700
Australasia	Sydney, Australia	17,000
Average (CAA statistics)		5,075

Notes: Distances based on International Passenger Survey (Office for National Statistics) calculations using airport geographic information. Average distances calculated from CAA statistics for flights to/from the UK in 2012.

Table 25: Illustrative short- and long- haul flight distances from the UK

Taking Account of Freight

8.8. Freight, including mail, are 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. The CAA data show that almost all freight carried by passenger aircraft is done on scheduled long-haul flights. In fact, the quantity of freight carried on scheduled long-haul passenger flights is nearly 5 times higher than the quantity of freight carried on scheduled long-haul cargo services. The apparent importance of freight movements by passenger services creates a complicating factor in calculating emission factors. Given the significance of air freight transport on passenger services there were good arguments for developing a method to divide the CO₂ between passengers and freight, which was developed for the 2008 update, and has also been applied in subsequent updates.

8.9. The CAA data provides a split of tonne km for freight and passengers (plus luggage) by airline for both passenger and cargo services. This data may be used as a basis for an allocation methodology. There are essentially three options, with the resulting emission factors presented in Table 26:

- a. **No Freight Weighting:** Assume all the CO₂ is allocated to passengers on these services. ;
- b. **Freight Weighting Option 1:** Use the CAA tonne km (tkm) data directly to apportion the CO₂ *between passengers and freight*. However, in this case the derived

emission factors for freight are significantly higher than those derived for dedicated cargo services using similar aircraft.

- c. **Freight Weighting Option 2:** Use the CAA tonne km data modified to treat freight on a more equivalent /consistent basis to dedicated cargo services. This takes into account the additional weight of equipment specific to passenger services (e.g. seats, galleys, etc.) in the calculations.

Freight Weighting: Mode	None		Option 1: Direct		Option 2: Equivalent	
	Passenger tkm % of total	gCO ₂ /pkm	Passenger tkm % of total	gCO ₂ /pkm	Passenger tkm % of total	gCO ₂ /pkm
Domestic flights	100.0%	148.2	98.5%	142.1	98.5%	142.1
Short-haul flights	100.0%	82.6	97.4%	80.6	97.4%	80.6
Long-haul flights	100.0%	119.4	70.7%	82.9	85.9%	101.9

Table 26: CO₂ emission factors for alternative freight allocation options for passenger flights based on 2014 GHG Conversion Factors

- 8.10. The basis of the freight weighting **Option 2** is to take account of the supplementary equipment (such as seating, galley) and other weight for passenger aircraft compared to dedicated cargo aircraft in the allocation. The Boeing 747 cargo/freighter configurations account for the vast majority (99% of tkm) of long-haul freight services (and over 90% of all tkm for dedicated freight services). In comparing the freight capacities of the cargo configuration compared to passenger configurations we may assume that the difference represents the tonne capacity for passenger transport. This will include the weight of passengers and their luggage (around 100 kg per passenger according to IATA), plus the additional weight of seating, the galley, and other airframe adjustments necessary for passenger service operations. The derived average weight per passenger seat used in the calculations for the 2014 GHG Conversion Factors is around 266 kg. This is almost 3 times the weight per passenger and their luggage alone. In the **Option 2** methodology the derived ratio of 2.66 is used to upscale the CAA passenger tonne km data, increasing this as a percentage of the total tonne km – as shown in Table 26.
- 8.11. It does not appear that there is a distinction made (other than in purely practical size/bulk terms) in the provision of air freight transport services in terms of whether something is transported by dedicated cargo service or on a passenger service. The related calculation of freight emission factors (discussed in a later section) leads to very similar emission factors for both passenger service freight and dedicated cargo services for domestic and short-haul flights. This is also the case for long-haul flights under freight weighting **Option 2**, whereas under **Option 1** the passenger service factors are substantially higher than those calculated for dedicated cargo services. It therefore seems preferable to treat freight on an equivalent basis by utilising freight weighting **Option 2**.
- 8.12. **Option 2** was selected as the preferred methodology to allocate emissions between passengers and freight for the 2008 and subsequent GHG Conversion Factors.

8.13. Under the previous methodology it had been necessary to provide an additional uplift to the emission factors calculated using data from the EMEP/CORINAIR Emissions Inventory Guidebook (EIG 2007)⁴⁷. This was due to perceived underestimation of emissions from key aircraft types. It has not been necessary to apply any uplifts to the emission factors calculated using the EUROCONTROL small emitters tool, as validation checks using the derived emission factors and CAA flights data have shown a very close comparison in derived CO₂ emissions with those from the UK GHG Inventory (which is scaled using actual fuel supplied).

8.14. The final average emission factors for aviation are presented in Table 27. The figures in Table 27 DO NOT include the 8% uplift for Great Circle distance NOR the uplift to account for additional impacts of radiative forcing which are applied to the emission factors provided in the 2014 GHG Conversion Factor data tables.

Mode	Factors for 2014	
	Load Factor%	gCO ₂ /pkm
Domestic flights	70.8%	142.1
Short-haul flights	86.4%	80.6
Long-haul flights	82.0%	101.9

Table 27: Final average CO₂ emission factors for passenger flights for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

Seating Class Factors

8.15. The efficiency of aviation per passenger km is influenced not only by the technical performance of the aircraft fleet, but also by the occupancy/load factor of the flight. Different airlines provide different seating configurations that change the total number of seats available on similar aircraft. Premium priced seating, such as in First and Business class, takes up considerably more room in the aircraft than economy seating and therefore reduces the total number of passengers that can be carried. This in turn raises the average CO₂ emissions per passenger km.

8.16. At the moment there is no agreed data/methodology for establishing suitable scaling factors representative of average flights. However, for the 2008 update a review was carried out of the seating configurations from a selection of 16 major airlines⁴⁸ and average seating configuration information from Boeing and Airbus websites. 24 different aircraft variants were considered including those from the Boeing 737, 747, 757, 767 and 777 families, and the Airbus A319/320, A330 and A340 families. These represent a

⁴⁷ Available at the EEA website at: <http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009>

⁴⁸ The list of airline seating configurations was selected on the basis of total number of passenger km from CAA statistics, supplemented by additional non-UK national carriers from some of the most frequently visited countries according to the UK's International Passenger Survey. The list of airlines used in the analysis included: BA, Virgin Atlantic, Continental Airlines, Air France, Cathay Pacific, Gulf Air, Singapore Airlines, Emirates, Lufthansa, Iberia, Thai Airways, Air New Zealand, Air India, American Airlines, Air Canada, and United Airlines.

mix of the major representative short-, medium- and long- haul aircraft types. The different seating classes were assessed on the basis of the space occupied relative to an economy class seat for each of the airline and aircraft configurations. This evaluation was used to form a basis for the seating class based emission factors provided in Table 28. Information on the seating configurations including seating numbers, pitch, width and seating plans were obtained either directly from the airline websites or from specialist websites that had already collated such information for most of the major airlines (e.g. SeatGuru⁴⁹, UK-AIR.NET⁵⁰, FlightComparison⁵¹ and SeatMaestro⁵²).

8.17. For long-haul flights, the relative space taken up by premium seats can vary by a significant degree between airlines and aircraft types. The variation is at its most extreme for First class seats, which can account for from 3 to over 6 times⁵³ the space taken up by the basic economy seating. Table 28 shows the seating class based emission factors, together with the assumptions made in their calculation. An indication is also provided of the typical proportion of the total seats that the different classes represent in short- and long-haul flights. The effect of the scaling is to lower the economy seating emission factor in relation to the average, and increase the business and first class factors.

Flight type	Size	Load Factor %	gCO ₂ /pkm	Number of economy seats	% of average gCO ₂ /pkm	% Total seats
Domestic	Average	70.8%	142.1	1.00	100%	100%
Short-haul	Average	86.4%	80.6	1.05	100%	100%
	Economy class	86.4%	76.8	1.00	95%	90%
	First/Business class	86.4%	115.2	1.50	143%	10%
Long-haul	Average	82.0%	101.9	1.37	100%	100%
	Economy class	82.0%	73.0	1.00	72%	80%
	Economy+ class	82.0%	116.8	1.60	115%	3%
	Business class	82.0%	211.6	2.90	208%	12%
	First class	82.0%	291.9	4.00	286%	5%

Table 28: Seating class based CO₂ emission factors for passenger flights for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

Freight Air Transport Direct CO₂ Emission Factors

8.18. Freight Air Transport Direct CO₂ Emission Factors Freight, including mail, are transported by two types of aircraft – dedicated cargo aircraft which carry freight only,

⁴⁹ See: <http://www.seatguru.com/>

⁵⁰ See: <http://www.uk-air.net/seatplan.htm>

⁵¹ See: <http://www.flightcomparison.co.uk/flightcomparison/home/legroom.aspx>

⁵² See: <http://www.seatmaestro.com/airlines.html>

⁵³ For the first class sleeper seats/beds frequently used in long-haul flights.

and passenger aircraft which carry both passengers and their luggage, as well as freight.

8.19. Data on freight movements by type of service are available from the Civil Aviation Authority (CAA, 2012). These data show that almost all freight carried by passenger aircraft is done on scheduled long-haul flights and accounts approximately for 70% of all long-haul air freight transport. How this freight carried on long-haul passenger services is treated has a significant effect on the average emission factor for all freight services.

8.20. The next section describes the calculation of emission factors for freight carried by cargo aircraft **only** and then the following sections examine the impact of freight carried by passenger services and the overall average for all air freight services.

Emission Factors for Dedicated Air Cargo Services

8.21. Following the further development of emission factors for passenger flights and discussions with DfT and the aviation industry, revised average emission factors for dedicated air cargo were developed for previous updates. These have been updated for the 2014 update for the GHG Conversion Factors – presented in Table 29. As with the passenger aircraft methodology the factors presented here do not include the distance or radiative forcing uplifts applied to the emission factors provided in the 2014 GHG Conversion Factor data tables.

Mode	Revised factors for 2014	
	Load Factor%	kgCO ₂ /tkm
Domestic flights	45.1%	2.33
Short-haul flights	72.1%	1.06
Long-haul flights	73.7%	0.43

Table 29: Revised average CO₂ emission factors for dedicated cargo flights for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

8.22. The updated factors have been calculated in the same basic methodology as for the passenger flights, which has been updated this year to use the aircraft specific fuel consumption /emission factors calculated using the EUROCONTROL small emitters tool⁵⁴. A full summary of the representative aircraft selection and the main assumptions influencing the emission factor calculation are presented in Table 30. The key features of the calculation methodology, data and assumptions for the 2008 and all subsequent GHG Conversion Factors include:

- a. A wide variety of representative aircraft have been used to calculate emission factors for domestic, short- and long-haul flights;
- b. Average freight capacities, load factors and proportions of tonne km by the different airlines/aircraft types have been calculated from CAA (Civil Aviation Authority) statistics for UK registered airlines for the year 2012 (the latest available complete dataset).

⁵⁴ The EUROCONTROL small emitters tool is available at: <https://www.eurocontrol.int/articles/small-emitters-tool>

	Average Cargo Capacity, tonnes	Av. Load Factor	Proportion of tonne km	EF, kgCO ₂ /vkm	Av. flight length, km
Domestic Flights					
BAE ATP	8.0	47%	16.1%	6.75	278
BAE 146-200/QT	10.0	34%	10.9%	12.04	664
Boeing 737-300	15.2	45%	63.6%	16.51	400
Boeing 757-200	23.2	56%	8.6%	22.04	385
Boeing 747-8 (freighter)	124.3	19%	0.01%	7.98	2
Lockheed L188 Electra	11.6	39%	0.8%	10.95	199
Total	14.1	45%	100.0%	13.22	380
Short-haul Flights					
BAE ATP	8.0	43%	2.4%	6.08	605
Boeing 757-200	22.0	77%	88.5%	14.95	1,860
Boeing 747-400F	103.0	10%	0.0%	51.17	500
Boeing 747-8 (freighter)	124.3	33%	8.3%	49.74	724
Lockheed L188 Electra	11.9	51%	0.7%	10.95	497
Total	30.0	72%	100.0%	14.99	1,432
Long-haul Flights					
BAE ATP	8.0	16%	0.02%	6.25	470
Boeing 757-200	21.6	79%	0.2%	14.17	3,217
Boeing 747-400F	161.7	119%	0.8%	38.52	3,967
Boeing 747-8 (freighter)	129.4	73%	99.0%	40.28	5,443
Total	129.5	74%	100.0%	34.92	4,381

Notes: Figures on cargo, load factors, % tkm and av. flight length have been calculated from 2012 CAA statistics for UK registered airlines for different aircraft. Figures of kgCO₂/vkm were calculated using the average flight lengths in the EUROCONTROL small emitters tool.

Table 30: Assumptions used in the calculation of average CO₂ emission factors for dedicated cargo flights for the 2014 GHG Conversion Factors

Emission Factors for Freight on Passenger Services

8.23. The CAA data provides a similar breakdown for freight on passenger services as it does for cargo services. As already discussed earlier, the statistics give tonne-km data for passengers and for freight. This information has been used in combination with the assumptions for the earlier calculation of passenger emission factors to calculate the respective total emission factor for freight carried on passenger services. These emission factors are presented in the following Table 31 with the two different allocation options for long-haul services. The factors presented here do not include the distance or

radiative forcing uplifts applied to the emission factors provided in the 2014 GHG Conversion Factor data tables (discussed later).

Freight Weighting: Mode	% Total Freight tkm		Option 1: Direct		Option 2: Equivalent	
	Passenger Services (PS)	Cargo Services	PS Freight tkm, % total	Overall kgCO ₂ /tkm	PS Freight tkm, % total	Overall kgCO ₂ /tkm
Domestic flights	4.8%	95.2%	1.5%	2.32	1.5%	2.32
Short-haul flights	23.4%	76.6%	2.6%	1.02	2.6%	1.02
Long-haul flights	70.2%	29.8%	29.3%	0.91	14.1%	0.58

Table 31: Air freight CO₂ emission factors for alternative freight allocation options for passenger flights for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

8.24. It is useful to compare the emission factors calculated for freight carried on passenger services (in Table 31) with the equivalent factors for freight carried on dedicated cargo services⁵⁵ (in Table 29). The comparison shows that in the case of domestic and European services, the CO₂ emitted per tonne-km of either cargo or combined cargo and passengers are very similar. In other words, freight transported on a passenger aircraft could be said to result in similar CO₂ emissions as if the same freight was carried on a cargo aircraft. In the case of other international flights, the factor in Table 31 is around 2.6 times the comparable figure given in Table 29 for **Option 1**, but is much closer to (around 50% higher than) the figure for **Option 2**. This would mean that under **Option 1**, freight transported on a passenger aircraft could be said to result in over 2.6 times as much CO₂ being emitted than if the same freight was carried on a cargo/freighter aircraft. This is counter-intuitive since freight carriage on long-haul services is used to help maximise the overall efficiency of the service. Furthermore, CAA statistics do include excess passenger baggage in the 'freight' category, which would under **Option 1** also result in a degree of under-allocation to passengers. **Option 2** therefore appears to provide the more reasonable means of allocation.

8.25. **Option 2** was selected as the preferred methodology for freight allocation for the 2008 update. The same methodology has been applied in subsequent GHG Conversion Factors and is included in all of the presented emission factors.

Average Emission Factors for All Air Freight Services

8.26. The following Table 32 presents the final average air freight emission factors for all air freight for the 2014 GHG Conversion Factors. The emission factors have been calculated from the individual factors for freight carried on passenger and dedicated freight services, weighted according to their respective proportion of the total air freight tonne km. The factors presented here do not include the distance or radiative forcing uplifts applied to the emission factors provided in the 2014 GHG Conversion Factor data tables (discussed later).

55 Although freight only flights generally adjust course less frequently in order to avoid turbulence.

Mode	% Total Air Freight tkm		All Air Freight kgCO ₂ /tkm
	Passenger Services	Cargo Services	
Domestic flights	4.8%	95.2%	2.32
Short-haul flights	23.4%	76.6%	1.02
Long-haul flights	70.2%	29.8%	0.58

Table 32: Final average CO₂ emission factors for all air freight for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

Air Transport Direct Emission Factors for CH₄ and N₂O

Emissions of CH₄

8.27. Total emissions of CO₂, CH₄ and N₂O are calculated in detail and reported at an aggregate level for aviation as a whole are reported from the UK GHG inventory. Therefore the relative proportions of total CO₂ and CH₄ emissions from the UK GHG inventory for 2012 (see Table 33) were used to calculate the specific CH₄ emission factors per passenger km or tonne-km relative to the corresponding CO₂ emission factors. The resulting air transport emission factors for the 2014 GHG Conversion Factors are presented in Table 34 for passengers and Table 35 for freight.

2012	CO ₂		CH ₄		N ₂ O	
	Mt CO ₂ e	% Total CO ₂ e	Mt CO ₂ e	% Total CO ₂ e	Mt CO ₂ e	% Total CO ₂ e
Aircraft - domestic	1.65	98.98%	0.00	0.04%	0.02	0.97%
Aircraft - international	32.00	99.02%	0.00	0.01%	0.31	0.97%

Table 33: Total emissions of CO₂, CH₄ and N₂O for domestic and international aircraft from the UK GHG inventory for 2012

Emissions of N₂O

8.28. Similar to those for CH₄, emission factors for N₂O per passenger-km or tonne-km were calculated on the basis of the relative proportions of total CO₂ and N₂O emissions from the UK GHG inventory for 2012 (see Table 33), and the corresponding CO₂ emission factors. The resulting air transport emission factors for the 2014 GHG Conversion Factors are presented in Table 34 for passengers and Table 35 for freight.. The factors presented here do not include the distance or radiative forcing uplifts applied to the emission factors provided in the 2014 GHG Conversion Factor data tables (discussed later).

Air Passenger Mode	Seating Class	CO ₂ gCO ₂ /pkm	CH ₄ gCO ₂ e/pkm	N ₂ O gCO ₂ e/pkm	Total GHG gCO ₂ e/pkm
Domestic flights	Average	142.1	0.06	1.40	143.6
Short-haul flights	Average	80.6	0.00	0.79	81.4
	Economy	76.8	0.00	0.76	77.5
	First/Business	115.2	0.01	1.13	116.3
Long-haul flights	Average	101.9	0.01	1.00	102.9
	Economy	73.0	0.00	0.72	73.7
	Economy+	116.8	0.01	1.15	117.9
	Business	211.6	0.01	2.08	213.7
	First	291.9	0.02	2.87	294.8

Notes: Totals may vary from the sums of the components due to rounding in the more detailed dataset.

Table 34: Final average CO₂, CH₄ and N₂O emission factors for all air passenger transport for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

Air Freight Mode	CO ₂ kgCO ₂ /tkm	CH ₄ kgCO ₂ e/tkm	N ₂ O kgCO ₂ e/tkm	Total GHG kgCO ₂ e/tkm
<i>Passenger Freight</i>				
Domestic flights	2.07	0.00	0.02	2.09
Short-haul flights	0.87	0.00	0.01	0.88
Long-haul flights	0.64	0.00	0.01	0.64
<i>Dedicated Cargo</i>				
Domestic flights	2.33	0.0010	0.0230	2.36
Short-haul flights	1.06	0.0001	0.0104	1.07
Long-haul flights	0.43	0.0000	0.0042	0.43
<i>All Air Freight</i>				
Domestic flights	2.32	0.0010	0.0228	2.34
Short-haul flights	1.02	0.0001	0.0100	1.03
Long-haul flights	0.58	0.0000	0.0057	0.58

Notes: Totals may vary from the sums of the components due to rounding in the more detailed dataset.

Table 35: Final average CO₂, CH₄ and N₂O emission factors for air freight transport for 2014 GHG Conversion Factors (excluding distance and RF uplifts)

Indirect/WTT Emission Factors from Air Transport

8.29. Indirect/WTT emissions factors (EFs) for air passenger and air freight services include only emissions resulting from the fuel lifecycle (i.e. production and distribution of the relevant transport fuel). These indirect/WTT emission factors were derived using simple ratios of the direct CO₂ EFs and the indirect/WTT EFs for aviation turbine fuel (kerosene) and the corresponding direct CO₂ EFs for air passenger and air freight transport in sections “Business travel – air” and “Freighting goods”.

Other Factors for the Calculation of GHG Emissions

Great Circle Flight Distances

8.30. We wish to see standardisation in the way that emissions from flights are calculated in terms of the distance travelled and any uplift factors applied to account for circling and delay. However, we acknowledge that a number of methods are currently used.

8.31. A 9% uplift factor has previously been used in the UK Greenhouse Gas Inventory to scale up Great Circle distances (GCD) for flights between airports to take into account indirect flight paths and delays, etc. This factor (also provided previously with previous GHG Conversion Factors) 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. Recent analysis for DfT has suggested that a lower uplift of 8% is more appropriate for flights arriving and departing from the UK and this is the factor being used in the 2014 GHG Conversion Factors.

8.32. It is not practical to provide a database of origin and destination airports to calculate flight distances in the GHG Conversion Factors. However, the principal of adding a factor of 8% to distances calculated on a Great Circle is recommended (for consistency with the existing Defra/DfT approach) to take into account of indirect flight paths and delays/congestion/circling. This is the methodology recommended to be used with the Defra/DECC GHG Conversion Factors and is applied already to the emission factors presented in the 2014 GHG Conversion Factors tables.

Non-CO₂ impacts and Radiative Forcing

8.33. The emission factors provided in the 2014 GHG Conversion Factors sections “Business travel – air” and “Freighting goods” refer to aviation's direct CO₂, CH₄ and N₂O emissions only. There is currently uncertainty over the other non-CO₂ climate change effects of aviation (including water vapour, contrails, NO_x, etc.) which have been indicatively accounted for by applying a multiplier in some cases.

8.34. Currently there is no suitable climate metric to express the relationship between emissions and climate warming effects from aviation but this is an active area of research. Nonetheless, it is clear that aviation imposes other effects on the climate which are greater than that implied from simply considering its CO₂ emissions alone.

8.35. The application of a ‘multiplier’ to take account of non-CO₂ effects is a possible way of illustratively taking account of the full climate impact of aviation. A multiplier is not a straight forward instrument. In particular it implies that other emissions and effects are directly linked to production of CO₂, which is not the case. Nor does it reflect accurately the different relative contribution of emissions to climate change over time, or reflect the potential trade-offs between the warming and cooling effects of different emissions.

8.36. On the other hand, consideration of the non-CO₂ climate change effects of aviation can be important in some cases, and there is currently no better way of taking these effects into account. A multiplier of 1.9 is recommended as a central estimate, based on the best available scientific evidence, as summarised in Table 36 and the GWP₁₀₀ figure (consistent with UNFCCC reporting convention) from the ATTICA research presented in Table 37 below⁵⁶ and in analysis by Lee et al (2009) reported on by the Committee on Climate Change (2009)⁵⁷.

From CCC (2009): “The recent European Assessment of Transport Impacts on Climate Change and Ozone Depletion (ATTICA, <http://ssa-attica.eu>) was a series of integrated studies investigating atmospheric effects and applicable climate metrics for aviation, shipping and land traffic. Results have been published which provide metrics to compare the different effects across these sectors in an objective way, including estimates of Global Warming Potentials (GWPs) and Global Temperature Potentials (GTPs) over different time horizons (20, 50 and 100 years). [Table 37] shows the 20-year and 100-year GWPs, plus 100-year GTPs, for each forcing agent from aviation. Based on estimates of fuel usage and emission indices for 2005, the emission equivalent of each agent for these metrics is given on the right, and on the bottom right is the overall ratio of total CO₂-equivalent emissions to CO₂ emissions for aviation in 2005.

8.37. It is important to note that **the value of this 1.9 multiplier is subject to significant uncertainty** and should only be applied to the CO₂ component of direct emissions (i.e. not also to the CH₄ and N₂O emissions components). The 2014 GHG Conversion Factors now provide separate emission factors including this radiative forcing uplift in separate tables in sections “Business travel – air” and “Freighting goods”

Year	Study	RF [mW/m ²]							
		CO ₂	O ₃	CH ₄	H ₂ O	Direct Sulphate	Direct Soot	Contrails	Total (w/o Cirrus)
1992	IPCC (1999)	18.0	23.0	-14.0	1.5	-3.0	3.0	20.0	48.5
2000	IPCC (1999) scaled to 2000	25.0	28.9	-18.5	2.0	-4.0	4.0	33.9	71.3
2000	TRADEOFF	25.3	21.9	-10.4	2.0	-3.5	2.5	10.0	47.8

Notes: Estimates for scaling CO₂ emissions to account for Radiative Forcing impacts are not quoted directly in the table, but are derived as follows: IPCC (1999) = 48.5/18.0 = 2.69 ≈ 2.7; TRADEOFF = 47.8/25.3 = 1.89 ≈ 1.9

Table 36: Impacts of radiative forcing according to R. Sausen et al. (2005)

⁵⁶ R. Sausen et al. (2005). Aviation radiative forcing in 2000: An update on IPCC (1999) Meteorologische Zeitschrift 14: 555-561, available at: <http://elib.dlr.de/19906/1/s13.pdf>

⁵⁷ CCC (2009). Meeting the UK Aviation target – options for reducing emissions to 2050, <http://www.theccc.org.uk/publication/meeting-the-uk-aviation-target-options-for-reducing-emissions-to-2050/>

	Metric values			CO ₂ e emissions (MtCO ₂ e/yr) for 2005			LOSU
	GWP ₂₀	GWP ₁₀₀	GTP ₁₀₀	GWP ₂₀	GWP ₁₀₀	GTP ₁₀₀	
CO ₂	1	1	1	641	641	641	High
Low NOx	120	-2.1	-9.5	106	-1.9	-8.4	Very low
High NOx	470	71	7.6	415	63	6.7	Very low
Water vapour	0.49	0.14	0.02	123	35	5.0	–
Sulphate	-140	-40	-5.7	-25	-7	-1.0	–
Black carbon	1600	460	64	10	2.8	0.38	–
Contrail	0.74	0.21	0.03	474	135	19	Low
AIC	2.2	0.63	0.089	1410	404	57	Very low
				CO₂e/CO₂ emissions for 2005			
Low NOx, inc. AIC				4.3	1.9	1.1	Very low
High NOx, inc. AIC				4.8	2.0	1.1	Very low
Low NOx, exc. AIC				2.1	1.3	1.0	Very low
High NOx, exc. AIC				2.6	1.4	1.0	Very low

Source: Adapted by CCC (2009) from Lee et al. (2009) Transport impacts on atmosphere and climate; Aviation, *Atmospheric Environment*. The level of scientific understanding (LOSU) is given for each process in the right column. Values are presented for both high and low GWP values for NOx reflecting the wide uncertainties in current estimates. The ratios on the bottom right are presented both including and excluding aviation induced cloudiness (AIC) because of uncertainties both in estimates of the magnitude of this effect and in the future incidence of AIC due to air traffic. The different time horizons illustrate how a unit emission of CO₂ increases in importance relative to shorter-lived effects as longer timescales are considered.

Notes: GWP = Global Warming Potential, GTP = Global Temperature Potential

Table 37: Findings of ATTICA project

9. Bioenergy and Water

Summary of changes since the previous update

- 9.1. There have been two changes made to bioenergy (specifically biomass) conversion factors in the 2014 update to improve the accuracy of reporting.
- An addition of methane (CH₄) and nitrous oxide (N₂O) emissions into the direct (Scope 1) conversion factors from bioenergy combustion.
 - A modification of the WTT-bioenergy conversion factors (Scope 3). The WTT biomass and biogas factors have been updated with new data sourced from two carbon calculators, produced by Ofgem (the UK Bioliquid Carbon Calculator and the UK Solid and Gaseous Biomass Carbon Calculator⁵⁸)
- 9.2. All other factors have been updated with more recent data in the latest 2014 GHG Conversion Factors.

General Methodology

- 9.3. The 2014 GHG Conversion Factors provides a number of additional tables with other UK emission factors, including those for water supply and treatment, biofuels, and for biomass and biogas.
- 9.4. The emission factors presented in the tables incorporate emissions from the full life-cycle and include net CO₂, CH₄ and N₂O emissions. The addition of indirect/WTT emissions factors to other tables means the emission factors are now directly comparable with the total lifecycle (direct + indirect/WTT) emission factors in other tables.
- 9.5. The basis of the different emission factors is discussed in the following sub-sections.

Water

- 9.6. The emission factors for water supply and treatment in sections “Water supply” and “Water treatment” of the 2014 GHG Conversion Factors have been sourced from Water UK (2008, 2009, 2010, 2011) and are based on submissions by UK water suppliers. Water UK represents all UK water and wastewater service suppliers at national and European level.
- 9.7. Water UK (2011) gives total GHG emissions from water supply, waste water treatment, offices and transport. In the 2012 update of the GHG Conversion Factors, these emissions were split between Water supply and Water treatment using the same proportional split from previous years. However, since this publication, Water UK has

⁵⁸ <https://www.ofgem.gov.uk/publications-and-updates/uk-solid-and-gaseous-biomass-carbon-calculator>

discontinued its “Sustainability Indicators” report and so no longer produces further updates to these emission factors. Therefore the 2014 update is unchanged from the 2013 and 2012 GHG Conversion Factors values.

Biofuels

9.8. The emission factors for biofuels were based on UK average factors from the Quarterly Report (2012/13)⁵⁹ on the Renewable Transport Fuel Obligation (RTFO). These average factors are presented in Table 38.

9.9. The indirect/WTT/fuel lifecycle emission factors from the RTFO reporting do not include the direct emissions of CH₄ and N₂O that are produced by the use of biofuels in vehicles. Unlike the direct emissions of CO₂, these are not offset by adsorption of CO₂ in the growth of the feedstock used to produce the biofuel. In the absence of other information these emissions factors have been assumed to be equivalent to those produced by combusting the corresponding fossil fuels (i.e. diesel, petrol or CNG) from the “Fuels” section.

9.10. Since the previous update there have been minor modifications made to the methodology of how the Scope 3 figures for biofuels have been calculated. Since biofuels volume and sales figures are taken over two financial years, the carbon intensity figures (used to calculate Scope 3 emissions) should also ideally be consistent with this. The carbon intensity was therefore taken as a weighted average of the total volume of the fuels which is a more accurate method, given the large fluctuations in carbon intensity between the two years datasets.

Biofuel	Emissions Factor, gCO ₂ e/MJ				
	RTFO Lifecycle ⁽¹⁾	Direct CH ₄ ⁽²⁾	Direct N ₂ O ⁽²⁾	Total Lifecycle	Direct CO ₂ Emissions (Out of Scope ⁽³⁾)
Biodiesel	16.511	0.019	0.570	17.100	75.300
Bioethanol	35.135	0.093	0.159	35.386	71.600
Biomethane	31.000	0.094	0.034	31.128	55.408

Notes:

(1) Based on UK averages from the RTFO Quarterly Report (2011/12) from DfT

(2) Based on corresponding emission factors for diesel, petrol or CNG.

(3) The Total GHG emissions outside of the GHG Protocol Scope 1, 2 and 3 is the actual amount of CO₂ emitted by the biofuel when combusted. This will be counter-balanced by /equivalent to the CO₂ absorbed in the growth of the biomass feedstock used to produce the biofuel. These factors are based on data from BEC (2013)

Table 38: Fuel lifecycle GHG Conversion Factors for biofuels

9.11. The net GHG emissions for biofuels vary significantly depending on the feedstock source and production pathway. Therefore, for accuracy, it is recommended that more detailed/specific figures are used where available. For example, detailed indirect/WTT

⁵⁹ These cover the period from April 2010 - April 2011 and April 2011 - April 2012, and were the most recent figures available at the time of production of the 2013 GHG Conversion Factors. The report is available from the DfT website at: <http://www.dft.gov.uk/topics/sustainable/biofuels/rtfo/>

emission factors by source/supplier are provided and updated regularly in the Quarterly Reports on the RTFO. available from DfT's website at:

<https://www.gov.uk/government/organisations/department-for-transport/series/biofuels-statistics>

9.12. In addition to the direct and indirect/WTT emission factors provided in Table 38, emission factors for the out of scope CO₂ emissions have also been provided in the 2014 GHG Conversion Factors (see table and the table footnote), based on data sourced from the Biomass Energy Centre (BEC, 2013)⁶⁰.

Other biomass and biogas

9.13. A number of different bioenergy types can be used in dedicated biomass heating systems, including wood logs, chips and pellets, as well as grasses/straw or biogas. Emission factors produced for these bioenergy sources are presented in the "Bioenergy" section of the 2014 GHG Conversion Factors.

9.14. All emission factors here except for wood logs are sourced from the Ofgem carbon calculators⁶¹, since logs were not covered them. These calculators have been developed to support operators determining the GHG emissions associated with the cultivation, processing and transportation of their biomass fuels.

9.15. Emission factors for wood logs were obtained from the Biomass Energy Centre's (BEC) tool, BEAT2⁶², provided by Defra.

9.16. In some cases calorific values were required to convert the data into the required units. These were also sourced from BEC (2013). The values used and their associated moisture contents are provided in Table 39.

9.17. In addition to the direct and indirect/WTT emission factors provided in, emission factors for the out of scope CO₂ emissions are also provided in the 2014 GHG Conversion Factors (see "Outside of scopes" and the relevant notes on the page), also based on data from sourced from BEC (2013).

⁶⁰ BEC (2013). BEC 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, and http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,163182&_dad=portal&_schema=PORTAL

⁶¹ <https://www.ofgem.gov.uk/publications-and-updates/uk-bioliquid-carbon-calculator> and <https://www.ofgem.gov.uk/publications-and-updates/uk-solid-and-gaseous-biomass-carbon-calculator>

⁶² http://www.biomassenergycentre.org.uk/portal/page?_pageid=74,153193&_dad=portal&_schema=PORTAL

Source	Moisture content	Net calorific value (GJ/tonne)
Wood chips	25% moisture	13.6
Wood logs	Air dried 20% moisture	14.7
Pellets	10% moisture	16.9
Straw	10% moisture	15.1
Miscanthus (grass)	10% moisture	16
Biogas	DECC GHG values - based on 60% CH ₄	30

Table 39: Fuel sources and properties used in the calculation of biomass and biogas emission factors

10. Overseas Electricity Emission Factors

Summary of changes since the previous update

10.1. There have been no new methodological changes to this section since last year's (2013) update.

Direct Emissions from Overseas Electricity Generation

10.2. UK companies reporting on their emissions may need to include emissions resulting from overseas activities. Whilst many of the standard fuel emissions factors are likely to be similar for fuels used in other countries, grid electricity emission factors vary very considerably. It was therefore deemed useful to provide a set of overseas electricity emission factors to aid in reporting where such information is hard to source locally.

10.3. The dataset on electricity and heat emission factors from the IEA provided mainly from the IEA website⁶³ was identified as the best available consistent dataset for electricity emission factors. However, these factors are a time series of combined electricity CO₂ emission factors per kWh GENERATED. Therefore they exclude losses from the transmission and distribution grid and are not directly comparable with the point-of-use grid electricity emission factors provided in the "UK electricity" section.

10.4. The 2014 Conversion Factors have been updated using 2011 country energy balances available at the IEA website⁶⁴. Data on the proportion of electricity⁶⁵ (for 2011) is used to estimate the weighted net losses in the distribution of electricity and heat for different countries.

10.5. An example of the format for the Energy Balances data source from the IEA is provided in Table 40 for the UK (columns for other forms of energy have been removed). These data are for 2008. The percentage distribution losses for electricity are calculated from the 'Distribution Losses' and 'total Fuel Consumption' (*TFC*) figures from the Energy Balance tables.

⁶³ Emission factor data is from the International Energy Agency (IEA) Data Services, 2012 for "CO₂ Emissions per kWh from electricity generation", from the IEA publication "CO₂ Emissions from Fuel Combustion - 2012 Highlights", found here

<http://www.iea.org/publications/freepublications/publication/CO2emissionfromfuelcombustionHIGHLIGHTSMarch2013.pdf>

⁶⁴ Energy balances information is available at:

<http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances>

⁶⁵ Information is available at: <http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Electricity/Heat>

SUPPLY and CONSUMPTION	Electricity, ktoe
Production	0
Imports	1057
Exports	-109
International Marine Bunkers**	0
Stock Changes	0
TPES	948
Transfers	0
Statistical Differences	0
Electricity Plants	30859
CHP Plants	2274
Heat Plants	0
Gas Works	0
Petroleum Refineries	0
Coal Transformation	0
Liquefaction Plants	0
Other Transformation	0
Own Use	-2283
Distribution Losses	-2425
TFC	29374
Industry sector	9766
Transport sector	725
Other sectors	18883
Residential	10134
Commercial and Public Services	8399
Agriculture / Forestry	350
Fishing	0
Non-Specified	0
Non-Energy Use	0
- of which	
<i>Petrochemical Feedstocks</i>	<i>0</i>

Source: Subset of data from the IEA Data Services⁶⁶

Notes: Figures are in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis.

* Totals may not add up due to rounding.

** International marine bunkers are not subtracted out of the total primary energy supply for world totals.

Table 40: 2008 Energy Balances for Electricity for the United Kingdom

10.6. An example of the format for the Electricity data source from the IEA is provided in Table 41 for the UK (an additional column with Heat presented in units of GWh has been

⁶⁶ Energy balances information is available at:

<http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Balances>

added). The percentage electricity comprises of the total for electricity is calculated both for the Total Production (corresponding to electricity GENERATED) and the Total Final Consumption (corresponding to electricity CONSUMED).

	Electricity <i>Unit: GWh</i>
Production from:	
- coal	126699
- oil	6101
- gas	176748
- biomass	8090
- waste	2871
- nuclear	52486
- hydro	9257
- geothermal	0
- solar PV	17
- solar thermal	0
- wind	7097
- tide	0
- other sources	0
Total Production	389366
Imports	12294
Exports	-1272
Domestic Supply	400388
Statistical Differences	1
Total Transformation*	0
Electricity Plants	0
Heat Plants	0
Energy Sector**	30632
Distribution Losses	28195
Total Final Consumption	341562
Industry	113558
Transport	8434
Residential	117841
Commercial and Public Services	97662
Agriculture / Forestry	4067
Fishing	0
Other Non-Specified	0

Source: Subset of data from the IEA Data Services⁶⁷

Notes: Figures are in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis.

* Transformation sector includes electricity used by heat pumps and electricity used by electric boilers.

** Energy Sector also includes own use by plant and electricity used for pumped storage.

⁶⁷ Information from the IEA website is available at:

<http://www.iea.org/Textbase/stats/prodresult.asp?PRODUCT=Electricity/Heat>

% Electricity (of total electricity + heat) =	96.3%	Total Production
	96.0%	Total Final Consumption

Table 41: Electricity for United Kingdom in 2008

10.7. The emission factors for overseas electricity in “Overseas electricity” of the 2014 GHG Conversion Factors are presented as electricity CO₂ emission factors per kWh GENERATED (i.e. before losses in transmission/distribution). CO₂ emission factors per kWh due to LOSSES in transmission/distribution can be found in the “Transmission and distribution” part of the GHG conversion factors tables. This data is calculated using the following formulae:

$$(1) \text{ Emission Factor (Electricity CONSUMED)} = \text{Emission Factor (Electricity GENERATED)} / (1 - \% \text{Electricity Total Grid LOSSES})$$

$$(2) \text{ Emission Factor (Electricity LOSSES)} = \text{Emission Factor (Electricity CONSUMED)} - \text{Emission Factor (Electricity GENERATED)}$$

10.8. Emission factors have been provided for all EU Member States and major UK trading partners. Additional emission factors for other countries not included in this list can be found at the GHG Protocol website⁶⁸, though it should be noted that the figures supplied there do not include losses from transmission and distribution of heat and electricity.

Indirect/WTT Emissions from Overseas Electricity Generation

10.9. In addition to the GHG emissions resulting directly from the generation of electricity, there are also indirect/WTT emissions resulting from the production, transport and distribution of the fuels used in electricity generation (i.e. indirect/WTT / fuel lifecycle emissions as included in the “Fuel” section). The average fuel lifecycle emissions per unit of electricity generated will be a result of the mix of different sources of fuel/primary energy used in electricity generation.

10.10. Average indirect/WTT emission factors for UK electricity were calculated and included in “UK electricity” by using the “Fuels” sections indirect/WTT emission factors and data on the total fuel consumption by type of generation for the UK. This information was not available for the overseas emission factors included in “Overseas electricity”. As an approximation therefore, the indirect/WTT (Scope 3) emission factors for different countries are estimated as being roughly a similar ratio of the direct CO₂ emission factors as for the UK (which is 13.6%).

⁶⁸ GHG Protocol website: <http://www.ghgprotocol.org/calculation-tools>

11. Material Consumption/Use and Waste Disposal

- 11.1. Additional primary material production and open loop source factors for 'average construction' have been included in the 2014 GHG Conversion Factors. These two factors were previously unavailable.
- 11.2. Additionally, within the "Material use" section, previous compost source factors for "wood", "books" and "Organic: food and drink waste" have been removed as they were deemed to be causing confusion with users.
- 11.3. Data on Aluminium has been updated using the latest European Aluminium Association Environmental Profile report (2013), which replaces the 2008 edition previously used.
- 11.4. Data on paper and board has been updated using the latest reports from two trade associations: FEFCO (2013) and ProCarton (2013).
- 11.5. Besides this there are no changes to the methodology or emission factors provided in the 2014 GHG Conversion Factors compared to the previous year.
- 11.6. Following publication of the 2011 update, separate guidance on accounting for indirect greenhouse gas emissions at a corporate level has been published. The GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard ('the Scope 3 Standard')⁶⁹ sets down rules on accounting for emissions associated with material consumption and waste management.
- 11.7. One key change was whereas in previous iterations 'avoided emissions' from energy recovery and sending materials for recycling had been shown, these 'avoided emissions' are considered outside of the account of the company producing these wastes. They are instead exclusively within the scope of the company using these materials.
- 11.8. Whereas in previous editions negative carbon numbers were presented to show savings from recycling and energy recovery, all figures presented in the 2012 update onwards are positive, showing only emissions from processing materials with no avoided impacts accounted for. This is in line with the Scope 3 Standard.
- 11.9. The company sending waste for recycling may see a reduction in waste management emissions, but does not receive any benefit to its carbon account from recycling as the figures for waste disposal no longer include the potential benefits where primary resource extraction is replaced by recycled material. Under this accounting methodology, the organisation using recycled materials will see a reduction in their account where this use is in place of higher impact primary materials.
- 11.10. Whilst the factors are appropriate for accounting, they are therefore not appropriate for informing decision making on alternative waste management options (i.e. from a waste management perspective they do not indicate the lowest or highest impact option). DEFRA has previously indicated that separate figures appropriate for informing

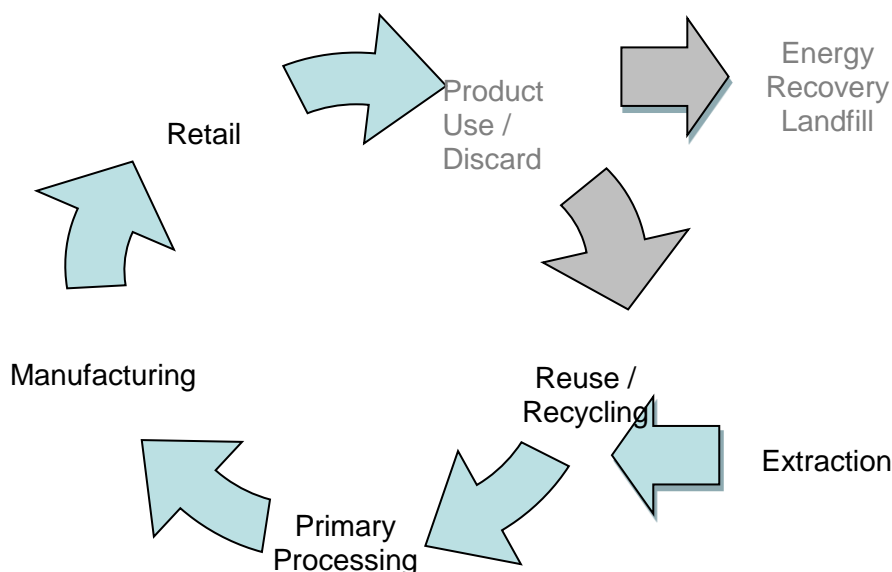
⁶⁹ <http://www.ghgprotocol.org/standards/scope-3-standard>

decision making on waste disposal would be provided in the future. However, these are still pending.

- 11.11. In addition to these changes, emission factors for construction materials and wastes are also presented.
- 11.12. All figures expressed are kilograms of carbon dioxide equivalent (CO₂e) per tonne of material. This includes the Kyoto protocol basket of greenhouse gases. Please note that biogenic⁷⁰ CO₂ has also been excluded from these figures.
- 11.13. The information for material consumption presented in the GHG Conversion Factor tables has been separated out from the emissions associated with waste disposal in order to allow separate reporting of these emission sources, in compliance with the Scope 3 Standard.
- 11.14. It is important that businesses quantify emissions associated with both material use and waste management in their Scope 3 accounting, to fully capture changes due to activities such as waste reduction.
- 11.15. The following subsections provide a summary of the methodology, key data sources and assumptions used to define the emission factors.

Material Consumption/Use

- 11.16. Figure 2 shows the boundary of greenhouse gas emissions summarised in the material consumption table.



Notes: Arrows represent transportation stages; greyed items are excluded.

Figure 2: Boundary of material consumption data sets

⁷⁰ Biogenic CO₂ is the CO₂ absorbed and released by living organisms during and at the end of their life. By convention, this is assumed to be in balance in sustainably managed systems.

- 11.17. The factors presented for material consumption cover all greenhouse gas emissions from the point of raw material extraction through to the point at which a finished good is manufactured and provided for sale. Commercial enterprises may therefore use these figures to estimate the impact of goods they procure. Organisations involved in manufacture of goods using these materials should note that if they separately report emissions associated with their energy use in forming products with these materials, there is potential for double counting. As many of the data sources used in preparing the tables are confidential we are unable to publish a more detailed breakdown. However, the standard assumptions made are described below.
- 11.18. Emission factors are provided for both recycled and primary materials. To identify the appropriate carbon factor, an organisation should seek to identify the level of recycled content in materials and goods purchased. Under this accounting methodology, the organisation using recycled materials in place of primary materials receives the benefit of recycling in terms of reduced Scope 3 emissions.
- 11.19. These figures are estimates to be used in the absence of data specific to your goods and services. If you have more accurate information for your products, then please refer to the more accurate data for reporting your emissions
- 11.20. Information on the extraction of raw materials and manufacturing impacts are commonly sourced from the same reports, typically life cycle inventories published by trade associations. The sources utilised in this study are listed in Appendix 1 to this report. The stages covered include mining activities for non-renewable resources, agriculture and forestry for renewable materials, production of materials used to make the primary material (e.g. soda ash used in glass production) and primary production activities such as casting metals and producing board. Intermediate transport stages are also included. Full details are available in the referenced reports.
- 11.21. Emission factors provided include emissions associated with product forming.
- 11.22. Table 43 identifies the transportation distances and vehicle types which have been assumed as part of the emission factors provided. The impact of transporting the raw material (e.g. forestry products, granules, glass raw materials) is already included in the manufacturing profile for all products:

Destination / Intermediate Destination	One Way Distance	Mode of transport	Source
Transport of raw materials to factory	112km	Average, all HGVs	Department for Transport (2009) ⁷¹ Based on average haulage distance for all commodities, not specific to the materials in the first column.
Distribution to Retail Distribution Centre & to retailer	95km		McKinnon (2007) ⁷² IGD (2008) ⁷³

Table 42: Distances and transportation types used in EF calculations

11.23. Transport of goods by consumers is excluded from the factors presented, as is use of the product. The transportation tables and Greenhouse Gas Protocol⁷⁴ guidelines on vehicle emissions have been used for most vehicle emission factors.

11.24. The final material consumption GHG emission factors for the 2014 update is provided in the tables in the 2014 GHG Conversion Factors.

Waste Disposal

11.25. Figure 3 shows the boundary of greenhouse gas emissions summarised in the waste disposal table.

⁷¹ Department for Transport (2009) *Transport Statistics Bulletin: Road Freight Statistics 2008* National Statistics Table 1.14d. Available at:

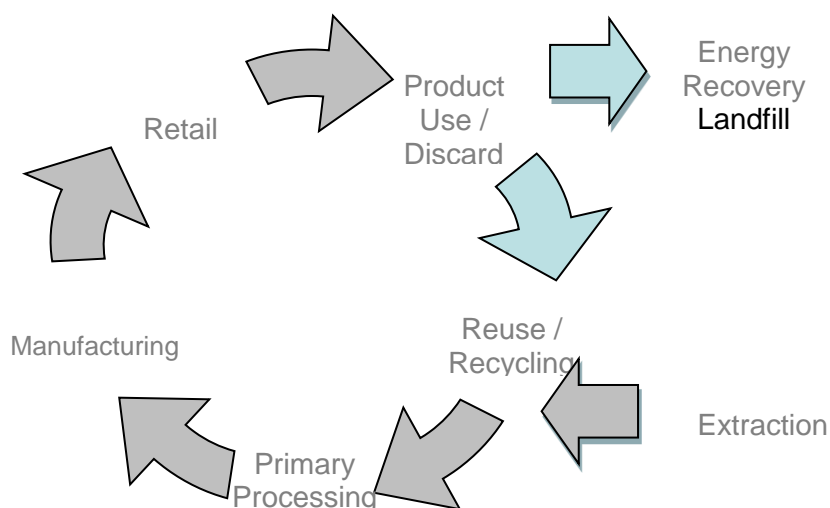
<http://www.dft.gov.uk/pgr/statistics/datatablespublications/freight/goodsbyroad/roadfreightstatistics2008>

⁷² McKinnon, A.C. (2007) Synchronised Auditing of Truck Utilisation and Energy Efficiency: A Review of the British Government's Transport KPI Programme. Available at: [http://www.greenlogistics.org/SiteResources/77a765d8-b458-4e5f-b9e0-1827e34f2f1f_Review%20of%20Transport%20KPI%20programme%20\(WCTR%202007\).pdf](http://www.greenlogistics.org/SiteResources/77a765d8-b458-4e5f-b9e0-1827e34f2f1f_Review%20of%20Transport%20KPI%20programme%20(WCTR%202007).pdf)

⁷³ IGD (2008) UK Food & Grocery Retail Logistics Overview Date Published: 15/01/2008. Available at:

<http://www.igd.com/our-expertise/Supply-chain/Logistics/3457/UK-Food--Grocery-Retail-Logistics-Overview/>

⁷⁴ The Greenhouse Gas Protocol (2010). Available at: www.ghgprotocol.org/downloads/calcs/CO2-mobile.pdf



Notes: Arrows represent transportation stages; greyed items are excluded.

Figure 3: Boundary of waste disposal data sets

- 11.26. Whereas the 2011 factors covered the whole life cycle of products and materials, the factors presented in the 2012 guidelines onwards have taken account of the changes in published accounting guidelines. A key change is that, as defined under the Scope 3 standard, emissions associated with recycling and energy recovery are attributed to the organisation which uses the recycled material or which uses the waste to generate energy. The emissions attributed to the company which generates the waste cover only the collection of waste from their site. This does not mean that these emissions are zero, or are not important; it simply means that, in accounting terms, these emissions are for another organisation to report.
- 11.27. The final waste disposal GHG emission factors for the 2014 update are provided in the tables of the 2014 GHG Conversion Factors.
- 11.28. The final emissions factor data summarised in the tables has been revised to be in line with company reporting requirements in the Scope 3 Standard. Under this standard, in order to avoid double-counting, the emissions associated with recycling are attributed to the user of the recycled materials, and the same attribution approach has also been applied to the emissions from energy generation from waste. Only transportation and minimal preparation emissions are attributed to the entity disposing of the waste. DEFRA will separately provide information on the full GHG impact of different waste disposal options.
- 11.29. Landfill emissions remain within the accounting scope of the organisation producing waste materials. Factors for landfill are shown. As noted above, these factors now exclude avoided emissions achieved through use of landfill gas to generate energy.

11.30. Figures for Refuse Collection Vehicles have been taken from the Environment Agency's Waste and Resource Assessment Tool for the Environment (WRATE)⁷⁵.

11.31. Transport distances for waste were estimated using a range of sources, principally data supplied by the Environment Agency for use in the WRATE tool (2005). The distances adopted are shown in Table 43.

Destination / Intermediate Destination	One Way Distance	Mode of transport	Source
Household, commercial and industrial landfill	25km by Road	26 Tonne Refuse Collection Vehicle, maximum capacity 12 tonnes	WRATE (2005)
Inert landfill	10km by Road		WRATE (2005)
Transfer station / CA site	10km by Road		
MRF	25km by Road		
MSW incinerator	50km by Road		
Cement kiln	50km by Road		
Recyclate	50km by Road	Average, all HGVs	WRATE (2005)
Inert recycling	10km by Road		WRATE (2005)

Table 43: Distances used in calculation of EFs

11.32. Road vehicles are volume limited rather than weight limited. For all HGVs, an average loading factor (including return journeys) of 56% is used based on DEFRA (2009)⁷⁶. Waste vehicles leave a depot empty and return fully laden. A 50% loading assumption reflects the change in load over a collection round which could be expected.

11.33. In landfill, it is assumed that as biogenic materials degrade, they will release greenhouse gases, including methane. A proportion of this is captured for flaring or electricity generation. In this methodology, we assume that 75% of methane is captured⁷⁷. 10% of uncaptured methane is assumed to be oxidised at the cap. Key data sources for waste disposal emissions are identified in Appendix 1.

11.34. Emissions from the landfill of different materials are calculated using WRATE and the LandGem model⁷⁸. Methane generation rate constants have been taken from IPCC⁷⁹.

⁷⁵ Environment Agency (2010), Waste and Resource Assessment Tool for the Environment. Available at: www.environment-agency.gov.uk/research/commercial/102922.aspx

⁷⁶ DEFRA (2009). Greenhouse Gas Conversion Factors. Available at: <http://archive.defra.gov.uk/environment/business/reporting/pdf/20090928-guidelines-ghg-conversion-factors.pdf>

⁷⁷ Jackson J, Choudrie S, Thistlethwaite G, Passant N, Murrells T, Watterson J, Mobbs D, Cardenas L, Thomson A, Leech A (2009) UK Greenhouse Gas Inventory, 1990 to 2007: Annual Report for submission under the Framework Convention on Climate Change Annex 3. Available at: <http://www.naei.org.uk/reports.php?list=GHG>

⁷⁸ US EPA (2005) Landfill Gas Emissions Model (LandGEM) V3.02. Available at: <http://www.epa.gov/ttn/catc1/products.html>

12. Fuel Properties

- 12.1. To complement the addition to the new fuel factor for 'Coal - home imports only', an accompanying fuel properties factor can now be found in this section of the data tables for the 2014 GHG Conversion Factors.
- 12.2. Information on standard fuel properties of key fuels is also provided in the GHG Conversion Factors for:
- Gross Calorific Value (GCV) in units of GJ/tonne and kWh/kg
 - Net Calorific Value (NCV) in units of GJ/tonne and kWh/kg
 - Density in units of litres/tonne and kg/m³
- 12.3. The standard emission factors from the UK GHGI in units of mass have been converted into different energy and volume units for the various data tables using information on these fuel properties (i.e. Gross and Net Calorific Values (CV), and fuel densities in litres/tonne) from DECC's Digest of UK Energy Statistics (DUKES) 2013.⁸⁰
- 12.4. Fuel properties (GCV, NCV and density) for CNG and biofuels are predominantly based on data from JEC - Joint Research Centre-EUCAR-CONCAWE collaboration, "Well-to-Wheels Analysis of Future Automotive Fuels and Powertrains in the European Context" Version 4, 2013 (Report EUR 26028 EN - 2013).⁸¹
- 12.5. Fuel properties for various forms of wood bioenergy are based on average information on wood pellets, wood chips, grasses/straw (bales) sourced from the BIOMASS Energy Centre (BEC), which is owned and managed by the UK Forestry Commission, via Forest Research, its research agency.⁸²

⁷⁹ IPCC (2006) Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan 2006. Available at: <http://www.ipcc-nggip.iges.or.jp/>

⁸⁰ Available at: <https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/digest-of-uk-energy-statistics-dukes>

⁸¹ Available at: <http://iet.jrc.ec.europa.eu/about-jec/>

⁸² 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, and http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,163182&_dad=portal&_schema=PORTAL

APPENDIX 1: Additional Methodological Information on the Material Consumption/Use and Waste Disposal Factors

1.0 Data Quality

This section explains the methodology for the choice of data used in the calculation of carbon emissions used in the waste management GHG Conversion Factors. Section 3.1 details the indicators used to assess whether data met the data quality standards required for this project. Section 3.2 states the sources used to collect data. Finally, Section 3.3 explains and justifies the use of data which did not meet the data quality requirements.

1.1 Data Quality Requirements

Data used in this methodology should meet the data quality indicators described in Table 1.1 below.

Data Quality Indicator	Requirement	Comments
Time-related coverage	Data less than 5 years old	Ideally data should represent the year of study. However, the secondary data in material eco-profiles is only periodically updated.
Geographical coverage	Data should be representative of the products placed on the market in the UK	Many datasets reflect European average production.
Technology coverage	Average technology	A range of information is available, covering best in class, average and pending technology. Average is considered the most appropriate but may not reflect individual supply chain organisations.
Precision / variance	No requirement	Many datasets used provide average data with no information on the range. It is therefore not possible to identify the variance.
Completeness	All datasets must be reviewed to ensure they cover inputs and outputs pertaining to the life cycle stage	
Representativeness	The data should represent UK conditions	This is determined by reference to the above data quality indicators

Data Quality Indicator	Requirement	Comments
Consistency	The methodology has been applied consistently.	
Reproducibility	An independent practitioner should be able to follow the method and arrive at the same results.	
Sources of data	Data will be derived from credible sources and databases	Where possible data in public domain will be used. All data sources referenced
Uncertainty of the information		Many data sources come from single sources. Uncertainty will arise from assumptions made and the setting of the system boundaries.

Table 1-1: Data Quality Indications for the waste management GHG factors

1.2 Data Sources

The methodology is based on published greenhouse gas emission data rather than data collected from onsite measurements directly.

Data has been taken from a combination of trade associations, who provide average information at a UK or European level, data from the Ecoinvent database and reports / data from third parties (e.g. academic journals, Intergovernmental Panel on Climate Change). Data on wood and many products are taken from published life cycle assessments as no trade association eco-profile is available. Data sources for transport are referenced in Section 11. Data on waste management options has been modelled using SimaPro⁸³ and WRATE.

Some data sources used do not meet the quality criteria. The implications of this are discussed in the following section.

1.3 Use of data below the set quality standard

Every effort has been made to obtain relevant and complete data for this project. For the majority of materials and products data which fits the quality standards defined in Section 1.1 above are met. However, it has not always been possible to find data which meets these standards in a field which is still striving to meet the increasing data demands set by science and government. This section details data which do not meet the expected quality standard set out in the methodology of this project but were never-the-less included because they represent the best current figures available. The justification for inclusion of each dataset is explained. The most common data quality issues encountered concerned data age and availability.

⁸³ SimaPro (2010). Life Cycle Assessment Software. Available at: <http://www.lifecycles.com.au/#!simapro/c1il2>

Wood and Paper data

Published data on wood products is sparse, an issue highlighted by the Waste and Resources Action Programme (WRAP) in 2006 and 2010⁸⁴. Data used in this report for material consumption is based on studies from the USA, where production processes may not be representative of activity in the UK (e.g. different fuel mix to generate electricity). This data should therefore be viewed with caution. Data on different types of wood has been used in combination with information on the composition of wood waste in the UK⁸⁵ to provide a figure which represents a best estimate of the impact of a typical tonne of wood waste.

Many trade associations publish data on the impact of manufacturing 100% primary and 100% recycled materials. However, for various reasons, the bodies representing paper and steel only produce industry average profile data, based on a particular recycling rate.

Furthermore, paper recycling in particular is dependent on Asian export markets, for which information on environmental impacts of recycling or primary production is rare. This means that the relative impact of producing paper from virgin and recycled materials is difficult to identify. The figure for material consumption for paper represents average production, rather than 100% primary material, so already accounts for the impact of recycling. Caution should therefore be taken in using these numbers.

Steel data

The figures on steel production are an estimate only and should be treated as such.

Plastics data

Whilst not an issue from a data quality perspective, Plastics Europe are in the process of updating the Life Cycle Inventories for plastic polymers. Again, as the publications are updated the factors for material consumption for plastics can be updated.

Data on polystyrene recycling does not meet the age criteria, as it originates from one 2002 study. This will be updated as new sources are identified.

Textiles and footwear

The BIO IS study is the most relevant data source to calculate the carbon factors for textiles even though the report is not yet published. This is because the factor proposed is based upon the market share of all textile products in Europe, categorised by product types and fibre types. The factor is considered to be representative of household textiles in general rather than specific fibres. It is understood that this will be published by the EU.

Information for footwear comes from one study from the USA. As with wood, this may not reflect UK impacts, and so the results should be viewed with caution.

⁸⁴ WRAP (2006) Environmental Benefits of Recycling and WRAP (2010) Environmental Benefits of Recycling – 2010 update. WRAP; Banbury. Available at:

http://www.wrap.org.uk/sites/files/wrap/Executive_summary_Environmental_benefits_of_recycling_-_2010_update.d1af1398.8671.pdf

⁸⁵ WRAP (2009) Wood Waste Market in the UK WRAP; Banbury. Available at:

<http://www.wrap.org.uk/sites/files/wrap/Wood%20waste%20market%20in%20the%20UK.pdf>

Oil Data

Vegetable oil factors are based on studies of rapeseed oil. There is discussion in scientific journals on which is the appropriate oil to use when assessing environmental impacts, since growth is strongest in palm oil manufacture and use. However, palm oil has particular properties (e.g. high ignition point) which mean its use as a standalone product, rather than as an ingredient in other products, is limited.

Mineral oil will be included in the waste management GHG factors. Although there is no available data on waste arising for mineral oil, this waste stream is banned from landfill. Therefore, it is assumed that all collected mineral oil is recycled or combusted and the data on recycled mineral oil is used both for the arising and the recycled figure.

Excluded Materials and Products

For some materials and products, such as automotive batteries and fluorescent tubes, no suitable figures have been identified to date. WRAP are in the process of identifying factors for industrial waste streams, furniture and paint.

2.0 Data Sources

Material	Reference	
	Material Consumption	Waste Disposal
Aluminium cans and foil	European Aluminium Association (2008) <i>Environmental Profile Report for the European Aluminium Industry</i> , European Aluminium Association	WRATE (2005)
Steel Cans	Estimate based on data from World Steel Life Cycle Inventory (2009), BOF route, 1kg, weighted average, EU, World Steel Association, Brussels	WRATE (2005)
Mixed Cans	Estimate based on aluminium and steel data.	WRATE (2005)
Glass	PE International (2009) <i>Life Cycle Assessment of Container Glass in Europe</i> FEVE; Brussels	
Wood	Corrim (2005 & 2010) <i>Life Cycle Environmental Performance of Renewable Building Materials in the Context of Residential Construction</i> ; Corrim, Seattle WRAP (2009) <i>Life Cycle Assessment of Closed Loop MDF Recycling</i> ; WRAP, Banbury	WRAP (2009) <i>Life Cycle Assessment of Closed Loop MDF Recycling</i> ; WRAP, Banbury Gasol C., Farreny, R., Gabarrell, X., and Rieradevall, J., (2008) Life cycle assessment comparison among different reuse intensities for industrial wooden containers <i>The International Journal of LCA</i> Volume 13, Number 5, 421-431 Merrild, H., and Christensen, T.H. (2009) Recycling of wood for particle board production: accounting of greenhouse gases and global warming contributions <i>Waste Management and Research</i> (27) 781-788 WRATE (2005)
Aggregates (Rubble)	WRAP CO ₂ Emissions Estimator Tool Environment Agency (2007) Construction Carbon Calculator	

Material	Reference	
Paper	Ecoinvent v2.0 (2007) Swiss Centre for Life Cycle Inventories	Ecoinvent v2.0 (2007) Swiss Centre for Life Cycle Inventories
Books	Estimate based on paper	
Board	FEFCO (2009) <i>European Database for Corrugated Board Life Cycle Studies</i> , FEFCO Procarton (2009) <i>Carbon Footprint for Cartons</i> , Zurich, Switzerland	Ecoinvent v2.0 (2007) Swiss Centre for Life Cycle Inventories
Mixed paper and board	Estimate based on above	
Scrap Metal	British Metals Recycling Association (<i>website</i> ⁸⁶) Ecoinvent v2.0 (2007) Swiss Centre for Life Cycle Inventories	Ecoinvent v2.0 (2007) Swiss Centre for Life Cycle Inventories WRATE (2005)
Incinerator Residues (Non Metal)	To be identified	To be identified
Automotive Batteries	To be identified	To be identified
WEEE - Fluorescent Tubes	To be identified	To be identified
WEEE - Fridges and Freezers	ISIS (2008) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 13: Domestic Refrigerators & Freezers	ISIS (2008) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 13: Domestic Refrigerators & Freezers WRATE (2005)
Food and Drink Waste	Several data sources used to estimate food production impacts. WRAP (2011) <i>The Water and Carbon Footprint of UK Household Food Waste</i>	AFOR (2009) <i>Market survey of the UK organics recycling industry - 2007/08</i> ; WRAP, Banbury (Substitution rates for compost) Williams AG, Audsley E and Sandars DL (2006) <i>Determining the Environmental Burdens and Resource Uses in the Production of Agricultural and Horticultural Commodities. Main Report. ISO205</i> , DEFRA (avoided fertiliser impacts)
Garden Waste	-	Kranert, M. & Gottschall (2007) <i>Grünabfälle – besser kompostieren oder energetisch verwerten?</i> Eddie (information on peat) DEFRA (unpublished) (information on composting impacts)

⁸⁶ http://www.recyclemetals.org/about_metal_recycling

Material	Reference	
Plastics:		
LDPE and LLDPE (excel forming)	Boustead (2005) <i>Eco-profiles of the European Plastics Industry Low Density Polyethylene (LDPE)</i> . Plastics Europe, Brussels	WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
HDPE (excel forming)	Boustead (2005) <i>Eco-profiles of the European Plastics Industry High Density Polyethylene (HDPE)</i> . Plastics Europe, Brussels	WRAP (2010) LCA of Example Milk Packaging Systems; WRAP, Banbury
PP (excel forming)	Boustead (2005) <i>Eco-profiles of the European Plastics Industry Polypropylene (PP)</i> . Plastics Europe, Brussels	WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
PVC (excel forming)	Boustead (2005) <i>Eco-profiles of the European Plastics Industry Polyvinyl Chloride (PVC) (Suspension)</i> . Plastics Europe, Brussels	WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
PS (excel forming)	Boustead (2005) <i>Eco-profiles of the European Plastics Industry Polystyrene (High Impact) (HIPS)</i> . Plastics Europe, Brussels	PWC (2002) <i>Life Cycle Assessment of Expanded Polystyrene Packaging</i> , Umps
PET (excel forming)	Boustead (2005) <i>Eco-profiles of the European Plastics Industry Polyethylene Terephthalate (PET)</i> . Plastics Europe, Brussels	WRAP (2010) LCA of Example Milk Packaging Systems; WRAP, Banbury
Average plastic film (inch bags)	Based on split in AMA Research (2009) <i>Plastics Recycling Market UK 2009-2013</i> , UK; Cheltenham	WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
Average plastic rigid (inch bottles)		
Clothing	BIO IS (unpublished data)	Farrant (2008) <i>Environmental Benefit from Reusing Clothes</i> , WRATE (2005)
Footwear	Albers, K., Canapé, P., Miller, J. (2008) <i>Analysing the Environmental Impacts of Simple Shoes</i> , University of Santa Barbara, California	
Furniture	To be updated following pending WRAP research	
WEEE – Large	Huisman, J., et al (2008) <i>2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment – Study No. 07010401/2006/442493/ETU/G4</i> , United Nations University, Bonn Germany	
WEEE – Mixed		
WEEE – Small		
Batteries (Post Consumer Non-Automotive)	-	DEFRA (2006) <i>Battery Waste Management Life Cycle Assessment</i> , prepared by ERM; WRAP, Banbury
Paint	Althaus et al (2007) <i>Life Cycle Inventories of Chemicals, Final report Ecoinvent data v2.2</i> ; ESU Services, Switzerland CBI (2009) Market Survey The paints and other coatings market in the United Kingdom; CBI, The Netherlands	-

Material	Reference
Vegetable Oil	Schmidt, J (2010) Comparative life cycle assessment of rapeseed oil and palm oil <i>International Journal of LCA</i> , 15, 183-197 Schmidt, Jannick and Weidema, B., (2008) Shift in the marginal supply of vegetable oil <i>International Journal of LCA</i> , 13, 235-239
Mineral Oil	IFEU (2005) <i>Ecological and energetic assessment of re-refining used oils to base oils: Substitution of primarily produced base oils including semi-synthetic and synthetic compounds</i> ; GEIR
Plasterboard	WRAP (2008) <i>Life Cycle Assessment of Plasterboard</i> , prepared by ERM; WRAP; Banbury
Aggregates	WRAP (2008) <i>Life Cycle Assessment of Aggregates</i>
Concrete	Hammond, G.P. and Jones (2008) <i>Embodied Energy and Carbon in Construction Materials</i> Prc Instn Civil Eng, WRAP (2008) <i>Life Cycle Assessment of Aggregates</i>
Bricks	Environment Agency (2011) <i>Carbon Calculator</i> USEPA (2003) <i>Background Document for Life-Cycle Greenhouse Gas Emission Factors for Clay Brick Reuse and Concrete Recycling</i> Christopher Koroneos, Aris Dompros, <i>Environmental assessment of brick production in Greece</i> , <i>Building and Environment</i> , Volume 42, Issue 5, May 2007, Pages 2114-2123
Asphalt	Aggregain (2010) <i>CO₂ calculator</i>
Asbestos	Swiss Centre for Life Cycle Inventories (2007) <i>Ecoinvent</i>
Insulation	Hammond, G.P. and Jones (2008) <i>Embodied Energy and Carbon in Construction Materials</i> Prc Instn Civil Eng WRAP (2008) <i>Recycling of Mineral Wool Composite Panels Into New Raw Materials</i>

3.0 Greenhouse Gas Conversion Factors

Industrial Designation or Common Name	Chemical Formula	Lifetime (years)	Radiative Efficiency ($\text{Wm}^{-2} \text{ppb}^{-1}$)	Global Warming Potential with 100 year time horizon (previous estimates for 1 st IPCC assessment report)	Possible source of emissions
Carbon dioxide	CO ₂	Variable	1.4×10^{-5}	1	Combustion of fossil fuels
Methane	CH ₄	12	3.7×10^{-4}	25 (23)	Decomposition of biodegradable material, enteric emissions.
Nitrous Oxide	N ₂ O	114	3.03×10^{-3}	298 (296)	N ₂ O arises from Stationary Sources, mobile sources, manure, soil management and agricultural residue burning, sewage, combustion and bunker fuels
Sulphur hexafluoride	SF ₆	3200	0.52	22,800 (22,200)	Leakage from electricity substations, magnesium smelters, some consumer goods
HFC 134a (R134a refrigerant)	CH ₂ FCF ₃	14	0.16	1,430 (1,300)	Substitution of ozone depleting substances, refrigerant manufacture / leaks, aerosols, transmission and distribution of electricity.
Dichlorodifluoromethane CFC 12 (R12 refrigerant)	CCl ₂ F ₂	100	0.32	10900	
Difluoromono-chloromethane HCFC 22 (R22 refrigerant)	CHClF ₂	12	0.2	1810	

No single lifetime can be determined for carbon dioxide because of the difference in timescales associated with long and short cycle biogenic carbon. For a calculation of lifetimes and a full list of greenhouse gases and their global warming potentials please see:

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller (eds.) (2007) *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge University Press, Cambridge, United Kingdom Table 2.14. *Lifetimes, radiative efficiencies and direct (except for CH₄) global warming potentials (GWP) relative to CO₂*. Available at: <http://www.ipcc.ch/ipccreports/assessments-reports.htm>

APPENDIX 2: Updated full time series – Electricity and Heat and Steam Factors

The tables below provide the fully updated and consistent timeseries data for electricity, heat and steam emission factors. This is provided for organisations wishing to use fully consistent timeseries data for purposes OTHER than for company reporting (e.g. policy analysis).

Data Year	Electricity Generation ⁽¹⁾	Total Grid Losses ⁽²⁾	UK electricity generation emissions ⁽³⁾ , ktonne		
	GWh	%	CO ₂	CH ₄	N ₂ O
1990	290,666	8.08%	204,614	2.671	5.409
1991	293,743	8.27%	201,213	2.499	5.342
1992	291,692	7.55%	189,327	2.426	5.024
1993	294,935	7.17%	172,927	2.496	4.265
1994	299,889	9.57%	168,551	2.658	4.061
1995	310,333	9.07%	165,700	2.781	3.902
1996	324,724	8.40%	164,875	2.812	3.612
1997	324,412	7.79%	152,439	2.754	3.103
1998	335,035	8.40%	157,171	2.978	3.199
1999	340,218	8.25%	149,036	3.037	2.772
2000	349,263	8.38%	160,927	3.254	3.108
2001	358,185	8.56%	171,470	3.504	3.422
2002	360,496	8.26%	166,751	3.490	3.223
2003	370,639	8.47%	177,054	3.686	3.536
2004	367,881	8.71%	175,883	3.665	3.415
2005	370,976	7.25%	175,106	4.123	3.579
2006	368,313	7.21%	184,538	4.258	3.927
2007	365,252	7.34%	181,280	4.227	3.624
2008	356,778	7.43%	176,534	4.486	3.386
2009	343,403	7.87%	155,249	4.463	2.915
2010	348,610	7.31%	160,231	4.653	3.028
2011	330,054	7.78%	147,823	4.609	3.038
2012	320,470	8.04%	161,903	5.258	3.934

Notes:

- (1) Based upon calculated total for centralised electricity generation (GWh supplied) from DUKES (2013) Table 5.6 Electricity fuel use, generation and supply. The total consistent with UNFCCC emissions reporting categories 1A1a+1A2f includes (according to Table 5.6 categories) GWh supplied (net) from all thermal and non-thermal sources except 'wind and solar'; plus GWh supplied from thermal renewables + coal and gas thermal sources, hydro-natural flow and other non-thermal sources from 'Other generators'.
- (2) Based upon calculated net grid losses from data in DUKES (2013) Table 5.1.2 (long term trends, only available online).
- (3) Emissions from UK centralised power generation (including Crown Dependencies only) listed under UNFCC reporting category 1A1a and autogeneration - exported to grid (UK Only) listed under UNFCC reporting category 1A2f from the UK Greenhouse Gas Inventory for 2012 (Ricardo-AEA, 2014)

Table 44: Base electricity generation emissions data - most recent datasets for timeseries

2014 Government GHG Conversion Factors for Company Reporting:
Methodology Paper for Emission Factors

Data Year	Emission Factor, kgCO ₂ e / kWh												% Net Electricity Imports	Imported Electricity EF
	For electricity GENERATED (supplied to the grid)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)					
	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	TOTAL	kgCO ₂ e / kWh
1990	0.70395	0.00019	0.00577	0.70991	0.06185	0.00002	0.00051	0.06237	0.76580	0.00021	0.00628	0.77229	3.85%	0.11300
1991	0.68500	0.00018	0.00564	0.69081	0.06175	0.00002	0.00051	0.06228	0.74675	0.00019	0.00615	0.75309	5.18%	0.12790
1992	0.64907	0.00017	0.00534	0.65458	0.05298	0.00001	0.00044	0.05343	0.70205	0.00019	0.00578	0.70801	5.29%	0.10097
1993	0.58632	0.00018	0.00448	0.59098	0.04528	0.00001	0.00035	0.04564	0.63160	0.00019	0.00483	0.63662	5.25%	0.06828
1994	0.56204	0.00019	0.00420	0.56643	0.05950	0.00002	0.00044	0.05996	0.62154	0.00021	0.00464	0.62639	5.22%	0.06899
1995	0.53394	0.00019	0.00390	0.53803	0.05327	0.00002	0.00039	0.05368	0.58721	0.00021	0.00429	0.59170	4.97%	0.07830
1996	0.50774	0.00018	0.00345	0.51137	0.04658	0.00002	0.00032	0.04691	0.55432	0.00020	0.00376	0.55828	4.80%	0.08212
1997	0.46989	0.00018	0.00297	0.47304	0.03972	0.00002	0.00025	0.03998	0.50961	0.00019	0.00322	0.51302	4.76%	0.07552
1998	0.46912	0.00019	0.00296	0.47226	0.04299	0.00002	0.00027	0.04328	0.51211	0.00020	0.00323	0.51555	3.51%	0.10497
1999	0.43806	0.00019	0.00253	0.44077	0.03940	0.00002	0.00023	0.03964	0.47745	0.00020	0.00275	0.48041	3.94%	0.09039
2000	0.46076	0.00020	0.00276	0.46372	0.04217	0.00002	0.00025	0.04244	0.50293	0.00021	0.00301	0.50616	3.82%	0.08117
2001	0.47872	0.00021	0.00296	0.48189	0.04482	0.00002	0.00028	0.04512	0.52354	0.00022	0.00324	0.52701	2.78%	0.06550
2002	0.46256	0.00020	0.00277	0.46554	0.04162	0.00002	0.00025	0.04189	0.50418	0.00022	0.00302	0.50742	2.24%	0.07114
2003	0.47770	0.00021	0.00296	0.48087	0.04420	0.00002	0.00027	0.04449	0.52190	0.00023	0.00323	0.52536	0.57%	0.07478
2004	0.47810	0.00021	0.00288	0.48119	0.04561	0.00002	0.00027	0.04591	0.52371	0.00023	0.00315	0.52710	1.97%	0.07244
2005	0.47201	0.00023	0.00299	0.47524	0.03687	0.00002	0.00023	0.03712	0.50888	0.00025	0.00322	0.51236	2.16%	0.08482
2006	0.50104	0.00024	0.00331	0.50458	0.03896	0.00002	0.00026	0.03923	0.53999	0.00026	0.00356	0.54382	1.97%	0.07754
2007	0.49631	0.00024	0.00308	0.49963	0.03930	0.00002	0.00024	0.03956	0.53561	0.00026	0.00332	0.53920	1.37%	0.08121
2008	0.49480	0.00026	0.00294	0.49801	0.03969	0.00002	0.00024	0.03995	0.53449	0.00029	0.00318	0.53796	2.91%	0.07784
2009	0.45209	0.00027	0.00263	0.45499	0.03860	0.00002	0.00022	0.03885	0.49069	0.00030	0.00286	0.49385	0.80%	0.08417
2010	0.45963	0.00028	0.00269	0.46260	0.03623	0.00002	0.00021	0.03646	0.49586	0.00030	0.00291	0.49907	0.73%	0.08540
2011	0.44788	0.00029	0.00285	0.45102	0.03777	0.00002	0.00024	0.03804	0.48565	0.00032	0.00309	0.48906	1.76%	0.06522
2012	0.50520	0.00034	0.00381	0.50935	0.04418	0.00003	0.00033	0.04454	0.54938	0.00037	0.00414	0.55389	3.40%	0.06522

Notes: The dataset above uses the most recent, consistent data sources across the entire timeseries.

Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) / (1 - %Electricity Total Grid LOSSES)

Emission Factor (Electricity LOSSES) = Emission Factor (Electricity CONSUMED) - Emission Factor (Electricity GENERATED)

⇒ Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) + Emission Factor (Electricity LOSSES),

Table 45: Base electricity generation emission factors (excluding imported electricity) – fully consistent timeseries dataset

Data Year	Emission Factor, kgCO ₂ e / kWh												% Net Electricity Imports	Imported Electricity EF kgCO ₂ e / kWh
	For electricity GENERATED (supplied to the grid, plus imports)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)					
	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	TOTAL	
1990	0.68120	0.00019	0.00558	0.68697	0.05985	0.00002	0.00049	0.06036	0.74106	0.00020	0.00607	0.74733	3.85%	0.11300
1991	0.65616	0.00017	0.00540	0.66174	0.05915	0.00002	0.00049	0.05966	0.71532	0.00019	0.00589	0.72139	5.18%	0.12790
1992	0.62005	0.00017	0.00510	0.62532	0.05061	0.00001	0.00042	0.05104	0.67066	0.00018	0.00552	0.67636	5.29%	0.10097
1993	0.55913	0.00017	0.00428	0.56358	0.04318	0.00001	0.00033	0.04352	0.60232	0.00018	0.00461	0.60710	5.25%	0.06828
1994	0.53633	0.00018	0.00401	0.54051	0.05678	0.00002	0.00042	0.05722	0.59311	0.00020	0.00443	0.59773	5.22%	0.06899
1995	0.51130	0.00018	0.00373	0.51521	0.05101	0.00002	0.00037	0.05140	0.56231	0.00020	0.00410	0.56661	4.97%	0.07830
1996	0.48731	0.00017	0.00331	0.49080	0.04471	0.00002	0.00030	0.04502	0.53202	0.00019	0.00361	0.53582	4.80%	0.08212
1997	0.45112	0.00017	0.00285	0.45414	0.03813	0.00001	0.00024	0.03839	0.48925	0.00019	0.00309	0.49253	4.76%	0.07552
1998	0.45633	0.00018	0.00288	0.45939	0.04182	0.00002	0.00026	0.04210	0.49816	0.00020	0.00314	0.50150	3.51%	0.10497
1999	0.42438	0.00018	0.00245	0.42700	0.03816	0.00002	0.00022	0.03840	0.46254	0.00020	0.00267	0.46541	3.94%	0.09039
2000	0.44628	0.00019	0.00267	0.44914	0.04084	0.00002	0.00024	0.04111	0.48712	0.00021	0.00292	0.49024	3.82%	0.08117
2001	0.46725	0.00020	0.00289	0.47034	0.04375	0.00002	0.00027	0.04404	0.51100	0.00022	0.00316	0.51438	2.78%	0.06550
2002	0.45378	0.00020	0.00272	0.45670	0.04083	0.00002	0.00024	0.04109	0.49461	0.00022	0.00296	0.49779	2.24%	0.07114
2003	0.47540	0.00021	0.00294	0.47855	0.04399	0.00002	0.00027	0.04428	0.51939	0.00023	0.00322	0.52283	0.57%	0.07478
2004	0.47012	0.00021	0.00283	0.47316	0.04485	0.00002	0.00027	0.04514	0.51498	0.00023	0.00310	0.51830	1.97%	0.07244
2005	0.46365	0.00023	0.00294	0.46682	0.03622	0.00002	0.00023	0.03646	0.49987	0.00025	0.00317	0.50328	2.16%	0.08482
2006	0.49269	0.00024	0.00325	0.49618	0.03831	0.00002	0.00025	0.03858	0.53100	0.00026	0.00350	0.53476	1.97%	0.07754

Data Year	Emission Factor, kgCO ₂ e / kWh												% Net Electricity Imports	Imported Electricity EF
	For electricity GENERATED (supplied to the grid, plus imports)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)					
	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	CO ₂	CH ₄	N ₂ O	Total	TOTAL	kgCO ₂ e / kWh
2007	0.49061	0.00024	0.00304	0.49389	0.03885	0.00002	0.00024	0.03911	0.52946	0.00026	0.00328	0.53300	1.37%	0.08121
2008	0.48265	0.00026	0.00287	0.48578	0.03872	0.00002	0.00023	0.03897	0.52137	0.00028	0.00310	0.52474	2.91%	0.07784
2009	0.44915	0.00027	0.00261	0.45204	0.03835	0.00002	0.00022	0.03860	0.48750	0.00029	0.00284	0.49064	0.80%	0.08417
2010	0.45689	0.00028	0.00268	0.45985	0.03601	0.00002	0.00021	0.03625	0.49291	0.00030	0.00289	0.49610	0.73%	0.08540
2011	0.44114	0.00029	0.00281	0.44424	0.03721	0.00002	0.00024	0.03747	0.47834	0.00031	0.00305	0.48170	1.76%	0.06522
2012	0.49023	0.00033	0.00369	0.49426	0.04287	0.00003	0.00032	0.04322	0.53310	0.00036	0.00402	0.53748	3.40%	0.06522

Notes: The dataset above uses the most recent, consistent data sources across the entire timeseries.

Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) / (1 - %Electricity Total Grid LOSSES)

Emission Factor (Electricity LOSSES) = Emission Factor (Electricity CONSUMED) - Emission Factor (Electricity GENERATED)

⇒ Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) + Emission Factor (Electricity LOSSES)

Table 46: Base electricity generation emissions factors (including imported electricity) – fully consistent timeseries dataset

Data Year	KgCO ₂ /kWh supplied heat/steam			KgCO ₂ /kWh supplied power		
	Method 1 (DUKES: 2/3rd - 1/3rd)	Method 2 (Boiler displaced)	Method 3 (Power displaced)	Method 1 (DUKES: 2/3rd - 1/3rd)	Method 2 (Boiler displaced)	Method 3 (Power displaced)
2001	0.23605	0.26158	0.05862	0.22545	0.19383	0.44513
2002	0.22830	0.25207	0.07057	0.23620	0.20716	0.42894
2003	0.23180	0.25991	0.04880	0.23165	0.19929	0.44228
2004	0.22639	0.25513	0.05354	0.23967	0.20734	0.43415
2005	0.21959	0.24639	0.05081	0.23774	0.20890	0.41929
2006	0.22929	0.25385	0.06184	0.25521	0.22927	0.43198
2007	0.22988	0.25349	0.04025	0.24309	0.21965	0.43136
2008	0.22396	0.24680	0.04054	0.23516	0.21214	0.41998
2009	0.22089	0.24430	0.04545	0.23903	0.21545	0.41572
2010	0.21682	0.23968	0.05403	0.23930	0.21563	0.40786
2011	0.21500	0.23856	0.05893	0.24330	0.21875	0.40595
2012	0.20539	0.23419	0.04379	0.21689	0.18452	0.39852

Notes: Added data, 1 October 2014.

Table 47: Comparison of calculated Electricity and Heat/Steam CO₂ emission factors for the 3 different allocation method – fully consistent timeseries dataset

APPENDIX 3: Summary and Explanation of Major Changes to Emission Factors Compared to the 2013 GHG Conversion Factors

The following table provides a summary of major changes (i.e. greater than 10% change) in emission factors for the 2014 GHG Conversion Factors, compared to the equivalent factors provided in the 2013 GHG Conversion Factors, and a short explanation for the reason for the change.

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
Fuels (former Annex 1 tables)							
1	CNG	CH ₄	All	13%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
2	LNG	CH ₄	All	13%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
3	LPG	All	mass	n/a	Per tonne factor for LPG added this year.		(ii)
4	Natural gas	CH ₄	Gross CV	13%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
5	Natural gas	CH ₄	Net CV	13%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
6	Natural gas	All	mass	n/a	Per tonne factor for natural gas added this year.		(ii)
7	Aviation spirit	CH ₄	All	-51%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
8	Diesel (average biofuel blend)	CH ₄	All	-14%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
9	Diesel (100% mineral)	CH ₄	Net CV	-14%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
10	Diesel (100% mineral)	CH ₄	volume	-15%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
11	Coal (industrial)	CH ₄	Gross CV	-12%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
12	Coal (industrial)	N ₂ O	Gross CV	10%	Change due to difference in NEAI N ₂ O activity data.		(i)
13	Coal (industrial)	CH ₄	Net CV	-12%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
14	Coal (industrial)	N ₂ O	Net CV	10%	Change due to difference in NEAI N ₂ O activity data.		(i)
15	Coal (industrial)	CH ₄	mass	-14%	Change due to difference in NEAI CH ₄ emission factor and activity data.		(i)
16	Coal (electricity generation - home produced coal only)	All	Gross CV	n/a	New coal factor for coal used in power stations to generate electricity (only for coal produced in the UK).	Section II	(ii)
17	Coal (electricity generation - home produced coal only)	All	Net CV	n/a	New coal factor for coal used in power stations to generate electricity (only for coal produced in the UK).	Section II	(ii)
18	Coal (electricity generation - home produced coal only)	All	mass	n/a	New coal factor for coal used in power stations to generate electricity (only for coal produced in the UK).	Section II	(ii)
WTT- fuels (former Annex 1 tables)							
19	LPG	All indirect / WTT	Mass	n/a	Per tonne factor for LPG added this year.		(ii)
20	Natural gas	All indirect / WTT	Mass	n/a	Per tonne factor for natural gas added this year.		(ii)
21	Natural gas	All indirect / WTT	Gross CV	-12%	JRC WTT natural gas dataset has been corrected/updated.	Section II	(iii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
22	Natural gas	All indirect / WTT	Net CV	-12%	JRC WTT natural gas dataset has been corrected/updated.	Section II	(iii)
23	Natural gas	All indirect / WTT	Volume	-11%	JRC WTT natural gas dataset has been corrected/updated.	Section II	(iii)
24	Naphtha	All indirect / WTT	Gross CV	44%	Significant increase in the base dataset from JRC-EUCAR-CONCAWE in the latest update.	Section II	(iii)
25	Naphtha	All indirect / WTT	Net CV	44%	Significant increase in the base dataset from JRC-EUCAR-CONCAWE in the latest update.	Section II	(iii)
26	Naphtha	All indirect / WTT	Mass	44%	Significant increase in the base dataset from JRC-EUCAR-CONCAWE in the latest update.	Section II	(iii)
UK Electricity, including managed assets (former Annex 3 tables)							
27	Electricity EFs	All	kWh	11% to 31.3%	Significant increase in coal powered electricity generation share in 2012		(iv)
Heat and steam (former Annex 3 tables)							
28	Heat/Steam	CH ₄ and N ₂ O	kWh	182% and 1304% (respectively)	Changes to base emission factors used for some of the CHP fuels have made; specifically domestic refuse and refuse derived fuels.	Section III	(i)
29	District heat & steam distribution	CH ₄ and N ₂ O	kWh	182% and 1304% (respectively)	Changes to base emission factors used for some of the CHP fuels have made; specifically domestic refuse and refuse derived fuels.	Section III	(i)
WTT -Heat and steam (former Annex 3 tables)							
30	Heat/Steam	All indirect / WTT	kWh	-51%	Reduction in natural gas WTT figure used in the majority of CHP.		(iii)
31	District heat & steam distribution	All indirect / WTT	kWh	-51%	Reduction in natural gas WTT figure used in the majority of CHP.		(iii)
Transmission and distribution (former Annex 3 tables)							
32	Electricity, losses in transmission and distribution	All	kWh	13% to 50%	Significant increase in coal powered electricity generation share in 2012		(iv)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
33	Distribution - district heat & steam	All	kWh	12% to 162%	Significant increases to base emission factors from NAEI for a number of fuels.		(i)
Business travel- land (former Annex 6 tables)							
34	Regular Taxi	CO ₂ and CO ₂ e	passenger.km & km	23%	Methodology change - new source of data based on specific taxi drive cycles (higher fuel consumption).		(v)
35	Regular Taxi	CH ₄	passenger.km	12%	Methodology change - new source of data based on specific taxi drive cycles (higher fuel consumption).		(v)
36	Black cab	CO ₂ and CO ₂ e	passenger.km & km	43%	Methodology change - new source of data based on specific taxi drive cycles (higher fuel consumption).		(v)
37	Local bus (not London)	CH ₄	passenger.km	-10%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
38	Local London bus	CH ₄	passenger.km	-17%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
39	Average local bus	CH ₄	passenger.km	-11%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
40	National rail	N ₂ O	passenger.km	20%	N ₂ O - changes in base inventory datasets.		(vi)
41	International rail	N ₂ O	passenger.km	13%	N ₂ O - changes in base inventory datasets.		(vi)
42	Light rail and tram	N ₂ O	passenger.km	21%	N ₂ O - changes in base inventory datasets.		(vi)
43	London Underground	N ₂ O	passenger.km	18%	N ₂ O - changes in base inventory datasets.		(vi)
WTT- passenger vehicles and business travel- land (former Annex 6 tables)							
44	Medium car - CNG	All indirect / WTT	km	-11%	Reduction in natural gas WTT emission factor and a reduction in LNG imports which reduces this WTT factor further.		(iii)
45	Medium car - CNG	All indirect / WTT	miles	-11%	Reduction in natural gas WTT emission factor and a reduction in LNG imports which reduces this WTT factor further.		(iii)
46	Large car - CNG	All indirect / WTT	km & miles	-11%	Reduction in natural gas WTT emission factor and a reduction in LNG imports which reduces this WTT factor further.		(iii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
47	Average car - CNG	All indirect / WTT	km	-11%	Reduction in natural gas WTT emission factor and a reduction in LNG imports which reduces this WTT factor further.		(iii)
48	Average car - CNG	All indirect / WTT	miles	-11%	Reduction in natural gas WTT emission factor and a reduction in LNG imports which reduces this WTT factor further.		(iii)
49	Regular Taxi	All indirect / WTT	passenger.km & km	26%	Methodology change - new source of data based on specific taxi drive cycles (higher fuel consumption)		(v)
50	Black cab	All indirect / WTT	passenger.km & km	46%	Methodology change - new source of data based on specific taxi drive cycles (higher fuel consumption)		(v)
Delivery vehicles and freighting goods, including managed assets (former Annex 7 tables)							
51	Average LPG van up to 3.5 tonne	CH ₄	All	-69%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
52	HGV - Rigid, (>3.5 - 7.5 tonnes), diesel, all laden weights	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
53	HGV - Rigid, (>7.5 tonnes-17 tonnes), diesel, all laden weights	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
54	HGV - Rigid, (>17 tonnes), diesel, all laden weights	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
55	HGV - All rigid, diesel, average laden	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
56	HGV - All rigid, diesel, 0%, 50% and 100% laden	All	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
57	HGV - Articulated (>3.5 -33t), diesel, all laden weights	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
58	HGV - Articulated (>33t), diesel, all laden weights	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
59	HGV - All artics diesel, average laden	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
60	HGV - All artics, diesel, 0%, 50% and 100% laden	All	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
61	All HGVs, diesel, average laden	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
62	All HGVs, diesel, 0%, 50% and 100% laden	All	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
63	Refrigerated HGVS - Rigid, (>3.5 - 7.5 tonnes), diesel, all laden weights	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
64	Refrigerated HGVs - Rigid, (>7.5 tonnes-17 tonnes), diesel, all laden weights	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
65	Refrigerated HGVs - Rigid, (>17 tonnes), diesel, all laden weights	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
66	All rigids HGVs, diesel, average laden	CH ₄	All	-68%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
67	Refrigerated HGVs - All rigids, diesel, 0%, 50% and 100% laden	All	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
68	Refrigerated HGVs- Articulated (>33t), diesel, all laden weights	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
69	Refrigerated HGVs - Articulated (>33t), diesel, all laden weights	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
70	Refrigerated HGVs- All artics diesel, average laden	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
71	Refrigerated HGVs- All artics, diesel, 0%, 50% and 100% laden	All	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
72	Refrigerated - All HGVs, diesel, average laden	CH ₄	All	-70%	Change in NAEI CH ₄ emission factors mainly due to fleet composition shifts.		(i)
73	Refrigerated - All HGVs, diesel, 0%, 50% and 100% laden	All	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
74	Freight flights - Domestic, with and without RF	All	tonne.km	16% to 23%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
75	Freight flights - Short haul, with and without RF	All	tonne.km	16% to 23%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
76	Freight flights - Long-haul. with and without RF	CH ₄	tonne.km	-31%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
77	Sea tanker, all types	N ₂ O	tonne.km	-10% to +17%	Rounding amendments this year.		(viii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
78	Sea tanker, all types	CH ₄	tonne.km	-40% to +50%	Rounding amendments this year.		(viii)
79	Cargo ship, all types	N ₂ O	tonne.km	-10% to +15%	Rounding amendments this year.		(viii)
80	Cargo ship, all types	CH ₄	tonne.km	-50% to +20%	Rounding amendments this year.		(viii)
WTT- delivery vehicles and freighting goods (former Annex 7 tables)							
81	Van Average (up to 3.5 tonnes) - CNG	All indirect / WTT	All	-10%	Reduction in natural gas WTT emission factor and a reduction in LNG imports which reduces this WTT factor.	Section II	(iii)
82	HGV - All rigids, diesel, 0%, 50% and 100% laden	All indirect / WTT	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
83	HGV - All artics, diesel, 0%, 50% and 100% laden	All indirect / WTT	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
84	All HGVs, diesel, 0%, 50% and 100% laden	All indirect / WTT	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
85	Refrigerated HGVs - All rigids, diesel, 0%, 50% and 100% laden	All indirect / WTT	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
86	Refrigerated HGVs- All artics, diesel, 0%, 50% and 100% laden	All indirect / WTT	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
87	Refrigerated - All HGVs, diesel, 0%, 50% and 100% laden	All indirect / WTT	All	n/a	New values calculated for using current methodology.	Section VI	(ii), (vii)
88	Freight flights - Domestic, with and without RF	All indirect / WTT	tonne.km	16%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
89	Freight flights - Short haul, with and without RF	All indirect / WTT	tonne.km	-19%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
Business travel- sea (former Annex 6 tables)							
90	Ferry - foot passenger	CH ₄	passenger.km	-40%	Change to NAEI CH ₄ shipping data.		(i)
Business travel- air (former Annex 6 tables)							
91	Domestic. Average passenger. With and without RF.	All	passenger.km	10% to 50%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
92	Short -haul. Average passenger. With and without RF.	All	passenger.km	14% to 100%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
93	Short -haul. Economy class. With and without RF.	All	passenger.km	14% to 100%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
94	Short -haul. Business class. With and without RF.	All	passenger.km	14%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
WTT - Business travel air (former Annex 6 tables)							
95	Domestic. Average passenger. With and without RF.	All indirect / WTT	passenger.km	-10%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
96	Short -haul. Average passenger. With and without RF.	All indirect / WTT	passenger.km	-14%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
97	Short -haul. Economy class. With and without RF.	All indirect / WTT	passenger.km	-14%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)
98	Short -haul. Business class. With and without RF.	All indirect / WTT	passenger.km	-14%	Significant change to flight emission factor methodology and data source.	Section VIII	(ix)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
Bioenergy (former Annex 9 tables)							
99	Bioethanol	All indirect / WTT	kg	n/a	New factor added, based on calculation using fuel properties.	Section IX	(ii)
100	Biodiesel	All indirect / WTT	kg	n/a	New factor added, based on calculation using fuel properties.	Section IX	(ii)
101	Wood logs	All indirect / WTT	tonnes	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
102	Wood logs	All indirect / WTT	kWh	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
103	Wood chips	All indirect / WTT	tonnes	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
104	Wood chips	All indirect / WTT	kWh	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
105	Wood pellets	All indirect / WTT	tonnes	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
106	Wood pellets	All indirect / WTT	kWh	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
107	Grass/straw	All indirect / WTT	tonnes	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
108	Grass/straw	All indirect / WTT	kWh	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
109	Biogas	All indirect / WTT	tonnes	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
110	Biogas	All indirect / WTT	kWh	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
111	Landfill gas	All indirect / WTT	tonnes	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)
112	Landfill gas	All indirect / WTT	kWh	n/a	New emission factors for CH ₄ and N ₂ O based on data from the NAEI which was added this year.	Section IX	(ii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
WTT- bioenergy (former Annex 9 tables)							
113	Bioethanol	All indirect / WTT	litres	-19%	Difference in the RTFO figures between years.	Section IX	(x)
114	Bioethanol	All indirect / WTT	GJ	-19%	Difference in the RTFO figures between years.	Section IX	(x)
115	Bioethanol	All indirect / WTT	Mass	n/a	New factor added, based on calculation using fuel properties.	Section IX	(ii)
116	Biodiesel	All indirect / WTT	litres	-42%	Difference in the RTFO figures between years.	Section IX	(x)
117	Biodiesel	All indirect / WTT	GJ & kg	-42%	Difference in the RTFO figures between years.	Section IX	(x)
118	Biomethane	All indirect / WTT	GJ & kg	15%	Difference in the RTFO figures between years.	Section IX	(x)
119	Wood logs	All indirect / WTT	tonnes & kWh	-33%	New data used, figures obtained from Biomass Environmental Assessment Tool (BEAT2), provided by Defra.	Section IX	(xi)
120	Wood pellets	All indirect / WTT	tonnes & kWh	-18%	New data used, figures obtained from Ofgem's 'UK Solid and Gaseous Biomass Carbon Calculator'.	Section IX	(xii)
121	Grass/straw	All indirect / WTT	tonnes & kWh	108%	New data used, figures obtained from Ofgem's 'UK Solid and Gaseous Biomass Carbon Calculator'.	Section IX	(xii)
122	Biogas	All indirect / WTT	tonnes & kWh	n/a	New data used, figures obtained from Ofgem's 'UK Bioliquid Carbon Calculator'.	Section IX	(ii), (xii)
Outside of scope (former Annex 9 tables)							
123	Petrol (average biofuel blend)	All indirect / WTT	tonnes	14%	Change due to difference in DUKES data.		(xiii)
124	Petrol (average biofuel blend)	All indirect / WTT	litres	13%	Change due to difference in DUKES data.		(xiii)
125	Petrol (average biofuel blend)	All indirect / WTT	kWh	14%	Change due to difference in DUKES data.		(xiii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
126	Bioethanol	All indirect / WTT	kg	n/a	New factor added, based on calculation using fuel properties.		(ii)
127	Biodiesel	All indirect / WTT	kg	n/a	New factor added, based on calculation using fuel properties.		(ii)
Overseas electricity, including managed assets (former Annex 10 tables)							
128	Overseas electricity, generated	CO ₂	kWh	-43% to +41%	Due to differences between the most recent years IEA CO ₂ emission data and the previous year.		(xiv)
Transmission and distribution (former Annex 10 tables)							
129	Overseas electricity, losses in transmission and distribution	CO ₂	kWh	-48% to +158%	Due to a combination of changes to the IEA source data and amends to the T&D loss calculations.		(xv)
WTT - UK & Overseas electricity (former Annex 10 tables)							
130	Overseas electricity, generated	All indirect / WTT	kWh	-46% to +33%	Due to differences between the most recent years IEA CO ₂ emission data and the previous year.		(xiv)
131	Overseas electricity, losses in transmission and distribution	All indirect / WTT	kWh	+10% to +553%	Due to a combination of changes to the IEA source data and amends to the T&D loss calculations.		(xv)
Materials use (former Annex 14 tables)							
132	Construction - aggregates. Open loop source	All indirect / WTT	tonnes	33%	Changed due to better analysis of material composition.	Section XI	(xvii)
133	Construction, average construction. Primary material production and open loop source	All indirect / WTT	tonnes	n/a	New value added this year, previously unavailable.	Section XI	(ii)
134	Construction, wood. Compost source	All indirect / WTT	tonnes	-100%	Compost source has been removed, because no products available only containing these sources.	Section XI	(xvi)
135	Other, books. Compost source	All indirect / WTT	tonnes	-100%	Changed due to updated data from trade associations.	Section XI	(xvii)

Ref	Emission factor	GHG	Unit	Magnitude of change vs 2013 update	Reason for change	For more information see:	Major changes ref
136	Refuse, Organic: food and drink waste. Compost source	All indirect / WTT	tonnes	-100%	Compost source has been removed, because no products are available which only contain these sources.	Section XI	(xvi)
137	Metal: aluminium cans and foil (excl. forming). Primary material production	All indirect / WTT	tonnes	23%	Changed due to updated data from trade associations.	Section XI	(xvii)
138	Paper and board: board. Compost source	All indirect / WTT	tonnes	-100%	Compost source has been removed, because no products are available which only contain these sources.	Section XI	(xvi)
139	Paper and board: board. Primary material production.	All indirect / WTT	tonnes	-12%	Changed due to updated data from trade associations.	Section XI	(xvii)
140	Paper and board: mixed. Compost source	All indirect / WTT	tonnes	-100%	Compost source has been removed, because no products are available which only contain these sources.	Section XI	(xvi)
141	Paper and board: paper. Compost source	All indirect / WTT	tonnes	-100%	Compost source has been removed, because no products are available which only contain these sources.	Section XI	(xvi)

Major changes Reference:

- i. Changes in NAEI emissions factor/ activity data for this year using 2012 NAEI data compared to 2011 NAEI.
- ii. New emission factors presented this year.
- iii. Updates and corrections in the JRC WTT dataset from previous year. This means that there is also a reduction in heat and steam figure because of the reduction in natural gas WTT figure used in the majority of combined heat and power (CHP). There is also a significant increase in the base dataset from JRC-EUCAR-CONCAWE in the latest update.
- iv. Significant increase in coal powered electricity generation share in 2012 (inventory year for which this EF was derived).

- v. Methodology change - new source of data based on specific taxi drive cycles (higher fuel consumption).
- vi. N₂O - changes in base inventory datasets.
- vii. There have been two changes made to HGV conversion factors in the 2014 update of the GHG Conversion factors to improve the accuracy of reporting. The new factors for the 2014 GHG Conversion Factors now include new conversion factors by 0%, 50% and 100% vehicle laden weight have been added for 'All rigids', 'All artics' and 'All HGVs' from this year.
- viii. Rounding amends to sea tanker and cargo ship data.
- ix. Significant change to flight emission factor methodology and data source.
- x. Difference in the Renewable Transport Fuels Obligation (RTFO) figures between years this year and the previous year.
- xi. New data used, figures obtained from Biomass Environmental Assessment Tool (BEAT2), provided by Defra.
- xii. New data used, figures obtained from Ofgem's 'UK Solid and Gaseous Biomass Carbon Calculator' or 'UK Bioliquid Carbon Calculator '.
- xiii. Change due to difference in data from this year to last year in the Dukes Table 6.2 Liquid biofuels for transport consumption (i.e. share of bioethanol in forecourt fuel).
- xiv. Due to difference between the most recent years IEA CO₂ emission data and the previous year.
- xv. Due to a combination of changes to the IEA source data and amends to the T&D loss calculations
- xvi. Compost source has been removed, because no products are available which only contain these sources.
- xvii. Material use data has been updated due to new data from trade association.

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