National
Atmospheric
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Inventory

EMISSION FACTORS FOR ALTERNATIVE VEHICLE TECHNOLOGIES.

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Introduction

The NAEI currently only reports and forecasts emissions from conventional vehicle technologies using petrol and diesel engines. Average speed-related emission factors are used from reviews and analysis of emission test data undertaken by various organisations whose primary objectives were providing factors for compiling national emission inventories. Emission factors are categorised according to vehicle type, size and fuel type and Euro emission standard, the latter providing a means for estimating emission factors for future vehicles not yet in the fleet.

Vehicles using alternative fuels or powertrains currently make up a very small proportion of the UK vehicle fleet, but various vehicle technologies are expected to penetrate the fleet in increasing proportions, mostly driven by plans and measures to reduce CO_2 emissions from road transport and to address exceedences of air quality limits in towns and cities. It will therefore be necessary for the NAEI to consider the fleet penetration of these vehicles and the impact they have on forecasts of UK air quality pollutant emissions, especially NO_x and PM. This requires a comparable set of emission factors to be available for a range of alternative vehicle technologies, a requirement that extends to those involved in evaluating options for local air quality management, transport planning and scheme appraisals.

At present, a consolidated set of emission factors for alternative fuels and vehicle technologies is not available. This note aims to provide this information for the key pollutants NO_x and PM for vehicles and technologies where at least some emissions data are available and which are currently entering the fleet or are expected to do so in the short to medium-term. The choice of technologies covered also reflects the specific interests and requirements of various stakeholder groups expressed to the inventory team. The technology choice is not exhaustive and the review only covers tailpipe emissions, not life-cycle or fuel-cycle emissions which are outside the scope of this assessment.

Not all the information used to derive emission factors for alternative technologies covered here is in the public domain and a degree of expert judgement has had to be applied in some cases. However, we are particularly grateful for the input provided by TfL from whom some of the factors are taken.

Emission factors for NO_x and PM from alternative vehicle technologies

A number of technology types were selected for including in this review. The selection was based on the NAEI's own understanding of emerging technologies and the suggestions of other organisations involved in local air quality management support and national air quality modelling and assessments, namely Bureau Veritas, Amec, Imperial College and TfL. The NAEI has been asked to provide some default emission factors for technologies that may be included in Action Plans and assessments of low emission zone options within tools such as the Emission Factor Toolkit and Highways Agency "*Design Manual Roads and Bridges*".

The study considered:

- ***Alternative power trains*** – namely hybrid electric, battery electric and fuel cell electric vehicles
- ***Alternative fuels*** – namely CNG buses, LPG cars and high strength biofuels (E85 bioethanol and B100 biodiesel)
- ***Retrofit options –*** referring to alterations to existing vehicles in the fleet

The review was severely limited by available emission factors for pollutants like NO_x and PM and in some cases it was necessary to use expert judgement where emissions data were completely lacking or where information from different sources was incomplete, variable and even contradictory. This in part reflects the variability in emission behaviour of these technologies and the fact that a variety of engineering approaches may be used for a notionally common technology type (e.g. hybrids). These different approaches may offer the same benefits in fuel economy and CO_2 emissions but markedly different pollutant emissions making it very difficult to generalise.

Tables 1 and 2 show the emission factors or scaling factors developed for each vehicle technology type for NO_x and PM_{10} respectively.

The tables indicate the main vehicle type (car/van, HGV and bus), the technology or fuel type and the model year.

There are then two methods used to define emissions. Where appropriate, a specific emission factor value is quoted in g/km. This is usually where emission factors are provided in this format by the reference source and are available for average speeds associated with the road types indicated: urban, rural (single carriageway) or highway (motorway/duel carriageway). In most cases, emissions are shown as a scaling factor for different road types which is to be multiplied by the emission factor for the conventional petrol/diesel vehicle type and Euro class mentioned in the table for the same road type. So, for example, a scaling factor of 0.2 for urban roads relative to Euro 4 petrol means the emission factor for the technology is 0.2 times the emission factor that would be calculated for the conventional Euro 4 petrol vehicle at urban speeds. This implies the technology offers a 80% reduction in emissions against the Euro 4 petrol car under urban conditions.

Finally, the data source is provided and brief comments are made about the source of factors given.

There are many caveats and further comments that need to be made to fully understand the limitations of the factors provided. These are given in the following sections.

The factors for the technologies covered in this assessment have been included in the January 2013 update of the Emission Factor Toolkit (http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft). The choice of technologies is not exhaustive and the list is not a closed one. Further technologies will be added and the factors covered in this assessment will be kept under regular review and updated as further evidence becomes available. These will also be added to future updates of the Emission Factor Toolkit. The focus of this assessment has been on important air quality pollutant emissions of NO_x and PM, but other pollutants will be added when emission factors become available, e.g. CO, VOCs and air toxics such as benzene, 1,3-butadiene and polyaromatic hydrocarbons.

Further technologies and fuels are entering the market now and others will in the future. These include, but are not limited to, diesel full- and plug-in hybrid cars, petrol and diesel range extender electric vehicles, hydrogen and natural gas flex fuel vehicles and second-generation biofuels.

Hybrid electric cars

There are a number of different hybrid car concepts and only two are listed here. The Full Hybrid factors refer to the most popular type of hybrid car currently in the fleet, the Toyota Prius, these being the only type of hybrid car for which any air pollutant emissions data are available. The factors reflect the technology approach adopted by Toyota and it cannot be assumed with any certainty that these factors would apply to other Full Hybrids, let alone mild or mirco hybrids for which no data are available. As the same Euro emission standards apply to hybrids as conventional vehicle types, it does not necessarily follow that emissions of air pollutants from a hybrid are any lower than a conventional car. The scaling factors do at least indicate how the most common Full Hybrid car performs.

Factors for Plug-In Hybrids are not available and the factors quoted are taken from a study which estimated the fraction of mileage done under electric (zero emitting) traction on each main road type.

Battery and fuel cell electric vehicles

These have zero emissions at the point of use. The aim of these factors is not to represent fuel cycle emissions and include emissions from the generation of electricity or production of hydrogen. This is consistent with national inventory reporting where these emissions will be captured elsewhere in the inventory (e.g. under the power generation sector) and are more valid for use in air quality modelling assessments where emissions from traffic at the point of use are required.

LPG cars and CNG buses

These are taken from the EMEP/EEA Emissions Inventory Guidebook (2010 update)[1] and are provided as g/km emission factors. In the case of CNG buses, it is assumed that these buses will only operate in urban areas and emission factors are only provided for these conditions.

Biofuels

Most biofuels are consumed as weak (<10%) blends with fossil fuels in vehicles with conventional petrol and diesel engines. The effect of weak biofuel blends on emissions is already accounted for in the NAEI (and other) models in the same way as other fuel composition changes are accounted for (e.g. changes in sulphur content), via a set of scaling factors that are applied to the base emission factor. It makes no sense to treat the two component parts of a biofuel blend separately as it is the combined presence of both components that determines the emissions.

However, in this review, special attention is given to the high strength blends of bioethanol (E85) and biodiesel (B100) because using these fuels requires modification to the vehicle for it to run at all or the vehicle is manufactured to run specifically on these types of fuels, as is the case of flexi-fuelled cars that run on E85. The changes in emissions are then as much a feature of the change in engine technology to be able to operate on these fuels with different physical properties, as they are the fuel itself. The factors given here for E85 and B100 are taken from the EMEP/EEA Emissions Inventory Guidebook (2010), but are consistent with an earlier NAEI study on the effects of biofuels on air quality emissions from a review of the literature (Murrells and Li, 2008)[2]

[1] http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009
[2] http://uk-air.defra.gov.uk/reports/cat15/0901151441_NAEI_Road_Transport_Biofuels_report_2008_v1.pdf

and used in the recent AQEG report on biofuels (AQEG, 2011)[3].

The factors for B100 biodiesel refer to esterified plant oils, the most common types used. Vehicles can tolerate running on virgin plant oils, but these usually require some engine re-tuning to cope with the different physical properties of the fuel and this can lead to quite different, possibly higher, emissions.

Emissions of second-generation biofuels have not been considered due to lack of available information. Again, assuming these are used as weak blends, it is unlikely they will lead to significantly different emission changes to those of first-generation biofuels.

Retrofit options for heavy duty vehicles

These are of particular interest to local authorities and those making plans for low emission zones which may require vehicles to meet a minimum Euro standard equivalence. Compliance may be achieved by retrofitting the vehicle with an exhaust abatement device rather than buying a new vehicle.

The retrofit options of most relevance to achieving LEZ compliance centred on minimum standards for PM and NO_x are diesel particulate filters and selective catalytic reduction (SCR) systems, respectively. There is much uncertainty and variation in the NO_x reductions achieved with SCR retrofits. This probably reflects the type of SCR system employed and how well optimised it is for the cycle intended. It is becoming increasingly understood that Original Equipment Manufacturer (OEM) SCR systems are tuned for type approval and may not perform well under low load urban situations where the catalyst remains at too low a temperature to function correctly. Retrofit systems can be optimised for urban applications, as have the systems used by TfL on London buses. The scaling factor quoted for buses operating in London over urban cycles (0.3) is based on the 70% reduction rate typically quoted by suppliers and users who have set minimum, optimised performance standards. This figure is quoted by TfL for their Euro III buses retrofitted with SCR. For buses operating in other towns and cities which have **not** set minimum 70% reduction targets similar to TfL, a more conservative 50% reduction is assumed consistent with reports from a study in Finland.

It should be noted that the factors from COPERT 4 for an OEM Euro V HDV equipped with an SCR are 0-20% less than the factors for a Euro IV equivalent vehicle when calculated using COPERT speed-emission curves for a speed of 40 kph. It is possible then that some retrofit SCR systems that have not been optimised at all for urban cycles could have much lower efficiencies than 50%.

The emission reductions for PM from retrofit DPFs are also taken from information provided by TfL.

Hybrid buses

Again, there are varied hybrid strategies reported for buses and with such little emission test data available, it is very difficult to conclude a single scaling factor that is of universal applicability even for the same drive cycle. Many studies in the literature report reductions in air quality emissions with comments like "typically 30% reduction" without backing this up with firm data or making clear what the hybrid technology type is, what cycle the changes refer to, or what technology/ emission standard the reduction is being compared against. It is also not certain that reported emission changes are solely due to hybrid technology itself. One study even reported an increase in NO_x emissions compared with conventional diesel engines, but the majority report an overall reduction in emissions.

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[3] http://archive.defra.gov.uk/environment/quality/air/airquality/panels/aqeg/publications/road-transport-biofuels.pdf

The NO_x emission scaling factor quoted here is based on a figure reported by TfL from vehicle trials, averaged over the fleet tested on a London bus cycle. No changes in PM emissions are reported by TfL for hybrid buses compared with conventional buses.

In conclusion, there are high levels of uncertainty in the emission factors provided here and we fully understand that there may be differences of opinions concerning some of the factors given and how generally applicable they are, especially when they are based on expert judgement rather than actual measurements. The factors will need to be reviewed regularly as opinions develop and further emission measurements become available.

Emission scaling factors for other pollutants (e.g. CO, HCs) have not yet been developed. Future uptake rates for these technologies have also not yet been considered in the NAEI fleet projections, however this situation is under review and it is anticipated that a set of default projections for at least some of these technologies in the national fleet will be developed following consultation with DfT and other stakeholders in the next year.

Effects of alternative vehicle technologies on CO_2 emissions

An assessment of the impact of alternative vehicle technologies on CO_2 emissions is outside the scope of this document.

Information and tools for assessing the impact of alternative technologies and fuels on CO_2 and Greenhouse Gas emissions are already available, for example the Defra/DECC GHG Conversion Factors at http://www.defra.gov.uk/publications/2012/05/30/pb13773-2012-ghg-conversion/. The Low Carbon Vehicle Partnership also provides information on various technology and fuel options for road transport at http://www.lowcvp.org.uk/lceb/monitoring/index.asp .

These cover exhaust emissions of CO_2 at source. For some assessments, it may be necessary to consider the fuel-cycle or Well-To-Wheel emissions of GHGs associated with different fuels (e.g. natural gas, hydrogen, biofuels). The Defra/DECC Conversion Factors provide sources of information on these emissions. The Defra/DECC Conversion Factors also provides the means of calculating GHG emissions from generating the electricity taken from the grid used for charging electric vehicles.

Information on the effects of retrofit DPF and SCR systems on CO_2 emissions are not covered by these sources. Based on information from TfL, it can be assumed that a retrofit DPF system on an HGV and bus increases CO_2 exhaust emissions per km by 1%; assume a retrofit SCR system on an HGV and bus has no effect on CO_2 exhaust emissions.

Table 1: NO_x Emission factors or scaling factors developed for different alternative vehicle technology types

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
Passenger car/van	Full hybrid electric vehicle (petrol HEV)	2005-2009	-	-	-	0.5	0.7	0.9	Euro 4 petrol	Average scaling factors for rural and motorways calculated from 2009 EEA Emission Inventory Guidebook (June 2010) emission factors for full hybrid car at typical average speeds. A more conservative factor is applied to urban speeds than derived from the Guidebook	A more conservative factor for urban speeds than that derived from the Guidebook is adopted to reflect real-world operations and the effect of frequent engine-off periods affecting the performance of the catalyst emission control device. These factors are based on measurements for a Toyota Prius. These are the only data available and it cannot necessarily be assumed that other models will achieve the same reduction in emissions.
		2010-	-	-	-	0.5	0.7	0.9	Euro 5 petrol		Assumes emission scaling same as for Euro 4
	Plug-in Hybrid Electric Vehicle (petrol-PHEV)	2010-	-	-	-	0.1	0.5	0.9	Euro 5 petrol	Based on study by Helms et al (2010) "Electric vehicle and plug-in hybrid energy efficiency and life cycle", http://www.ifeu.org/verkehrundumwelt/pdf/Helms%20et%20al.%20(2010)%20Electric%20vehicles%20(TAP%20conference%20paper).pdf emissions	No emission measurements available. Estimated from assumptions about the fraction of distance likely to be done under electric motor on each road type
	Battery Electric Vehicle (BEV)	All	0	0	0	-	-	-	-		Zero emissions. Refers to emissions at point of use, not full fuel-cycle emissions
	Fuel Cell Electric Vehicle (FCEV)	All	0	0	0	-	-	-	-		Zero emissions. Refers to emissions at point of use, not full fuel-cycle emissions
	E85 Bioethanol	All	-	-	-	1	1	1	Emissions from fossil fuel petrol	AQEG (2011) report on biofuels	Based on previous NAEI report reviewing impact of biofuels on AQ emissions

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
Passenger car	LPG	1994-1996	0.317	0.292	0.326	-	-	-	-	2009 EEA Emission Inventory Guidebook (June 2010)	The Guidebook provides speed-related emission functions and the following speeds (30, 60 and 70 mph) have been used to derive the emission factors for urban, rural and motorway as shown here..
		1997-2000	0.114	0.105	0.117	-	-	-	-		
		2001-2005	0.076	0.070	0.078	-	-	-	-		
		2006-2010	0.041	0.038	0.042	-	-	-	-		
		2011-2015	0.031	0.029	0.032	-	-	-	-		assume 25% reduction relative to Euro 4
		2016 -	0.031	0.029	0.032	-	-	-	-		assume 25% reduction relative to Euro 4
Van	LPG	1994-1996	-	-	-	0.56	0.45	0.44	Euro 1 diesel van	Scaling factors derived from the ratio of emission factors for an LPG car relative to a medium sized diesel car and assumed to apply to a diesel van. Factors used for calculating these ratios are taken from the COPERT 4 v8.1 source of emission factors (http://www.emisia.com/copert/).	
		1997-2000	-	-	-	0.19	0.16	0.15	Euro 2 diesel van		
		2001-2005	-	-	-	0.11	0.10	0.09	Euro 3 diesel van		
		2006-2010	-	-	-	0.09	0.07	0.06	Euro 4 diesel van		
		2011-2015	-	-	-	0.09	0.07	0.06	Euro 5 diesel van		
		2016 -	-	-	-	0.20	0.16	0.14	Euro 6 diesel van		
HGV	Retrofit diesel particulate filter	2000 - 2012	-	-	-	1	1	1	Euro standard of vehicle being retrofitted (Euro III-V)		Assumes a DPF has no effect on NOx emissions
	B100 Biodiesel	2000-	-	-	-	1.1	1.1	1.1	Emissions from fossil fuel diesel for the appropriate Euro standard	2009 EEA Emission Inventory Guidebook (June 2010)	Consistent with AQEG report on biofuels.

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
Bus	Retrofit diesel particulate filter	2000 - 2012	-	-	-	1	1	1	Euro standard of vehicle being retrofitted (Euro III-V)		Assumes a DPF has no effect on NOx emissions
	Retrofit SCR (OUTSIDE LONDON)	1996 - 2012	-	-	-	0.5	0.5	0.5	Euro standard of vehicle being retrofitted (Euro II-V)	The assumption made here is that buses operating outside London have retrofit systems that have ***not*** been as well optimised by setting a minimum 70% reduction target as TfL have done for its buses in London. The scaling factor comes from a Finnish study.	
	Retrofit SCR (LONDON)	1996 - 2012	-	-	-	0.3	-	-	Euro standard of vehicle being retrofitted (Euro II-V)	Based on 70% typical reduction rates quoted by suppliers and experiences of some users, e.g. TfL. Assumes some tuning or optimising of SCR is put in place to ensure this level of performance is achieved under urban/low-load cycles. Without this, much lower reduction efficiencies may occur on urban cycles.	These scaling factors are applicable only for buses operating in London and in other towns and cities which have specified similar 70% reduction targets
	B100 Biodiesel	2000-	-	-	-	1.1	1.1	1.1	Emissions from fossil fuel diesel for the appropriate Euro standard	2009 EEA Emission Inventory Guidebook (June 2010)	Consistent with AQEG report on biofuels.
	CNG Biomethane Biogas	2007 -	2.5	-	-	-	-	-	-	2009 EEA Emission Inventory Guidebook (June 2010)	The Guidebook provides typical emission factors for CNG buses. This represents approx. 36% to 56% emissions reduction compared to a conventional Euro IV buses at speed range between 15 and 30 mph using COPERT 4 v8.1 NOx EFs.

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
	Hybrid	2006-2009	-	-	-	0.8	-	-	Euro IV	Estimate based on figure reported by TfL from vehicle trials, averaged over the fleet tested on a London bus cycle. No evidence for impacts on Euro VI	Very difficult to conclude a single scaling factor as it depends on hybrid technology and drive cycle. Many studies in literature report reductions in AQ emissions with comments like "typically 30% reduction" without backing this up with firm data or making clear what the technology type is, what cycle the changes refer to, or what technology/ emission standard the reduction is being compared against. It is not certain that reported emission changes are solely due to hybrid technology. One study even reported an increase in NOx emissions compared with conventional diesel engines, but the majority report an overal reduction in emissions
		2010 - 2012	-	-	-	0.8	-	-	Euro V		
		2013-	-	-	-	1	-	-	Euro VI		
	Fuel Cell Electric Vehicle (FCEV)	All	0	0	0	-	-	-	-		Zero emissions. Refers to emissions at point of use, not full fuel-cycle emissions

Table 2: PM Emission factors or scaling factors developed for different alternative vehicle technology types

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
Passenger car/van	Full hybrid electric vehicle (petrol HEV)	2005-2009	-	-	-	1	1	1	Euro 4 petrol		No measurements are available. Since PM mass emissions from petrol cars are already extremely low and are not regulated, it is not possible to estimate what impact hybrid technology would have. Therefore a conservative assumption is made that PM emissions are not affected
		2010-	-	-	-	1	1	1	Euro 5 petrol		
	Plug-in Hybrid Electric Vehicle (petrol-PHEV)	2010-	-	-	-	0.1	0.5	0.9	Euro 5 petrol	Based on study by Helms et al (2010) "Electric vehicle and plug-in hybrid energy efficiency and life cycle", http://www.ifeu.org/verkehrundumwelt/pdf/Helms%20et%20al.%20(2010)%20Electric%20vehicles%20(TAP%20conference%20paper).pdf emissions	No emission measurements available. Estimated from assumptions about the fraction of distance likely to be done under electric motor on each road type
	Battery Electric Vehicle (BEV)	All	0	0	0	-	-	-	-		Zero emissions. Refers to emissions at point of use, not full fuel-cycle emissions
	Fuel Cell Electric Vehicle (FCEV)	All	0	0	0	-	-	-	-		Zero emissions. Refers to emissions at point of use, not full fuel-cycle emissions
	E85 Bioethanol	All	-	-	-	0.8	0.8	0.8	Emissions from fossil fuel petrol	AQEG (2011) report on biofuels	Based on previous NAEI report reviewing impact of biofuels on AQ emissions
Passenger car and van	LPG	1994-1996	-	-	-	1	1	1	Euro 1 petrol		No data available on PM emissions from LPG vehicles, but would expect emissions to be very low and similar to petrol cars and vans
		1997-2000	-	-	-	1	1	1	Euro 2 petrol		
		2001-2005	-	-	-	1	1	1	Euro 3 petrol		
		2006-2010	-	-	-	1	1	1	Euro 4 petrol		
		2011-2015	-	-	-	1	1	1	Euro 5 petrol		
		2016 -	-	-	-	1	1	1	Euro 6 petrol		

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
HGV	Retrofit diesel particulate filter	1996-2000	-	-	-	0.1	0.1	0.1	Euro II	Assumed efficiencies same as for buses based on information from TfL	
		2001-2005	-	-	-	0.1	0.1	0.1	Euro III		
		2006-2007	-	-	-	0.23	0.23	0.23	Euro IV		
	B100 Biodiesel	2000 - 2005	-	-	-	0.55	0.55	0.55	Emissions from fossil fuel diesel for the appropriate Euro standard up to Euro III	2009 EEA Emission Inventory Guidebook (June 2010)	Consistent with AQEG report on biofuels.
		2006-2009	-	-	-	0.9	0.9	0.9	Euro IV	Emissions relative to fossil fuel diesel. Smaller emission reductions assumed for more recent Euro standards	
		2010-2012	-	-	-	0.9	0.9	0.9	Euro V		
		2013-	-	-	-	0.9	0.9	0.9	Euro VI		
Bus	Retrofit diesel particulate filter	1996-2000	-	-	-	0.1	0.1	0.1	Euro II	Data from TfL (April 2012)	
		2001-2005	-	-	-	0.1	0.1	0.1	Euro III		
		2006-2007	-	-	-	0.23	0.23	0.23	Euro IV		
	Retrofit SCR	1996 - 2012	-	-	-	1	1	1	Euro standard of vehicle being retrofitted (Euro II-V)		Assumes SCR has no effect on PM emissions. SCR and DPF are often fitted as combined retrofit units, but each is considered individually
	B100 Biodiesel	2000 - 2005	-	-	-	0.55	0.55	0.55	Emissions from fossil fuel diesel for the appropriate Euro standard up to Euro III	2009 EEA Emission Inventory Guidebook (June 2010)	Consistent with AQEG report on biofuels.

Vehicle Type	Alternative fuel / technology	Model Year	Emission factors [g/km]			Scaling factors				Data source	Comment
			Urban	Rural	Mway	Urban	Rural	Mway	Relative to		
		2006-2009	-	-	-	0.9	0.9	0.9	Euro IV	Emissions relative to fossil fuel diesel. Smaller emission reductions assumed for more recent Euro standards	
		2010-2012	-	-	-	0.9	0.9	0.9	Euro V		
		2013-	-	-	-	0.9	0.9	0.9	Euro VI		
	CNG Biomethane Biogas	2007 -	0.005	-	-	-	-	-	-	2009 EEA Emission Inventory Guidebook (June 2010)	The Guidebook provides typical emission factors for CNG buses. This represents approx. 84% to 89% emissions reduction compared to a conventional Euro IV buses at speed range between 15 and 30 mph using COPERT 4 v9 PM EFs.
	Hybrid	2006-2009	-	-	-	1	-	-	Euro IV	Information from TfL (April 2012)	
		2010 - 2012	-	-	-	1	-	-	Euro V		
		2013-	-	-	-	1	-	-	Euro VI		
	Fuel Cell Electric Vehicle (FCEV)	All	0	0	0	-	-	-	-		Zero emissions. Refers to emissions at point of use, not full fuel-cycle emissions

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