Department for
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2017 GOVERNMENT GHG CONVERSION FACTORS FOR COMPANY REPORTING

Methodology Paper for Emission Factors - Final Report

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1. General Introduction

1.1. Greenhouse gases (GHG) 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 GHG emissions from a range of activities, including energy use, water consumption, and transport activities. For instance, a conversion factor can be used to calculate the amount of GHG emitted as a result of burning a particular quantity of oil in a heating boiler.

1.3. The 2017 Government Greenhouse Gas Conversion Factors for Company Reporting[1] (hereafter the 2017 GHG Conversion Factors) represent the current official set of UK 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 2017 GHG Conversion Factors.

1.4. Values for the non-carbon dioxide (CO_2) GHGs, methane (CH_4) and nitrous oxide (N_2O), are presented as CO_2 equivalents (CO_2e), using Global Warming Potential (GWP) factors from the Intergovernmental Panel on Climate Change (IPCC)'s fourth assessment report (GWP for CH_4 = 25, GWP for N_2O = 298), consistent with reporting under the United Nations Framework Convention on Climate Change (UNFCCC). Although the IPCC have prepared a newer version since, the methods have not yet been officially accepted for use under the UNFCCC. As this is the basis upon which all emissions are calculated in the UK GHG inventory (GHGI), the 2017 GHG Conversion Factors are therefore consistent with this.

1.5. The GHGI for 2015, on which these 2017 GHG Conversion Factors are based on, is available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1705121352_ukghgi-90-15_Main_Issue2.pdf.

1.6. The 2017 GHG Conversion Factors are for one year, from the end of August 2017, and will continue to be reviewed and updated on an annual basis.

1.7. The GHG Conversion Factors have been provided on the GOV.UK site: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting.

1.8. 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 2017 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

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

practicalities of reporting for organisations. Rather, the intention is to provide an overview with key information so that the basis of the emission factors provided can be better understood and assessed.

1.9. Further information about the 2017 GHG Conversion Factors together with previous methodology papers is available at: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting.

Overview of changes since the previous update

1.10. Major changes and updates in terms of methodological approach from the 2016 update version are summarised below. All other updates are essentially revisions of the previous year's data based on new/improved data whilst using existing calculation methodologies (i.e. using a similar methodological approach as for the 2016 update):

a) A number of emission factors for plug in electric vehicles (xEVs[2]), for electric cars and vans, has been provided to cover the different emission components/scope. For plug-in hybrid electric vehicles (PHEVs, including range-extended electric vehicles) the situation is particularly complex since the resulting emissions can be categorised into Scope 1[3] (i.e. direct emissions from petrol or diesel use), Scope 2[4] (from electricity use) and Scope 3[5] (electricity transmission and distribution (T&D) losses, and Well-to-Tank (WTT) emissions).

b) We have added a number of factors which can be used to report emissions associated with an overnight hotel stay, which complement the existing emission factors for business travel that are already available. These new emission factors are based on estimates for an overnight stay in an average hotel, and different emission factors provided for a range of countries on a 'room per night' basis.

c) The methodological source for WTT emission factors for a range of different transport fuels (including petrol, diesel, kerosene and natural gas/CNG/LNG) has been updated this year. The new, and more accurate, source has also recently been used to update the default emission factors for these fuels used in EC Directives, and is based on a more recent and in-depth analysis of WTT emissions of European fuels.

d) For a number of years, separate emission factors have been provided for pure fossil-based petrol and diesel road transport fuels, pure biofuels, and also emission factors that account for the average share of biofuel blended with these fuels in public refuelling stations. The methodologies used to calculate vehicle emission factors have previously been based upon pure conventional fossil-based road transport fuels.

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[2] xEVs is a generic term used to refer collectively to battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), range-extended electric vehicles (REEVs, or ER-EVs, or REX) and fuel cell electric vehicles (FCEVs).

[3] Scope 1 (direct emissions) emissions are those from activities owned or controlled by your organisation.

[4] Scope 2 (energy indirect) emissions are those released into the atmosphere that are associated with your consumption of purchased electricity, heat, steam and cooling. These indirect emissions are a consequence of your organisation’s energy use, but occur at sources you do not own or control.

[5] Scope 3 (other indirect) emissions are a consequence of your actions that occur at sources you do not own or control and are not classed as Scope 2 emissions

The share of biofuels has been increasing for a number of years now, and therefore this year the methodologies used to develop the road vehicle emission factors (both direct CO_2 and WTT) have been modified to account for the average petrol and diesel biofuel blend in public refuelling stations.

e) There have been some changes to the landfill gas and biogas factors:

- Landfill gas fuel properties have now been added to the fuel properties table
- The fuel properties of biogas have been updated to reflect a change in the methodology
- The outside of Scope factors for biogas and landfill gas and the WTT biogas factor has been updated due to a more robust data source and improved methodology.

1.11. Additional information is also provided in Appendix 3 of this report on major changes to the values of specific emission factors (i.e. for many factors this is plus or minus 10% compared with the 2016 GHG Conversion Factors, though a lower threshold is used in some cases where a much lower degree of annual variation is expected). Some of these changes are due to the methodological adjustments outlined above and in the later sections of this methodology paper, whist others are due to changes in the underlying source datasets.

1.12. Detailed guidance on how the emission factors provided should be used is contained in the introduction to the 2017 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.

1.13. It is important to note that this methodology paper's primary aim is to provide information on the methodology used in creating the Government GHG Conversion Factors for Company Reporting (GCF). It does not provide guidance on the approach or methodology required for GHG reporting.

Structure of this methodology paper

1.14. The following Sections 2 to 13 provide methodological summary for the data tables contained in the GCF.

Area covered	Location in this document
Fuel Emission Factors	see Section 2
UK Electricity, Heat and Steam Emission Factors	see Section 3
Refrigerant and Process Emission Factors	see Section 4
Passenger Land Transport Emission Factors	see Sections 5

Freight Land Transport Emission Factors	see Sections 6
Sea Transport Emission Factors	see Section 7
Air Transport Emission Factors	see Section 8
Bioenergy and Water	see Section 9
Overseas Electricity Emission Factors	see Section 10
Hotel Stay	see Section 11
Material Consumption/Use and Waste Disposal	see Section 12
Fuel Properties	see Section 13
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. There have been changes since the previous update to the indirect/ Well-To-Tank (WTT) emissions. The methodological source for these emission factors for a range of different transport fuels (including petrol, diesel, kerosene and natural gas/CNG/LNG) has been updated this year. The new, and more accurate source (Study on Actual GHG Data for Diesel, Petrol, Kerosene and Natural Gas' by Exergia, EM Lab and COWI for DG Ener in 2015) has been used to update the default emission factors for these fuels used in EC Directives and is based on a more recent and in-depth analysis of WTT emissions of European fuels.

Direct Emissions

2.2. All the fuel conversion factors for direct emissions presented in the 2017 GHG Conversion Factors are based on the emission factors used in the UK GHG Inventory (GHGI) for 2015 (managed by Ricardo Energy & Environment[6]).

2.3. The CO_2 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 CH_4 and N_2O 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 in the 2017 GHG Conversion Factors are based on an activity-weighted average of all the different CH_4 and N_2O 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) (see definition of Gross CV and Net CV in the footnote below[7]) from BEIS's Digest of UK Energy Statistics (DUKES) 2016[8].

2.5. There are three tables presented in the new layout (introduced in 2016) for 2017 GHG Conversion Factors, the first of which provides emission factors for gaseous fuels, the second for liquid fuels and the final table provides the emission factors for solid fuels.

2.6. 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

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[6] UK Greenhouse Gas Inventory for 2015 (Ricardo Energy & Environment), available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1705121352_ukghgi-90-15_Main_Issue2.pdf .

[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] Available at: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

kWh by suppliers in the UK are generally calculated (from the volume of gas used) on a Gross CV basis[9]. Therefore, the emission factor for energy 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. They result from the extraction, 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 previous versions of the GHG Conversion Factors WTT data from the JEC Well-To-Wheels[10] study was used as a basis for the factors. However, a newer report: 'Study on Actual GHG Data for Diesel, Petrol, Kerosene and Natural Gas' by Exergia, EM Lab and COWI for DG Ener in 2015, has been used in the 2017 Conversion Factors to calculate the WTT factors for the following fuels:

- Petrol
- Diesel
- Kerosene
- Natural gas
- CNG
- LNG.

2.9. The Exergia *et al* report does not contain data on the WTT emissions from Coal, Naphtha and LPG and therefore the JEC Well-To-Wheels (2014) study is used for these fuels.

2.10. For fuels covered by the 2017 GHG Conversion Factors where no fuel lifecycle emission factor was available in either source, these were estimated based on similar fuels, according to the assumptions in Table 4.

2.11. WTT emissions for petrol, diesel and kerosene in the Exergia *et al* study, used within the 2017 GHG Conversion Factors, are based on:

- Detailed modelling of upstream emissions associated with 35 crude oils used in EU refining, which accounted for 88% of imported oil in 2012.
- Estimates of the emissions associated with transport of these crude oils to EU refineries by sea and pipeline, based on location of ports and refineries.

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9 See information available on National Grid website: http://www2.nationalgrid.com/UK/Industry-information/Gas-transmission-operational-data/calorific-value-description/

10 In 2016 GHG Conversion Factors the version used was: "Well-to-Wheels Analysis of Future Automotive Fuels and Powertrains in the European Context" Version 4a, May 2014. Report EUR 26236 EN– 2014. http://iet.jrc.ec.europa.eu/about-jec/

- Emissions from refining, modelled on a country by country basis, based on the specific refinery types in each country. An EU average is then calculated based on the proportion of each crude oil going to each refinery type.
- An estimate of emissions associated with imported finished products from Russia and the US.

2.12. Emission factors are also calculated for diesel as supplied at public and commercial refuelling stations, by factoring in the WTT component due to biodiesel supplied in the UK as a proportion of the total supply of diesel and biodiesel (2.71% by unit volume, 2.50% by unit energy – see Table 2). These estimates have been made based on BEIS's Quarterly Energy Statistics for Renewables[11].

2.13. Emission factors are also calculated for petrol as supplied at public and commercial refuelling stations, by factoring in the bioethanol supplied in the UK as a proportion of the total supply of petrol and bioethanol (4.47% by unit volume, 2.96% by unit energy – see Table 2). These estimates have also been made based on BEIS's Quarterly Energy Statistics for Renewables.[11].

	Total Sales, millions of litres		Biofuel % Total Sales		
	Biofuel	Conventional Fuel	per unit mass	per unit volume	per unit energy
Diesel/Biodiesel	799	28,688	2.87%	2.71%	2.50%
Petrol/Bioethanol	768	16,399	4.84%	4.47%	2.96%

Source: Department for Transport, Table RTFO 01: Volumes of fuels by fuel type. Data used here comes from two different versions of the report: Year 8 report 6 (final version) and Year9 report 2, both published in February 2017.

Available at: - https://www.gov.uk/government/collections/biofuels-statistics

Table 2: Liquid biofuels for transport consumption: 4th quarter 2014 – 3rd quarter 2015

2.14. Emissions for natural gas, LNG and CNG in the Exergia *et al* study, used within the 2017 GHG Conversion Factors, are based on:

- Estimates of emissions associated with supply in major gas producing countries supplying the EU. These include both countries supplying piped gas and countries supplying LNG.
- The pattern of gas supply for each Member State (based on IEA data for natural gas supply in 2012)[12].
- Combining the information on emissions associated with sources of gas, with the data on the pattern of gas supply for each Member State, including the proportion of LNG that is imported.

2.15. A similar methodology was developed for use in the 2017 GHG Conversion Factors, to allow the value calculated for gas supply in the UK in the Exergia *et al* study to be

[12] IEA, 2014. Natural Gas Information 2014.

[12] IEA, 2014. Natural Gas Information 2014.

updated annually. This allows changes in the sources of imported gas, particularly LNG, to be reflected in the emissions value.

2.16. Information on quantities and source of imported gas are available annually from DUKES[13] and can be used to calculate the proportion of gas in UK supply coming from each source. These can then be combined with the Exergia *et al* emissions factors for gas from each source, to calculate a weighted emissions factor for UK supply.

2.17. The methodology for calculating the WTT emission factors for natural gas and CNG is different to the other fuels as it takes into account 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 3 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, updated to include the most recent data used in the 2017 update. Small quantities of imported LNG are now re -exported, so a value for **net** imports is used in the methodology. The figures in Table 3 have been used to calculate the revised figures for Natural Gas and CNG WTT emission factors provided in Table 4 below.

Year	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
2010	35.4%	39.3%	19.1%
2011	47.2%	42.0%	29.5%
2012	27.9%	47.2%	17.5%
2013	19.5%	50.1%	12.1%
2014	26.7%	44.7%	15.9%
2015	30.7%	42.0%	18.9%

Source: DUKES 2015, (1) Table 4.1 - Commodity balances and (2) Table 4.5 - Natural gas imports and exports.

Table 3: Imports of LNG into the UK as a share of imports and net total natural gas supply

2.18. The final combined emission factors (in $kgCO_2e/GJ$, Net CV basis) are presented in Table 4. These include WTT emissions of CO_2, N_2O and CH_4 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 2017 GHG Conversion Factors alongside the emission factor data tables.

[13] From Table 4.5 Commodity balances for natural gas and Table 4.1 Natural gas imports and exports, DUKES 2016

Fuel	Indirect/WTT EF ($kgCO_2e/GJ$, Net CV basis)	Source of Indirect/WTT Emission Factor	Assumptions
Aviation Spirit	18.20	Estimate	Similar to petrol
Aviation turbine fuel[1]	15.00	Exergia, EM Lab and COWI (2015)	Emission factor for kerosene
Burning oil[1]	15.00	Estimate	Assume same as factor for Kerosene, as above
CNG[2]	12.11	Exergia, EM Lab and COWI (2015)	Factors in UK % share LNG imports
Coal (domestic)	14.70	JEC WTW (2014)	Emission factor for coal
Coal (electricity generation)	14.70	JEC WTW (2014)	Emission factor for coal
Coal (industrial)	14.70	JEC WTW (2014)	Emission factor for coal
Coal (electricity generation - home produced coal only)	14.70	JEC WTW (2014)	Emission factor for coal
Coking coal	14.70	Estimate	Assume same as factor for coal
Diesel (100% mineral diesel)	17.40	Exergia, EM Lab and COWI (2015)	
Fuel oil[4]	15.00	Estimate	Assume same as factor for kerosene
Gas oil[5]	17.40	Estimate	Assume same as factor for diesel
LPG	8.04	JEC WTW (2014)	
LNG[6]	19.60	Exergia, EM Lab and COWI (2015)	
Lubricants	9.53	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Marine fuel oil	15.00	Estimate	Assume same as factor for fuel oil
Marine gas oil	17.40	Estimate	Assume same as factor for gas oil
Naphtha	14.10	JEC WTW (2014)	

Fuel	Indirect/WTT EF ($kgCO_2e$/GJ, Net CV basis)	Source of Indirect/WTT Emission Factor	Assumptions
Natural gas	8.59	Exergia, EM Lab and COWI (2015)	Factors in UK % share LNG imports
Other petroleum gas	6.89	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Petrol (100% mineral petrol)	18.20	Exergia, EM Lab and COWI (2015)	
Petroleum coke	12.16	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Processed fuel oils - distillate oil	9.18	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Processed fuel oils - residual oil	9.66	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Refinery miscellaneous	8.79	Estimate	Based on LPG figure, scaled relative to direct emissions ratio
Waste oils	9.53	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) Fuel oil is used for stationary power generation. Also use this emission factor for similar marine fuel oils.
(4) 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.
(5) 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.

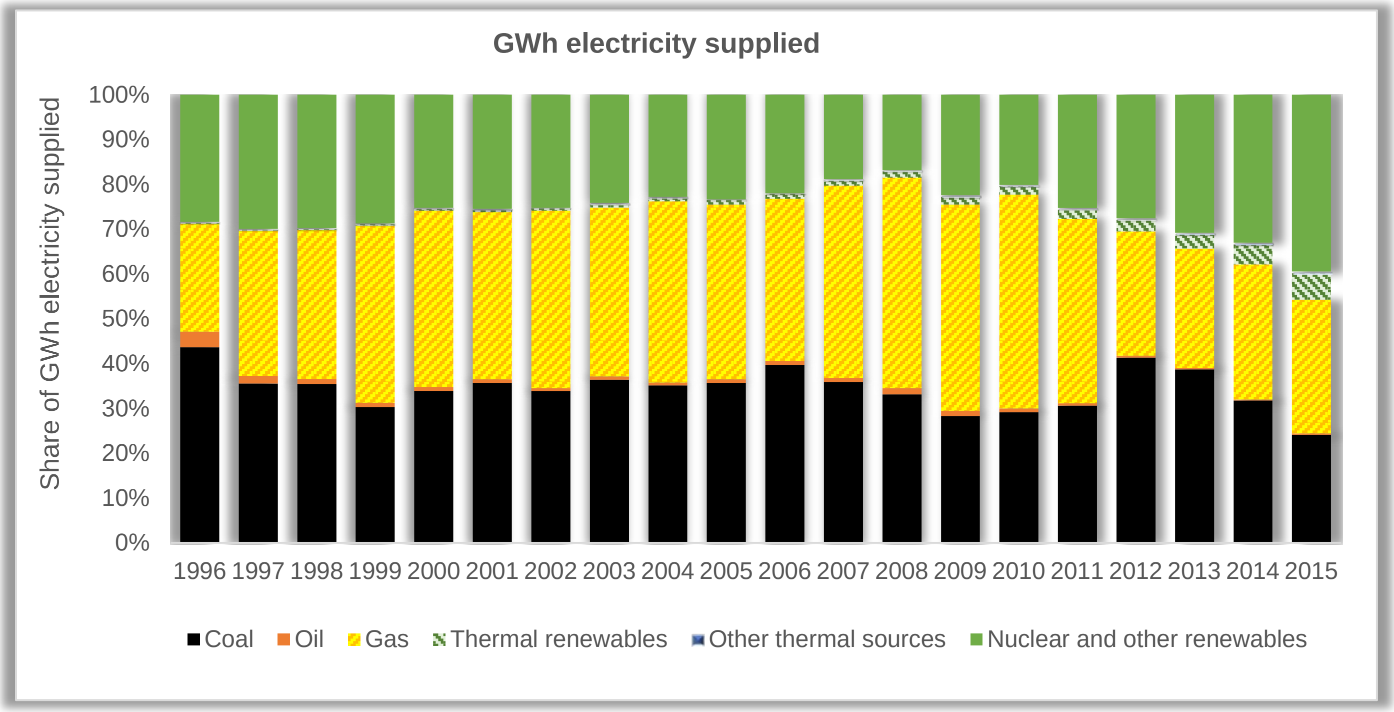
Table 4: Basis of the indirect/WTT emissions factors for different fuels

3. UK Electricity, Heat and Steam Emission Factors

Direct Emissions from UK Grid Electricity

3.1. The electricity conversion factors given represent the average CO_2 emission from the UK national grid per kWh of electricity generated, classed as Scope 2 of the GHG Protocol and separately for electricity transmission and distribution losses, classed as Scope 3. The calculations also factor in net imports of electricity via the interconnectors with Ireland, the Netherlands and France. These factors include only direct CO_2, CH_4 and N_2O emissions at UK power stations and from autogenerators (the latter added 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.).

3.2. The UK grid electricity 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. This fluctuation in UK electricity generation mix is illustrated in Figure 1 below.



Notes: The chart presents data for actual years; the emissions factors for a given GHG Conversion Factor update year correspond to the data for the actual year 2 years previous, i.e. the 2017 emission factors are based on 2015 data.

Figure 1: Time series of the mix of UK electricity generation by type

3.3. The UK electricity conversion factors provided in the 2017 GHG Conversion Factors are based on emissions from sector 1A1a (power stations) and 1A2f (autogenerators) in the UK Greenhouse Gas Inventory (GHGI) for 2015 (Ricardo Energy & Environment) according to the amount of CO_2, CH_4 and N_2O emitted per unit of electricity consumed (from DUKES 2016)[14]. These emissions from the GHGI only include autogeneration from coal and natural gas fuels, and do not include emissions for electricity generated and supplied by autogenerators using oil or other thermal non-renewable fuels[15]. In previous updates, this was accounted for by removing this component from the DUKES GWh data. However, since the 2016 update, estimates of the emissions due to these components have been made using standard NAEI emission factors, and information from DUKES Table 5.5, and BEIS's DUKES team on the total fuel use (and shares by fuel type) for this component. An additional correction is made to account for the share of autogeneration electricity that is exported to the grid (~16.1% for the 2015 data year), which varies significantly from year-to-year.

3.4. The UK is a net importer of electricity from the interconnectors with France and Netherlands, and a net exporter of electricity to Ireland according to DUKES (2016). For the 2017 GHG Conversion Factors the total net electricity imports were calculated from DUKES (2016) Table 5.1.2 (Electricity supply, availability and consumption 1970 to 2015). The net shares of imported electricity over the interconnectors are calculated from data from DUKES (2016) Table 5B (Net Imports via interconnectors, GWh).

3.5. An average imported electricity emission factor is calculated from the individual factors for the relevant countries[16] weighted by their respective share of net imports. This average electricity emission factor – including losses – is used to account for the net import of electricity, as it will also have gone through the relevant countries' distribution systems. Note that this method effectively reduces the UK's electricity emission factors as the resulting average net imported electricity emission factor 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, and accounts for the largest share of the net imports.

3.6. 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 2014 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

[14] DUKES (2016): https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

[15] Other thermal non-renewable fuels include the following (with ~2016 update % share): blast furnace gas (~43%), chemical waste (~12%), coke oven gas (~9%) and municipal solid waste (MSW, ~36%)

[16] French electricity factor: Rte. Available at: http://www.rte-france.com/en/eco2mix/eco2mix-telechargement-en.

Dutch electricity factor: CBS. Available at: https://www.cbs.nl/nl-nl/achtergrond/2017/06/rendementen-en-co2-emissie-elektriciteitsproductie-2015

Irish electricity factor, SAEI. Available at: http://www.seai.ie/Energy-Data-Portal/Emission_Factors/

most recent emission factor for the 2017 GHG Conversion Factors is based on a data year of 2015

3.7. A full time series of data using the most recently available GHGI and DUKES datasets for all years is also provided in Appendix 1 of this report. This is provided for purposes **other than company reporting**, where a fully consistent data time series is desirable, e.g. for policy impact analysis. This dataset also reflects the changes in the methodological approach implemented for the 2016 update, and applied across the whole time series.

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_2O
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
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
2013	2015	308,955	7.63%	146,852	4.468	3.595

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_2O
2014*	2016	297,897	8.30%	126,358	4.769	2.166
2015	2017	296,959	8.55%	106,209	7.567	2.136

Notes:

(1) **From 1990-2013**: Based upon calculated total for centralised electricity generation (GWh supplied) from DUKES Table 5.5 Electricity fuel use, generation and supply for year 1990 to 2014. The total is consistent with UNFCCC emissions reporting categories 1A1a+1A2f includes (according to Table 5.5 categories) GWh supplied (gross) from all '*Major power producers*'; plus, GWh supplied from thermal renewables + coal and gas thermal sources, hydro-natural flow and other non-thermal sources from '*Other generators*'.

* **From 2014 onwards**: based on the **total** for **all** electricity generation (GWh supplied) from DUKES (2015) Table 5.5, with a reduction of the total for autogenerators based on unpublished data from the BEIS DUKES team on the share of this that is actually exported to the grid (~16% in 2015).

(2) Based upon calculated net grid losses from data in DUKES Table 5.1.2 (long term trends, only available online).

(3) **From 1990-2013**: 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) for data years 1990-2012, for the GHGI for 2013 (Ricardo-AEA, 2015) for the 2013 data year.

* **From 2014 onwards**: Excludes emissions from Crown Dependencies and also includes an accounting (estimate) for autogeneration emissions not specifically split out in the NAEI, consistent with the inclusion of the GWh supply for these elements also from 2014 onwards. Data is from the GHGI for 2015 (Ricardo Energy & Environment, 2017) for the 2015 data year.

Table 5: Base electricity generation emissions data

Data Year	Emission Factor, kgCO$_2$e / kWh												% Net Electricity Imports
	For electricity GENERATED (supplied to the grid)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)				
	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
1999	0.43806	0.00019	0.00253	0.44077	0.04375	0.00002	0.00027	0.04404	0.47745	0.00020	0.00275	0.48041	**3.94%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
2013	0.4753	0.0004	0.0035	0.4791	0.0392	0.0000	0.0003	0.0396	0.5146	0.0004	0.0038	0.5187	**4.10%**
2014	0.42417	0.00040	0.00217	0.42673	0.03837	0.00004	0.00020	0.03860	0.46254	0.00044	0.00236	0.46534	**6.44%**
2015	0.35766	0.00064	0.00214	0.36044	0.03343	0.00006	0.00020	0.03369	0.39108	0.00070	0.00234	0.39412	**6.59%**

Notes: * From 1990-2013 the emission factor used was for French electricity only, and is as published in previous methodology papers. The methodology was updated from 2014 onwards with new data on the contribution of electricity from the other interconnects, hence these figures are based on a weighted average emission factor of the emission factors for France, the Netherlands and Ireland, based on the % share supplied.

Time series data in light grey is locked/fixed for the purposes of company reporting and has not been updated in the database in the 2017 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)

$\Rightarrow$ 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, $kgCO_2e$ / kWh												% Net Elec Imports
	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_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
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%**
2013	0.4585	0.00035	0.00334	0.46219	0.03786	0.00003	0.00028	0.03816	0.49636	0.00038	0.00362	0.50035	**4.10%**
2014	0.40957	0.00039	0.00209	0.41205	0.03705	0.00003	0.00019	0.03727	0.44662	0.00042	0.00228	0.44932	**6.44%**
2015	0.34885	0.00062	0.00209	0.35156	0.03261	0.00006	0.0002	0.03287	0.38146	0.00068	0.00229	0.38443	**6.59%**

Notes: * From 1990-2013 the emission factor used was for French electricity only. The methodology was updated from 2014 onwards with new data on the contribution of electricity from the other interconnects, hence these figures are based on a weighted average emission factor of the emission factors for France, the Netherlands and Ireland, based on the % share supplied. The individual country factors may not be published due to restrictions in republication of the underlying IEA datasets.
Time series data in light grey is locked/fixed for the purposes of company reporting and has not been updated in the database in the 2017 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

3.8. 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.

3.9. Average WTT emission factors for electricity have been calculated using the corresponding fuels WTT emission factors and data on the total fuel consumption by type of generation from Table 5.5, DUKES, 2016. The data used in these calculations are presented in Table 8, Table 9 and Table 10, together with the final WTT emission factors for electricity. As for the direct emission factors presented in the previous section, earlier years (those prior to the current update) are based on data reported in previous versions of DUKES and following the convention set from 2014, historic time series factors/data have not been updated. The relevant time series source data and emission factors that are fixed/locked have therefore been highlighted in light grey and are unchanged since the last update (i.e. in 2016).

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
2013	365,697	6,849	202,325	15,198	239,526	829,594
2014	280,452	6,167	218,395	19,934	275,426	800,374
2015	212,336	7,192	212,976	23,050	323,693	779,248

Source: For the latest 205 data year, Table 5.5, Digest of UK Energy Statistics (DUKES) 2016 (BEIS, 2016), available at: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes#2015. Earlier years are based on data reported in previous versions of DUKES and following the new convention set from 2013 update (2011 data year), historic time series factors/data (i.e. prior to the very latest year) 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%
2013	44.08%	0.83%	24.39%	1.83%	28.87%	100.00%
2014	35.04%	0.77%	27.29%	2.49%	34.41%	100.00%
2015	27.25%	0.92%	27.33%	2.96%	41.54%	100.00%

Notes: Calculated from figures in Table 8.

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 ((kg CO_2/ kWh)	Calc Indirect /WTT (kg CO_2e/ kWh
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
2013	16.38%	18.92%	12.62%	12.59%	15.02%	**15.02%**	0.4585	0.0689
2014	16.38%	18.45%	13.61%	12.59%	15.11%	**15.11%**	0.40957	0.06188
2015	16.38%	19.01%	16.03%	12.59%	16.07%	**16.07%**	0.34885	0.05605

Notes: Indirect/WTT emissions as % direct CO_2 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

3.10. Updated time-series emission factors for the supply of purchased heat or steam have been provided for the 2017 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) scheme[17] operators for a given year. This factor changes from year to year, as the fuel mix consumed changes and is therefore 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.

3.11. 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 2017 GHG Conversion Factors.

Fuel allocation to electricity from CHP

3.12. 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 QHO 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)

3.13. Under the UK’s Climate Change Agreements (CCAs)[18], 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%.

[17] See https://www.gov.uk/guidance/combined-heat-power-quality-assurance-programme

[18] 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).

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

$$Heat\_Energy = \left(\frac{Total\ Fuel\ Input}{(2 \times Electricity\_Output) + Heat\_Output} \right) \times Heat\_Output$$

$$Electricity\_Energy = \left(\frac{2 \times Total\ Fuel\ Input}{(2 \times Electricity\_Output) + Heat\_Output} \right) \times Electricity\_Output$$

Where:

- *'Total Fuel Input (TFI)'* 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.

3.15. 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

3.16. 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 basis[19]), but that the boiler uses the same fuel mix as the actual fuel mix to the CHP to determine the CO_2 emissions.

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

$$Heat\_Energy = \left(\frac{Heat\_Output}{0.81} \right)$$

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

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

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

CO_2 emission from Fuel for Boiler

$$= \left(\frac{QHO}{0.81} \right) * Fuelmix\_CO2\_Factor$$

CHP Heat EF = CO_2 emission from Fuel for Boiler / QHO

$$= \left(\frac{Fuelmix\_CO2\_Factor}{0.81} \right)$$

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

CO_2 emission from Fuel for Electricity

$$= \{TFI - \left(\frac{QHO}{0.81}\right)\} * Fuelmix\_CO2\_factor$$

3 - CHP Electricity EF

$$= \{\{TFI - \left(\frac{QHO}{0.81}\right)\} * Fuelmix\_CO2\_factor\} / TPO$$

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

Method 3: Power Station Displacement Method

3.20. 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.

3.21. 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.

3.22. 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 48.0% on a GCV basis[20].

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

CO_2 emission from Fuel for Boiler

$$= \{TFI - \left(\frac{Electricity\_Output}{0.477}\right)\} * Fuelmix\_CO2\_factor$$

CHP Heat emission factor= CO_2 emission from Fuel for Boiler / QHO CO_2 emission from Fuel for Electricity

$$= \left(\frac{TPO}{0.477}\right) * Fuelmix\_CO2\_factor$$

CHP Electricity Emission factor

[20] Digest of UK Energy Statistics (DUKES) 2016, Chapter 5, Table 5.9. Plant loads, demands and efficiency in 2015.

$$= \left(\frac{Fuelmix\_CO2\_Factor}{0.477} \right)$$

Calculation of CO_2 Emissions Factor for CHP Fuel Input, FuelMixCO_2factor

3.24. The value *FuelMixCO_2factor* referred to above is the carbon emission factor per unit fuel input to a CHP scheme. This factor is determined using fuel input data provided by CHP scheme operators to the CHPQA programme, which is held in confidence.

The value for *FuelMixCO_2factor* is determined using the following expression:

$$FuelMixCO2factor = \frac{\sum(Fuel\ Input \times Fuel\ CO2\ Emissions\ Factor)}{TFI}$$

Where:

- *FuelMixCO_2factor* is the composite emissions factor (in tCO_2/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 CO_2 Emissions factor* is the CO_2 emissions factor (in tCO_2/MWh_{th}) for the fuel considered.
- *TFI* is total fuel input (in MWh thermal) for all fuels supplied to the prime mover

3.25. 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 CHPQA scheme.

Fuel	CO_2 Emissions Factor ($kgCO_2/kWh_{th}$)
Biodiesel, bioethanol etc	0.000
Biomass (such as woodchips, chicken litter etc)	0.000
Blast furnace gas	0.981
Coal and lignite	0.321
Coke oven gas	0.141
Domestic refuse (raw)	0.127
Ethane	0.186
Fuel oil	0.267
Gas oil	0.254
Hydrogen	0.000
Methane	0.184
Mixed refinery gases	0.245
Natural gas	0.184
Other Biogas (e.g. gasified woodchips)	0.000
Other gaseous waste	0.184
Other liquid waste (non-renewable)	0.195
Other liquid waste (renewable)	0.000
Other solid waste	0.237
Refuse-derived Fuels (RDF)	0.127

Fuel	CO_2 Emissions Factor ($kgCO_2/kWh_{th}$)
Sewage gas	0.000
Unknown process gas	0.186
Waste exhaust heat from high temperature processes	0.000
Waste heat from exothermic chemical reactions	0.000
Wood Fuels (woodchips, logs, wood pellets etc)	0.000

Sources: Defra/BEIS GHG Conversion Factors for Company Reporting (2017 update) and National Atmospheric Emissions Inventory (NAEI).

Note: For waste derived fuels the emission factor can vary significantly according to the waste mix. Therefore, if you have site-specific data it is recommended that you use that instead of the waste derived fuel emissions factors in this table.

Table 11: Fuel types and associated emissions factors used in determination of FuelMixCO_2factor

3.26. The 1/3 : 2/3 method (method 1) was utilised in deriving the new heat/steam emission factors provided in the Heat and Steam tables of the 2017 GHG Conversion Factors, for consistency with DUKES. However, results are provided for comparison according to all three methods in Table 12.

3.27. As for the electricity emission factors, the historic time series source data and emission factors from previous updates have been fixed/locked, highlighted in light grey in the table below, 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 2017 GHG Conversion Factors is based on the data year of 2015 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

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)
2013	0.20763	0.23209	0.0582	0.2229	0.1948	0.3949
2014	0.20245	0.22963	0.04394	0.21541	0.18534	0.39076
2015	0.19564	0.22660	0.01850	0.19445	0.16155	0.38273

Table 12: Comparison of calculated Electricity and Heat/Steam CO_2 emission factors for the 3 different allocation method

Calculation of Non-CO_2 and Indirect/WTT Emissions Factor for Heat and Steam

3.28. CH_4 and N_2O emissions have been estimated relative to the CO_2 emissions, based upon activity weighted average values for each CHP fuel used (using relevant average fuel emission factors from the NAEI). Where fuels are not included in the NAEI, the value for the closest/most similar alternative fuel was utilised instead.

3.29. Indirect/WTT GHG emission factors have been estimated relative to the CO_2 emissions, based upon activity weighted average indirect/WTT GHG emission factor values for each CHP fuel used (see Indirect/WTT Emissions from Fuels from Fuels section for more information). Where fuels are not included in the set of indirect/WTT GHG emission factors provided in the 2017 GHG Conversion Factors, the value for the closest/most similar alternative fuel was utilised instead.

3.30. The complete final emission factors for supplied heat or steam utilised are presented in the 'Heat and Steam' tables of the 2017 GHG Conversion Factors, and are counted as Scope 2 emissions under the GHG Protocol.

3.31. For district heating systems, the location of use of the heat will often be some distance from the point of production and therefore 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

Global Warming Potentials of Greenhouse Gases

4.1. Although revised GWP values have since been published by the IPCC in the Fifth Assessment Report (2013), the conversion factors in the Refrigerant tables incorporate (GWP) values relevant to reporting under UNFCCC, as published by the IPCC in its Fourth Assessment Report that is required to be used in inventory reporting.

Greenhouse Gases Listed in the Kyoto Protocol

4.2. *Mixed/Blended gases:* GWP values for refrigerant blends are be calculated on the basis of the percentage blend composition (e.g. the GWP for R404a that comprises is 44% HFC125[21], 52% HFC143a and 4% HFC134a is [3500 x 0.44] + [4470 x 0.52] + [1430x 0.04] = 3922). A limited selection of common blends is presented in the Refrigerant tables.

Other Greenhouse Gases

4.3. *CFCs and HCFCs[22]:* Not all refrigerants in use are classified as GHGs 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.

[21] HFC: Hydrofluorocarbon

[22] CFCs: Chlorofluorocarbons; HCFCs: Hydrochlorofluorocarbons

5. Passenger Land Transport Emission Factors

Summary of changes since the previous update

5.1. For a number of years, separate emission factors have been provided for pure fossil-based petrol and diesel road transport fuels, pure biofuels, and also emission factors that account for the average share of biofuel blended with these fuels in public refuelling stations. The methodologies used to calculate vehicle emission factors have previously been based upon pure conventional fossil-based road transport fuels. The share of biofuels has been increasing for a number of years now, and therefore this year the methodologies used to develop the road vehicle emission factors (both direct CO_2 and WTT) have been modified to account for the average petrol and diesel biofuel blend in public refuelling stations.

5.2. Plug-in Hybrid and Battery Electric Passenger (xEVs) are gaining in market share rapidly in the UK and are increasingly seeing commercial applications; this market is expected to continue to grow significantly in the future. The emissions resulting from these vehicles could already be calculated with the available emission factors, from the fuel and electricity consumption of these vehicles. However, with the increasing importance of EVs, there is now a greater need to also provide complementary vehicle emission factors, expanding on those already provided for conventionally fuelled vehicles. We have added a number of emission factors for electric cars to cover their different emissions components.

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)[23] provides numbers of registrations and averages of the NEDC[24] gCO_2/km figures for new vehicles registered from 1997 to 2016[25]. The dataset represents a good indication of the relative NEDC gCO_2/km by size category. Table 13 presents the 2000-2016 average CO_2 emission factors and number of vehicle registrations.

Vehicle Type	Engine size	Size label	NEDC gCO_2 per km	Total no. of registrations	% Total

[23] SMMT is the Society of Motor Manufacturers and Traders that represents the UK auto industry. http://www.smmt.co.uk/

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

[25] The SMMT gCO_2/km dataset for 1997 represented around 70% of total registrations, which rose to about 99% by 2000 and essentially all vehicles thereafter.

Vehicle Type	Engine size	Size label	NEDC gCO_2 per km	Total no. of registrations	% Total
Petrol car	< 1.4 l	Small	128.9	12,933,301	54%
	1.4 - 2.0 l	Medium	167.3	9,572,641	40%
	> 2.0 l	Large	252.2	1,581,254	7%
Average petrol car		***All***	***157.5***	**24,087,196**	***100%***
Diesel car	<1.7 l	Small	111.9	4,914,413	32%
	1.7 - 2.0 l	Medium	141.0	7,131,944	47%
	> 2.0 l	Large	176.5	3,257,377	21%
Average diesel car		***All***	***143.2***	**15,303,734**	**100%**

Table 13: Average CO_2 emission factors and total registrations by engine size for 2000 to 2016 (based on data sourced from SMMT)

5.4. For the 2017 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 2015 (the ANPR dataset is only updated in the NAEI on a bi-annual basis)).

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. 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, 2011, 2013, 2014 and 2015. 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 2015 ANPR dataset and categorised according to their engine size, fuel type and year of registration. The 2017 GHG Conversion Factors' emission factors for petrol and diesel passenger cars were subsequently calculated based upon the equation below:

$$2017 \text{ update gCO}_2/\text{km} = \Sigma \left(gCO_2/km_{yr\ reg} \times \frac{ANPR_{yr\ reg}}{ANPR_{total\ 2015}} \right)$$

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.

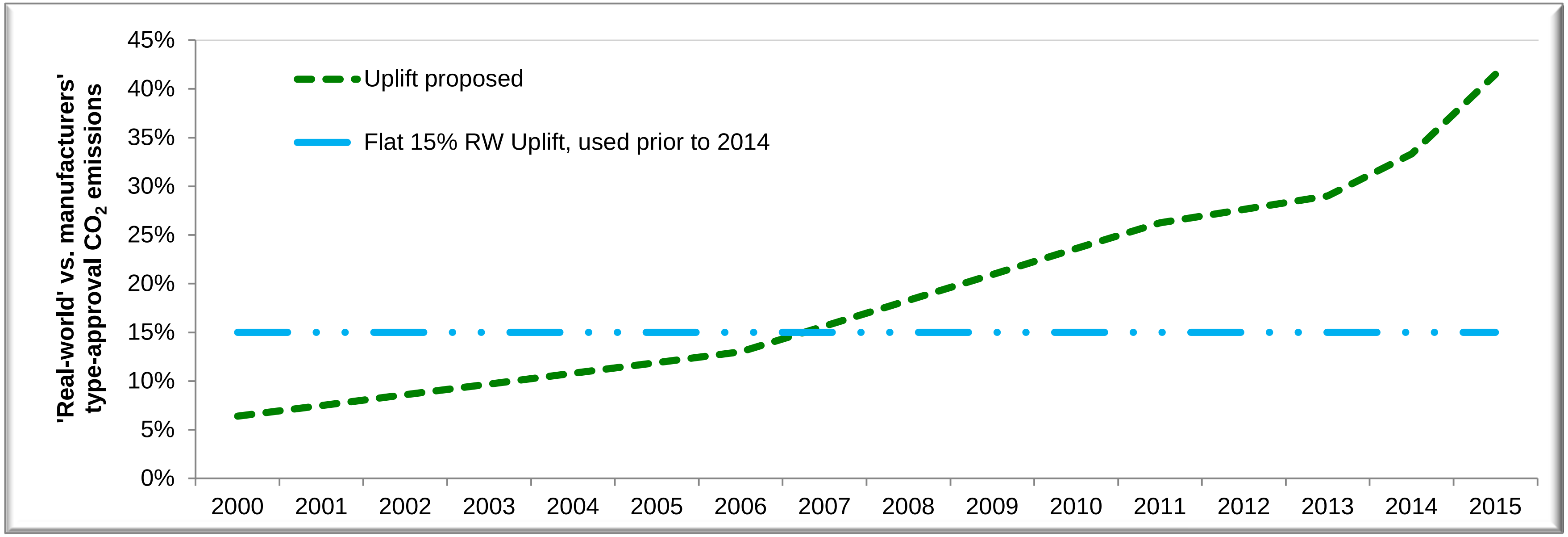
5.8. An uplift factor over NEDC based gCO_2/km factors is applied to take into account the combined ‘real-world’ effects on fuel consumption. The uplift applied varies over time and is based on work performed by ICCT (2016)[26]; this study used data on almost 600,000 vehicles from eleven data sources and six countries, covering the fuel consumption/CO_2 from actual real-world use and the corresponding type-approval values. The values used are based on average data from the two UK-based sources analysed in the ICCT study, as summarised in Table 14 below, and illustrated in Figure 2: Updated GCF 'Real world' uplift values for the UK based on ICCT (2015) alongside the source data / chart reproduced from the ICCT (2016) report. This was an update of the previous reports used for the 2016 updates to the GHG Conversion Factors. The methodology for the revised approach was also agreed with DfT upon its introduction in 2014.

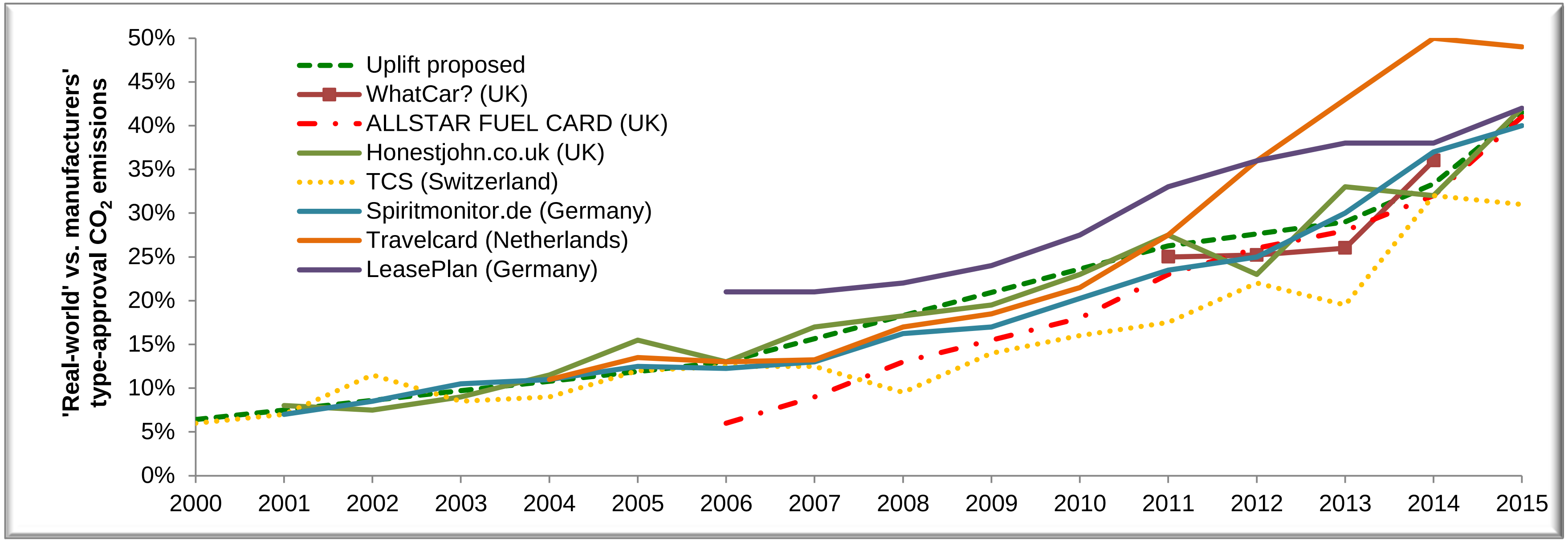
[26] ‘FROM LABORATORY TO ROAD: A 2016 update of official and ‘real-world’ fuel consumption and CO_2 values for passenger cars in Europe’ a report by the ICCT, November 2016. Available at: http://www.theicct.org/sites/default/files/publications/ICCT_LaboratoryToRoad_2016.pdf **Error! Hyperlink reference not valid.**

Model year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
RW uplift %	6.40 %	7.50 %	8.60 %	9.70 %	10.80 %	11.90 %	13.00 %	15.65 %	18.30 %	20.95 %	23.60 %	26.25 %	27.63 %	29.00 %	33.33 %	41.50 %

Table 14: Average GCF ‘real-world’ uplift for the UK, applied to the NEDC-based gCO_2/km data

5.9. The above uplifts have been applied to the ANPR weighted SMMT gCO_2/km to give the *New ‘Real-World’* 2017 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. The final average equivalent uplift averaged across all vehicles was 20.2% on top of NEDC gCO_2/km.





Notes: In the above charts a y-axis value of 0% would mean no difference between the CO_2 emissions per km experienced in ‘real-world’ driving conditions and those from official type-approval testing.

Figure 2: Updated GCF 'Real world' uplift values for the UK based on ICCT (2015)

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 52.1% petrol and 47.9% diesel, and can be compared to the respective total registrations of the different vehicle types for 2000-2016, which were 63.3% petrol and 36.7% diesel.

5.11. Emission factors for CH_4 and N_2O have been updated for all vehicle classes and are based on the emission factors from the NAEI. The emission factors used in the NAEI are based on COPERT 4 version 11[27].

5.12. The final 2017 emission factors for petrol and diesel passenger cars by engine size are presented in the ‘passenger vehicles’ and ‘business travel- land’ tables of the 2017 GHG Conversions Factors.

Hybrid, LPG and CNG Passenger Cars

5.13. The methodology used in the 2017 update for medium and large hybrid petrol/diesel electric cars is similar to that used previously, and is calculated in a similar way to conventional petrol and diesel vehicles. The emission factors are based on datasets on the numbers of registrations and averages of the NEDC gCO_2/km figures from SMMT for new hybrid vehicles registered between 2000 and 2016.

5.14. Due to the significant size and weight of the LPG and CNG fuel tanks it is assumed only medium and large sized vehicles are available. In the 2017 GHG Conversion Factors, CO_2 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 emission factors on a unit energy (Net CV) basis. For example, for a Medium car run on CNG:

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

5.15. For the 2017 GHG Conversion Factors, the emission factors for CH_4 and N_2O were updated, but the methodology remains unchanged. These are based on the emission factors from the NAEI (produced by Ricardo Energy & Environment) and are presented together with an overall total emission factors in the ‘passenger vehicles’ and ‘business travel- land’ tables of the 2017 GHG Conversion Factors.

Plug-in Hybrid Electric and Battery Electric Passenger Cars (xEVs)

5.16. Since the number electric vehicles (xEVs[28]) in the UK fleet is rapidly increasing (and will continue to increase in the future), at least for passenger cars and vans, there is now a need to add specific emission factors for such vehicles to complement the

[27] COPERT 4 is a software tool used world-wide to calculate air pollutant and greenhouse gas emissions from road transport, see: http://emisia.com/products/copert-4.

[28] xEVs is a generic term used to refer collectively to battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), range-extended electric vehicles (REEVs, or ER-EVs, or REX) and fuel cell electric vehicles (FCEVs).

existing emission factors for vehicles fuelled primarily by petrol, diesel, natural gas or LPG.

5.17. Consequently, for the first time in the 2017 GHG Conversion Factors, new emission factors were therefore developed for these vehicle types. The methodology, data sources and key assumptions utilised in the development of these emission factors for xEVs were discussed and agreed with the Department for Transport (DfT).

5.18. These emission factors are currently presented in a number of data tables in the GHG Conversion Factors workbook, according the type / 'Scope' of the emission component. The following tables / worksheets, shown in Table 15, are required for BEVs (battery electric vehicles) and PHEVs (plug-in hybrid electric vehicles), and related REEVs (range-extended electric vehicles). Since there are still relatively few models available on the market, all PHEVs and REEVs are grouped into a single category. There are not yet meaningful numbers of fuel cell electric vehicles (FCEVs) in use, so these are not included at this time.

5.19. Table 15 provides an overview of the GHG Conversion Factor tables that have been developed for the reporting of emissions from electric vehicles, which aligns with current reporting. Whilst most emission factors could be accommodated by simply extending existing tables for cars and vans, two new tables (marked NEW) were needed to account for emissions resulting from electricity consumption.

Emission component	Emissions Scope and Reporting Worksheet	Plug-in hybrid electric vehicles (PHEVs)	Battery electric vehicles (BEVs)
Direct emissions from use of petrol or diesel	**Scope 1:** • Passenger vehicles • Delivery vehicles	Yes	(Zero emissions)
Emissions resulting from electricity use: (a) Electricity Generation (b) Electricity Transmission & Distribution losses	**(a) Scope 2:** • UK electricity for EVs [NEW] **(b) Scope 3:** • UK electricity T&D for EVs [NEW]	Yes	Yes
Upstream emissions from use of liquid fuels and electricity	**Scope 3:** • WTT- pass vehs & travel- land • WTT- delivery vehs & freight	Yes	Yes
Total GHG emissions for all components for not directly owned /controlled assets	**Scope 3:** • Business travel- land • Freighting goods • Managed assets- vehicles	Yes	Yes

Note:

- **Scope 1 (direct) emissions** are those from activities owned or controlled by your organisation. Examples of Scope 1 emissions include emissions from combustion in owned or controlled boilers, furnaces and vehicles; and emissions from chemical production in owned or controlled process equipment.
- **Scope 2 (energy indirect) emissions** are those released into the atmosphere that are associated with consumption of purchased electricity, heat, steam and cooling. These indirect emissions are a consequence of an organisation's energy use, but occur at sources the organisation does not own or control.
- **Scope 3 (other indirect) emissions** are a consequence of your actions that occur at sources an organisation does not own or control and are not classed as Scope 2 emissions. Examples of Scope 3 emissions are business travel by means not owned or controlled by an organisation, waste disposal, materials or fuels an organisation's purchases. Deciding if emissions from a vehicle, office or factory that you use are Scope 1 or Scope 3 may depend on how organisations define their operational boundaries. Scope 3 emissions can be from activities that are upstream or downstream of an organisation. More information on Scope 3 and other aspects of reporting can be found in the Greenhouse Gas Protocol Corporate Standard.

Table 15: Summary of emissions reporting and tables for new electric vehicle emission factors

Data inputs, sources and key assumptions

5.20. A number of data inputs and assumptions were needed in order to calculate the final GHG conversion factors for electric cars and vans. The following Table 17 provides a summary of the key data inputs needed, the key data sources and other assumptions used for the calculation of the final xEV emission factors.

5.21. The calculation of UK fleet average emission factors for electric vehicles is based upon data obtained from the EEA CO_2 monitoring databases for cars and for vans, which are publically available[29] [30]. This database provides details by manufacturer and vehicle type (and by EU member state) on the annual number of registrations and test cycle performance for average CO_2 emissions (gCO_2/km) and electrical energy consumption (Wh/km, for plug-in vehicles). This allows for the classification of vehicles into market segments and also the calculation of registrations weighted average performance figures. The xEV models included in the current database (which covers registrations up to the end of 2015), and their allocation to different market segments, is provided in Table 16. For the purposes of calculating the corresponding emission factors for the tables split by car 'size' category, it is assumed segments A and B are 'Small' cars, segments C and D are 'Medium' cars and all other segments are 'Large' cars.

Make	Model	Segment	Segment Name	BEV	PHEV
AUDI	A3	C	Lower Medium	-	Yes
BMW	I3	B	Supermini	Yes	-
BMW	I3 REEV	B	Supermini	-	Yes
BMW	I8	G	Specialist Sports	-	Yes
BMW	X5	H	Dual Purpose	-	Yes
BYD	E6Y	C	Lower Medium	Yes	-
CHEVROLET	VOLT	C	Lower Medium	-	Yes
CITROEN	C-ZERO	A	Mini	Yes	-
FORD	FOCUS	C	Lower Medium	Yes	-
KIA	SOUL	B	Supermini	Yes	-

[29] http://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-11

[30] http://www.eea.europa.eu/data-and-maps/data/vans-7

Make	Model	Segment	Segment Name	BEV	PHEV
MCLAREN	P1	G	Specialist Sports	-	Yes
MERCEDES BENZ	B CLASS	C	Lower Medium	Yes	-
MERCEDES BENZ	C CLASS	D	Upper Medium	-	Yes
MERCEDES BENZ	E CLASS	E	Executive	-	Yes
MERCEDES BENZ	GL	H	Dual Purpose	-	Yes
MERCEDES BENZ	S CLASS	F	Luxury Saloon	-	Yes
MIA	MIA	A	Mini	Yes	-
MITSUBISHI	I-MIEV	A	Mini	Yes	-
MITSUBISHI	OUTLANDER	H	Dual Purpose	-	Yes
NISSAN	E-NV200	I	Multi-Purpose Vehicle	Yes	-
NISSAN	LEAF	C	Lower Medium	Yes	-
OPEL	AMPERA	D	Upper Medium	-	Yes
PEUGEOT	ION	A	Mini	Yes	-
PORSCHE	918	G	Specialist Sports	-	Yes
PORSCHE	CAYENNE	H	Dual Purpose	-	Yes
PORSCHE	PANAMERA	F	Luxury Saloon	-	Yes
RENAULT	FLUENCE Z.E.	D	Upper Medium	Yes	-
RENAULT	KANGOO	I	Multi-Purpose Vehicle	Yes	-
RENAULT	ZOE	C	Lower Medium	Yes	-
SMART	FORTWO	A	Mini	Yes	-
TESLA	MODEL S	F	Luxury Saloon	Yes	-
TESLA	MODEL X	H	Dual Purpose	Yes	-
TESLA	ROADSTER	G	Specialist Sports	Yes	-
THINK	THINKCITY	A	Mini	Yes	-
TOYOTA	PRIUS	C	Lower Medium	-	Yes
VOLKSWAGEN	E-GOLF	C	Lower Medium	Yes	-
VOLKSWAGEN	E-UP	A	Mini	Yes	-
VOLKSWAGEN	GOLF	C	Lower Medium	-	Yes
VOLVO	V60	D	Upper Medium	-	Yes

Notes: Only includes models with registrations in the UK fleet up to the end of 2015.

Table 16: xEV car models and their allocation to different market segments

5.22. During the course of the derivation of the emission factors, a number of discrepancies were found in the EEA CO_2 monitoring database for the gCO_2/km and Wh/km data for certain models, which were then updated based on other sources of official NEDC type-approval data, for example from manufacturer's websites and the Green Car Guide[31].

[31] https://www.greencarguide.co.uk/

5.23. Consistent with the approach used for the calculation of emission factors for conventionally fuelled passenger cars, the gCO_2/km and Wh/km figures from type approval with NEDC need adjusting to account for real-world performance (charging losses are already accounted for under the type approval methodology[32]). A number of assumptions are therefore made in order to calculate adjusted 'Real-World' energy consumption and emission factors, consistent with the approach for conventionally fuelled passenger cars. These assumptions were discussed and agreed with DfT.

5.24. A further complication for PHEVs is that the real-world electric range is lower than that calculated on the standard regulatory testing protocol, which also needs to be accounted for in the assumption of the average share of total km running on electricity. Figure 3 provides an illustration of the utility function used to calculate the share of electric km based on the electric range of a PHEV. Real-World factors for average gCO_2/km and Wh/km for PHEVs are therefore further adjusted based on the ratio of calculated electric shares of total km under Test-Cycle and Real-World conditions.

5.25. The key assumptions used in the calculation of adjusted Real-World gCO_2/km and Wh/km figures are summarised in Table 17. The calculated real-world figures for individual vehicle models are used to calculate the final registrations-weighted average factors for different vehicle segments/sizes. These are then combined with other GHG Conversion Factors to calculate the final set of emission factors for different Scopes/reporting tables (i.e. as summarised in earlier Table 15).

Data type	Raw data source / assumption	Other notes
Numbers of registrations of different vehicle types/models	Reported for GB by vehicle make/model in EEA CO_2 monitoring databases: • Data for 2010-2015 for cars • Data for 2012-2015 for vans	This data is used in conjunction with CO_2/km and Wh/km data to calculate registrations-weighted average figures by market segment or vehicle size category.
CO_2 emissions from petrol or diesel fuel use per km (test-cycle)	As for registrations	Zero for BEVs. For PHEVs the emission factors are for the average share of km driven in charge-sustaining mode / average liquid fuel consumption per km
Wh electricity consumption per km (test-cycle)	As for registrations	Average electricity consumption per average km (i.e. factoring in for PHEVs that only a fraction of total km will be in electric mode).
Test-Cycle to Real-World conversion for gCO_2 / km	Assumption based on literature, consistent with source used for the car EFs for conventional powertrains.	An uplift of **35%** is applied to the test-cycle emission component.

[32] www.vda.de/dam/vda/publications/2014/facts-and-arguments-about-fuel-consumption.pdf

Data type	Raw data source / assumption	Other notes
Test-Cycle to Real-World conversion for Wh per km	Assumption based on best available information on the average difference between test-cycle and real-world performance	An uplift of **40%** is applied to the test-cycle electrical energy consumption component. This is consistent with the uplift currently being used in analysis for the EC DG CLIMA, developed/agreed with the EC's JRC.
Electric range for PHEVs under Test-Cycle conditions	Available from various public sources for specific models	Values representative of the models currently available on the market are used, i.e. generally between 30-50km. The notable exception is the BMW i3 REX, which was 200km up to 2015.
Electric range for PHEVs under Real-World conditions	Calculated based on Test-Cycle electric range and Test-Cycle to Real-World conversion for Wh per km	Calculated based on Test-Cycle electric range and Test-Cycle to Real-World conversion for Wh/km
Share of electric km on Test-Cycle	Calculated using the standard formula used in type-approval*: **Electric km %** = 1 – (25 / (25 + Electric km range))	Uses Test-Cycle electric range in km
Share of electric km in Real-World conditions	Calculated using standard formula*: **Electric km %** = 1 – (25 / (25 + Electric km range))	Uses Real-World electric range in km
Loss factor for electric charging	N/A	Charging losses are already accounted for under the type approval testing protocol in the Wh/km dataset.
GHG emission factors for electricity consumption	UK electricity emission factors ($kgCO_2e$ / kWh): • Electricity generated • Electricity T&D • WTT electricity generated • WTT electricity T&D	From the UK GHG Conversion Factors model outputs for UK Electricity
CH_4, N_2O and WTT CO_2e emissions from petrol /diesel use	Calculated based on derived Real-World g/km for petrol /diesel.	Calculation uses GHG Conversion Factors for petrol/diesel: uses ratio of direct CO_2 emission component to CH_4, N_2O or WTT CO_2e component for petrol/diesel.

Notes: * the result of this formula is illustrated in Figure 3 below.

Table 17: Summary of key data elements, sources and key assumptions used in the calculation of GHG conversion factors for electric cars and vans

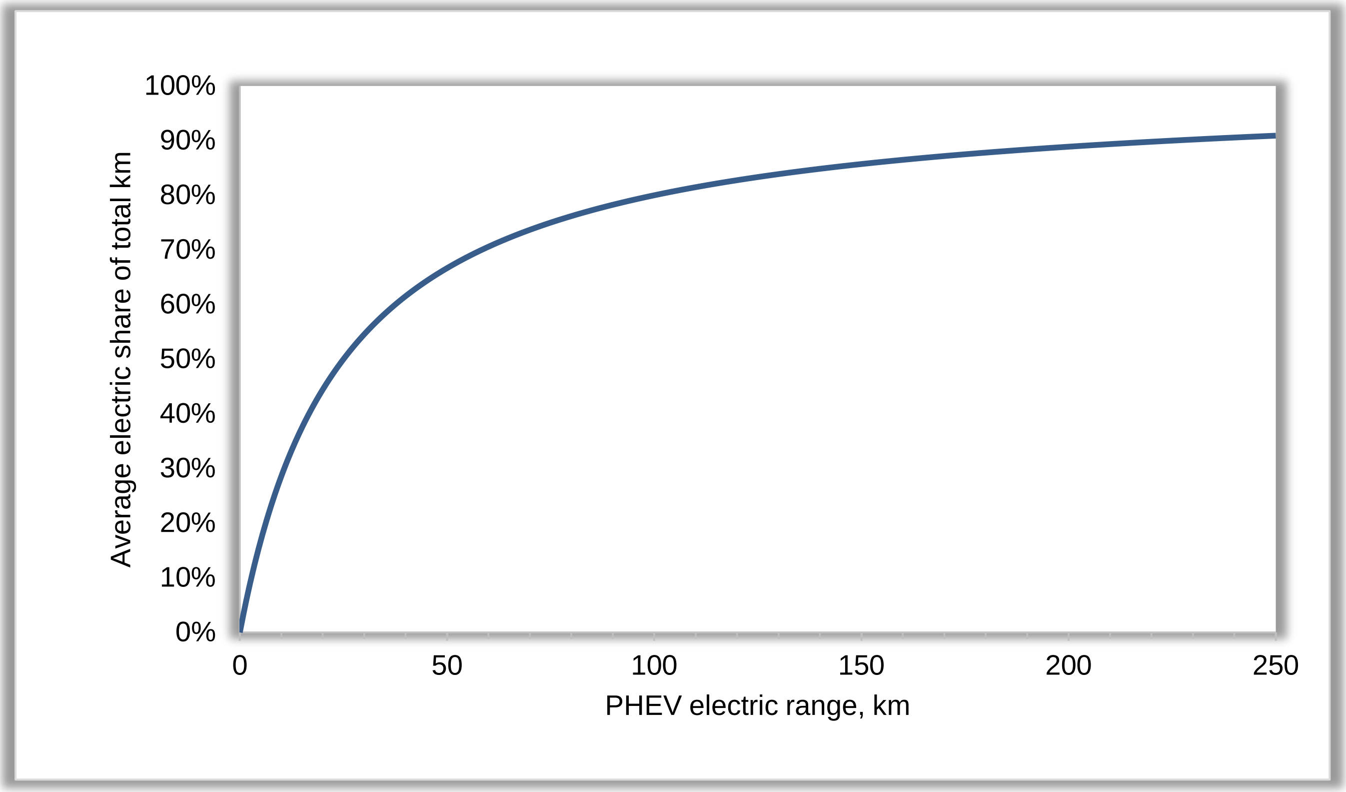


Figure 3: Illustration of the relationship of electric range to average electric share of total km for PHEVs assumed in the calculations

Emission Factors by Passenger Car Market Segments

5.26. For the 2017 GHG Conversion Factors, the market classification split (according to SMMT classifications) was derived using detailed SMMT data on new car registrations between 2000 and 2016 split by fuel[33], presented in Table 16, and again combining this with information extracted from the 2015 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 2017 GHG Conversion Factors.

5.27. Emission factors for CH_4 and N_2O were also updated for all car classes. These figures are based on the emission factors from the UK GHG Inventory. The emission factors used in the NAEI are now based on COPERT 4 version 11[34]. The factors are presented together with the overall total emission factors in the tables of the 2017 GHG Conversion Factors.

5.28. As a final additional step, this year, an accounting for biofuel use has been included in the calculation of the final passenger car emission factors.

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

[34] COPERT 4 is a software tool used world-wide to calculate air pollutant and greenhouse gas emissions from road transport, see: http://emisia.com/products/copert-4.

Fuel Type	Market Segment	Example Model	2000-2016		
			gCO_2/km	# registrations	% Total
Diesel	A. Mini	Smart Fortwo	90.2	9,117	0.1%
	B. Super Mini	VW Polo	108.2	1,859,251	12%
	C. Lower Medium	Ford Focus	120.4	4,612,125	30%
	D. Upper Medium	Toyota Avensis	138.2	3,553,416	23%
	E. Executive	BMW 5-Series	148.3	1,266,023	8%
	F. Luxury Saloon	Bentley Continental GT	183.1	73,353	0.5%
	G. Specialist Sports	Mercedes SLK	136.3	108,419	0.71%
	H. Dual Purpose	Land Rover Discovery	172.9	2,567,249	17%
	I. Multi Purpose	Renault Espace	149.3	1,254,782	8%
	All	**Total**	**143.2**	**15,303,734**	**100%**
Petrol	A. Mini	Smart Fortwo	114.3	843,868	3%
	B. Super Mini	VW Polo	131.7	11,508,780	48%
	C. Lower Medium	Ford Focus	156.7	6,431,817	27%
	D. Upper Medium	Toyota Avensis	185.9	2,343,015	10%
	E. Executive	BMW 5-Series	214.1	598,971	2%
	F. Luxury Saloon	Bentley Continental GT	294.3	99,370	0%
	G. Specialist Sports	Mercedes SLK	212.5	829,090	3%
	H. Dual Purpose	Land Rover Discovery	219.6	731,375	3%
	I. Multi Purpose	Renault Espace	170.7	761,550	3%
	All	**Total**	**157.5**	**24,147,836**	**100%**
Unknown Fuel (Diesel + Petrol)	A. Mini	Smart Fortwo	113.0	852,985	2%
	B. Super Mini	VW Polo	127.1	13,368,031	34%
	C. Lower Medium	Ford Focus	139.0	11,043,942	28%
	D. Upper Medium	Toyota Avensis	151.7	5,896,431	15%
	E. Executive	BMW 5-Series	163.2	1,864,994	5%
	F. Luxury Saloon	Bentley Continental GT	234.3	172,723	0.4%
	G. Specialist Sports	Mercedes SLK	196.6	937,509	2%
	H. Dual Purpose	Land Rover Discovery	179.9	3,298,624	8%
	I. Multi Purpose	Renault Espace	156.7	2,016,332	5%
	All	**Total**	**149.9**	**39,451,571**	**100%**

Table 18: Average car CO_2 emission factors and total registrations by market segment for 2000 to 2016 (based on data sourced from SMMT)

Direct Emissions from Taxis

5.29. The emission factors for black cabs are based on data provided by Transport for London (TfL)[35] 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 methodology accounts for the significantly different operational cycle of black cabs/taxis in the real world when compared to the NEDC (official vehicle type-approval) values, which significantly increases the emission factor (by ~40% vs NEDC).

5.30. The emission factors (per passenger km) for regular taxis were estimated on the basis of the average type-approval CO_2 factors for medium and large cars, uplifted by the same factor as for black cabs (i.e. 40%, based on TfL data) to reflect the difference between the type-approval figures and those operating a real-world taxi cycle (i.e. based on different driving conditions to average car use), plus an assumed average passenger occupancy of 1.4 (CfIT, 2002[36]).

5.31. 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 2017 GHG Conversion Factors.

5.32. Emission factors for CH_4 and N_2O have been updated for all taxis for the 2017 update. These figures are based on the emission factors for diesel cars from the latest UK GHG Inventory and are presented together with overall total emission factors in the tables of the 2017 GHG Conversion Factors.

5.33. 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.

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[35] The data was provided by TfL in a personal communication and is not available in a public TfL source.

[36] 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

Direct Emissions from Vans/Light Goods Vehicles (LGVs)

5.34. Average emission factors by fuel, for light good vehicles (LGVs: N1 vehicles, vans up to 3.5 tonnes gross vehicle weight) and by size class (I, II or III) are presented in Table 19 and in the “delivery vehicles” section of the 2017 GHG Conversion Factors. These have been updated for 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) from an extraction from the SMMT MVRIS (Motor Vehicle Registration Information System) data set used in previous work for the DfT. The assumed split of petrol van stock between size classes uses the split of registrations from this dataset.

5.35. Emission factors for petrol and diesel LGVs are based upon emission factors and vehicle km from the NAEI for 2015. These emission factors are further uplifted by 15% to represent ‘real-world’ emissions (i.e. also factoring in typical vehicle loading versus unloaded test-cycle based results), 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). In a future update, it is envisaged this uplift will be further reviewed.

5.36. In the 2017 GHG Conversion Factors, CO_2 emission factors for CNG and LPG vans are calculated from the emission factors for conventionally fuelled vans 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 2015, as presented in Table 19.

5.37. Emission factors for CH_4 and N_2O were also updated for all van classes, based on the emission factors from the UK GHG Inventory.

5.38. As a final additional step, this year, an accounting for biofuel use has been included in the calculation of the final LGVs emission factors.

Van fuel	Van size	Direct gCO_2e per km				vkm	Capacity
		CO_2	CH_4	N_2O	Total	% split	Tonnes
Petrol (Class I)	Up to 1.305 tonne	243.7	0.53	1.23	245.5	38.37%	0.64
Petrol (Class II)	1.305 to 1.740 tonne	271.5	0.53	1.23	273.3	48.63%	0.72
Petrol (Class III)	Over 1.740 tonne	328.2	0.53	1.23	329.9	13.00%	1.29
Petrol (average)	**Up to 3.5 tonne**	**268.2**	**0.53**	**1.23**	**270.0**	**0.00%**	**0.76**
Diesel (Class I)	Up to 1.305 tonne	151.5	0.01	1.87	153.4	6.18%	0.64
Diesel (Class II)	1.305 to 1.740 tonne	239.4	0.01	1.87	241.3	25.74%	0.98
Diesel (Class III)	Over 1.740 tonne	280.8	0.01	1.87	282.7	68.08%	1.29
Diesel (average)	**Up to 3.5 tonne**	**262.2**	**0.01**	**1.87**	**264.0**	**0.00%**	**1.17**
LPG	Up to 3.5 tonne	275.3	0.12	1.47	276.9		1.17
CNG	Up to 3.5 tonne	249.1	2.64	1.47	253.2		1.17
Average		**262.4**	**0.0**	**1.8**	**264.3**		**1.16**

Table 19: New emission factors for vans for the 2017 GHG Conversion Factors

Plug-in Hybrid Electric and Battery Electric Vans (xEVs)

5.39. As outlined earlier for cars, since the number electric cars and vans (xEVs[37]) in the UK fleet is rapidly increasing, there is now a need to include specific emission factors for such vehicles to complement the existing emission factors for other vehicle types.

5.40. Consequently, for the first time in the 2017 GHG Conversion Factors, new emission factors were therefore developed for these vehicle types for both cars and vans. The methodology, data sources and key assumptions utilised in the development of these emission factors for xEVs is the same for vans as that outlined earlier for cars. These were discussed and agreed with the Department for Transport (DfT).

5.41. The following Notes: Only includes models with registrations in the UK fleet up to the end of 2015.

5.42. Table 20 provides a summary of the van models registered into the UK market by the end of 2015 (the most recent data year for the source EEA CO_2 monitoring database at the time of the development of the 2017 GHG Conversion Factors). At this point there are only battery electric vehicle (BEV) models available in the vans marketplace.

Make	Model	Van Segment	BEV	PHEV
CITROEN	BERLINGO	Class II	Yes	-
FORD	TRANSIT CONNECT	Class III	Yes	-
MERCEDES	VITO	Class III	Yes	-
MIA	MIA	Class I	Yes	-
NISSAN	E-NV200	Class II	Yes	-
PEUGEOT	PARTNER	Class II	Yes	-
RENAULT	KANGOO	Class II	Yes	-
TATA	ACE	Class I	Yes	-

Notes: Only includes models with registrations in the UK fleet up to the end of 2015.

Table 20: xEV van models and their allocation to different size categories

5.43. All other methodological details are as already outlined for xEV passenger cars.

[37] xEVs is a generic term used to refer collectively to battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), range-extended electric vehicles (REEVs, or ER-EVs, or REX) and fuel cell electric vehicles (FCEVs).

Direct Emissions from Buses

5.44. The 2015 and earlier updates used data from DfT from the Bus Service Operators Grant (BSOG) in combination with DfT bus activity statistics (vehicle km, passenger km, average passenger occupancy) 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 CO_2 emissions) could be calculated from this, which when combined with DfT statistics on total vehicle km, bus occupancy and passenger km allows the calculation of emission factors[38].

5.45. From the 2016 update onwards, it was necessary to make some methodological changes to the calculations due to changes in the scope/coverage of the underlying DfT datasets, which include:

a) BSOG datasets are now only available for commercial services, and not also local authority supported services.
b) BSOG datasets are now only available for England, outside of London: i.e. datasets are no longer available for London, due to a difference in how funding for the city is managed/provided, nor for other parts of the UK.

5.46. Briefly, the main calculation for local buses can be summarised as follows:

- Total fuel consumption (Million litres) = Total BSOG (£million) / BSOG fuel rate (p/litre) x 100
- Total bus passenger-km (Million) = Total activity (Million vkm) x Average bus occupancy (#)
- Average fuel consumption (litres/pkm) = Total fuel consumption / Total bus passenger-km
- **Average bus emission factor** = Average fuel consumption x Emission Factor ($kgCO_2e$/litre)

5.47. Whilst the overall the fundamental approach used in the 2016 and 2017 update is similar to that previously used (i.e. as outlined above), the scope of coverage of the underlying data is different, which has resulted in step-change increase in emission factors for non-London local buses. In addition, since no BSOG data is available for London any more, the emission factors for London buses are taken directly from TfL's environmental reporting. Overall average emission factors for all local buses are estimated from DfT statistics on the relative passenger-km activity for London and non-London local buses[39].

5.48. As a final additional step, an accounting for biofuel use has been included in the calculation of the final bus emission factors.

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

[38] The robustness of the BSOG data has reduced over the years because of the changes to the way BSOG is paid to operators and local authorities. Approximations have been made in recent update years where data was not available (based on previous year data) and a revised methodology has commenced from 2016.

[39] DfT Bus statistics, Table BUS0302b "Passenger kilometres on local bus services by metropolitan area status and country: Great Britain, annual from 2004/05", available at: https://www.gov.uk/government/statistical-data-sets/bus03-passenger-distance-travelled

2017 update, an additional accounting for the share of biofuels included in retail fuels has also been made.

5.50. Emission factors for CH_4 and N_2O are based on the emission factors from the UK GHG Inventory. These factors are also presented together with an overall total factor in Table 21.

5.51. Table 21 gives a summary of the 2017 GHG Conversion 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_2O	Total
Local bus (not London)	9.47	121.68	0.06	0.85	122.59
Local London bus	19.83	72.26	0.03	0.41	72.70
Average local bus	**11.97**	**101.87**	**0.05**	**0.67**	**102.59**
Coach	17.56*	27.40	0.02	0.38	27.80

Notes: Average load factors/passenger occupancy mainly taken from DfT Bus statistics, Table BUS0304 "Average bus occupancy on local bus services by metropolitan area status and country: Great Britain, annual from 2004/05".
* Combined figure based on data from DfT for non-local buses and coaches combined calculated based on an average of the last 5 years for which this was available (up to 2007). Actual occupancy for coaches alone is likely to be significantly higher.

Table 21: Emission factors for buses for the 2017 GHG Conversion Factors

Direct Emissions from Motorcycles

5.52. Data from type approval is not currently readily available for motorbikes and CO_2 emission measurements were only mandatory in motorcycle type approval from 2005.

5.53. 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).

5.54. Since the 2009 update the emission factors have been calculated based on a large dataset kindly provided by Clear (2008)[40], based on a mix of magazine road test reports and user reported data. A summary is presented in Table 22, with the corresponding complete emission factors developed for motorcycles presented in the ‘passenger vehicles’ tables of the 2017 GHG Conversion Factors. The total average has been calculated weighted by the relative number of registrations of each category in 2008 according to DfT licencing statistics for 2015[41]. In the absence of newer information, the methodology and dataset are unchanged for the 2017 GHG Conversion Factors.

5.55. These emission factors are based predominantly upon data derived from real-world riding conditions (rather than 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 other figures based upon test-cycle data from ACEM[42] (+9%) is smaller than the corresponding differential previously used to uplift cars and vans test cycle data to real-world equivalents (+15%).

5.56. Emission factors for CH_4 and N_2O were updated for the 2017 GHG Conversion Factors based on the emission factors from the 2015 UK GHG Inventory (Ricardo Energy & Environment, 2017). These factors are also presented together with overall total emission factors in the tables of the 2017 GHG Conversion Factors.

CC Range	Model Count	Number	Av. gCO_2/km	Av. MPG*
Up to 125cc	24	58	85.0	76.1
125cc to 200cc	3	13	77.8	83.1
200cc to 300cc	16	57	93.1	69.5
300cc to 400cc	8	22	112.5	57.5
400cc to 500cc	9	37	122.0	53.0
500cc to 600cc	24	105	139.2	46.5

[40] Dataset of motorcycle fuel consumption compiled by Clear (http://www.clear-offset.com/) for the development of its motorcycle CO_2 model used in its carbon offsetting products.

[41] DfT Vehicle Licencing Statistics, Table VEH0306 “Licensed motorcycles by engine size, Great Britain, annually: 1994 to 2015”, available at: https://www.gov.uk/government/collections/vehicles-statistics

[42] The European Motorcycle Manufacturers Association

CC Range	Model Count	Number	Av. gCO_2/km	Av. MPG*
600cc to 700cc	19	72	125.9	51.4
700cc to 800cc	21	86	133.4	48.5
800cc to 900cc	21	83	127.1	50.9
900cc to 1000cc	35	138	154.1	42.0
1000cc to 1100cc	14	57	135.6	47.7
1100cc to 1200cc	23	96	136.9	47.2
1200cc to 1300cc	9	32	136.6	47.4
1300cc to 1400cc	3	13	128.7	50.3
1400cc to 1500cc	61	256	132.2	48.9
1500cc to 1600cc	4	13	170.7	37.9
1600cc to 1700cc	5	21	145.7	44.4
1700cc to 1800cc	3	15	161.0	40.2
1800cc to 1900cc	0	0		0.0
1900cc to 2000cc	0	0		0.0
2000cc to 2100cc	1	5	140.9	45.9
<125cc	24	58	85.0	76.1
126-500cc	36	129	103.2	62.7
>500cc	243	992	137.2	47.1
Total	303	1179	117.5	55.1

Note: Summary data based data provided by Clear (www.clear-offset.com) from a mix of magazine road test reports and user reported data. * MPG has been calculated from the supplied gCO_2/km dataset, using the fuel properties for petrol from the latest conversion factors dataset.

Table 22: Summary dataset on CO_2 emissions from motorcycles based on detailed data provided by Clear (2008)

Direct Emissions from Passenger Rail

5.57. Emission factors for passenger rail services have been updated and provided in the “Business travel – land” section of the 2017 GHG Conversion Factors. These include updates to the national rail, international rail (Eurostar), light rail schemes and the London Underground. Emission factors for CH_4 and N_2O emissions were also updated in the 2017 GHG Conversion Factors. These factors are based on the assumptions outlined in the following paragraphs.

International Rail (Eurostar)

5.58. The international rail factor is based on a passenger-km weighted average of the emission factors for the following Eurostar routes: London-Brussels, London-Paris, London-Marne Le Vallee (Disney), London-Avignon and the ski train from London-Bourg St Maurice[43]. The emission factors were provided by Eurostar for the 2017 update, together with information on the basis of the electricity figures used in their calculation.

[43] Although there are now also direct Eurostar routes to Lyon and Marseille, information relating to these routes has not been provided in 2017.

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

a. Total electricity use by Eurostar trains on the UK and France/Belgium track sections;
b. Total passenger numbers (and therefore calculated passenger km) on all Eurostar services;
c. Emission factors for electricity (in $kgCO_2$ 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 from the last freely available version of the IEA CO_2 Emissions from Fuel Combustion highlights dataset (from 2013).

5.60. The new figure from Eurostar is $12.157gCO_2/pkm$.

5.61. CH_4 and N_2O emission factors have been estimated from the corresponding emission factors for electricity generation, proportional to the CO_2 emission factors.

National Rail

5.62. The national rail factor refers to an average emission per passenger kilometre for diesel and electric trains in 2015-16. The factor is sourced from information from the Office of the Rail Regulator's National rail trends for 2015-16 (ORR, 2016)[44]. 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).

5.63. CH_4 and N_2O emission factors have been estimated from the corresponding emissions factors for electricity generation and diesel rail (from the UK GHG Inventory), proportional to the CO_2 emission factors. The emission factors were calculated based 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

5.64. 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 23.

5.65. Figures for the DLR, London Overground and Croydon Tramlink for 2015/16 based on figures kindly provided by Transport for London, adjusted to the new 2017 grid electricity CO_2 emission factor.

5.66. The factors for Midland Metro, Tyne and Wear Metro, the Manchester Metrolink and Sheffield Supertram were calculated based on annual passenger km data from DfT's Light rail and tram statistics[45] and the new 2017 grid electricity CO_2 emission factor.

5.67. The factor for the Glasgow Underground were calculated based on the annual passenger km data from DfT's Glasgow Underground statistics, and the new 2017 grid electricity CO_2 emission factor.

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[44] Available from the ORR's website at: https://dataportal.orr.gov.uk/displayreport/html/html/31212a97-cf7a-42d5-9fe3-a134b5c08b6a

[45] DfT Light rail and tram statistics, http://www.dft.gov.uk/statistics/series/light-rail-and-tram

5.68. The average emission factor was estimated based on the relative passenger km of the eight different rail systems (see Table 23

5.69. CH_4 and N_2O emission factors have been estimated from the corresponding emissions factors for electricity generation, proportional to the CO_2 emission factors.

	Type	Electricity use	gCO_2e per passenger km				Million pkm
		kWh/pkm	CO_2	CH_4	N_2O	Total	
DLR (Docklands Light Rail)	Light Rail	0.1081	41.2	0.1	0.2	41.6	623
Glasgow Underground	Light Rail	0.1643	62.7	0.1	0.4	63.2	13
Midland Metro	Light Rail	0.1353	51.6	0.1	0.3	52.0	51
Tyne and Wear Metro	Light Rail	0.2805	107.0	0.2	0.6	107.8	344
London Overground	Light Rail	0.0692	26.4	0.0	0.2	26.6	1,237
London Tramlink	Tram	0.1126	43.0	0.1	0.3	43.3	140
Manchester Metrolink	Tram	0.0784	29.9	0.1	0.2	30.2	359
Sheffield Supertram	Tram	0.3500	133.5	0.2	0.8	134.6	75
Average*		**0.12**	**44.12**	**0.08**	**0.26**	**44.47**	**Total: 2842**

Notes: * Weighted by relative passenger km

Table 23: GHG emission factors, electricity consumption and passenger km for different tram and light rail services

London Underground

5.70. The London Underground rail factor was provided from Transport for London, which was based on the 2015 UK electricity emission factor, so was therefore adjusted to be consistent with the 2017 grid electricity CO_2 emission factor.

5.71. CH_4 and N_2O emission factors have been estimated from the corresponding emissions factors for electricity generation, proportional to the CO_2 emission factors.Indirect/WTT Emissions from Passenger Land Transport

Cars, Vans, Motorcycles, Taxis, Buses and Ferries

5.72. Indirect/WTT emission factors 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 CO_2 emission factors and the indirect/WTT emission factors for the relevant fuels from the “Fuels” section and the corresponding direct CO_2 emission factors for vehicle types using these fuels in the “Passenger vehicles”, “Business travel – land” and “Business travel – air” sections in the 2017 GHG Conversion Factors.

Rail

5.73. Indirect/WTT emission factors for international rail (Eurostar), light rail and the London Underground were derived using a simple ratio of the direct CO_2 emission factors and the indirect/WTT emission factors for grid electricity from the “UK Electricity” section and the corresponding direct CO_2 emission factors for vehicle types in the “passenger vehicles”, “Business travel – land” and “Business travel – air” sections in the GHG Conversion Factors.

5.74. The emission factors for national rail services are based on a mixture of emissions from diesel and electric rail. Indirect/WTT emission factors 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

Direct Emissions from Heavy Goods Vehicles (HGVs)

6.1. The HGV factors are based on road freight statistics from the Department for Transport (DfT, 2016)[46] for Great Britain (GB), from a survey on different sizes of rigid and articulated HGVs in the fleet in 2015. The statistics on fuel consumption figures (in miles per gallon) have been estimated by DfT from the survey data. For the 2017 GHG Conversion Factors these are combined with test data from the European ARTEMIS project showing how fuel efficiency, and therefore the CO_2 emissions, varies with vehicle load.

6.2. The miles per gallon (MPG) figures in Table RFS0141 of DfT (2016) are converted to gCO_2 per km factors using the standard fuel conversion factor for diesel in the 2017 GHG Conversion Factors tables. Table RFS0117 of DfT (2016) shows the percent loading factors are on average between 43-76% 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 24 showing the change in CO_2 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 cycle. So, for example, a >17t rigid HGV emits 18% more CO_2 per kilometre when fully laden and 18% less CO_2 per kilometre when empty relative to emissions at half-load.

6.3. The refrigerated/temperature-controlled HGVs included a 19% and 16% uplift which is applied to rigid and arctic refrigerated/temperature-controlled HGVs respectively. The refrigerated/temperature-controlled average factors have a 18% uplift applied. This is based on average data for different sizes of refrigerated HGV from Tassou et al (2009)[47].This accounts for the typical additional energy needed to power refrigeration equipment in such vehicles over similar non-refrigerated alternatives[48].

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[46] "Transport Statistics Bulletin: Road Freight Statistics 2011-2015, (DfT, 2016). Available at: https://www.gov.uk/government/statistics/road-freight-statistics-2015

[47] *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

[48] '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

	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 24: Change in CO_2 emissions caused by +/- 50% change in load from average loading factor of 50%

6.4. Using these loading factors, the CO_2 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 CO_2 factor shown for each class of HGV. These are shown in the final factors presented in sections "Delivery vehicles" and "Freighting goods" of the 2017 GHG Conversion Factors.

6.5. The loading factors in Table 24 were then used to derive corresponding CO_2 factors for 0% and 100% loadings in the above sections. Because the effect of vehicle loading on CO_2 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 CO_2 factor halfway between the values for 50% and 100% laden factors.

6.6. It might be surprising to see that the CO_2 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 CO_2 factors for large rigid HGVs may be lower than indicated in "Delivery vehicles" and "Freighting goods" of the 2017 GHG Conversion Factors. Thus the factors in "Delivery vehicles" and "Freighting goods", linked to the DfT (2016) statistics on MPG (estimated by DfT from the survey data) reflect each HGV class's typical usage pattern on the GB road network.

6.7. UK average factors for all rigid and articulated HGVs are also provided in sections "Delivery vehicles" and "Freighting goods" of the 2017 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 2015. These are derived directly from the mpg values for rigid and articulated HGVs in Table RFS0141of DfT (2016).

6.8. At a more aggregated level, factors for all HGVs are still representing the average MPG for all rigid and articulated HGV classes in Table RFS0141 of DfT (2016). This factor should be used if the user has no knowledge of or requirement for different classes of HGV and may be suitable for analysis of HGV CO_2 emissions in, for example, inter-modal freight transport comparisons.

6.9. The conversion factors provided in “Delivery vehicles” of the 2017 GHG Conversion Factors are in distance units, that is to say, they enable CO_2 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.

6.10. For comparison with other freight transport modes (e.g. road vs. rail), the user may require CO_2 factors in tonne km (tkm) units. The “Freighting goods” section of the 2017 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 fleet average gCO_2 per vehicle km factors in “Delivery vehicles”. 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, 2016). 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 44%. The 2017 GHG Conversion Factors, include factors in tonne km (tkm) for all loads, (0%, 50%, 100% and average).

6.11. A tkm is the distance travelled multiplied by the weight of freight carried by the HGV. So, for example, a HGV carrying 5 tonnes freight over 100 km has a tkm value of 500 tkm. The CO_2 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 CO_2 conversion factor in “Freighting goods” of the 2017 GHG Conversion Factors for the relevant HGV class.

6.12. Emission factors for CH_4 and N_2O have been updated for all HGV classes. These are based on the emission factors from the 2015 UK GHG Inventory. CH_4 and N_2O emissions are assumed to scale relative to vehicle class/CO_2 emissions for HGVs. These factors are presented with an overall total factor in sections “Delivery vehicles” and “Freighting goods” of the 2017 GHG Conversion Factors.

Direct Emissions from Vans/Light Goods Vehicles (LGVs)

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

6.14. 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 25. These are based on quantitative assessment of a van database used by Ricardo Energy & Environment previously in a variety of policy assessments for DfT.

Van fuel	Van size, Gross Vehicle Weight	Vkm % split	Av. Capacity tonnes	Av. Payload tonnes
Petrol (Class I)	Up to 1.305 tonne	38.37%	0.64	0.24
Petrol (Class II)	1.305 to 1.740 tonne	48.63%	0.72	0.26
Petrol (Class III)	Over 1.740 tonne	13.00%	1.29	0.53
Petrol (average)	**Up to 3.5 tonne**		**0.76**	**0.31**

Van fuel	Van size, Gross Vehicle Weight	Vkm % split	Av. Capacity tonnes	Av. Payload tonnes
Diesel (Class I)	Up to 1.305 tonne	6.18%	0.64	0.24
Diesel (Class II)	1.305 to 1.740 tonne	25.74%	0.98	0.36
Diesel (Class III)	Over 1.740 tonne	68.08%	1.29	0.53
Diesel (average)	**Up to 3.5 tonne**		**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 (unknown fuel)			**1.16**	**0.47**

Table 25: Typical van freight capacities and estimated average payload

6.15. The average load factors assumed for different vehicle types used to calculate the average payloads in Table 25 are summarised in Table 26, 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
Mid-point for van loading ranges	*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, 2008[49]

Table 26: Utilisation of vehicle capacity by company-owned LGVs: annual average 2003 – 2005 (proportion of total vehicle kilometres travelled)

6.16. Emission factors for CH_4 and N_2O have been updated for all van classes in the 2017 GHG Conversion Factors. These are based on the emission factors from the UK GHG Inventory. N_2O emissions are assumed to scale relative to vehicle class/CO_2 emissions for diesel vans.

[49] 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

6.17. 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 25 and the earlier emission factors per vehicle-km in the "Delivery vehicles" and "Freighting goods" sections of the 2017 GHG Conversion Factors.

Direct Emissions from Rail Freight

6.18. Data provided by the Office of the Rail Regulator's (ORR) Table 2.100 Sustainable development: Estimates of normalised passenger and freight CO_2e emissions for 2014-16 (ORR, 2016)[50] has been used to update the rail freight emission factors for the 2017 GHG Conversion Factors. This factor is presented in "Freighting goods" in the 2017 GHG Conversion Factors. There have been no further updates to the methodology in the 2017 update.

6.19. 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 CO_2 emissions from diesel rail freight are over 95% of the total for 2015-16 (ORR,2016).

6.20. 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).

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

6.22. CH_4 and N_2O emission factors have been estimated from the corresponding emissions for diesel rail from the UK GHG Inventory, proportional to the CO_2 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

6.23. Indirect/WTT emission factors 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 CO_2 emission factors and the indirect/WTT emission factors for the relevant fuels and the corresponding direct CO_2 emission factors for vehicle types using these fuels.

Rail

6.24. The emission factors for freight rail services are based on a mixture of emissions from diesel and electric rail. Indirect/WTT emission factors were therefore calculated in a similar way to the other freight transport modes, except from combining indirect/WTT emission factors for diesel and electricity into a weighted average for freight rail using relative CO_2 emissions from traction energy for diesel and electric

[50] Available from the ORR's website here: https://dataportal.orr.gov.uk/displayreport/html/html/31212a97-cf7a-42d5-9fe3-a134b5c08b6a

freight rail provided from ORR in table 2.101 Sustainable development: Estimates of passenger and freight energy consumption and CO_2e emissions (2016).

7. Sea Transport Emission Factors

Direct Emissions from RoPax Ferry Passenger Transport and freight

7.1. Direct emission factors from RoPax passenger ferries and ferry freight transport is based on information from the Best Foot Forward (BFF) work for the Passenger Shipping Association (PSA) (BFF, 2007)[51]. No new methodology or updated dataset has been identified for the 2017 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 CO_2 emissions were calculated. CO_2 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[52]
Average weight of passenger + luggage, total	0.100	MCA, 2007[52]
Average Freight Unit*, total	22.173	BFF, 2007[53]
Average Freight Load (per freight unit)*, tonnes	13.624	RFS 2005, 2006[54]

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

Table 27: Assumptions used in the calculation of ferry emission factors

7.4. CO_2 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 2017 GHG Conversion Factors. A further split has been provided between foot-only passengers and passengers with cars in the 2017 GHG Conversion Factors, again on a weight allocation basis.

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[51] 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.

[52] 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

[53] 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.

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

7.5. CO_2 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 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 2017 GHG Conversion Factors tables.

7.6. 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).

7.7. CH_4 and N_2O emission factors have been estimated from the corresponding emissions for shipping from the 2015 UK GHG Inventory, proportional to the CO_2 emissions.

Direct Emissions from Other Marine Freight Transport

7.8. CO_2 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)[55] report on GHG emissions from ships. The figures in “Freighting goods” of the 2017 GHG Conversion Factors represent international average data (i.e. including vessel characteristics and typical loading factors), as UK-specific datasets are not available.

7.9. CH_4 and N_2O emission factors have been estimated from the corresponding emissions for shipping from the UK GHG Inventory for 2015, proportional to the CO_2 emissions.

Indirect/WTT Emissions from Sea Transport

7.10. Indirect/WTT emissions factors 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 CO_2 emission factors and the indirect/WTT emission factors for the relevant fuels and the corresponding direct CO_2 emission factors for ferries and ships using these fuels.

[55] “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 CO_2 efficiency for cargo ships, International Maritime Organisation, 2009. Available at: https://www.transportenvironment.org/docs/mepc59_ghg_study.pdf

8. Air Transport Emission Factors

Passenger Air Transport Direct CO_2 Emission Factors

8.1. A brand new set of aviation factors was added for international flights between non-UK destinations in the 2015 update. This relatively high-level analysis allows users to choose a different factor for passenger air travel if flying between countries outside of the UK. All factors presented are for direct (non-stop) flights only. This analysis was only possible for passenger air travel and so international freight factors are assumed to be equal to the current UK long haul air freight factors[56].

8.2. The 2017 update of the average factors (presented at the end of this section) has been calculated using the same updated data source as in 2015 and 2016. The EUROCONTROL small emitters tool was used as the basis for calculating the CO_2 emissions factors resulting from fuel burn over average flights for different aircraft. The principal advantages of the source are:

- ❖ The tool is based on a methodology designed to estimate the fuel burn for an entire flight, it 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 wide range of aircraft, including many newer (and more efficient) aircraft increasingly used in flights to/from the UK, and also 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.

8.3. A full summary of the representative aircraft selection and the main assumptions influencing the emission factor calculation is presented in Table 28. Key features of the calculation methodology, data and assumptions include:

- ❖ A wide variety of representative aircraft have been used to calculate emission factors for domestic, short- and long-haul flights;
- ❖ 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, 2016) statistics for UK registered airlines for the year 2015 (the most recent complete dataset available at the time of calculation), split by aircraft and route type (Domestic, European Economic Area, other International)[57];
- ❖ 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.

[56] Please note - The international factors included are an average of short and long-haul flights which explains the difference between the UK factors and the international ones.

[57] 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&sglid=1

	Av. No. Seats	Av. Load Factor	Proportion of passenger km	Emissions Factor, $kgCO_2/vkm$	Av. flight length, km
Domestic Flights					
AIRBUS A319	191	77%	37%	14.6	462
AIRBUS A320-100/200	239	70%	24%	14.9	481
AIRBUS A321	272	73%	4%	17.2	497
BOEING 737-400	203	72%	0.3%	15.3	494
BOEING 737-800	232	79%	5%	14.5	489
BOEING 767-300ER/F	376	67%	2%	25.5	534
BOMBARDIER DASH 8 Q400	113	67%	18%	7.2	371
EMB ERJ175 (170-200)	101	73%	1%	9.3	540
EMBRAER ERJ190	142	67%	3%	12.1	551
EMBRAER ERJ195	179	65%	1%	14.7	353
SAAB 2000	86	58%	2%	6.6	394
SAAB FAIRCHILD 340	54	61%	1%	4.1	268
Weighted average	***192***	***72%***	***100%* (total)***	***11.4***	***417***
Short-haul Flights					
AIRBUS A319	181	81%	16%	11.4	1057
AIRBUS A320-100/200	219	78%	26%	11.3	1365
AIRBUS A321	273	76%	12%	12.6	1774
BOEING 737-300	155	89%	2%	11.4	1620
BOEING 737-400	189	81%	1%	12.0	1451
BOEING 737-700	159	82%	1%	10.6	1106
BOEING 737-800	214	86%	35%	11.4	1449
BOEING 757-200	269	84%	6%	14.7	2377
BOEING 767-300ER/F	357	76%	2%	20.3	2092
EMBRAER ERJ190	142	71%	1%	10.4	866
Weighted average	***221***	***81%***	***100%* (total)***	***11.8***	***1,366***
Long-haul Flights					
AIRBUS A320-100/200	357	77%	5%	20.9	6763
AIRBUS A330-300	410	71%	5%	21.8	6108
AIRBUS A340-300	351	76%	1%	24.9	9133
AIRBUS A340-600	406	76%	3%	31.6	6972
AIRBUS A380-800	625	80%	15%	47.0	7141
BOEING 747-400	493	76%	17%	37.3	7064
BOEING 757-200	248	75%	2%	14.4	5200
BOEING 767-300	353	65%	5%	19.1	6122
BOEING 767-400	334	74%	1%	20.7	6151
BOEING 777-200ER	386	72%	15%	25.3	6843
BOEING 777-300ER	489	74%	21%	29.7	7298
BOEING 787-800 DREAMLINER	369	75%	8%	23.3	7084
BOEING 787-900 DREAMLINER	323	80%	2%	24.7	7562
Weighted average	***453***	***75%***	***100%***	***28.3***	***6,823***

Notes: Figures on seats, load factors, % tkm and av. flight length have been calculated from 2016 CAA statistics for UK registered airlines for the different aircraft types. Figures of $kgCO_2/vkm$ were calculated using the average flight lengths in the

EUROCONTROL small emitters tool. * 100% denotes the pkm share of the aircraft included in the assessment - as listed in the table. The aircraft listed in the table above account for 94% of domestic pkm, 94% of short-haul pkm and 95% of long-haul pkm.

Table 28: Assumptions used in the calculation of revised average CO_2 emission factors for passenger flights for 2017

8.4. **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.

8.5. The current preferred definition is to assume that all fights 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 29 below (as previously provided within the 2012 Annexes in the old format. The methodology/basis has been unchanged since 2013, and it is up to users of the GHG Conversion Factors to use their best judgement on which category to allocate particular flights into.

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	2,400
Average (CAA statistics)		***1,366***
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)		***6,823***

Notes: Distances based on International Passenger Survey (Office for National Statistics) calculations using airport geographic information. Average distances calculated from CAA statistics for all flights to/from the UK in 2013

Table 29: Illustrative short- and long- haul flight distances from the UK

Taking Account of Freight

8.6. 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 8 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 CO_2 between passengers and freight, which was developed for the 2008 update, and has also been applied in subsequent updates.

8.7. 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 30:

a. ***No Freight Weighting*****:** Assume all the CO_2 is allocated to passengers on these services.

b. ***Freight Weighting Option 1*****:** Use the CAA tonne km (tkm) data directly to apportion the CO_2 ***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 tkm 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:	None		Option 1: Direct		Option 2: Equivalent	
Mode	**Passenger tkm % of total**	**gCO_2 /pkm**	**Passenger tkm % of total**	**gCO_2 /pkm**	**Passenger tkm % of total**	**gCO_2 /pkm**
Domestic flights	100.00%	130.0	99.74%	129.7	99.74%	129.7
Short-haul flights	100.00%	79.2	98.60%	78.1	98.60%	78.1
Long-haul flights	100.00%	117.5	66.46%	78.0	81.49%	95.7

Table 30: CO_2 emission factors for alternative freight allocation options for passenger flights based on 2017 GHG Conversion Factors

8.8. 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. 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 weight per passenger seat used in the calculations for the 2017 GHG Conversion Factors were calculated for the specific aircraft used and are on average over twice the weight per passenger and their luggage alone. In the **Option 2** methodology the derived ratio for different aircraft types were used to upscale the CAA passenger tonne km data, increasing this as a percentage of the total tonne km – as shown in Table 30.

8.9. 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**.

8.10. **Option 2** was selected as the preferred methodology to allocate emissions between passengers and freight for the 2008 and subsequent GHG Conversion Factors.

8.11. Validation checks using the derived emission factors calculated using the EUROCONTROL small emitters tool and CAA flights data have shown a very close comparison in derived CO_2 emissions with those from the UK GHG Inventory (which is scaled using actual fuel supplied).

8.12. The final average emission factors for aviation are presented in Table 31. The figures in Table 31 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 2017 GHG Conversion Factor data tables.

Mode	Factors for 2017	
	Load Factor%	gCO_2/pkm
Domestic flights	72.2%	129.7
Short-haul flights	81.5%	78.1
Long-haul flights	74.7%	95.7

Notes: Load factors based on data provided by DfT that contains detailed analysis of CAA statistics for the year 2015

Table 31: Final average CO_2 emission factors for passenger flights for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

Taking Account of Seating Class Factors

8.13. 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 CO_2 emissions per passenger km.

8.14. There is no agreed data/methodology for establishing suitable scaling factors representative of average flights. However, in 2008 a review was carried out of the seating configurations from a selection of 16 major airlines and average seating configuration information from Boeing and Airbus websites. This evaluation was used to form a basis for the seating class based emission factors provided in Table 32, together with additional information obtained either directly from airline websites or from other specialist websites that had already collated such information for most of the major airlines.

8.15. 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 times[58] the space taken up by the basic economy seating. Table 32 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.

8.16. The relative share in the number of seats by class for short-haul and long-haul flights was updated/revised in 2015 using data provided by DfT's aviation team, following checks conducted by them on the validity of the current assumptions based on more recent data.

Flight type	Cabin Seating Class	Load Factor %	gCO_2 /pkm	Number of economy seats	% of average gCO_2/pkm	% Total seats
Domestic	**Weighted average**	**72.2%**	**129.7**	**1.00**	**100.0%**	**100.0%**
Short-haul	**Weighted average**	**81.5%**	**78.1**	**1.02**	**100.0%**	**100.0%**
	Economy class	81.5%	76.8	1.00	98.4%	96.7%
	First/Business class	81.5%	115.2	1.50	147.6%	3.3%
Long-haul	**Weighted average**	**74.7%**	**95.7**	**1.31**	**100.0%**	**100.0%**
	Economy class	74.7%	73.3	1.00	76.6%	83.0%
	Economy+ class	74.7%	117.3	1.60	122.5%	3.0%
	Business class	74.7%	212.6	2.90	222.1%	11.9%
	First class	74.7%	293.2	4.00	306.3%	2.0%

Notes: Load factors based on data provided by DfT that contains detailed analysis of CAA statistics for the year 2015

Table 32: Seating class based CO_2 emission factors for passenger flights for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

Freight Air Transport Direct CO_2 Emission Factors

8.17. Air 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.

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

8.18. Data on freight movements by type of service are available from the Civil Aviation Authority (CAA, 2016). These data show that almost all freight carried by passenger aircraft is done on scheduled long-haul flights and accounts approximately for 89% 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.

8.19. 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

8.20. 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 2017 update for the GHG Conversion Factors – presented in Table 33. 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 2017 GHG Conversion Factor data tables.

Mode	Revised factors for 2017	
	Load Factor%	$kgCO_2$ /tkm
Domestic flights	46.5%	2.5
Short-haul flights	76.0%	0.9
Long-haul flights	78.7%	0.8

Notes: Load factors based on Annual UK Airlines Statistics by Aircraft Type – CAA 2012 (Equivalent datasets after this are unavailable due to changes to CAA's confidentiality rules)

Table 33: Revised average CO_2 emission factors for dedicated cargo flights for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

8.21. The updated factors have been calculated in the same basic methodology as for the passenger flights, which was updated in 2015 to use the aircraft specific fuel consumption /emission factors calculated using the EUROCONTROL small emitters tool[59]. A full summary of the representative aircraft selection and the main assumptions influencing the emission factor calculation are presented in Table 34. The key features of the calculation methodology, data and assumptions for the 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 2015 (the latest available complete dataset).

[59] 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%	48.6%	6.8	230
BAE 146-200/QT	10.0	34%	0.0%	0.0	0
BOEING 737-300	15.2	45%	34.7%	28.3	145
BOEING 757-200	23.2	56%	4.0%	23.3	156
BOEING 747-8 (FREIGHTER)	126.9	19%	0.0%	0.0	200
BOEING 767-300ER/F	58.0	47%	12.7%	25.8	515
Average	***17.4***	***47%***	***100% (total)***	***13.3***	***379***
Short-haul Flights					
BAE ATP	8.0	43%	1.6%	5.6	501
BOEING 757-200	22.0	77%	73.7%	16.0	753
BOEING 747-8 (FREIGHTER)	124.3	33%	0.0%	0.0	0
BOEING 767-300ER/F	30.8	76%	24.8%	20.4	1904
Average	***23.9***	***76%***	***100% (total)***	***16.01***	***1,432***
Long-haul Flights					
BAE ATP	8.0	16%	0.0%	5.88	389
BOEING 757-200	21.6	79%	25.0%	15.23	1303
BOEING 747-8 (FREIGHTER)	129.4	73%	0.0%	0.00	0
BOEING 767-300ER/F	29.6	79%	75.0%	19.19	5131
Average	***27.6***	***79%***	***100% (total)***	***17.9***	***4,381***

Notes: Figures on cargo, load factors, % tkm and av. flight length have been calculated from CAA statistics for UK registered airlines for different aircraft in the year 2015. Figures of $kgCO_2$/vkm were calculated using the average flight lengths in the EUROCONTROL small emitters tool.

Table 34: Assumptions used in the calculation of average CO_2 emission factors for dedicated cargo flights for the 2017 GHG Conversion Factors

Emission Factors for Freight on Passenger Services

8.22. 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 35 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 2017 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	4.2%	95.8%	0.3%	2.5	0.3%	2.5
Short-haul flights	23.3%	76.7%	1.4%	1.0	1.4%	1.0
Long-haul flights	88.7%	11.3%	33.5%	1.0	18.5%	0.7

Table 35: Air freight CO_2 emission factors for alternative freight allocation options for passenger flights for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

8.23. CAA statistics include excess passenger baggage in the ‘freight’ category, which would under **Option 1** result in a degree of under-allocation to passengers. **Option 2** therefore appears to provide the more reasonable means of allocation.

8.24. **Option 2** was selected as the preferred methodology for freight allocation for the 2008 update, when this analysis was original performed. The same methodology has been applied in subsequent updates and is included in all of the presented emission factors for 2017.

Average Emission Factors for All Air Freight Services

8.25. Table 36 presents the final average air freight emission factors for all air freight for the 2017 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 2017 GHG Conversion Factor data tables (discussed later).

Mode	% Total Air Freight tkm		All Air Freight $kgCO_2$/tkm
	Passenger Services	Cargo Services	
Domestic flights	4.2%	95.8%	2.5
Short-haul flights	23.3%	76.7%	1.0
Long-haul flights	88.7%	11.3%	0.7

Notes: % Total Air Freight tkm based on CAA statistics for 2015 (T0.1.6 All Services)

Table 36: Final average CO_2 emission factors for all air freight for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

Air Transport Direct Emission Factors for CH_4 and N_2O

Emissions of CH_4

8.26. Total emissions of CO_2, CH_4 and N_2O 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 CO_2 and CH_4 emissions from the UK GHG inventory for 2015 (see Table 37) were used to calculate the specific CH_4 emission factors per passenger km or tonne-km relative to the corresponding CO_2 emission factors. The resulting air transport emission factors for the 2017 GHG Conversion Factors are presented in Table 38 for passengers and Table 39 for freight.

	CO_2		CH_4		N_2O	
	Mt CO_2e	% Total CO_2e	Mt CO_2e	% Total CO_2e	Mt CO_2e	% Total CO_2e
Aircraft - domestic	1.70	99.02%	0.0008	0.05%	0.0161	0.94%
Aircraft - international	33.04	99.06%	0.0022	0.01%	0.3126	0.94%

Table 37: Total emissions of CO_2, CH_4 and N_2O for domestic and international aircraft from the UK GHG inventory for 2015

Emissions of N_2O

8.27. Similar to those for CH_4, emission factors for N_2O per passenger-km or tonne-km were calculated on the basis of the relative proportions of total CO_2 and N_2O emissions from the UK GHG inventory for 2015 (see Table 37), and the corresponding CO_2 emission factors. The resulting air transport emission factors for the 2017 GHG Conversion Factors are presented in Table 38 for passengers and Table 39 for freight. The factors presented here do not include the distance or radiative forcing uplifts applied to the emission factors provided in the 2017 GHG Conversion Factor data tables (discussed later).

Air Passenger Mode	Seating Class	CO_2 gCO_2/pkm	CH_4 gCO_2e/pkm	N_2O gCO_2e/pkm	Total GHG gCO_2e/pkm
Domestic flights	**Average**	**129.7**	**0.06**	**1.23**	**130.9**
Short-haul flights	**Average**	**78.1**	**0.01**	**0.74**	**78.8**
	Economy	76.8	0.01	0.73	77.6
	First/Business	115.2	0.01	1.09	116.3
Long-haul flights	**Average**	**95.7**	**0.01**	**0.91**	**96.7**
	Economy	73.3	0.00	0.69	74.0
	Economy+	117.3	0.01	1.11	118.4
	Business	212.6	0.01	2.01	214.6
	First	293.2	0.02	2.77	296.0
International flights (non-UK)	**Average**	**87.4**	**0.01**	**0.83**	**88.2**
	Economy	66.9	0.00	0.63	67.6
	Economy+	107.1	0.01	1.01	108.1
	Business	194.1	0.01	1.84	195.9
	First	267.7	0.02	2.53	270.3

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

Table 38: Final average CO_2, CH_4 and N_2O emission factors for all air passenger transport for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

Air Freight Mode	CO_2 kgCO2/tkm	CH_4 kgCO2e/tkm	N_2O kgCO2e/tkm	Total GHG kgCO2e/tkm
Passenger Freight				
Domestic flights	1.8365	0.0008	0.0174	1.8547
Short-haul flights	1.0585	0.0001	0.0100	1.0685
Long-haul flights	0.6888	0.0000	0.0065	0.6954
Dedicated Cargo				
Domestic flights	2.5079	0.0012	0.0237	2.5328
Short-haul flights	0.9418	0.0001	0.0089	0.9508
Long-haul flights	0.8432	0.0001	0.0080	0.8512
All Air Freight				
Domestic flights	2.4799	0.0011	0.0235	2.5045
Short-haul flights	0.9690	0.0001	0.0092	0.9782
Long-haul flights	0.7062	0.0000	0.0067	0.7130

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

Table 39: Final average CO_2, CH_4 and N_2O emission factors for air freight transport for 2017 GHG Conversion Factors (excluding distance and RF uplifts)

Indirect/WTT Emission Factors from Air Transport

8.28. Indirect/WTT emissions factors 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 CO_2 emission factors and the indirect/WTT emission factors for aviation turbine fuel (kerosene) and the corresponding direct CO_2 emission factors 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

8.29. 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.

8.30. 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. DfT has indicated (in discussions with their Aviation team) that 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 that has been used since the 2014 update, and therefore also in the 2017 GHG Conversion Factors.

8.31. 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 approach) to take into account of indirect flight paths and delays/congestion/circling. This is the methodology recommended to be used with the GHG Conversion Factors and is applied already to the emission factors presented in the 2017 GHG Conversion Factors tables.

Non-CO_2 impacts and Radiative Forcing

8.32. The emission factors provided in the 2017 GHG Conversion Factors sections "Business travel – air" and "Freighting goods" refer to aviation's direct CO_2, CH_4 and N_2O emissions only. There is currently uncertainty over the other non-CO_2 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.

8.33. 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 CO_2 emissions alone.

8.34. The application of a 'multiplier' to take account of non-CO_2 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 CO_2, 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.

8.35. On the other hand, consideration of the non-CO_2 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 40 and the GWP_{100} figure (consistent with UNFCCC reporting convention) from the ATTICA research presented in Table 41 below[60] and in analysis by Lee et al (2009) reported on by the Committee on Climate Change (2009)[61].

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,*

[60] 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

[61] 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/

*including estimates of Global Warming Potentials (GWPs) and Global Temperature Potentials (GTPs) over different time horizons (20, 50 and 100 years). [*Table 41*] 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* CO_2*-equivalent emissions to* CO_2 *emissions for aviation in 2005.*

8.36. 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 CO_2 component of direct emissions (i.e. not also to the CH_4 and N_2O emissions components). The 2017 GHG Conversion Factors provide separate emission factors including this radiative forcing uplift in separate tables in sections “Business travel – air” and “Freighting goods”

		RF [mW/m^2]							
Year	Study	CO_2	O_3	CH_4	H_2O	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 CO_2 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 40: Impacts of radiative forcing according to R. Sausen et al. (2005)

	Metric values			CO_2e emissions (MtCO_2e/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 NO_x	120	-2.1	-9.5	106	-1.9	-8.4	Very low
High NO_x	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
				CO_2e/CO_2 emissions for 2005			
Low NO_x, inc. AIC				4.3	1.9	1.1	Very low
High NO_x, inc. AIC				4.8	2.0	1.1	Very low
Low NO_x, exc. AIC				2.1	1.3	1.0	Very low
High NO_x, 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 CO_2 increases in importance relative to shorter-lived effects as longer timescales are considered.

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

Table 41: Findings of ATTICA project

9. Bioenergy and Water

Summary of changes since the previous update

9.1. The only change to the 2017 GHG Conversion Factors is that the outside of Scope factors for biogas and landfill gas and the WTT biogas factor has been updated due to a more robust data source and improved methodology.

General Methodology

9.2. The 2017 GHG Conversion Factors provide tables of emission factors for: water supply and treatment; biofuels; and biomass and biogas.

9.3. The emission factors presented in the tables incorporate emissions from the fuel life-cycle and include net CO_2, CH_4, N_2O emissions and Indirect/WTT emissions factors. These are presented for biofuels, biomass and biogas.

9.4. The basis of the different emission factors is discussed in the following sub-sections.

Water

9.5. The emission factors for water supply and treatment in sections “Water supply” and “Water treatment” of the 2017 GHG Conversion Factors were sourced from Water UK (for reporting in 2008, 2009, 2010 and 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.

9.6. 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 discontinued its “Sustainability Indicators” report and so no longer produces further updates to these emission factors. Therefore, the 2017 update is unchanged since the 2012 GHG Conversion Factors values.

Biofuels

9.7. Biofuels are defined as “net carbon zero” or “carbon neutral” as any CO_2 expelled during the burning of the fuel is cancelled out by the CO_2 absorbed by the feedstock used to produce the fuel during growth[62]. Therefore, all direct emissions from biofuels provided in the GHG Conversion Factors dataset are only made up of CH_4 and N_2O emissions.

9.8. Unlike the direct emissions of CO_2, CH_4 and N_2O are not offset by adsorption 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

[62] This is a convention required by international GHG Inventory guidelines and formal accounting rules

produced by combusting the corresponding fossil fuels (i.e. diesel, petrol or CNG) from the "Fuels" section.

9.9. The indirect/WTT/fuel lifecycle emission factors for biofuels were based on UK average factors from the Quarterly Report (2015/16)[63] on the Renewable Transport Fuel Obligation (RTFO). These average factors and the direct CH_4 and N_2O factors are presented in Table 42.

Biofuel	Emissions Factor, gCO_2e/MJ				
	RTFO Lifecycle (1)	Direct CH_4 (2)	Direct N_2O (2)	Total Lifecycle	Direct CO_2 Emissions (Out of Scope (3))
Biodiesel	12.33	0.01	0.59	12.93	75.30
Bioethanol	30.32	0.22	0.11	30.65	71.60
Biomethane	10.00	0.08	0.03	10.11	55.28
Biodiesel (from used cooking oil)	11.56	0.01	0.59	12.17	75.30
Biodiesel (from Tallow)	14.03	0.01	0.59	14.63	75.30

Notes:
(1) Based on UK averages from the RTFO Quarterly Report (2015/16) 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 CO_2 emitted by the biofuel when combusted. This will be counter-balanced by /equivalent to the CO_2 absorbed in the growth of the biomass feedstock used to produce the biofuel. These factors are based on data from Forest Research, the Forestry Commission's research agency (previously BEC), (2016)

Table 42: Fuel lifecycle GHG Conversion Factors for biofuels

9.10. 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 emission factors by source/supplier are provided and updated regularly in the Quarterly Reports on the RTFO, available from GOV. website at: https://www.gov.uk/government/organisations/department-for-transport/series/biofuels-statistics.

9.11. In addition to the direct and indirect/WTT emission factors provided in Table 42, emission factors for the out of scope CO_2 emissions have also been provided in the 2017 GHG Conversion Factors (see table and the table footnote), based on data sourced from Forest Research, the Forestry Commission's research agency (previously BEC), (2016)[64].

[63] These cover the period from April 2015 - April 2016, and were the most recent figures available at the time of production of the 2017 GHG Conversion Factors. The report is available from the GOV. website at: https://www.gov.uk/government/collections/biofuels-statistics

[64]. Carbon emissions of different fuels; available at: https://www.forestry.gov.uk/fr/beeh-absIby

Other biomass and biogas

9.12. A number of different bioenergy/biomass 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 2017 GHG Conversion Factors.

9.13. All indirect/WTT/fuel lifecycle emission factors here, except for wood logs, are sourced from the Ofgem carbon calculators[65]. These calculators have been developed to support operators determining the GHG emissions associated with the cultivation, processing and transportation of their biomass fuels.

9.14. Indirect/WTT/fuel lifecycle emission factors for wood logs, which are not covered by the Ofgem tool, were obtained from the Biomass Energy Centre's (BEC) tool, $BEAT_2$[66], provided by Defra.

9.15. The direct CH_4 and N_2O emission factors presented in the 2017 GHG Conversion Factors are based on the emission factors used in the UK GHG Inventory (GHGI) for 2015 (managed by Ricardo Energy & Environment).

9.16. In some cases, calorific values were required to convert the data into the required units. The most appropriate source was used and this was either from th Forest Research, DUKES (Table A.1) or Swedish Gas Technology Centre 2012 (which is also backed up by other data sources). The values used and their associated moisture contents are provided in Table 43.

9.17. In addition to the direct and indirect/WTT emission factors provided, emission factors for the out of scope CO_2 emissions are also provided in the 2017 GHG Conversion Factors (see "Outside of scopes" and the relevant notes on the page), also based on data from sourced from Forest Research, the Forestry Commission's research agency (previously BEC) (2016)[67].

Biomass	Moisture content	Net calorific value (GJ/tonne)	Source
Wood chips	25% moisture	13.6	Forest Research
Wood logs	Air dried 20% moisture	14.7	DUKES
Wood pellets	10% moisture	16.85	DUKES
Grass/Straw	10% moisture	13.4	DUKES
Biogas	Based on 65% CH_4	20	Swedish Gas Technology Centre
Landfill gas	Based on 40% CH_4	12.3	Swedish Gas Technology Centre

Table 43: Fuel sources and properties used in the calculation of biomass and biogas emission factors

[65] Ofgem carbon calculator tools: 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

[66] Biomass Energy Centre's (BEC) tool, $BEAT_2$: http://www.biomassenergycentre.org.uk/portal/page?_pageid=74,153193&_dad=portal&_schema=PORTAL

[67] Carbon emissions of different fuels; available at: https://www.forestry.gov.uk/fr/beeh-abslby

10. Overseas Electricity Emission Factors

Summary of changes since the previous update

10.1. There have been no new methodological changes to this section; and the overseas electricity factors are still no longer available, due to a change in the licencing conditions for the underlying International Energy Association (IEA) dataset upon which they were based. Instead these can be purchased from the IEA[68] .

10.2. The conversion factors supplied by the IEA for electricity supplied to the grid can be purchased by organisations; this does not include the emissions associated with electricity losses during transmission and distribution of electricity between the power station and an organisation's site(s). These are still provided within the 2017 GHG Conversion Factors (see below for more detail). Likewise, the conversion factors supplied by the IEA also do not include the emissions associated with the extraction, refining and transportation of primary fuels before their use in the generation of electricity (WTT emissions). These are also still available.

Direct Emissions from Overseas Electricity Generation

10.3. UK companies reporting on their emissions may need to include emissions resulting from overseas activities. Whilst many of the standard fuel emission factors are likely to be similar for fuels used in other countries, grid electricity emission factors vary considerably.

10.4. The dataset on electricity and heat emission factors from the IEA, provided from the IEA website, was identified as the best available consistent dataset for electricity emissions factors. These factors are a time series of combined electricity CO_2 emission factors per kWh GENERATED. As stated these can be purchased from the IEA website.

Transmission and distribution losses from Overseas Electricity Generation

10.5. CO_2 emission factors, per kWh, associated with the LOSSES in electricity transmission/distribution grids can be found in the "Transmission and distribution" (T&D) part of the GHG conversion factors tables.

10.6. The T&D LOSSES factors are calculated using the following formulae:

(1) Emission Factor (Electricity CONSUMED) = Emission Factor (Electricity GENERATED) / (1 - %Electricity Total T&D LOSSES)

(2) Emission Factor (Electricity T&D LOSSES) = Emission Factor (Electricity CONSUMED) - Emission Factor (Electricity GENERATED)

10.7. The electricity GENERATED figure used in this equation is the overseas emission factor figures published previously in the 2015 Update. The factors in the 2015 and 2014 update were taken from the last publically available overseas emission factors data set published by the IEA in 2013[69]. The 2017 GHG Conversion Factors

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[68] Available here: http://www.iea.org/bookshop/729-CO2_Emissions_from_Fuel_Combustion

[69] IEA (2013), CO2 Emissions from Fuel Combustion Highlights.

extrapolates the 2013 IEA data to provide the electricity GENERATED for each country.

10.8. The electricity T&D LOSSES figure comes from the 2014 country energy balances available at the IEA website. This figure is calculated from the ‘Distribution Losses’ and ‘Total Fuel Consumption’ (TFC) figures from the Energy Balance data tables.

10.9. Emission factors have been provided for all EU Member States and major UK trading partners.

Indirect/WTT Emissions from Overseas Electricity Generation

10.10. 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 “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.

10.11. 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. 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 CO_2 emission factors as for the UK (which is 15.8%).

11. Hotel Stay

11.1. A number of factors have been added to the 2017 GHG Conversion Factors which can be used to report emissions associated with an overnight hotel stay. These complement the existing emission factors for business travel. The new emission factors are based on estimates for an overnight stay in an average hotel, and different emission factors are provided for a range of countries on a 'room per night' basis.

Direct emissions from a hotel stay

11.2. All the hotel stay emission factors presented in the 2017 GHG Conversion Factors are in CO_2e. These are taken directly from the Cornell Hotel Sustainability Benchmarking Index (CHSB) Tool, produced by the International Tourism Partnership (ITP) and Greenview.

11.3. The factors use annual data from hotel companies comprising of 4,725 hotels from eleven international hotel organisations: Hilton Worldwide, Hong Kong and Shanghai Hotels, Host Hotels & Resorts, Hyatt Hotels Corporation, InterContinental Hotels Group, Mandarin Oriental, Marriott International, Park Hotel Group, PGA Golf Resort, Saunders Hotel Group, and Wyndham Worldwide.

11.4. For the 2017 GHG Conversion Factors the average benchmark for each country, for all hotel classes included within the tool was used.

11.5. The following five steps were carried out in the CHSB study to arrive at the emission factors included within the 2017 GHG Conversion factors:

1. **Harmonising.** The data received was converted into the same units and then converting to kg CO_2e.
2. **Validity tests** were carried out to remove outliners or errors from the data sets received.
3. **Geographic segmentation**. The data sets were grouped by location; either on a city, country or regional basis.
4. **Market segmentation**. Hotels were grouped by market segment, applying a revenue-based approach and a standardised industry methodology.
5. **Minimum output thresholds**. A minimum threshold of eight hotels per geographical region was required before it was populated within the tool. If there were less than eight hotels; these were excluded from the final outputs.

11.6. It should be noted that there are certain limitations with the CHSB tool used to derive the 2017 GHG Conversion factors. The main limitations are detailed below:

1. The factors are skewed toward large, more upmarket hotels and to branded chains. This is because it was mainly large owners or operators of hotels who submitted the aggregated data sets. The tool contains only 83 hotels within the economy or midscale segment.

2. The data sets used to derive the factors have not been verified and therefore it cannot be concluded to be 100% accurate.
3. The factors do not distinguish a property's amenities with the exception of outsourced laundry services, which are taken into consideration. The factors are an aggregation of all types of hotels within the revenue-based segmentation and geographic location. Which means it is very difficult to compare two hotels since some may contain distinct attributes, (such as restaurants, fitness centres, swimming pool and spa) while others do not.
4. The provision of conversion factors is limited by the availability of data in different parts of the world. The datasets used are updated each year, therefore it is expected that a wider range of countries will be covered in the future.
5. At present there is no breakdown of CH_4 and N_2O emissions, plus there are also no indirect/ WTT factors.

11.7. For more information about how the factors have been derived, please visit https://www.hotelfootprints.org where you will also find more granular data available by city and segment.

12. Material Consumption/Use and Waste Disposal

Summary of changes since the previous update

12.1. There has been one new methodological change to this section since last year's (2016) update:

- Emissions from landfill are now taken directly from DEFRA's landfill emissions calculation model "MELMod"70 for methane emissions from landfill, with the addition of collection and transport emissions. The MELMod model is used to calculate methane formation in landfills in the UK, using the IPCC 2006 methodology with UK country-specific input parameters, e.g. decay rates of biodegradable waste, C&I waste quantity and composition, Local Authority Collected Waste (LACW) quantity and composition, proportion of materials which are biodegradable under landfill conditions, carbon contents, methane oxidation factor in landfill surface layers and also the methane capture and utilisation (in flares and engines) data.

12.2. One update has also been made to the assumptions used in computing the closed-loop metal material use factors:

- Mixed non-ferrous metals arising from construction and demolition are now assumed to be 59% aluminium and 41% copper (based on average scrap metal composition from British Metals Recycling Association website This replaces an assumption that these materials are 100% aluminium. This impacts factors for mixed construction and demolition and metals from construction and demolition.

Emissions from Material Use and Waste Disposal

12.3. Since 2012 the greenhouse gas emission factors for material consumption / use and waste disposal have been aligned with the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard ('the Scope 3 Standard')[71]. This sets down rules on accounting for emissions associated with material consumption and waste management.

12.4. 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.

70 http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17448

71 http://www.ghgprotocol.org/standards/scope-3-standard

12.5. 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).

12.6. All figures expressed are kilograms of carbon dioxide equivalent (CO_2e) per tonne of material. This includes the Kyoto protocol basket of greenhouse gases. Please note that biogenic[72] CO_2 has also been excluded from these figures.

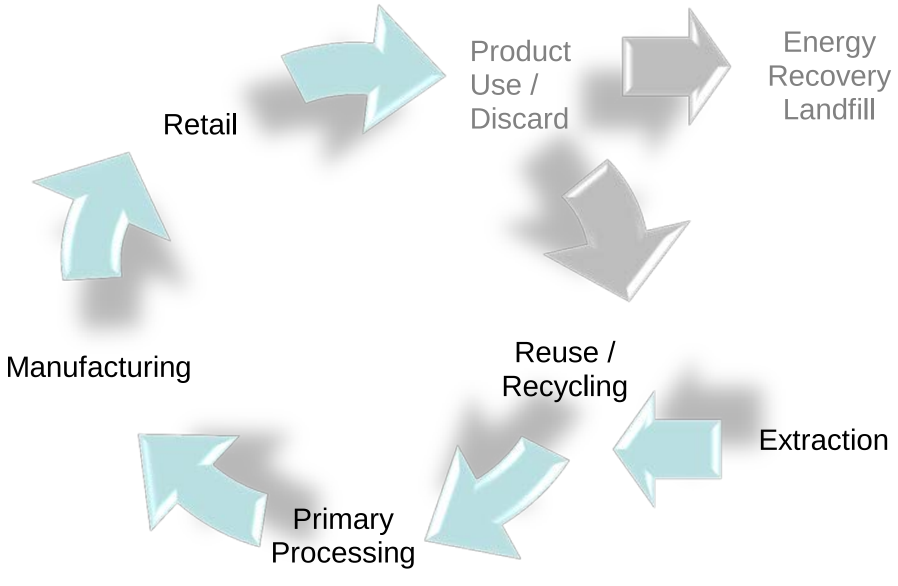
12.7. The information for material consumption presented in the GHG Conversion Factor tables has been separated out from the emissions associated with waste disposal in order to allow separate reporting of these emission sources, in compliance with the Scope 3 Standard.

12.8. 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.

12.9. The following subsections provide a summary of the methodology, key data sources and assumptions used to define the emission factors.

Material Consumption/Use

12.10. Figure 4 shows the boundary of greenhouse gas emissions summarised in the material consumption table.



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

Figure 4: Boundary of material consumption data sets

12.11. 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

[72] Biogenic CO_2 is the CO_2 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.

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.

12.12. 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.

12.13. 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.

12.14. 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.

12.15. Emission factors provided include emissions associated with product forming.

12.16. Table 44 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. The transportation tables and Greenhouse Gas Protocol guidelines on vehicle emissions have been used for most vehicle emission factors.

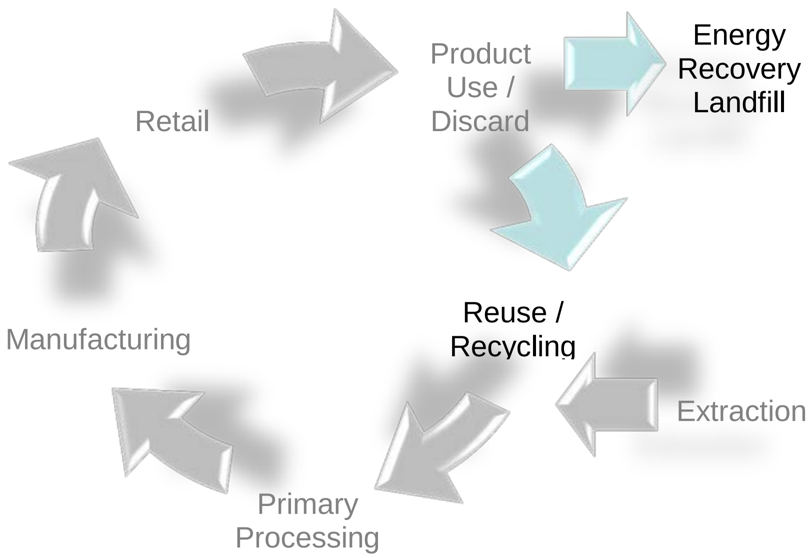
Destination / Intermediate Destination	One Way Distance	Mode of transport	Source
Transport of raw materials to factory	122km	Average, all HGVs	Department for Transport (2010)[73] Based on average haulage distance for all commodities, not specific to the materials in the first column.
Distribution to Retail Distribution Centre & to retailer	96km		McKinnon (2007)[74] IGD (2008)[75]

Table 44: Distances and transportation types used in EF calculations

12.17. Transport of goods by consumers is excluded from the factors presented, as is use of the product.

Waste Disposal

12.18. Figure 5 shows the boundary of greenhouse gas emissions summarised in the waste disposal table.



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

Figure 5: Boundary of waste disposal data sets

[73] 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

[74] 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

[75] 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/

12.19. 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.

12.20. 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.

12.21. Landfill emissions remain within the accounting scope of the organisation producing waste materials. Factors for landfill are provided within the waste disposal sheet in the 2017 GHG Conversion Factors. As noted above, these factors are now drawn directly from MELMod, which contains information on landfill waste composition and material properties, with the addition of collection and transport emissions.

12.22. Figures for Refuse Collection Vehicles have been taken from the Environment Agency's Waste and Resource Assessment Tool for the Environment (WRATE)[76].

12.23. 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 45.

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 45: Distances used in calculation of emission factors

12.24. Road vehicles are volume limited rather than weight limited. For all HGVs, an average loading factor (including return journeys) is used based on the HGV factors provided in the 2017 Conversion Factors. 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.

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

13. Fuel Properties

Summary of changes since the previous update

13.1. New fuel properties have been added for landfill gas and the properties of biogas have been updated to reflect a change in the methodology.

13.2. Separate fuel properties for petrol and diesel with average biofuel blend are also now provided.

General Methodology

13.3. Information on standard fuel properties of key fuels is also provided in the GHG Conversion Factors for:

a. Gross Calorific Value (GCV) in units of GJ/tonne and kWh/kg

b. Net Calorific Value (NCV) in units of GJ/tonne and kWh/kg

c. Density in units of litres/tonne and kg/m^3.

13.4. 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 BEIS's Digest of UK Energy Statistics (DUKES) 2016.[77]

13.5. The fuel properties of most 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 4a, 2014 (Report EUR 26236 EN - 2014).[78] The exception is for methyl-ester based biodiesels and bioethanol, where values for NCV and GCV are taken from DUKES 2016.

13.6. Fuel properties, both density and CV, for wood chips (25% moisture content) come from the Forest Research (previously Biomass Energy Centre (BEC)[79]. The density of wood logs (20% moister content), wood chips (25% moister content) and grasses/straw (25% water content) are also sourced from the Forest Research[80].

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[77]Available at: https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes

[78] Available at: http://iet.jrc.ec.europa.eu/about-jec/

[79] Available at: https://www.forestry.gov.uk/fr/beeh-9ukqcn

[80] Available at: https://www.forestry.gov.uk/fr/beeh-absg5h

Appendix 1. Additional Methodological Information on the Material Consumption/Use and Waste Disposal Factors

This section explains the methodology for the choice of data used in the calculation of carbon emissions used in the waste management 2017 GHG Conversion Factors. Section 1.1 details the indicators used to assess whether data met the data quality standards required for this project. Section 1.2 states the sources used to collect data. Finally, Section 1.3 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, so far as is possible, 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 be less than five years old. However, the secondary data in material eco-profiles is only periodically updated. In cases where no reliable data is available from within the five-year period, the most recent data available have been used. In cases where use of data over five years old creates specific issues, these are discussed below under "Use of data below the set quality standard". All data over five years old has been marked in the references with an asterisk within the 2.0Data Sources section.
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	
Representative-ness	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

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 12. Data on waste management options has been modelled using SimaPro 8.2.3.[81] 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.

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 2010[82]. Data used in this report for material consumption is based on studies from the USA, where production processes may not be

[81] SimaPro (2015). Life Cycle Assessment Software. Available at: http://www.lifecycles.com.au/#!simapro/c1il2

[82] 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

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 UK[83] 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[84] 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.

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 2017 GHG Conversion 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.

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[83] 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

84 Bio IS (2009) *Environmental Improvement Potentials of Textiles (IMPRO-Textiles)* http://susproc.jrc.ec.europa.eu/textiles/docs/120423%20IMPRO%20Textiles_Publication%20draft%20v1.pdf

Excluded Materials and Products

For some materials and products, such as automotive batteries and fluorescent tubes, no suitable figures have been identified to date.

2.0 Data Sources

Material	Reference	
Aluminium cans and foil	European Aluminium Association (2013) Environmental Profile Report for the European Aluminium Industry *CE Delft (2007) Environmental Indices for the Dutch Packaging Tax 2017 GHG Conversion Factors Swiss Centre for Life Cycle Inventories (2014) Ecoinvent v3.0 *Environment Agency (2008) Waste and Resources Assessment Tool for the Environment (WRATE) Version 1 *Wilmshurst, N. Anderson, P. and Wright, D. (2006) WRT142 Final Report Evaluating the Costs of 'Waste to Value' Management	*ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009
Steel Cans	*World Steel Association (2009) World Steel Life Cycle Inventory 2017 GHG Conversion Factors *Swiss Centre for Life Cycle Inventories (2010) Ecoinvent Report No 14 *Swiss Packaging Institute (1997) BUWAL *ERM (2008) Waste and Resources Assessment Tool for the Environment (WRATE) Version 1	*ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009
Mixed Cans	Estimate based on aluminium and steel data, combined with data returns from Courtauld Commitment retailers (confidential, unpublished)	*ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009
Glass	*PE International (2009) *Life Cycle Assessment of Container Glass in Europe* FEVE; Brussels *Enviros (2003 (a)) Glass Recycling - Life Cycle Carbon Dioxide Emissions *Enviros (2003 (b)) Glass Recycling - Life Cycle Carbon Dioxide Emissions	

Material	Reference	
Wood	* Pöyry Forest Industry Consulting Ltd and Oxford Economics Ltd (2009) Wood Waste Market in UK * Merrild H, and Christensen T. H. (2009) Recycling of wood for particle board production: accounting of greenhouse gases and global warming contributions CORRIM (2013) Particleboard: A Life-Cycle Inventory of Manufacturing Panels from Resource through Product *ERM (2008) Single trip pallet no biogenic CO_2 Swiss Centre for Life Cycle Inventories (2014) Ecoinvent v3.0 2017 GHG Conversion Factors *Gnosys (2009) Life Cycle Assessment of Closed Loop MDF Recycling * ERM (2008) Waste and Resources Assessment Tool for the Environment (WRATE) Version 1	* WRAP (2009) *Life Cycle Assessment of Closed Loop MDF Recycling*; WRAP, Banbury * Gasol C., Farreny, R., Gabarrell, X., and Rieradevall, J., (2008) Life cycle assessment comparison among different reuse intensities for industrial wooden containers *The International Journal of LCA* 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 *Waste Management and Research* (27) 781-788 *ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009
Aggregates (Rubble)	*WRAP CO_2 Emissions Estimator Tool (2010) *Environment Agency (2007) Construction Carbon Calculator	

Material	Reference	
Paper and board	2017 GHG Conversion Factors Procarton (2013) Carbon footprint for cartons FEFCO (2012) European database for Corrugated Board Life Cycle Studies DEFRA (2012) Streamlined LCA of Paper Supply Systems CPI (2016) Filename: CPI_WRAP_Papermaking_201612 Swiss Centre for Life Cycle Inventories (2014) *Ecoinvent v3.0* Wencong Yue, Yanpeng Cai, Qiangqiang Rong, Lei Cao and Xumei Wang (2014) A hybrid MCDA-LCA approach for assessing carbon foot-prints and environmental impacts of China's paper producing industry and printing services" "Wang & Mao (2012) Risk Analysis and Carbon Footprint Assessments of the Paper Industry in China" * Swiss Centre for Life Cycle Inventories (2007) Ecoinvent v2 *CEPI (2008) Key Statistics 2007 European Pulp and Paper Industry * Oakdene Hollins (2008) CO2 impacts of transporting the UK's recovered paper and plastic bottles to China *ERM (2008) Waste and Resources Assessment Tool for the Environment (WRATE) Version 1 * ERM (2010) LCA of Example Milk Packaging Containers *European Commission (2010) European Life Cycle Database 3 *Chen, C., Gan, J., Qui, R., (pending) Energy Use and CO2 Emissions in China's Pulp and Paper Industry: Supply Chain *Chen, S., Ren, L., Liu, Z., Zhou, C., Yue, W., and Zhang, J (2011) Life cycle assessment and type III environmental declarations for newsprint in China. Acta Scientiae Circumstantiae, 31, (6) 1331–1337. * WRAP (2010) Realising the value of recovered paper: An Update	*ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009

Material	Reference	
Books	Estimate based on paper	
Scrap Metal	British Metals Recycling Association (*website*[85]) Swiss Centre for Life Cycle Inventories (2014) *Ecoinvent v3.0*	*ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009
WEEE - Large, small, mixed, fridges and freezers	* Huisman, J., et al (2008) Review of Directive 2002/96 on Waste Electrical and Electronic Equipment * ISIS (2008) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 13: Domestic Refrigerators & Freezers * The Environment Agency (2005) Waste and Resources Assessment Tool for the Environment (WRATE) Version 1	*ISIS (2008) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 13: Domestic Refrigerators & Freezers *WRATE (2005)

[85] http://www.recyclemetals.org/about_metal_recycling. No longer online.

Material	Reference	
Food and Drink Waste	2017 GHG Conversion Factors *Bingemer, HG and Crutzen, PJ (1987) The Production of Methane from Solid Waste *DEFRA (2011) Greenhouse Gas Impacts of Biowaste Management - WR0210 *Cranfield University (Unpublished) Greenhouse Gas Impacts of Biowaste Management *Kranert, M. & Gottschall, R. Entsorgergemeinschaft der Deutschen Entsorgungswirtschaft e.V. (2007) Grünabfälle – besser kompostieren oder energetisch verwerten? EdDE-Dokumentation Nr. 11 * Williams AG, Audsley E and Sandars DL (2006) Determining the Environmental Burdens and Resource Uses in the Production of Agricultural and Horticultural Commodities. Main Report. Defra Research Project IS0205 *Association for Organics Recycling, WRAP and M-E-L Research (2009) Market survey of the UK organics recycling industry - 2007/08 *AIC (2009) Fertiliser Statistics 2009 Report *Greenhouse Gas Inventory Data - Detailed data by Party * Davis, J. and Haglund, C. (1999) Life Cycle Inventory (LCI) of Fertiliser Production * Brook Lyndhurst (2009) London's Food Sector GHG Emissions - Final Report *AEA Technology (2005) Food transport: The Validity of Food Miles as an Indicator of Sustainable Development *Tassou, S, Hadawey, A, Ge, Y and Marriot, D (2008) FO405 Greenhouse Gas Impacts of Food Retailing "Wood, S and Cowie A (2004) A Review of Greenhouse Gas Emission Factors for Fertiliser Production." *Zaher, U, Khachatryan, H, Ewing, T.; Johnson, R.; Chen, S.; Stockle, C.O. (2010) Biomass assessment for potential bio-fuels production: Simple methodology and case study *Mitaftsi, O and Smith, S R (2006) Quantifying Household Waste Diversion	*AFOR (2009) *Market survey of the UK organics recycling industry - 2007/08*; WRAP, Banbury (Substitution rates for compost) *Williams AG, Audsley E and Sandars DL (2006) *Determining the Environmental Burdens and Resource Uses in the Production of Agricultural and Horticultural Commodities. Main Report. IS0205*, DEFRA (avoided fertiliser impacts) *Kranert, M. & Gottschall (2007) *Grünabfälle – besser kompostieren oder energetisch verwerten?* Eddie (information on peat) * DEFRA (unpublished) (information on composting impacts) *ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009

Material	Reference	
Garden Waste	2017 GHG Conversion Factors Ecoinvent v 3 (2013) Plastics Processing options Plastics Europe (2014) Plastics Europe Ecoprofiles *Bingemer, HG and Crutzen, PJ (1987) The Production of Methane from Solid Waste	
Plastics:	*WRAP (2008) LCA of Mixed Waste Plastic Recovery Options * WRAP (2006) A review of supplies for recycling, global market demand, future trends and associated risks *PriceWaterhouseCoopers & Ecobilan (2002) Life Cycle Assessment of Expanded Polystyrene Packaging. Case Study: Packaging system for TV sets	
HDPE, LDPE and LLDPE	Plastics Europe (2014) *Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers High-density Polyethylene (HDPE), Low-density Polyethylene (LDPE), Linear Low-density Polyethylene (LLDPE)* Plastics Europe, Brussels	*WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
PP (excel forming)	Plastics Europe (2014) *Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers Polypropylene* (PP). Plastics Europe, Brussels	*WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
PVC (excel forming)	*Boustead (2006) *Eco-profiles of the European Plastics Industry Polyvinyl Chloride* (PVC) (Suspension). Plastics Europe, Brussels	*WRAP (2008) LCA of Mixed Waste Plastic Management Options; WRAP, Banbury
PS (excel forming)	Plastics Europe (2015) *Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers Polystyrene (High Impact)* (HIPS). Plastics Europe, Brussels	*PWC (2002) *Life Cycle Assessment of Expanded Polystyrene Packaging*, Umps
PET (excel forming)	Plastics Europe (2010) *Eco-profiles and Environmental Product Declarations of the European Plastics Manufacturers Polyethylene Terephthalate* (PET). 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) *Plastics Recycling Market UK 2009-2013*, UK; Cheltenham	*WRAP (2008) *LCA of Mixed Waste Plastic Management Options*; WRAP, Banbury
Average plastic rigid (inch bottles)		
Clothing	*BIO IS (2009) *Environmental Improvement Potentials of Textiles (IMPRO-Textiles),* EU Joint Research Commission	*Farrant (2008) *Environmental Benefit from Reusing Clothes*, ELCD data sets, http://lca.jrc.ec.europa.eu. (c) European Commission 1995-2009

Material	Reference	
Footwear	*Albers, K., Canapé, P., Miller, J. (2008) *Analysing the Environmental Impacts of Simple Shoes*, University of Santa Barbara, California	
Furniture	WRAP (2015) Benefits of Reuse	
Batteries (Post Consumer Non-Automotive)		*DEFRA (2006) *Battery Waste Management Life Cycle Assessment*, prepared by ERM; WRAP, Banbury
Paint	*Althaus et al (2007) Life Cycle Inventories of Chemicals, Final report ecoinvent data v2.2 *CBI (2009) CBI Market Survey The paints and other coatings market in the United Kingdom and CBI, The Netherlands Swiss Centre for Life Cycle Inventories (2014) *Ecoinvent v3.0*	-
Vegetable Oil	*Schmidt, J (2010) Comparative life cycle assessment of rapeseed oil and palm oil *International Journal of LCA*, 15, 183-197 *Schmidt, Jannick and Weidema, B., (2008) Shift in the marginal supply of vegetable oil *International Journal of LCA*, 13, 235-239	
Mineral Oil	*IFEU (2005) *Ecological and energetic assessment of re-refining used oils to base oils: Substitution of primarily produced base oils including semi-synthetic and synthetic compounds*; GEIR	
Plasterboard	*WRAP (2008) *Life Cycle Assessment of Plasterboard,* prepared by ERM; WRAP; Banbury	
Aggregates	*Environment Agency (2007) Construction emissions calculator *WRAP (2010) Aggregain	
Concrete	*Hammond, G.P. and Jones (2008) Embodied Energy and Carbon in Construction Materials Prc Instn Civil Eng, WRAP (2008) Life Cycle Assessment of Aggregates	
Bricks	*Environment Agency (2011) Carbon Calculator *USEPA (2003) Background Document for Life-Cycle Greenhouse Gas Emission Factors for Clay Brick Reuse and Concrete Recycling *Christopher Koroneos, Aris Dompros, Environmental assessment of brick production in Greece, Building and Environment, Volume 42, Issue 5, May 2007, Pages 2114-2123	
Asphalt	*Aggregain (2010) CO_2 *calculator*	
Asbestos	Swiss Centre for Life Cycle Inventories (2014) *Ecoinvent v3.0*	
Insulation	*Hammond, G.P. and Jones (2008) *Embodied Energy and Carbon in Construction Materials* Prc Instn Civil Eng *WRAP (2008) *Recycling of Mineral Wool Composite Panels into New Raw Materials*	

Greenhouse Gas Conversion Factors

Industrial Designation or Common Name	Chemical Formula	Lifetime (years)	Radiative Efficiency (Wm^{-2} ppb^{-1})	Global Warming Potential with 100 year time horizon (previous estimates for 1st 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_2O	114	3.03×10^{-3}	298 (296)	N_2O 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_2FCF_3	14	0.16	1,430 (1,300)	Substitution of ozone depleting substances, refrigerant manufacture / leaks, aerosols, transmission and distribution of electricity.
Dichlorodifluoro-methane CFC 12 (R12 refrigerant)	CCl_2F_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* CH_4*) global warming potentials (GWP) relative to* CO_2*.* 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 time series data for electricity, heat and steam emission factors. This is provided for organisations wishing to use fully consistent time series 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_2O	
1990	280,234	**8.08%**	205,803	3.033	3.693	
1991	283,201	**8.27%**	202,389	2.865	3.638	
1992	281,223	**7.55%**	190,392	2.750	3.423	
1993	284,350	**7.17%**	173,965	2.698	2.921	
1994	289,126	**9.57%**	169,591	2.826	2.790	
1995	299,196	**9.07%**	166,855	2.871	2.687	
1996	313,070	**8.40%**	166,188	2.866	2.494	
1997	311,221	**7.79%**	153,758	2.714	2.145	
1998	320,740	**8.40%**	158,475	2.886	2.209	
1999	323,872	**8.25%**	150,560	2.882	1.927	
2000	331,553	**8.38%**	162,994	3.061	2.154	
2001	342,686	**8.56%**	173,014	3.321	2.394	
2002	342,338	**8.26%**	167,707	3.264	2.256	
2003	354,225	**8.47%**	180,042	3.454	2.493	
2004	349,312	**8.71%**	178,170	3.448	2.398	
2005	350,778	**7.25%**	176,858	4.082	2.536	
2006	349,212	**7.21%**	185,904	4.176	2.734	
2007	352,778	**7.34%**	183,703	4.139	2.544	
2008	348,876	**7.43%**	179,093	4.415	2.397	
2009	338,984	**7.86%**	157,779	4.285	2.080	
2010	343,767	**7.42%**	162,436	4.500	2.165	
2011	329,071	**7.89%**	149,450	4.437	2.193	
2012	324,314	**8.15%**	163,409	4.857	2.769	
2013	319,102	**7.60%**	151,221	5.340	2.644	
2014	299,359	**8.11%**	127,655	6.100	2.297	
2015	296,959	**8.55%**	106,209	7.567	2.136	

Notes:

(1) Based upon calculated **total** for **all** electricity generation (GWh supplied) from DUKES (2016) Table 5.5, with a reduction of the total for autogenerators based on unpublished data from the BEIS DUKES team on the share of this that is actually exported to the grid (~16% in 2015).

(2) Based upon calculated net grid losses from data in DUKES (2016) Table 5.1.2 (long term trends, only available online).

(3) Emissions from UK centralised power generation (excluding Crown Dependencies and Overseas Territories) 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), with data from the GHGI for 2015 (Ricardo Energy & Environment, 2017) for the 2015 data year. Also includes an accounting (estimate) for autogeneration emissions not specifically split out in the NAEI, consistent with the inclusion of the GWh supply for these elements also.

Table 46: Base electricity generation emissions data - most recent datasets for time series

Data Year	Emission Factor, $kgCO_2e$ / kWh												% Net Electricity Imports
	For electricity GENERATED (supplied to the grid)				Due to grid transmission /distribution LOSSES				For electricity CONSUMED (includes grid losses)				
	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	TOTAL
1990	0.73440	0.00027	0.00393	0.73860	0.06453	0.00002	0.00035	0.06490	0.79892	0.00029	0.00427	0.80349	**4.08%**
1991	0.71465	0.00025	0.00383	0.71873	0.06443	0.00002	0.00035	0.06480	0.77908	0.00028	0.00417	0.78352	**5.48%**
1992	0.67701	0.00024	0.00363	0.68089	0.05526	0.00002	0.00030	0.05558	0.73228	0.00026	0.00392	0.73646	**5.60%**
1993	0.61180	0.00024	0.00306	0.61510	0.04725	0.00002	0.00024	0.04750	0.65905	0.00026	0.00330	0.66260	**5.55%**
1994	0.58656	0.00024	0.00288	0.58968	0.06210	0.00003	0.00030	0.06243	0.64866	0.00027	0.00318	0.65211	**5.52%**
1995	0.55768	0.00024	0.00268	0.56059	0.05564	0.00002	0.00027	0.05593	0.61331	0.00026	0.00294	0.61652	**5.26%**
1996	0.53083	0.00023	0.00237	0.53344	0.04870	0.00002	0.00022	0.04894	0.57953	0.00025	0.00259	0.58237	**5.08%**
1997	0.49405	0.00022	0.00205	0.49632	0.04176	0.00002	0.00017	0.04195	0.53581	0.00024	0.00223	0.53827	**5.06%**
1998	0.49409	0.00022	0.00205	0.49637	0.04528	0.00002	0.00019	0.04549	0.53937	0.00025	0.00224	0.54186	**3.74%**
1999	0.46487	0.00022	0.00177	0.46687	0.04181	0.00002	0.00016	0.04199	0.50668	0.00024	0.00193	0.50886	**4.21%**
2000	0.49161	0.00023	0.00194	0.49377	0.04499	0.00002	0.00018	0.04519	0.53660	0.00025	0.00211	0.53896	**4.10%**
2001	0.50488	0.00024	0.00208	0.50720	0.04727	0.00002	0.00019	0.04749	0.55215	0.00026	0.00228	0.55469	**2.95%**
2002	0.48989	0.00024	0.00196	0.49209	0.04408	0.00002	0.00018	0.04428	0.53397	0.00026	0.00214	0.53637	**2.40%**
2003	0.50827	0.00024	0.00210	0.51061	0.04703	0.00002	0.00019	0.04724	0.55530	0.00027	0.00229	0.55786	**0.61%**
2004	0.51006	0.00025	0.00205	0.51235	0.04866	0.00002	0.00020	0.04888	0.55872	0.00027	0.00224	0.56123	**2.10%**
2005	0.50419	0.00029	0.00215	0.50663	0.03938	0.00002	0.00017	0.03957	0.54357	0.00031	0.00232	0.54621	**2.32%**
2006	0.53235	0.00030	0.00233	0.53498	0.04139	0.00002	0.00018	0.04160	0.57375	0.00032	0.00251	0.57658	**2.11%**
2007	0.52073	0.00029	0.00215	0.52317	0.04123	0.00002	0.00017	0.04143	0.56197	0.00032	0.00232	0.56460	**1.46%**
2008	0.51334	0.00032	0.00205	0.51571	0.04121	0.00003	0.00016	0.04140	0.55455	0.00034	0.00221	0.55710	**3.06%**
2009	0.46545	0.00032	0.00183	0.46759	0.03970	0.00003	0.00016	0.03988	0.50514	0.00034	0.00198	0.50747	**0.84%**
2010	0.47252	0.00033	0.00188	0.47472	0.03789	0.00003	0.00015	0.03807	0.51041	0.00035	0.00203	0.51279	**0.77%**
2011	0.45416	0.00034	0.00199	0.45648	0.03890	0.00003	0.00017	0.03910	0.49306	0.00037	0.00216	0.49558	**1.86%**
2012	0.50386	0.00037	0.00254	0.50678	0.04472	0.00003	0.00023	0.04498	0.54858	0.00041	0.00277	0.55176	**3.53%**
2013	0.47390	0.00042	0.00247	0.47678	0.03897	0.00003	0.00020	0.03920	0.51286	0.00045	0.00267	0.51599	**4.33%**
2014	0.42643	0.00051	0.00229	0.42922	0.03764	0.00004	0.00020	0.03789	0.46407	0.00055	0.00249	0.46711	**6.41%**
2015	0.35766	0.00064	0.00214	0.36044	0.03343	0.00006	0.00020	0.03369	0.39108	0.00070	0.00234	0.39412	**6.59%**

Notes: * The 2017 update uses data on the contribution of electricity from the different interconnects, hence these figures are based on a weighted average emission factor of the emission factors for France, the Netherlands and Ireland, based on the % share supplied.

The dataset above uses the most recent, consistent data sources across the entire time series.

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)[86],

Table 47: Base electricity generation emission factors (excluding imported electricity) – fully consistent time series dataset

Data Year	Emission Factor, $kgCO_2e$ / kWh												% Net Electricity Imports
	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_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	TOTAL
1990	0.70906	0.00026	0.00379	0.71311	0.0623	0.00002	0.00033	0.06265	0.77136	0.00028	0.00412	0.77576	**4.08%**
1991	0.68251	0.00024	0.00366	0.68641	0.06153	0.00002	0.00033	0.06188	0.74404	0.00026	0.00399	0.74829	**5.48%**
1992	0.64474	0.00023	0.00345	0.64842	0.05263	0.00002	0.00028	0.05293	0.69737	0.00025	0.00373	0.70135	**5.60%**
1993	0.58161	0.00023	0.00291	0.58475	0.04492	0.00002	0.00022	0.04516	0.62653	0.00025	0.00313	0.62991	**5.55%**
1994	0.55800	0.00023	0.00274	0.56097	0.05907	0.00002	0.00029	0.05938	0.61707	0.00025	0.00303	0.62035	**5.52%**
1995	0.53246	0.00023	0.00256	0.53525	0.05312	0.00002	0.00025	0.05339	0.58558	0.00025	0.00281	0.58864	**5.26%**
1996	0.50804	0.00022	0.00227	0.51053	0.04661	0.00002	0.00021	0.04684	0.55465	0.00024	0.00248	0.55737	**5.08%**
1997	0.47289	0.00021	0.00197	0.47507	0.03997	0.00002	0.00017	0.04016	0.51286	0.00023	0.00214	0.51523	**5.06%**
1998	0.47953	0.00022	0.00199	0.48174	0.04395	0.00002	0.00018	0.04415	0.52348	0.00024	0.00217	0.52589	**3.74%**
1999	0.44910	0.00021	0.00171	0.45102	0.04039	0.00002	0.00015	0.04056	0.48949	0.00023	0.00186	0.49158	**4.21%**
2000	0.47478	0.00022	0.00187	0.47687	0.04345	0.00002	0.00017	0.04364	0.51823	0.00024	0.00204	0.52051	**4.10%**
2001	0.49199	0.00024	0.00203	0.49426	0.04607	0.00002	0.00019	0.04628	0.53806	0.00026	0.00222	0.54054	**2.95%**
2002	0.47984	0.00023	0.00192	0.48199	0.04318	0.00002	0.00017	0.04337	0.52302	0.00025	0.00209	0.52536	**2.40%**
2003	0.50570	0.00024	0.00209	0.50803	0.04679	0.00002	0.00019	0.04700	0.55249	0.00026	0.00228	0.55503	**0.61%**
2004	0.50087	0.00024	0.00201	0.50312	0.04779	0.00002	0.00019	0.04800	0.54866	0.00026	0.00220	0.55112	**2.10%**

[86] Slight differences in the CONSUMED figure shown in the table and the figure which can be calculated using the Emission Factor (Electricity GENERATED) + Emission Factor (Electricity LOSSES) in the table is due to rounding. The CONSUMED figure in the table is considered to be more accurate.

Data Year	Emission Factor, $kgCO_2e$ / kWh												% Net Electricity Imports
	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_2O	Total	CO_2	CH_4	N_2O	Total	CO_2	CH_4	N_2O	Total	TOTAL
2005	0.49447	0.00029	0.00211	0.49687	0.03862	0.00002	0.00017	0.03881	0.53309	0.00031	0.00228	0.53568	**2.32%**
2006	0.52277	0.00029	0.00229	0.52535	0.04065	0.00002	0.00018	0.04085	0.56342	0.00031	0.00247	0.56620	**2.11%**
2007	0.51433	0.00029	0.00212	0.51674	0.04073	0.00002	0.00017	0.04092	0.55506	0.00031	0.00229	0.55766	**1.46%**
2008	0.50000	0.00031	0.00199	0.5023	0.04014	0.00002	0.00016	0.04032	0.54014	0.00033	0.00215	0.54262	**3.06%**
2009	0.46226	0.00031	0.00182	0.46439	0.03942	0.00003	0.00015	0.0396	0.50168	0.00034	0.00197	0.50399	**0.84%**
2010	0.46954	0.00033	0.00186	0.47173	0.03766	0.00003	0.00015	0.03784	0.50720	0.00036	0.00201	0.50957	**0.77%**
2011	0.44888	0.00033	0.00196	0.45117	0.03845	0.00003	0.00017	0.03865	0.48733	0.00036	0.00213	0.48982	**1.86%**
2012	0.49517	0.00037	0.00250	0.49804	0.04395	0.00003	0.00022	0.0442	0.53912	0.00040	0.00272	0.54224	**3.53%**
2013	0.46310	0.00041	0.00241	0.46592	0.03808	0.00003	0.00020	0.03831	0.50118	0.00044	0.00261	0.50423	**4.33%**
2014	0.41200	0.00049	0.00221	0.41470	0.03637	0.00004	0.00020	0.03661	0.44837	0.00053	0.00241	0.45131	**6.41%**
2015	0.34885	0.00062	0.00209	0.35156	0.03261	0.00006	0.00020	0.03287	0.38146	0.00068	0.00229	0.38443	**6.59%**

Notes: * The updated 2016 methodology uses data on the contribution of electricity from the different interconnects, hence these figures are based on a weighted average emission factor of the emission factors for France, the Netherlands and Ireland, based on the % share supplied.

The dataset above uses the most recent, consistent data sources across the entire time series.

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 48: Base electricity generation emissions factors (including imported electricity) – fully consistent time series 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	0.23210	0.25721	0.06028	0.22169	0.19059	0.43443
2002	0.22526	0.24870	0.07221	0.23304	0.20439	0.42005
2003	0.22835	0.25608	0.05091	0.22827	0.19635	0.43251
2004	0.22204	0.25026	0.05534	0.23514	0.20338	0.42269
2005	0.21541	0.24170	0.05269	0.23320	0.20492	0.40823
2006	0.22457	0.24863	0.06356	0.24995	0.22455	0.41993
2007	0.22513	0.24824	0.04259	0.23804	0.21510	0.41928
2008	0.21932	0.24184	0.04229	0.23017	0.20750	0.40846
2009	0.21639	0.23948	0.04695	0.23397	0.21073	0.40448
2010	0.21270	0.23452	0.05990	0.23810	0.21555	0.39610
2011	0.25224	0.26592	0.08003	0.24772	0.23171	0.44914
2012	0.19483	0.22742	0.02518	0.19920	0.16367	0.38411
2013	0.19951	0.23052	0.02758	0.19516	0.16013	0.38934
2014	0.19639	0.22638	0.01422	0.19022	0.15859	0.38235
2015	0.19564	0.22660	0.01850	0.19445	0.16155	0.38273

Table 49: Comparison of calculated Electricity and Heat/Steam CO_2 emission factors for the 3 different allocation method – fully consistent time series dataset

Appendix 3. Major Changes to the Conversion Factors

The following table provides a summary of major changes in emission factors for the 2017 GHG Conversion Factors, compared to the equivalent factors provided in the 2016 GHG Conversion Factors, and a short explanation for the reason for the change. We have considered major changes to be those greater than 5% for fuels and electricity most Scope 1 and 2 emission sources and greater than 10% for Scope 3 most other emission sources.

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
Fuels						
1	CNG	CH_4	Tonnes and Litres	5%	The emissions are the same as natural gas and the CVs in DUKES has increased for natural gas. Plus, within the underlying NAEI database there is an increased activity for the combustion in collieries, cement production and gas production.	Section 2
2	LNG	CH_4	Tonnes and Litres	5%	As above	Section 2
3	LPG	CH_4	All	-16%	Within the underlying NAEI database there is a decrease in the LPG road transport emission factor and activity, plus a decrease in the activity of some of the other sources.	Section 2

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
4		N_2O	All	-19%	Decrease in road transport LPG emission factor and activity, plus decrease in the activity of some of the other sources, within the underlying NAEI dataset.	Section 2
5	Natural gas	CH_4	Tonnes and Litres	5%	The CVs in DUKES has increased for natural gas. Plus, within the underlying NAEI database there is an increased activity for the combustion in collieries, cement production and gas production	Section 2
6	Diesel (average biofuel blend)	CH_4	All	-14%	Improving emissions standards, causing a reduction in CH_4 emissions.	Section 2
7	Diesel (100% mineral diesel)	CH_4	All	-14%	As above	Section 2
8	Fuel oil	CH_4	All	-5%	Distribution of sources of emissions/change in activity data in the underlying NAEI database compared to the previous year.	Section 2
9	Petrol (average biofuel blend)	N_2O	All	-6%	Improving emissions standards, causing a reduction in N_2O emissions.	Section 2
10	Petrol (100% mineral petrol)	N_2O	All	-6%	As above	Section 2

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
11	Processed fuel oils - residual oil	CH_4	All	-5%	Same as fuel oil: distribution of sources/change in activity data in the underlying NAEI database compared to the previous year.	Section 2
12	Coal (industrial)	CH_4	All	9%	Increase in the emission factor within the underlying NAEI database	Section 2
13		N_2O	All	7%	As above	Section 2
14	Coking coal	CH_4	All	-20%	Reduction in domestic combustion, which has a relatively high emission factor. This has had the effect of decreasing the overall weighted average EF of coking coal.	Section 2
15		N_2O	All	-5%	As above	Section 2
16	Petroleum coke	N_2O	All	5%	Distribution of sources/change in activity data in the underlying NAEI database compared to the previous year.	Section 2
Bioenergy						
17	Wood pellets	CO2e	Tonnes	7%	Revisions to calorific values	Section 9
18	Grass/straw	CO2e	All	-17%	Increase in power station activity (within the underlying NAEI database) by approximately 20%, which lowers the EF by around 17%	Section 9
19	Biogas	CO2e	Tonnes	-35%	Change to the Net CV of biogas	Section 9

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
20	Landfill gas	CO2e	Tonnes	-59%	Change to the Net CV of landfill gas	Section 9
Refrigerants and other						
No changes						
Passenger Vehicles						
21	Cars by market segment- unknown fuel	CH_4	km & miles	-47% to 150%	Amended the methodology for CH_4 and N_2O for unknown fuel in 2017 to reflect calculation based on mix of petrol and diesel powertrains per segment, rather than relating to average for approximate vehicle size instead.	Section 5
22		N_2O	km & miles	-54% to 25%		Section 5
23	Cars by size: Medium car, Hybrid	CO_2e and CO_2	km & miles	-7%	Change to the underlying SMMT dataset.	Section 5
24		CH_4	km & miles	-5%	As above	Section 5
25	Cars by size: Large car, Hybrid	CO_2e and CO_2	km & miles	-27%	As above	Section 5
26		CH_4	km & miles	-8%	As above	Section 5
27	Cars by size: Average car, Hybrid	CO_2e and CO_2	km & miles	-27%	As above	Section 5

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
28	Cars by size: all car sizes, CNG	N_2O	km & miles	-13%	Within the underlying NAEI database less urban journeys and more rural and motorway journeys leads to reduction in weighted emission factor of N_2O.	Section 5
29	Cars by size: all car sizes, LPG	CH_4	miles	-14%	Within the underlying NAEI database less urban journeys and more rural and motorway journeys leads to a reduction in weighted emission factor of CH_4 and N_2O. Note CH_4 km data is proportionately reduced just like the miles data, but due to rounding this is not seen.	Section 5
30		N_2O	km & miles	-13%	Within the underlying NAEI database less urban journeys and more rural and motorway journeys leads to a reduction in weighted emission factor of CH_4 and N_2O.	Section 5
31	Motorbike: all sizes	CH_4	km & miles	-5% to -9%	Due to changes in the underlying NAEI caused mainly by the evolution of fleet, with higher proportion of higher Euro standards on the market which have lower CH_4 emissions.	Section 5
Delivery vehicles						
32	Petrol vans all classes	N_2O	km & miles	-16%	Decrease in N2O emissions within the underlying NAEI database.	Section 5

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
33	CNG vans, Average (up to 3.5 tonnes)	N_2O	km & miles	-22%	N_2O emissions are calculated based on car CNG N_2O emissions and the decrease in these is the main reason for a decrease seen here.	Section 5
34	LPG vans, Average (up to 3.5 tonnes)	N_2O	km & miles	-22%	N_2O emissions are calculated based on car LPG N_2O emissions and the decrease in these is the main reason for a decrease seen here.	Section 5
35	All HGVs	CH_4	km & miles	-8% to -18%	Decreases in CH_4 emissions factors within the underlying NAEI database.	Section 6
36		N_2O	km & miles	5% to 12%	Increase in the N_2O emissions within the underlying NAEI database.	Section 6
UK Electricity						
37	Electricity generated	CO_2e and CO_2	kWh	-15%	There was a significant decrease in coal generation, and an increase in gas and renewables generation since the previous year.	Section 3
38		CH_4	kWh	59%	Increase is due to changes in the NAEI default factors leading to increases in CH4 emissions from power generation (in particular due to increases in MSW and wood burning).	Section 3
Heat and Steam						
No major changes						

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
WTT fuels						
39	CNG	CO_2e	Tonnes and Litres	10%	The increase is mainly due to change in source for WTT factors to DG ENER Exergia study.	Section 2
40	Natural gas	CO_2e	All	11% to 15%	As above	Section 2
41	Aviation Spirit	CO_2e	All	32%	Increase is due to change in source for WTT factors to DG ENER Exergia study. Aviation spirit has the same WTT emissions as petrol (see below).	Section 2
42	Diesel (average biofuel blend)	CO_2e	All	12%	The increase is due to change in source for WTT factors to DG ENER Exergia study.	Section 2
43	Diesel (100% mineral diesel)	CO_2e	All	13%	As above	Section 2
44	Gas oil	CO_2e	All	13%	As above	Section 2
45	Petrol (average biofuel blend)	CO_2e	All	30%	As above	Section 2
46	Petrol (100% mineral petrol)	CO_2e	All	32%	As above	Section 2
47	Marine gas oil	CO_2e	All	13%	As above	Section 2
WTT- bioenergy						
48	Bioethanol	CO_2e	All	-6%	Changes to DfT data (Table RTFO 05).	Section 9
49	Biodiesel	CO_2e	All	-34%	As above	Section 9
50	Biodiesel (from	CO_2e	All	-19%	As above	Section 9

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
	UCO)					
51	Biogas	CO_2e	Tonnes	-60%	As above	Section 9
Transmission and distribution						
52	UK Electricity T&D losses	CO_2e and CO_2	kWh	-12%	The increase in renewables and nuclear power and a decrease in coal was partially offset by an increase in losses from the grid.	Section 3
53		CH_4	kWh	50%	As above, emissions reduction further offset by relative increases in CH4 from the NAEI for power generation.	Section 3
54		N_2O	kWh	5.3%	As above.	Section 3
55	T&D losses - Electricity: Australia	CO_2	kWh	-22%	Losses have decreased compared to last year.	Section 3
56	T&D losses - Electricity: Chinese Taipei	CO_2	kWh	16%	Losses increased this year compared to last year.	Section 3
57	T&D losses - Electricity: Hong Kong, China	CO_2	kWh	-13%	Losses have decreased compared to last year.	Section 3
58	T&D losses - Electricity: Iceland	CO_2	kWh	150%	Losses increased this year compared to last year.	Section 3
59	T&D losses - Electricity: Israel	CO_2	kWh	-31%	Losses have decreased compared to last year.	Section 3

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
60	T&D losses - Electricity: Latvia	CO_2	kWh	-19%	Losses have decreased compared to last year.	Section 3
61	T&D losses - Electricity: Malaysia	CO_2	kWh	40%	Losses and total final energy consumption increased compared to last year.	Section 3
62	T&D losses - Electricity: Malta	CO_2	kWh	-63%	Losses have significantly decreased compared to last year.	Section 3
63	T&D losses - Electricity: Netherlands	CO_2	kWh	45%	Losses increased this year compared to last year and a new source of data used	Section 3
64	T&D losses - Electricity: Norway	CO_2	kWh	-26%	Losses have decreased compared to last year.	Section 3
65	T&D losses - Electricity: Singapore	CO_2	kWh	306%	Losses have increased significantly, compared to last year whilst total final consumption has remained fairly stable.	Section 3
66	T&D losses - Electricity: Sweden	CO_2	kWh	-44%	Losses have decreased compared to last year.	Section 3
67	T&D losses - Electricity: Africa (average)	CO_2	kWh	14%	Losses have increased compared to last year.	Section 3
68	T&D losses - Electricity: Latin America (average)	CO_2	kWh	6%	Losses have increased compared to last year	Section 3

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
WTT- UK elec						
All changes are below 9%						
WTT- overseas electricity (generation)						
69	WTT- overseas electricity (generation) - Electricity: Australia	CO_2e	kWh	-19%	Losses have decreased compared to last year.	Section 10
70	WTT- overseas electricity (generation) - Electricity: Chinese Taipei	CO_2e	kWh	21%	Losses increased this year compared to last year.	Section 10
71	WTT- overseas electricity (generation) - Electricity: Croatia	CO_2e	kWh	-17%	Extrapolated previous IEA data from 2012 to 2015 this year, generally reducing EFs vs previous year.	Section 10
72	WTT- overseas electricity (generation) - Electricity: France	CO_2e	kWh	-20%	New data source is used.	Section 10
73	WTT- overseas electricity (generation) - Electricity: Israel	CO_2e	kWh	-28%	Losses have decreased compared to last year.	Section 10

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
74	WTT- overseas electricity (generation) - Electricity: Latvia	CO_2e	kWh	-15%	Losses have decreased compared to last year.	Section 10
75	WTT- overseas electricity (generation) - Electricity: Malaysia	CO_2e	kWh	47%	Losses and total final energy consumption increased compared to last year.	Section 10
76	WTT- overseas electricity (generation) - Electricity: Malta	CO_2e	kWh	-62%	Losses have significantly reduced this year compared to last.	Section 10
77	WTT- overseas electricity (generation) - Electricity: Netherlands	CO_2e	kWh	52%	Losses increased this year compared to last year and a new source of data used.	Section 10
78	WTT- overseas electricity (generation) - Electricity: Norway	CO_2e	kWh	-20%	Losses decreased this year compared to last year.	Section 10
79	WTT- overseas electricity (generation) - Electricity: Portugal	CO_2e	kWh	-12%	Extrapolated previous IEA data from 2012 to 2015 this year, generally reducing EFs vs previous year.	Section 10

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
80	WTT- overseas electricity (generation) - Electricity: Singapore	CO_2e	kWh	331%	Losses have increased significantly, compared to last year whilst total final consumption has remained fairly stable.	Section 10
81	WTT- overseas electricity (generation) - Electricity: Sweden	CO_2e	kWh	-40%	Losses decreased this year compared to last year.	Section 10
82	WTT- overseas electricity (generation) - Electricity: Africa (average)	CO_2e	kWh	19%	Losses have increased compared to last year.	Section 10
83	WTT- overseas electricity (generation) - Electricity: Latin America (average)	CO_2e	kWh	12%	Losses have increased compared to last year.	Section 10
WTT- overseas electricity (T&D)						
84	WTT T&D losses - Electricity: Australia	CO_2e	kWh	-19%	Losses have decreased compared to last year.	Section 10
85	WTT T&D losses - Electricity: Chinese Taipei	CO_2e	kWh	21%	Losses increased this year compared to last year.	Section 10

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
86	WTT T&D losses - Electricity: Hong Kong, China	CO_2e	kWh	-9%	Losses have decreased compared to last year.	Section 10
87	WTT T&D losses - Electricity: Israel	CO_2e	kWh	-28%	Losses have decreased compared to last year.	Section 10
88	WTT T&D losses - Electricity: Latvia	CO_2e	kWh	-15%	Losses have decreased compared to last year.	Section 10
89	WTT T&D losses - Electricity: Malaysia	CO_2e	kWh	47%	Losses and total final energy consumption increased compared to last year.	Section 10
90	WTT T&D losses - Electricity: Malta	CO_2e	kWh	-62%	Losses have significantly reduced this year compared to last.	Section 10
91	WTT T&D losses - Electricity: Netherlands	CO_2e	kWh	52%	Losses increased this year compared to last year and a new source of data used	Section 10
92	WTT T&D losses - Electricity: Norway	CO_2e	kWh	-20%	Losses decreased this year compared to last year.	Section 10

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
93	WTT T&D losses - Electricity: Singapore	CO_2e	kWh	331%	Losses have increased significantly, compared to last year whilst total final consumption has remained fairly stable.	Section 10
94	WTT T&D losses - Electricity: Sweden	CO_2e	kWh	-40%	Losses decreased this year compared to last year.	Section 10
95	WTT T&D losses - Electricity: Africa (average)	CO_2e	kWh	19%	Losses have increased compared to last year.	Section 10
96	WTT T&D losses - Electricity: Latin America (average)	CO_2e	kWh	12%	Losses have increased compared to last year.	Section 10
WTT- heat and steam						
No significant changes – all are 9% vs the 2016 update.						
Water supply						
No changes						
Water treatment						
No changes						
Business travel- air						
97	Domestic, to/from UK, with and without RF	CH_4	passenger.km	-14.3%	Due to rounding of a very small number.	Section 6
98	Long-haul, to/from UK, First	CH_4	passenger.km	100.0%	As above	Section 6

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
	class					
WTT- Business travel- air						
No significant changes – between -1% and 6% vs the 2016 update						
Business travel- sea						
No significant changes – between 0% and -0.2% vs the 2016 update						
WTT- Business travel- sea						
No significant changes – all 3.1% vs the 2016 update						
Business travel- land						
99	Cars by market segment- unknown fuel	CH_4	km & miles	-47% to 150%	Amended the methodology for CH_4 and N_2O for unknown fuel in 2017 to reflect calculation based on mix of petrol and diesel powertrains per segment, rather than relating to average for approximate vehicle size instead.	Section 5
100		N_2O	km & miles	-54% to 25%		Section 5
101	Cars by size: Large car, Hybrid	CO_2e and CO_2	km & miles	-27%	Change to the underlying SMMT dataset.	Section 5
102	Cars by size: Average car, Hybrid	CO_2e and CO_2	km & miles	-27%	As above	Section 5
103	Cars by size: all car sizes, CNG	N_2O	km & miles	-13%	Within the underlying NAEI database less urban journeys and more rural and motorway journeys leads to a reduction in weighted emission factor of N_2O.	Section 5

Ref number.	Emission factor	GHG	Unit (all units are kgCO$_2$e per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
104	Cars by size: all car sizes, LPG	CH_4	miles	-14%	Within the underlying NAEI database less urban journeys and more rural and motorway journeys lead to a reduction in weighted emission factor of CH_4 and N_2O. Note CH_4 km data is proportionately reduced just like the miles data, but due to rounding this is not seen.	Section 5
105		N_2O	km & miles	-13%	Within the underlying NAEI database less urban journeys and more rural and motorway journeys lead to a reduction in weighted emission factor of CH_4 and N_2O.	Section 5
106	Motorbike: all sizes	CH_4	km & miles	-5% to -9%	Due to changes in the underlying NAEI caused mainly by the evolution of fleet, with higher proportion of higher Euro standards on the market which have lower CH_4 emissions.	Section 5
107	Bus, all types	CH_4	passenger.km	-17% to -33%	Change in underlying NAEI data leading to decreased CH_4 emissions per km.	Section 5
108	Bus, all types	N_2O	passenger.km	9% to 14%	Change in underlying NAEI data leading to increased N_2O emissions per km.	Section 5

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
109	Rail: National Rail	CH_4	passenger.km	20%	The significant increase in CH_4 emission from electricity consumption has driven an increase here. This factor is a combination of electric and diesel trains.	Section 5
110	Rail: International rail	CH_4	passenger.km	100%	Significant increase in CH_4 emission from electricity consumption.	Section 5
111		N_2O	passenger.km	17%	The is calculation based on ratio of N_2O to CO_2 of electricity consumption conversions factors. The increase of N_2O values here is due to the widening gap between the two emissions.	Section 5
112	Rail: Light rail and tram	CO_2e and CO_2	passenger.km	-17%	Due to reduction of CO_2 emissions from all the light rail sources (which is linked to the decrease in CO_2 emissions from electricity).	Section 5
113		CH_4	passenger.km	60%	Significant increase in CH_4 emission from electricity consumption, but also linked to a ~17% decrease in the CO_2 emissions of light rail (CH_4 emissions are calculated from the ratio of CH_4 to CO_2 of the electricity consumption figure and light rail figure).	Section 5

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
114	Rail: London Underground	CO_2e and CO_2	passenger.km	-19%	Due to reduction of CO_2 emissions from London Underground (from the original source).	Section 5
115		CH_4	passenger.km	60%	Significant increase in CH_4 emission from electricity consumption, but also linked to a ~20% decrease in the CO_2 emissions of light rail (CH_4 emissions are calculated from the ratio of CH_4 to CO_2 of the electricity consumption figure and light rail figure).	Section 5
Freighting goods						
116	Vans	See delivery vehicles above. (The tonne.km magnitude of change is the same as the km and miles changes).				
117	HGV (all diesel)					
118	HGV refrigerated (all diesel)					
119	Freight flights, Short-haul, to/from UK	CH_4	tonne.km	-13%	Improved performance of the B752 in the latest EUROCONTROL Small Emitters Tool.	Section 6
120	Freight train	CO_2e and CO_2	tonne.km	15%	15% Increase in the underlying ORR CO_2 per net tonne.km.	Section 6

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
121		CH_4	tonne.km	33%	Mainly due to 15% Increase in ORR freight CO_2 per net freight tonne.km (which the CH_4 values are based on) and also due to a significant increase in CH_4 emissions from electricity consumption.	Section 6
122		N_2O	tonne.km	15%	Mainly due to 15% Increase in ORR freight CO_2 per net freight tonne.km (which the N_2O values are based on).	Section 6
WTT passenger vehicles and WTT business travel- land						
123	WTT- Diesel Cars by size and market segment	CO_2e	km & miles	10-14%	Due to changes in the source of the diesel and petrol WTT emission factors, which are now based on DG ENER Exergia study.	Section 5
124	WTT- Petrol Cars by size and market segment	CO_2e	km & miles	35-36%	As above	Section 5
125	WTT- Unknown Cars by size and market segment	CO_2e	km & miles	15-36%	As above	Section 5
126	WTT- Hybrid Cars by size (except large cars)	CO_2e	km & miles	13-30%	As above	Section 5

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per “unit” of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
127	WTT- Hybrid Cars by size- large cars	CO_2e	km & miles	-11%	Linked to the large decrease in direct emissions for hybrid cars. The decrease isn't as high due to the increase in WTT emissions due to the factors now being based on the DG ENER Exergia study.	Section 5
128	WTT- motorbike	CO_2e	km & miles	35%	Due to changes in the source of the petrol WTT emission factor, which is now based on DG ENER Exergia study.	Section 5
129	WTT- taxis. Regular taxi	CO_2e	passenger.km & km	11%	As above	Section 5
130	WTT- taxis. Black cab	CO_2e	passenger.km & km	13%	As above	Section 5
131	WTT- buses, all types	CO_2e	passenger.km	9-15%	Increase is due to change in source of the diesel WTT factor to DG ENER Exergia study.	Section 5
132	WTT- rail, light rail & tram and the London Underground	CO_2e	passenger.km	-12% and -14%	Due to the decrease in the direct emissions which these WTT emissions are linked to.	Section 5
WTT delivery vehicles & freighting goods						
133	WTT - Diesel vans, all classes.	CO_2e	km, miles & tonne.km	12%	The increase is due to change in source for WTT factors to DG ENER Exergia study.	Section 6
134	WTT - Petrol vans, all	CO_2e	km, miles & tonne.km	29%	As above	Section 6

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
	classes.					
135	WTT - Unknown fuel, vans, all classes.	CO_2e	km, miles & tonne.km	13%	As above	Section 6
136	WTT - HGV refrigerated and non-refrigerated, All HGVs, all ladens	CO_2e	km, miles & tonne.km	5-16%	Increase is due to change in source of the diesel WTT factor to DG ENER Exergia study.	Section 6
137	WTT-Freight train	CO_2e	tonne.km	29%	Linked to the increase in the direct emissions and the increase in diesel WTT emissions due to the change in source for WTT factors to DG ENER Exergia study.	Section 6
Managed assets- electricity						
See "UK electricity (which is identical for managed assets electricity)						
Managed assets- vehicles						
138	Managed cars (by market segment)	See passenger vehicles above (the values are identical to these)				
139	Managed cars (by size)					
140	Managed vans	See delivery vehicles above (the values are identical to these)				
141	Managed HGV (all diesel)					
142	Managed HGV					

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
	refrigerated (all diesel)					
143	Managed motorbikes	See passenger vehicles above (the values are identical to these)				
Outside of scopes						
144	Diesel (average biofuel blend)	CO2	All	11%	The litres of biodiesel consumed this year has increased by 15% causing the percentage of biodiesel within the diesel blend to be more (11% more) and therefore the emissions associated with the biodiesel are proportionately more.	Section 1
145	Wood pellets	CO2	Tonnes	10%	Revisions to calorific values	Section 9
146	Biogas	CO2	Tonnes	-46%	New data source and improved methodology	Section 9
147	Biogas	CO2	kWh	-19%	As above	Section 9
148	Landfill gas	CO2	Tonnes	-67%	As above	Section 9
149	Landfill gas	CO2	kWh	-19%	As above	Section 9
Waste: Material use						
150	Aggregates: Primary material production	CO2e	Tonnes	-28%	Correction following QA checks	Section 12
151	Aggregates: Re-used	CO2e	Tonnes	11%	Rounding of a small number.	Section 12

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
152	Aggregates: Open-loop source	CO2e	Tonnes	-18%	Correction following QA checks	Section 12
153	Average construction: Open-loop source	CO2e	Tonnes	195%	As above	Section 12
154	Metals: Primary material production	CO2e	Tonnes	-11%	This is due to a change in assumptions. Non-ferrous is now modelled as a mix of aluminium and copper. Previously it was all taken as aluminium	Section 12
155	Metals: Closed-loop source	CO2e	Tonnes	-61%	As above	Section 12
156	Soils: Closed-loop source	CO2e	Tonnes	-28%	Correction following QA checks.	Section 12
157	Tyres: Re-used	CO2e	Tonnes	51%	Figures for reuse and tyres reanalysed using latest version of SimaPro (8.3).	Section 12
158	Tyres: Open-loop source	CO2e	Tonnes	15,328%	Open loop recycling process assumption have been updated to include shredding process	Section 12
159	Wood: Re-used	CO2e	Tonnes	-15%	Change in transport emissions has led to the change in impact	Section 12
160	Clothing: Re-used	CO2e	Tonnes	16%	As above	Section 12
161	Clothing: Open-loop source	CO2e	Tonnes	16%	As above	Section 12

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per “unit” of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
162	Metal: scrap metal: Closed-loop source	CO2e	Tonnes	-17%	This is due to a change in assumptions. Non-ferrous is now modelled as a mix of aluminium and copper. Previously it was all taken as aluminium	Section 12
163	Plastics: PS (incl. forming): Open-loop source	CO2e	Tonnes	-20%	Changes to the underlying data set for PS resin production	Section 12
164	Plastics: PS (incl. forming): Closed-loop source	CO2e	Tonnes	-11%	As above	Section 12
165	paper (all types): Closed-loop source	CO2e	Tonnes	16%	Correction following QA checks	Section 12
Waste: Waste disposal						
166	Aggregates: Landfill	CO2e	Tonnes	-32%	Rounding of a small number.	Section 12
167	Average construction: Landfill	CO2e	Tonnes	-32%	As above	Section 12
168	Asbestos: Landfill	CO2e	Tonnes	-32%	As above	Section 12
169	Asphalt: Landfill	CO2e	Tonnes	-32%	As above	Section 12
170	Bricks: Landfill	CO2e	Tonnes	-32%	As above	Section 12

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
171	Concrete: Landfill	CO2e	Tonnes	-32%	As above	Section 12
172	Insulation: Landfill	CO2e	Tonnes	-32%	As above	Section 12
173	Metals: Landfill	CO2e	Tonnes	-32%	As above	Section 12
174	Soils: Closed-loop source	CO2e	Tonnes	-27%	Changed as transport assumptions for closed loop recycling have been standardised	Section 12
175	Soils: Landfill	CO2e	Tonnes	717%	Landfill emission are now calculated using MELMod. This is a completely different methodology that has no relation to the previous methods used. The results are not comparable	Section 12
176	Wood: Landfill	CO2e	Tonnes	31%	As above	Section 12
177	Other: Books: Landfill	CO2e	Tonnes	232%	As above	Section 12
178	Other: Clothing: Landfill	CO2e	Tonnes	19%	As above	Section 12
179	Municipal waste: Landfill	CO2e	Tonnes	717%	As above	Section 12
180	Organic: garden waste: Landfill	CO2e	Tonnes	717%	As above	Section 12
181	Organic: mixed food and garden waste:	CO2e	Tonnes	717%	As above	Section 12

Ref number.	Emission factor	GHG	Unit (all units are $kgCO_2e$ per "unit" of GHG, unless stated)	Magnitude of change vs 2016 update	Reason for change	For more information, see:
	Landfill					
182	Commercial and industrial waste: Landfill	CO2e	Tonnes	717%	As above	Section 12
183	Metal: scrap metal: Combustion	CO2e	Tonnes	-26%	Correction following QA checks	Section 12
184	Metal: steel cans: Combustion	CO2e	Tonnes	-30%	As above	Section 12
185	All Metals: Landfill	CO2e	Tonnes	-56%	As above	Section 12
186	All plastics: Landfill	CO2e	Tonnes	-73%	Landfill transport standardised for materials collected within residual waste. It no longer passes through a bulking up facility	Section 12
187	All paper: landfill	CO2e	Tonnes	232%	Landfill emission are now calculated using MELMod. This is a completely different methodology that has no relation to the previous methods used. The results are not comparable	Section 12

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