National Atmospheric Emissions Inventory

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METHOD FOR APPLYING EMISSION DEGRADATION CORRECTION FACTORS TO THE COPERT 4 NOx EMISSION FACTORS FOR LIGHT DUTY PETROL VEHICLES

1. Overview

Emission degradation is only taken into account for petrol cars and LGVs. It is also only used to adjust emission factors for Euro 1-4 vehicles, there being no degradation factors to use for Euro 5 and 6 vehicles. There are also no degradation corrections to make for diesel cars and LGVs.

The method assumes a linear rate of change in NO_x emission factor with increased accumulated mileage. The change is in a positive direction for all Euro standards. This is unlike the DfT/TRL degradation factors which assume positive rates of degradation for some vehicle classes (i.e. emissions get worse with increased mileage) and negative rates of degradation for others (i.e. emissions improve with increasing mileage).

The approach involves using a linear equation to work out a degradation correction factor for a given accumulated mileage using coefficients given by COPERT 4. For Euro 1 and 2 petrol cars, there is just one set of coefficients to use for all engine sizes. For Euro 3 and 4 cars, there is a separate set of coefficients for cars ≤ 1.4l and for cars >1.4l.

For all these vehicle classes, there is a set of coefficients to work out a degradation factor to be used for speeds <19 kph and another set for speeds >63 kph. For intermediate speeds, an interpolation method is used to calculate a degradation factor.

The degradation correction factor is multiplied by the emission factor calculated from the speed-emission coefficients. The degradation factors increase with increasing accumulated mileage, but only up to a limit of 120,000km for Euro 1 and 2 cars and 160,000km for Euro 3 and 4 cars. At mileages above this, the value of the correction factor given at these mileages stays constant.

2. Source of accumulated mileage data

It is unlikely a user would have accumulated mileage data for cars in the fleet, but some typical average values for each Euro standard and model year are provided already with the DfT/TRL emission factors. Go to http://www.dft.gov.uk/publications/road-vehicle-emission-factors-2009/

Go to the spreadsheet 'Mileage fuel scaling factors.xls'. Do not use the scaling factors for NO_x in this spreadsheet, but go to the tab 'AvgMileage'. Average mileage by mid year data can be found in columns AR to CA. These provide the average accumulated mileage (in km) for each Euro standard reached by each year up to 2030.

In the worked example that follows, we will estimate the degradation correction factor for a 1.4-2.0l Euro 4 petrol car in 2015. The DfT/TRL shows the average accumulated mileage is **110,328 km** for 2015**.**

3. Using the emission factor calculation spreadsheet provided by the NAEI

A template is included in the spreadsheet, ‘rtp_Copert4_NOxEFs_final.xlsx’ (all based on COPERT 4) for deriving the degradation correction factors. See the ‘Emis Degradation’ tab.

Worked example: Scaling factor for a 1.4-2.0l Euro 4 petrol car in 2015

Enter the accumulated mileage data in cell **L65** and the speed in cell **L66**.

Select Engine size >1.4l in drop down menu cell **L67**

Using a speed of 15 kph gives a scaling factor of 1.372.

Use a speed of 45 kph gives a scaling factor of 1.152

Use a speed of 80 kph gives a scaling factor of 1.000

In fact, you will notice from the equations that for a car ≤ 1.4l, the scaling factor is 1.000 at all speeds, so for these Euro 4 (and 3) vehicles, there is no need to apply a scaling factor.

Similarly, you will notice from the equations that for a car of any engine size, the scaling factor is 1.000 for all speeds > 63 kph

4. How are these scaling factors calculated?

The equations are shown in the spreadsheet of NO_x emission factors provided (all based on COPERT 4). See the 'Emis Degradation' tab. They are also shown below.

Table 1: Emission degradation due to vehicle age for Euro 1 and Euro 2 petrol cars and LGVs

$MC = A_M \times M_{MEAN} + B_M$	Engine Size [litre]	Average mileage [km]	A_M	B_M (Value at 0km)	Value at ? 120,000 km
Correction for speed (V) < 19 km/h (MC_{URBAN})					
NOx - MC_{URBAN}	ALL	44931	1.60E-05	0.282	2.2
Correction for speed (V) > 63 km/h (MC_{ROAD})					
NOx - MC_{ROAD}	ALL	47186	1.22E-05	0.424	1.89

Table 2: Emission degradation due to vehicle age for Euro 3 and Euro 4 petrol cars and LGVs

$MC = A_M \times M_{MEAN} + B_M$	Engine Size [litre]	Average mileage [km]	A_M	B_M (Value at 0km)	Value at ? 160,000 km
Correction for speed (V) < 19 km/h (MC_{URBAN})					
NOx - MC_{URBAN}	<=1.4	31313	0	1	1
	>1.4	16993	3.99E-06	0.932	1.57
Correction for speed (V) > 63 km/h (MC_{ROAD})					
NOx - MC_{ROAD}	ALL	26150	0	1	1

Table 3: Emission degradation correction factor as a function of speed

Speed - V [km/h]	Mileage correction - M_{corr} [-]
? 19	MC_{URBAN}
? 63	MC_{ROAD}
> 19 and < 63	$MC_{URBAN} + (V-19)*(MC_{ROAD}-MC_{URBAN})/44$

These equations are taken directly from the 2009 EMEP/EEA Emissions Inventory Guidebook.

The coefficients are for an equation of type: ***y = Am + B***, where y = correction factor and m = mileage:

For a 1.4-2.0l Euro 4 petrol car:

Speed (kph)	A	B	Value at >160,000km
<19	3.986E-06	0.932	1.57
>63	0	1	1.00

So, at 15 kph, y = 3.99E-06*110,328 + 0.932 = **1.372 (as shown above).**

So, at 80 kph, y = 0*110,328 + 1 **= 1.000 (as shown above)**

For the 45 kph speed, a slightly more complex interpolation-based algorithm is used, as shown in the Table 3 above.

This table shows that if the mileage correction at speeds < 19kph is called MC_{urban} and the mileage correction at speeds >63 kph is called MC_{road}, then the mileage correction at intermediate speeds is calculated:

$$M = MC_{urban} + \frac{(V-19).(MC_{road} - MC_{urban})}{44}$$

So, as calculated above MC_{urban} = 1.372 and MC_{road} = 1.000 and V = 45, then this equation leads to **M = 1.152 (as shown above).**

Note, from these functions a value of 1.57 is calculated for a mileage of 160,000km and speeds <19 kph and this value should be used for all mileages above 160,000km, i.e. there is no further increase in the scaling factor. This maximum value is shown in the right hand column of the tables.

The functions for other Euro standards and engine sizes are given in the spreadsheet provided.

5. Application of mileage degradation correction factors to emission factors

The degradation correction factors are simply multiplied by the emission factor calculated for the given speed.

Using this example, the base speed-emission equations given in the spreadsheet provided gives the following base emission factors for a 1.4-2.0l Euro 4 petrol car at 15, 45 and 80 kph:

NOx EF (g/km)	**15 kph**	**45 kph**	**80 kph**
1.4-2.0l Euro 4 petrol car	0.08421	0.04959	0.02536

So applying the mileage degradation correction factors calculated at these speeds, in combination with the accumulated mileage provided by DfT/TRL (110,328 km) the overall emission factor for the vehicle in 2015 is:

	15 kph	**45 kph**	**80 kph**
Correction factor for 2015	1.372	1.152	1.000
Emission factor in 2015 (g/km)	0.1155	0.0571	0.02536