Passenger transport emissions factors

Methodology paper

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I. Background and Summary

1. Emissions factors are required to estimate the CO_2 impact per km (or pkm) from passenger transport. These factors are to be used in a number of different policies including: offsetting, Defra (and DfT) personal CO_2 calculators and to update the guidelines to Defra's greenhouse gas (GHG) conversion factors for company reporting, which represent the current official set of government emissions factors. This paper outlines the methodology used to update the emissions factors for passenger cars, motorcycles, flights, rail travel and buses. The new factors are presented at the end of each of the relevant following sections.

II. PASSENGER CARS

Previous Approach

2. The Annexes to the Defra company reporting guidelines (CRG)[1], released in July 2005, reported the figures presented in Table 1 below. The factors derived refer to CO_2 emissions per km and are derived from speed emission curves also used by the UK's National Atmospheric Emissions Inventory (NAEI) / Greenhouse Gas Inventory (GHGI). These curves were developed mainly for Air Quality and national Greenhouse Gas emissions inventory purposes and were developed from a dataset derived from actual testing of a selection of different sized and different Euro 3 emission class cars for several different "real world" drive cycles.

Table 1: CO_2 emission factors for cars from the 2005 Defra CRG Annex 6 (July 2005)

Vehicle Type	Engine size	Size label	gCO_2 per km	MPG
Petrol car	< 1.4 l	Small	159.2	40.8
	1.4 - 2.0 l	Medium	188.0	34.6
	> 2.0 l	Large	219.7	29.6
Average petrol car			**178.2**	**36.5**
Diesel car		*Small*	*N/A*	*N/A*
	< 2.0 l	Medium	163.6	45.4
	> 2.0 l	Large	192.6	38.6
Average diesel car			**169.6**	**43.8**

3. The current factors take account of the impact of different UK average driving speeds and cycles relative to those of the NEDC (New European Driving Cycle – used in vehicle type approval) and to an extent the impacts of vehicle age. They take no account of further 'real-world' effects, such 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,

[1] The annexes updated in 2007 are now referred to as the 'Guidelines to Defra's GHG conversion factors for company reporting'.

maladjusted tracking, etc), gradients (tests effectively assume a level road), weather, more aggressive/harsher driving style, etc.

Revised Approach

4. The current factors have not been updated to take into account changes to the UK car fleet resulting from new sales and registrations. They also do not provide factors for small diesel cars, which are now a significant part of new car sales, and for hybrid vehicles. Furthermore, they only in part take into account important ‘real-world’ effects that act to significantly increase fuel consumption over test-cycle based figures. Several alternative datasets were considered in looking to update the car CO_2 factors to better reflect the current fleet and real-world conditions.

Real-World Effects

5. In terms of uplifting NEDC based emission factors to ‘real-world’ values, there are a number of sources of evidence and information to inform a decision on an appropriate value. Results of recent research by TUEV Nord for the German Environmental Agency[2] have shown that the CO_2 emissions for the NEDC test cycle can vary up to +30% for a specific vehicle type, due to vehicle and driving behaviour variations. The study concludes that on average the CO_2 emissions in real traffic are systematically higher than indicated by the type approval results by a factor in the order of +10-15%. In comparison, the IEA (International Energy Agency) uses a factor of +15-18% in its model calculations to convert from test-cycle to ‘real-world’ values. This is also similar to the value of +15.5% quoted by Energy Saving Trust (EST) based on information from ARVAL (the UK’s biggest fleet operator) on observations from the real performance of its vehicles relative to test cycle data. The ARVAL factor provides the only information specific to the UK, although it may be a small over-estimate for private cars in some cases due to nature of fleet vehicle usage compared to more typical driving styles of the general public.

6. Other information from EST on the impacts of various real-world effects on fuel consumption also supports the possible application of uplift factors. These effects include general maintenance and tyre pressure (increase of 1% for every 3 PSI under pressure), eco-driving (up to 5-10% reduction), air conditioning use (increase of 5% for average mixed use; up to 20-25% increase when on full power[3]).]

7. Air conditioning (a/c) is a particularly significant component of ‘real-world’ impacts on fuel consumption, as it is not currently included in the type-approval testing procedures. It is estimated that today around 85% of new cars are sold with air conditioning systems fitted as standard[4], with nearly all medium and large cars have air conditioning as standard equipment[5]. SMMT (Society for Motor

[2] Investigations for an Amendment of the EU Directive 93/116/EC (Measurement of Fuel Consumption and CO_2 Emission). Study by TUEV Nord Mobilitaet GmbH & Co.KG, Institute for Vehicle Technology and Mobility. Carried out by order of the German Environmental Agency (UBA). November 2005.
[3] Source: tests carried out by ADEME, France.
[4] From: www.boschautoparts.co.uk/teACon1.asp?c=2&d=2
[5] From: www.eberspacher.com/aircon.php?section=products

Manufacturers and Traders) has estimated that the proportion of the car fleet with a/c units increased from 10% in 1993 to 55% by 2002 further to 70% by 2005[6].

8. An uplift factor of **+15% over NEDC based gCO_2/km** factors has been agreed with DfT to take into account the combined 'real-world' effects on fuel consumption not already taken into account in the previous factors. [Note: This represents a decrease in MPG (miles per gallon) over NEDC figures of about 13% for petrol cars and 9% for diesel cars.]

[6] From CfIT (Commission for Integrated Transport): www.cfit.gov.uk/plenaries/0501mfp3.htm

New Factors for the UK Fleet

9. Several datasets were identified to help inform the updating of the average CO_2 emission factors. The most relevant one identified was based on SMMT data, and is presented in Table 2. This data provides an average of the NEDC gCO_2/km figures for new vehicles registered between 1997 and 2005. The average emission factors are likely to be slightly lower than the full UK fleet average as the dataset covers only 9 years of car registrations[7], with the average car lifetime being around 14-15 years. However, it does represent the best indication of the actual UK fleet split of vehicle/engine sizes and relative NEDC gCO_2/km by size category. The CRG Annex 6 engine size categories appear to provide a reasonable spread across the registrations. It therefore appears to provide validation for the existing split (and the proposed 'small' diesel category).

Table 2: Average CO_2 emission factors and total registrations from SMMT data for 1997 to 2005 (provided by EST, based on data sourced from SMMT).

Vehicle Type	Engine size	Size label	gCO_2 per km	MPG	Total no. of registrations	% Total
Petrol car	< 1.4 l	Small	154.5	42.1	7,095,263	43%
	1.4 - 2.0 l	Medium	190.7	34.1	8,000,819	48%
	> 2.0 l	Large	261.4	24.9	1,541,636	9%
Average petrol car			**181.8**	**35.8**	**16,637,718**	**100%**
Diesel car	<1.7 l	Small	126.9	58.5	634,134	13%
	1.7 - 2.0 l	Medium	158.4	46.9	3,167,262	66%
	> 2.0 l	Large	221.9	33.5	987,078	21%
Average diesel car			**167.3**	**44.4**	**4,788,474**	**100%**

10. The previous conversion factors for small and medium sized petrol and diesel cars appear to be approximately consistent with this dataset – being in general slightly higher, as would be expected for the UK fleet average. However, the 'large' category emission factors for both petrol and diesel in the existing guidelines seem to be significantly low and should be revised upwards. The reason for this discrepancy is likely to be two-fold: Primarily it is probably due to the selection of test vehicles that formed the basis behind the original speed-emission curves used to derive the old factors. These vehicles covered typical family cars and did not cover the very large (e.g. 4x4 or SUV) or higher-performance cars (e.g. sports, executive and luxury)[8]. Secondarily, the proportion of larger and higher performance categories has increased in recent years (particularly for diesel-powered cars), increasing the average for cars falling in the 'large' engine size category.

[7] 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.
[8] The focus of the work was also primarily towards development of air quality pollutant emission factors, where emission standards are very similar or the same across car sizes.

11. The SMMT dataset has therefore been used to calibrate the existing Defra conversion factors (DCF) to produce more up-to-date and accurate emission factors by size category based on NEDC. *Revised NEDC based DCF* figures are presented in Table 3, with the new figures for large petrol and diesel cars and for small diesel cars in **red**. These new figures have been calculated relative to medium cars using the SMMT dataset in Table 2. The *New 'Real-World'* Defra conversion factors to be used also include the +15% uplift factor to take into account the 'real-world' impacts on fuel consumption not captured by drive cycles such as the NEDC in type-approval.

12. New CO_2 emission factors have also been generated for medium and large hybrid petrol-electric cars, which are based on average emission factors for the main models currently widely available on the UK market. For medium cars this is an average of figures for the Toyota Prius and Honda Civic IMA. For large cars the emission factor is an average of data for the Lexus GS450h and Lexus RX400h.

Table 3: Revised CO_2 emission factors for cars

			Revised NEDC based DCF (1)		Final New 'real-world' DCF (2)	
Vehicle Type	**Engine size**	**Size label**	**gCO_2 per km**	**MPG**	**gCO_2 per km**	**MPG**
Petrol car	< 1.4 l	Small	159.2	40.8	183.1	35.5
	1.4 - 2.0 l	Medium	188.0	34.6	216.2	30.1
	> 2.0 l	Large	257.7	25.2	296.4	21.9
Average petrol car			**182.2**	**35.7**	**209.5**	**31.0**
Diesel car	<1.7 l	Small	131.0	56.7	150.7	49.3
	1.7 - 2.0 l	Medium	163.6	45.4	188.1	39.5
	> 2.0 l	Large	229.1	32.4	263.5	28.2
Average diesel car			**172.8**	**43.0**	**198.7**	**37.4**
Hybrid petrol-electric car	(3)	Medium	109.7	59.3	126.2	51.5
	(4)	Large	194.7	33.4	224.0	29.0
Average car (unknown fuel)	(5)	-	**180.4**	**37.0**	**207.5**	**32.2**

Notes:
(1) Revised figures (in **red**) are calculated relative to medium cars using the SMMT dataset in Table 2.
(2) Using a +15% uplift factor for NEDC ⇒ 'real-world';
(3) Average of Toyota Prius and Honda Civic IMA; (4) Average of Lexus GS450h and RX400h.
(5) Estimated from the relative vkm data from NAEI for petrol (81.5%) and diesel (18.5%)

13. Individuals may wish to calculate their carbon emissions for a particular door-to-door journey using Transport Direct[9] - www.transportdirect.info.

III. MOTORCYCLES

Previous Approach

14. Whilst no emission factors were provided for motorbikes in the previous Defra CRG Annexes, a dataset based on speed-emission curves[10] (from the UK Greenhouse Gas Inventory) had been provided in response to queries with a split of Mopeds <50cc and Motorcycles >50cc.

[9] Note that the emission factors and vehicle size categorisation in Transport Direct are not identical to the Defra conversion factors, as they are used in a different way and for a different purpose. However both figures produce consistent estimates.
[10] This is based on the COPERT III emissions inventory model data

Revised Approach

15. The previous dataset values looked like it might be slightly optimistic (equivalent to 102 mpg and 71 mpg respectively for the moped and motorcycle categories) and was less helpful in its categorisation compared to other data available (such as from the RAC[11]). Data from type approval is not currently readily available and CO_2 emission measurements were only mandatory in motorcycle type approval from 2005 in any case.

16. Data from the RAC is currently provided in 8 engine size ranges, however this was too diverse a range for the practical purposes of the reporting guidelines and the government 'Act on CO_2 calculator' for personal transport. Therefore it was decided to split the new emission factors into 3 categories:
    - Small motorbikes (mopeds/scooters up to 125cc),
    - Medium motorbikes (125-500cc), and
    - Large motorbikes (over 500cc)

17. New emission factors were developed based on reproduced data from the ACEM (European Motorcycle Manufacturers Association) website[12] – sourced from the European Commission's Joint Research Centre. The reproduced graph and table of values are provided in Figure 1 and Table 4 below.

Figure 1: Chart on CO_2 emissions from motorcycles based on engine capacity (reproduced from ACEM)

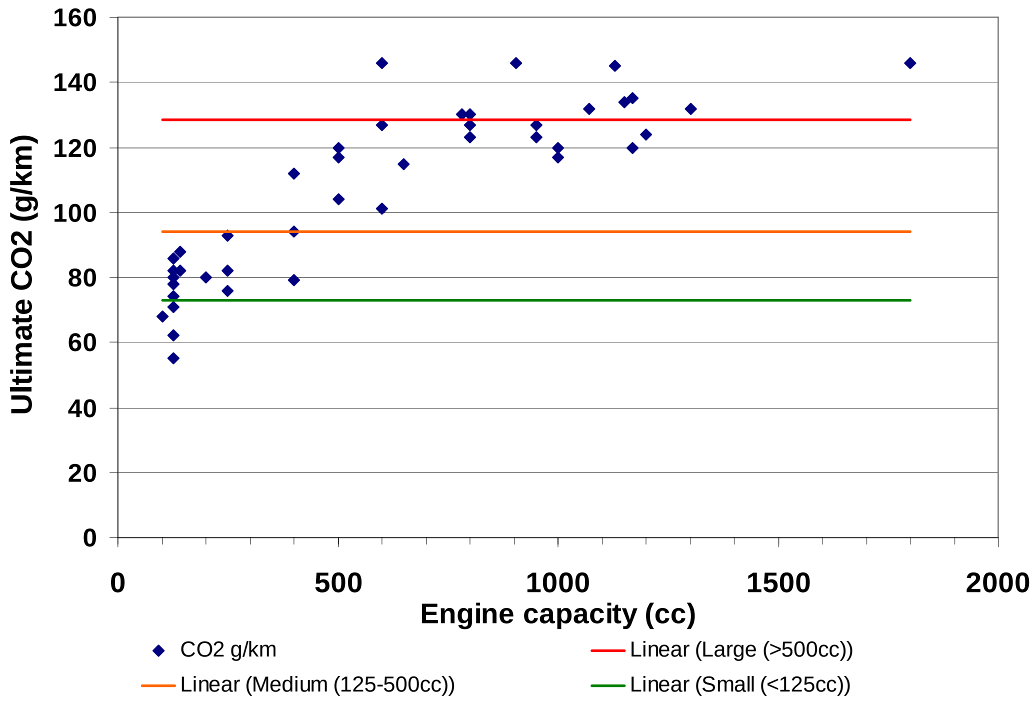

Table 4: Dataset on CO_2 emissions from motorcycles based on engine capacity (reproduced from ACEM)

[11] RAC data available at: www.rac.co.uk/web/knowhow/owning_a_car/running_costs/motorcycle_services/running_costs
[12] Available at: www.acembike.org/motorcycles&society/pressreleases/MS3-Environment-LMercanti.pdf

Motorbike Size	cc	gCO_2/km
Small	100	68.0
Small	125	55.0
Small	125	62.0
Small	125	74.0
Small	125	78.0
Small	125	80.0
Small	125	82.0
Small	125	86.0
Small	125	71.0
Average Small		**72.9**
Medium	140	88.0
Medium	140	82.0
Medium	200	80.0
Medium	250	93.0
Medium	250	82.0
Medium	250	76.0
Medium	400	79.0
Medium	400	94.0
Medium	400	112.0
Medium	500	117.0
Medium	500	104.0
Medium	500	120.0
Average Medium		**93.9**

Motorbike Size	cc	gCO_2/km
Large	600	146.0
Large	600	127.0
Large	600	101.0
Large	650	115.0
Large	780	130.0
Large	800	123.0
Large	800	127.0
Large	800	130.0
Large	905	146.0
Large	950	127.0
Large	950	123.0
Large	1000	117.0
Large	1000	120.0
Large	1070	132.0
Large	1130	145.0
Large	1150	134.0
Large	1170	120.0
Large	1170	135.0
Large	1200	124.0
Large	1300	132.0
Large	1800	146.0
Average Large		**128.6**
Total Average		**106.7**

18. The new revised emission factors and categories included in the 2007 update to the Defra conversion factors are summarised in the following Table 5 below.

Table 5: Revised CO_2 emission factors for motorcycles

Vehicle Type	Engine size	Size label	gCO_2 per km	MPG
Petrol motorcycle	Up to 125cc	Small (mopeds/scooters)	72.9	89.2
	125cc to 500cc	Medium	93.9	69.2
	Over 500cc	Large	128.6	50.6
	Average	**-**	**106.7**	**60.9**

IV. AVIATION

Previous Approach

19. The Annexes to the Defra Company Reporting Guidelines (CRG), released in July 2005, report CO_2 emission factors for estimating greenhouse gas emissions.

20. For aviation, there were two factors, one for short haul and one for long haul, as follows:
   - Long haul 110 g/CO_2 per passenger km
   - Short haul 150 g/CO_2 per passenger km

21. The CO_2 emission factors were calculated on the assumptions that for long haul, flight distance was 5000 nautical miles (9260km) on a B747-400 aircraft with 450 seat capacity and 70% load factor (for 2003 from TSGB 2005[13]). For short haul, a distance of 500 nautical miles was assumed (926km) for a B737-400 with 128 seat capacity aircraft and 65% load factor (TSGB 2004[13]).

22. Emissions per passenger km and were derived from fuel consumption data for particular aircraft making these flights, taken from the European CORINAIR (Core Inventory of Air Emissions in Europe) manual (2001) for reporting emissions, and based on the methodological recommendations provided in the EMEP/CORINAIR Emissions Inventory Guidebook (EIG)[14]. This dataset provides fuel consumption data for different aircraft by a range of total journey lengths for each of the different stages: LTO, Taxi out, Take off, Climb out, Climb/cruise/descent, Approach landing, Taxi in.

Revised Approach

23. The previous approach has been criticised for being too simplistic and for not taking into account the higher emissions per km from domestic aviation due to the increased influence of the take off and landing cycle on short haul flights.

24. The revised approach uses more up to date information and assumptions that allow a more representative view of the emissions per passenger km for different types of flights.

25. The revised emission factors are set out below in
26.
27. Table 6. In addition to the two types of flight for which the previous guidelines presented emissions factors, a factor for domestic flights is also provided.

28. Published data have been relied on to produce these estimates. In order to be consistent with earlier versions of the conversion factors, illustrative aircraft types for each type of flight has been used to illustrate the CO_2 emission factor.

[13] Transport Statistics Great Britain 2004
[14] Chapter B851 on aviation. The full guidebook is available at the EEA website: http://reports.eea.europa.eu/EMEPCORINAIR4/en/page002.html

Table 6: Emissions factors for domestic and international flights

	Grams CO_2 per passenger km[15]	Calculation Assumptions	Example Journey
Domestic (B737-400 and Dash 8-Q400)	158.0	• Load factor 65%[16] • Average emissions of two types of aircraft commonly used on domestic flights • Distance 250 nautical miles (463km) in line with CORINAIR published distance category • 78 seats on the Dash-8 Q400 and 139 seats on the B737-400[17]	**London - Scotland**
Short haul international (B737-400)	130.4	• Load factor 65%[18] • Typical illustrative aircraft type used • Distance 599 nautical miles (1108km)[19] interpolated between CORINAIR published distance categories • 139 seats[20]	**UK – Central Europe**
Long haul international (B767-300ER and B747-400)	105.6	• Load factor 79.7%[21] • Average emissions of two types of aircraft commonly used on domestic flights • Distance 3500 nautical miles (6482km) to be in line with CORINAIR published category • 346 seats on the B747-400 and 261 seats on the B767-300ER[20]	**UK – East Coast USA**

Notes:

- These emissions factors are intended to be an aggregate representation of the typical emissions per passenger km from illustrative types of aircraft for the 3 types of air services. Actual emissions will vary significantly according to the type of aircraft in use, the load etc.
- The emission factors do not include additional impacts of Radiative Forcing (i.e. non-CO_2 climate change impacts) and are designed to be used in conjunction with great circle distances. The total climate impacts of aviation due to Radiative Forcing are estimated by IPCC to be up to 2-4 times those of CO_2 alone, however the science of Radiative Forcing is currently uncertain.

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15 EMEP/CORINAIR Emissions Inventory Guidebook (2006) – available at the EEA website at: http://reports.eea.europa.eu/EMEPCORINAIR4/en/B851vs2.4.pdf

16 Source: Transport Statistics Great Britain, 2006, DfT, table 2.4

17 Source: derived from CAA data, table 1.11.1 of Airline Statistics, 2005

18 Assumed here to be the same as for domestic flights. Note that business flights will have a different load factor to this average which reflects all short haul flights

19 Short haul distance from Table D8, "Aviation and the Environment, Using Economic Instruments", HMT and DfT, March 2003

20 Source: derived from CAA data, table 1.11.1 of Airline Statistics, 2005

21 Load factor for all international flights. Source: Transport Statistics Great Britain 2006, table 2.4

29. In terms of the distances that these emission factors should be applied to, the short haul international figure should be applied to journeys up to 2000nm (3700km, the maximum range of a 737-400 according to the EIG 2006[22]) and the long distance factor applied to anything greater than that. Domestic is obviously applied to domestic flights.

30. The emissions factors in
31.
32. Table 6 are based on typical aircraft fuel burn over illustrative trip distances listed in the Emissions Inventory Guidebook (2006[22]). Long haul is based on a flight length of 6482 km, short haul 1108km and domestic 463km. Actual flight distances do however vary significantly, as demonstrated in the following examples in Table 7 and Table 8.

Table 7: Illustrative long haul flight distances

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

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

Table 8: Illustrative short haul flight distances

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

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

[22] EMEP/CORINAIR Emissions Inventory Guidebook (2006) – available at the EEA website at: http://reports.eea.europa.eu/EMEPCORINAIR4/en/B851vs2.4.pdf

33. Emissions impacts in
34.
35. Table 6 have been estimated based on a calculation using the average flight distance (or actual great circle) and should be increased by 9% to take into account indirect routing/delays. This factor comes from the IPCC's report "Aviation and the Global Atmosphere" (1999), section 8.2.2.3[23], which states that 9-10% should be added to take into account non-direct (i.e. not along the straight line between destinations) routes and delays/circling. DfT also use 9% in their work, which is also consistent with the approach take in the UK Greenhouse Gas Inventory.

36. The factors are slightly lower than those in the 2005 Defra CRG Annexes due to a combination of higher load factors (reflecting the latest data from DfT statistics) and more representative aircraft types included in the calculations.

[23] Available at: www.grida.no/climate/ipcc/aviation/121.htm#8223

V. RAIL

Previous Approach

37. The previous national rail factor of 40 gCO_2/pkm referred to an average emission per passenger kilometre for diesel and electric trains weighted by the proportion of electric to diesel train kilometres in 2003. The factor for diesel trains was calculated based on total diesel consumed by the railways in 2003 provided by ATOC. The factor for electric trains was calculated based on average kWh per kilometre for a typical electric train and the grid electricity factor in the Defra CRG Annexes. The diesel/electric passenger train weighting was based on data for 2003 from DeltaRail (formerly AEA Technology Rail).

Revised Approach

38. The previous approach has been criticised for not providing separate emission factors for light rail schemes or the London Underground. Separate factors have been included for the 2007 update, as provided in Table 5. These are based on the assumptions outlined in the following paragraphs.

39. The national rail factor refers to an average emission per passenger kilometre for diesel and electric trains in 2005/06. The factor is from the DfT Network Modelling Framework (NMF) Environmental Model and has been calculated based on total electricity and diesel consumed by the railways in 2005/06 provided by ATOC, and the total number of passenger kilometres for 2005/06 from DfT rail statistics. The factors factor for conversion of kWh electricity into CO_2 are based on the 2005 grid mix.

40. The light rail factors were based on an average of factors for the Docklands Light Rail (DLR) service, the Manchester Metrolink and the Croydon Tramlink. The factors for these light rail systems were based on annual electricity consumption and passenger km data provided by the network operators (referring to consumption in 2003/04) and a CO_2 emission factor for electricity generation on the national grid from the UK Greenhouse Gas Inventory.

41. The Underground rail factor is based on the Underground's annual electricity consumption and uses corresponding passenger km figures for the Underground from Transport Statistics Great Britain.

Table 9: Revised CO_2 emission factors for rail travel

Rail	gCO_2 per km	Source
National Rail	60.2	DfT Network Modelling Framework (NMF) Environmental ModelCO_2/fuel consumption and DfT rail statistics for 05/06
Light rail (and tram)	65.0	Average of DLR, Croydon Tramlink and Manchester Metrolink
Underground (Tube)	52.6	Based on information from London Underground and Transport Statistics Great Britain

VI. BUSES

Previous Approach

42. None provided in the Annexes to the 2005 Defra Company Reporting Guidelines.

Revised Approach

43. The bus factors are calculated based on fleet average gCO_2/km for all bus class and journey data from the UK Greenhouse Gas Inventory and an average load factor of 9.2 calculated using total bus vehicle km and passenger km from Transport Statistics Great Britain (TSGB).

44. Emission factors in gCO_2/vehicle km for buses in different legislative Euro classes operated on different types of road conditions are shown in the following table and are based on fuel efficiency factors (g fuel/km) taken from the UK's Greenhouse Gas Inventory report "*UK Greenhouse Gas Inventory, 1990 to 2004: Annual Report for submission under the Framework Convention on Climate Change*"[24]. The factors are based on emission tests on a limited sample of buses over different drive cycles carried out at different research facilities in Europe and are presented in Table 10.

Table 10: CO_2 emissions from different bus emission classes from the UK GHG Inventory

gCO2/km	Urban	Rural – single carriageway	Rural – dual carriageway	Motorway
Pre-1988	1254	561	683	718
Pre-Euro I	1212	547	669	704
Euro I	1003	613	656	669
Euro II	905	600	640	654
Euro III	905	600	640	654
Euro IV	878	582	620	635
Euro V	851	564	601	615

45. The estimated journey types by buses in the UK are presented in Table 11. These are based on national traffic census data for 2005 carried out in Great Britain by DfT and the Department for Regional Development, N Ireland.

Table 11: Split of journey types used in the UK GHG Inventory

Road type	Urban	Rural – single carriageway	Rural – dual carriageway	Motorway
Percentage of bus Vehicle km	62%	23%	6%	9%

[24] Available at www.airquality.co.uk/archive/reports/cat07/0605231047_ukghgi_90-04_v1.1.pdf

Source: DfT[25] and the Department for Regional Development, N Ireland.

46. Using these percentages and the above CO_2 factors for different road types, an overall average CO_2 emission factor can be calculated for all types of roads, as shown in the following table. It is assumed that all buses run the above proportions on the different road types. If figures can be found to improve this assumption, then figures will be revised accordingly.

47. The UK Greenhouse Gas Inventory (GHGI) makes an estimate of the proportion of bus vehicle km travelled by buses meeting the different Euro standards. This is linked to the age distribution of the fleet calculated in a fleet turnover model using data on new vehicle registrations from DfT's licensing statistics and historic trends in survival rates of buses of different ages. More details are given in the GHGI annual report. The table below refers to the proportion of bus vehicle km in 2005.

Table 12: Proportion of bus vehicle km travelled by buses meeting the different Euro standards in 2005 (UK GHGI)

	Average for all journeys (gCO2/km)	**Proportion of bus vehicle km (%)**
Pre-1988	1011	4
Pre-Euro I	980	6
Euro I	862	9
Euro II	796	38
Euro III	796	43
Euro IV	772	0
Euro V	748	0
FLEET AVERAGE	**822**	**100**

48. A national average load factor of 9.2 is estimated according to the following Table 13[26].

Table 13: Calculation of the average load factor for buses

	Billions	**Source**
GB passenger km by buses	48	TSGB 2006 – (Table 1.1)
GB vehicle km by buses	5.2	TSGB 2006 – (Table 7.2)
Passengers per bus	9.2	

49. The new Defra conversion factor is therefore an average of 89.1 gCO_2 per passenger km = 822 / 9.2, presented in Table 14.

Table 14: Revised CO_2 emission factors for bus travel

[25] "Transport Statistics Bulletin – Road Traffic Statistics: 2005", Report SB (06) 28, 2006
[26] Note that average bus occupancy factors in London busses are significantly higher at 14.7 in 2005 according to Transport for London. Occupancy outside of London will therefore be lower than the national average.

Rail	gCO_2 per km	Source
Buses	89.1	Based on CO_2 for all busses from the UK Greenhouse Gas Inventory and DfT statistics on bus vehicle km and passenger km.