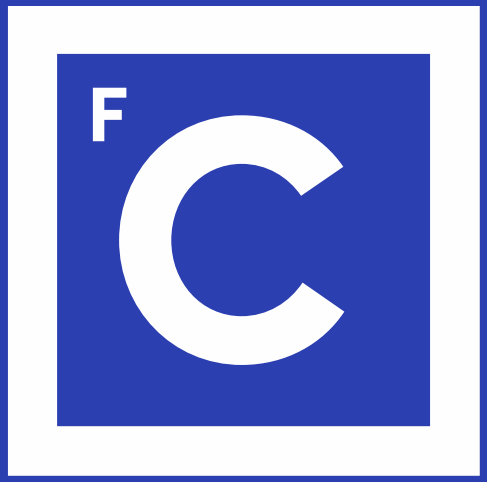


Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

DISCIPLINA MIEA 2018

Mobilidade Sustentável

Energy and emissions

Home ⟷ **Work/ University**

on a regular basis

Commuting by motorized or soft modes

↑ **Emissions**

Energy →

Emissions g/km

EMEP/EEA air pollutant emission inventory guidebook

Emissions g/km

EMEP/EEA air pollutant emission inventory guidebook

- Part B: sectoral guidance chapters
  - 1. Energy
    - 1.A Combustion
      - 1.A.1 Energy industries [2.4 MB]
      - 1.A.2 Manufacturing industries and construction [893.2 KB]
      - 1.A.3.a Aviation 2016 [1.5 MB]
      - 1.A.3.b.i-iv Road transport 201[illegible] [3.3 MB]
      - 1.A.3.b.i-iv Road transport Annex HDVs 201[illegible] [3.0 MB]
      - 1.A.3.b.v Gasoline evaporation 2016 [861.2 KB]
      - 1.A.3.b.vi-vii Road tyre and brake wear 2016 [542.7 KB]
      - 1.A.3.c Railways 2016 [476.0 KB]
      - 1.A.3.d Navigation (shipping) 2016 [804.2 KB]
      - 1.A.3.e.i Pipeline transport 2016 [93.3 KB]
      - 1.A.4 Small combustion 2016 [3.5 MB]
      - 1.A.4 Non road mobile machinery 2016 [1.7 MB]
      - 1.A.4 Non road mobile machinery Annex [99.6 KB]

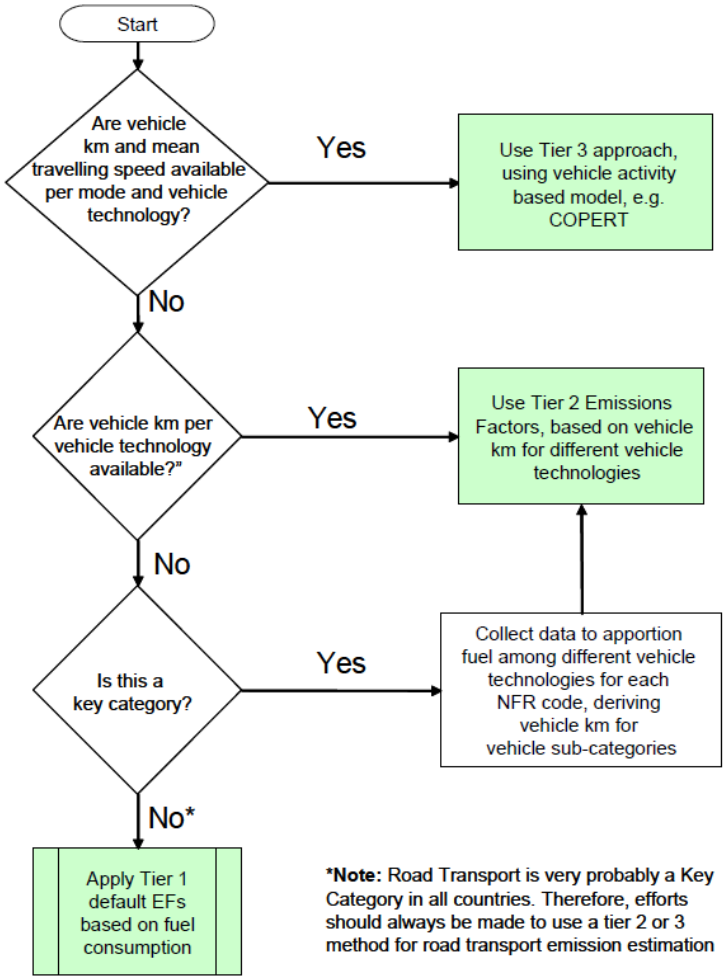
Not electric rail!

Emissions g/km

1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv

Passenger cars, light commercial trucks, heavy-duty vehicles including buses and motor cycles

Figure 3-1 Decision tree for exhaust emissions from road transport



Road transport/Tier 1

Tier 1

First estimation (low accuracy) emissions proportional to fuel consumption

EF = Emission Factor (g/km) = function (fuel consumption)

$$g/km = g/kg * kg/km$$

Road transport/Tier 1

First estimation (high uncertainty) emissions proportional to fuel consumption

Table 3.15: Tier 1 — Typical fuel consumption figures, per km, by category of vehicle

Vehicle category (j)	Fuel	Typical fuel consumption (g/km)
Passenger cars	Petrol	70
	Diesel	60
	LPG	57.5
	E85	86.5
	CNG	62.6
LCV	Petrol	100
	Diesel	80
HDV	Diesel	240
	CNG (buses)	500
Two-wheel vehicles	Petrol	35

Road transport/Tier 1

First estimation (high uncertainty) emissions proportional to fuel consumption

Table 3.5: Tier 1 emission factors for CO and NMVOCs

Category	Fuel	CO (g/kg fuel)			NMVOC (g/kg fuel)		
		Mean	Min	Max	Mean	Min	Max
PC	Petrol	84.7	49.0	269.5	10.05	5.55	34.42
	Diesel	3.33	2.05	8.19	0.70	0.41	1.88
	LPG	84.7	38.7	117.0	13.64	6.10	25.66
LCV	Petrol	152.3	68.7	238.3	14.59	3.91	26.08
	Diesel	7.40	6.37	11.71	1.54	1.29	1.96
HDV	Diesel	7.58	5.73	10.57	1.92	1.33	3.77
	CNG (Buses)	5.70	2.20	15.00	0.26	0.10	0.67
Two-wheel	Petrol	497.7	331.2	664.5	131.4	30.0	364.8

Road transport/Tier 1

First estimation (high uncertainty) emissions proportional to fuel consumption

Table 3.6: Tier 1 emission factors for NO_X and PM

Category	Fuel	NO_x (g/kg fuel)			PM (g/kg fuel)		
		Mean	Min	Max	Mean	Min	Max
PC	Petrol	8.73	4.48	29.89	0.03	0.02	0.04
	Diesel	12.96	11.20	13.88	1.10	0.80	2.64
	LPG	15.20	4.18	34.30	0.00	0.00	0.00
LCV	Petrol	13.22	3.24	25.46	0.02	0.02	0.03
	Diesel	14.91	13.36	18.43	1.52	1.10	2.99
HDV	Diesel	33.37	28.34	38.29	0.94	0.61	1.57
	CNG (Buses)	13.00	5.50	30.00	0.02	0.01	0.04
Two-wheel	Petrol	6.64	1.99	10.73	2.20	0.55	6.02

Surveys, energy & emissions

Exercise4: Take the exercise 2 community of 10 people (they get richer…). They now prefer car. What would be the yearly impact in biogenic and non-biogenic final energy consumption and CO_2, NO_x and PM if:

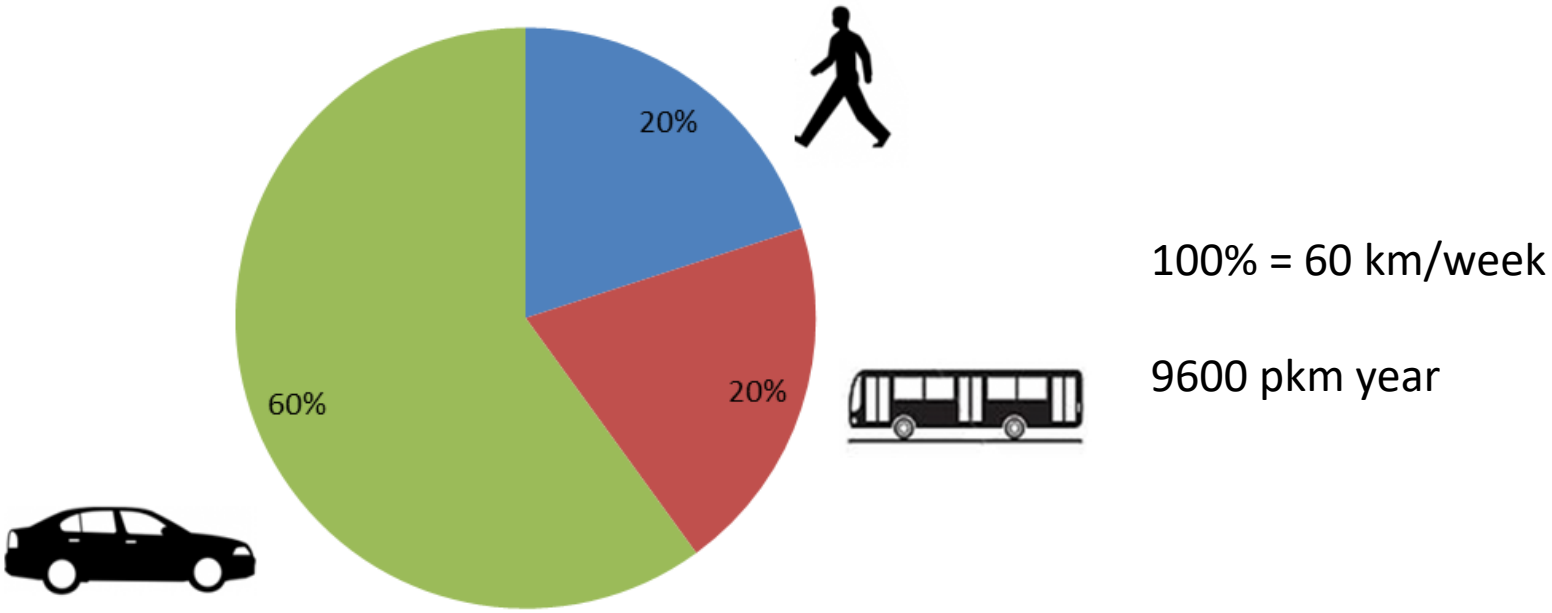
One-way trip

Weekday: 20% walk 2 km; 20% bus 2 km; 60% car 2 km

i) Conventional ICE technology
ii) Electric based technology
iii) Hydrogen based technology

Surveys, energ. & emissions

Travel to work by transport mode (km basis)

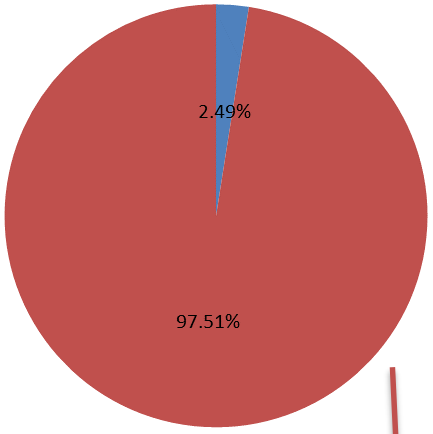


100% = 60 km/week

9600 pkm year

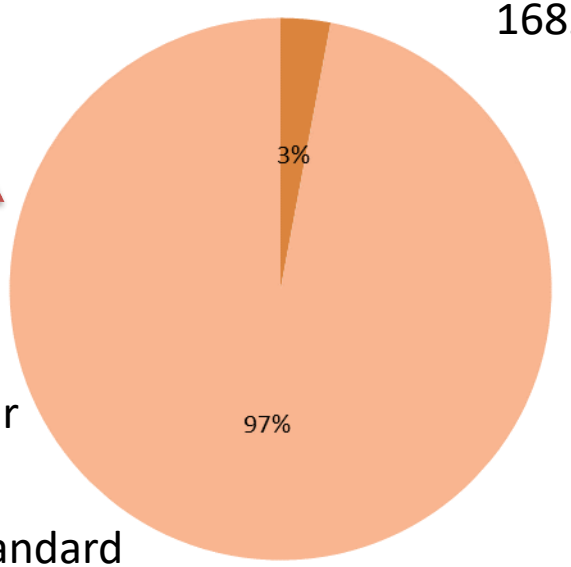
Surveys, energ. & emissions

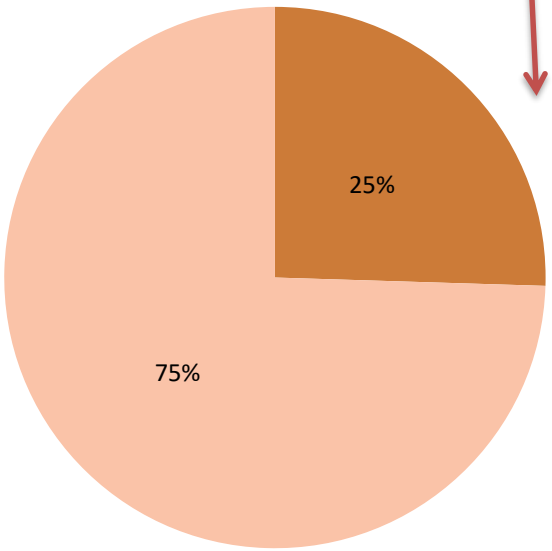
MJ/year, mostly from combustion



Biogenic versus combustion

EEA Tier 1
16822 MJ/year



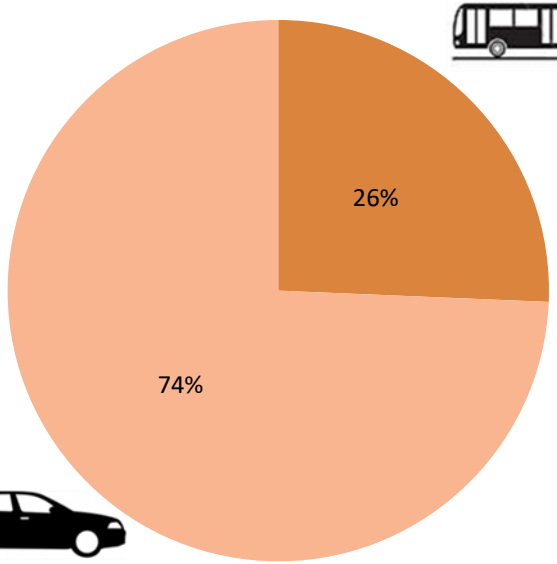


12051 MJ/year

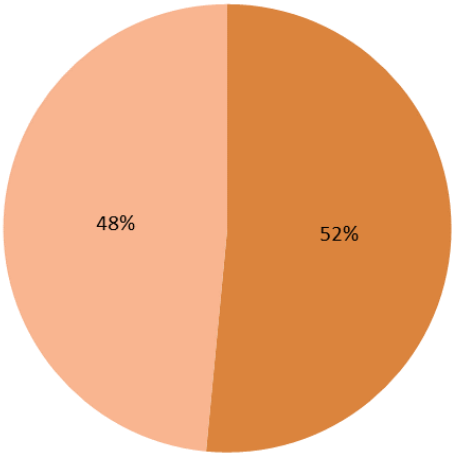
Renault clio standard
VCA-Vehicle certification agency
Sust.report Carris

Surveys, energ. & emissions

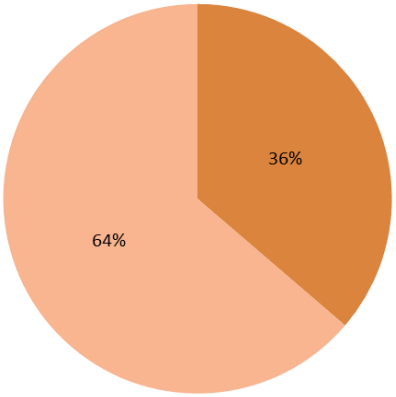
CO_2, NOx and PM2.5 (ton/year)



0.88 ton CO_2/year



0.005 ton NOx/year



0.00019 ton PM/year
(including PM2.5)

Surveys, energ. & emissions

Community 10 people

	VCA/standard	Tier 1 EEA
MJ/year	12052	16957
TonCO_2/year	0.619	1.245
kgNOx/year	0.3	4.5
kgPM/year	0.01	0.23

Surveys, energ. & emissions

Tier 2

EF = Emission Factor (g/km) = function (distance travelled and vehicle category & technology)

Surveys, energ. & emissions

Table 3-27: Tier 2 average fuel/energy consumption values

Vehicle category	Sub-category	Technology	FC (g/km)	EC (MJ/km)*
Passenger cars	Petrol Mini	Euro 4 and later	49	2.14
	Petrol Small	PRE-ECE to open loop	65	2.85
		Euro 1 and later	56	2.45
	Petrol Medium	PRE-ECE to open loop	77	3.37
		Euro 1 and later	66	2.89
	Petrol Large-SUV-Executive	PRE-ECE to open loop	95	4.16
		Euro 1 and later	86	3.76
	Diesel Small	Euro 4 and later	38	1.62
	Diesel Medium	Conventional	63	2.69
		Euro 1 and later	55	2.35
	Diesel Large-SUV-Executive	Conventional	75	3.2
		Euro 1 and later	73	3.12
	LPG	Conventional	59	2.75
		Euro 1 and later	57	2.65
	2-stroke	Conventional	82	3.59
	Hybrid Petrol Small	Euro 4	34	1.49
	Hybrid Petrol Medium	Euro 4	34	1.49
	Hybrid Petrol Large-SUV-Executive	Euro 4	34	1.49
	E85	Euro 4 and later	87	3.33
	CNG	Euro 4 and later	63	3.02

Surveys, energ. & emissions

Table 3-27: Tier 2 average fuel/energy consumption values

Vehicle category	Sub-category	Technology	FC (g/km)	EC (MJ/km)*
		Euro I and later	291	10.92
Buses	Urban CNG buses	HD Euro I	555	26.64
		HD Euro II	515	24.72
		HD Euro III	455	21.84
		EEV	455	21.84
	Urban buses, standard	Conventional	366	15.63
		Euro I and later	301	12.85
	Coaches, standard	Conventional	263	11.23
		Euro I and later	247	10.55
		Conventional	25	1.09

Surveys, energ. & emissions

Tier 2

Table 3-17: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i

Type	Technology	CO	NMVOC	NO_x	N_2O	NH_3	Pb	CO_2 lube
Units		g/km	g/km	g/km	g/km	g/km	g/km	g/km
Notes			Given as THC-CH4	Given as NO_2 equivalent				due to lube oil
Petrol Mini	Euro 4 - 98/69/EC II	0.67	0.048	0.056	0.002	0.0339	1.82E-05	0.398
	Euro 5 – EC 715/2007	0.67	0.048	0.056	0.0013	0.0123	1.82E-05	0.398
	Euro 6 up to 2016	0.67	0.048	0.056	0.0013	0.0123	1.82E-05	0.398
	Euro 6 2017-2019	0.67	0.048	0.056	0.0013	0.0123	1.82E-05	0.398
	Euro 6 2020+	0.67	0.048	0.056	0.0013	0.0123	1.82E-05	0.398
Petrol Small	PRE ECE	37.3	2.77	1.91	0.01	0.0020	1.82E-05	0.663
	ECE 15/00-01	29.6	2.19	1.91	0.01	0.0020	1.82E-05	0.663
	ECE 15/02	21.7	2.06	2.12	0.01	0.0020	1.82E-05	0.663
	ECE 15/03	21.1	2.06	2.30	0.01	0.0020	1.82E-05	0.663
	ECE 15/04	13.1	1.68	2.07	0.01	0.0020	1.82E-05	0.663
	Open Loop	11.3	0.96	1.53	0.01	0.0020	1.82E-05	0.663
	Euro 1 - 91/441/EEC	4.88	0.467	0.426	0.01	0.0922	1.82E-05	0.596
	Euro 2 - 94/12/EEC	2.42	0.206	0.229	0.006	0.1043	1.82E-05	0.530
	Euro 3 - 98/69/EC I	2.07	0.089	0.090	0.002	0.0342	1.82E-05	0.464
	Euro 4 - 98/69/EC II	0.69	0.048	0.056	0.002	0.0341	1.82E-05	0.398
	Euro 5 – EC 715/2007	0.69	0.048	0.056	0.0013	0.0123	1.82E-05	0.398
	Euro 6 up to 2016	0.69	0.048	0.056	0.0013	0.0123	1.82E-05	0.398
	Euro 6 2017-2019	0.69	0.048	0.056	0.0013	0.0123	1.82E-05	0.398

Surveys, energ. & emissions

Tier 2

Table 3-17: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i

Type	Technology	CO	NMVOC	NO_x	N_2O	NH_3	Pb	CO_2 lube
Units		g/km	g/km	g/km	g/km	g/km	g/km	g/km
Notes			Given as THC-CH4	Given as NO_2 equivalent				due to lube oil
	Euro 6 2020+	0.33	0.048	0.039	0.0013	0.0123	1.82E-05	0.398
Diesel Small	Euro 4 - 98/69/EC II	0.092	0.014	0.58	0.01	0.0010	1.82E-05	0.398
	Euro 5 – EC 715/2007	0.049	0.010	0.55	0.004	0.0019	1.82E-05	0.398
	Euro 6 up to 2016	0.040	0.010	0.45	0.004	0.0019	1.82E-05	0.398
	Euro 6 2017-2019	0.040	0.010	0.35	0.004	0.0019	1.82E-05	0.398
	Euro 6 2020+	0.040	0.010	0.17	0.004	0.0019	1.82E-05	0.398
Diesel Medium	Conventional	0.688	0.159	0.546	0.00	0.0010	1.82E-05	0.663
	Euro 1 - 91/441/EEC	0.414	0.047	0.690	0.003	0.0010	1.82E-05	0.596
	Euro 2 - 94/12/EEC	0.296	0.035	0.716	0.005	0.0010	1.82E-05	0.530
	Euro 3 - 98/69/EC I	0.089	0.02	0.773	0.007	0.0010	1.82E-05	0.464
	Euro 4 - 98/69/EC							

Surveys, energ. & emissions

Tier 2

Table 3-18: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i

Type	Technology	PM2.5	ID(1,2,3,cd)P	B(k)F	B(b)F	B(a)P
Units		g/km	g/km	g/km	g/km	g/km
Notes		PM2.5=PM10=TSP				
Petrol Mini	Euro 4 - 98/69/EC II	0.0011	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 5 – EC 715/2007	0.0014	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 6 up to 2016	0.0014	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 6 2017-2019	0.0016	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 6 2020+	0.0016	3.90E-07	2.60E-07	3.60E-07	3.20E-07
Petrol Small	PRE ECE	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/00-01	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/02	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/03	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/04	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	Open Loop	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	Euro 1 - 91/441/EEC	0.0022	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 2 - 94/12/EEC	0.0022	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 3 - 98/69/EC I	0.0011	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 4 - 98/69/EC II	0.0011	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 5 – EC 715/2007	0.0014	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 6 up to 2016	0.0014	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 6 2017-2019	0.0016	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 6 2020+	0.0016	3.90E-07	2.60E-07	3.60E-07	3.20E-07
Petrol Medium	PRE ECE	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/00-01	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/02	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/03	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	ECE 15/04	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	Open Loop	0.0022	1.03E-06	3.00E-07	8.80E-07	4.80E-07
	Euro 1 - 91/441/EEC	0.0022	3.90E-07	2.60E-07	3.60E-07	3.20E-07
	Euro 2 - 94/12/EEC	0.0022	3.90E-07	2.60E-07	3.60E-07	3.20E-07

Surveys, energ. & emissions

Table 3-18: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i

Type	Technology	PM2.5	ID(1,2,3,cd)P	B(k)F	B(b)F	B(a)P
Units		g/km	g/km	g/km	g/km	g/km
Notes		PM2.5=PM10=TSP				
Diesel Small	Euro 4 - 98/69/EC II	0.0314	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 5 – EC 715/2007	0.0021	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 6 up to 2016	0.0015	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 6 2017-2019	0.0015	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 6 2020+	0.0015	1.62E-06	1.53E-06	1.95E-06	1.74E-06
Diesel Medium	Conventional	0.2209	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 1 - 91/441/EEC	0.0842	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 2 - 94/12/EEC	0.0548	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 3 - 98/69/EC I	0.0391	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 4 - 98/69/EC II	0.0314	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 5 – EC 715/2007	0.0021	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 6 up to 2016	0.0015	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 6 2017-2019	0.0015	1.62E-06	1.53E-06	1.95E-06	1.74E-06
	Euro 6 2020+	0.0015	1.62E-06	1.53E-06	1.95E-06	1.74E-06

Surveys, energ. & emissions

Tier 2

Table 3-23: Tier 2 exhaust emission factors for buses, NFR 1.A.3.b.iii

Type	Technology	CO	NMVOC	NOx	N2O	NH3	Pb	CO2 lube
Units		g/km	g/km	g/km	g/km	g/km	g/km	g/km
Notes			Given as THC-CHA	Given as NO2 equivalent				due to lube oil
Urban CNG Buses	Euro I - 91/542/EEC I	8.400	0.371	16.500	n.a.	n.a.	2.89E-05	1.860
	Euro II - 91/542/EEC II	2.700	0.313	15.000	n.a.	n.a.	2.68E-05	1.590
	Euro III - 2000	1.000	0.052	10.000	n.a.	n.a.	2.37E-05	1.590
	EEV	1.000	0.045	2.500	n.a.	n.a.	2.37E-05	n.a.
Urban Buses Standard	Conventional	5.710	1.990	16.500	0.029	0.0029	1.90E-05	2.650
	Euro I - 91/542/EEC I	2.710	0.706	10.100	0.012	0.0029	1.61E-05	2.050
	Euro II - 91/542/EEC II	2.440	0.463	10.700	0.120	0.0029	1.55E-05	1.480
	Euro III - 2000	2.670	0.409	9.380	0.001	0.0029	1.62E-05	0.861
	Euro IV - 2005	0.223	0.022	5.420	0.012	0.0029	1.54E-05	0.265

Surveys, energ. & emissions

Tier 2

Table 3-23: Tier 2 exhaust emission factors for buses, NFR 1.A.3.b.iii

Type	Technology	CO	NMVOC	NOx	N2O	NH3	Pb	CO2 lube
Units		g/km	g/km	g/km	g/km	g/km	g/km	g/km
Notes			Given as THC-CHA	Given as NO2 equivalent				due to lube oil
	Euro VI	0.223	0.220	0.597	0.040	0.009	1.54E-05	0.265
Coaches Standard	Conventional	2.270	0.661	10.600	0.029	0.0029	1.37E-05	0.663
	Euro I - 91/542/EEC I	1.850	0.624	8.100	0.009	0.0029	1.26E-05	0.630
	Euro II - 91/542/EEC II	1.600	0.416	8.950	0.008	0.0029	1.25E-05	0.596
	Euro III - 2000	1.910	0.399	7.510	0.004	0.0029	1.35E-05	0.563
	Euro IV - 2005	0.150	0.021	4.510	0.012	0.0029	1.28E-05	0.530
	Euro V - 2008	0.150	0.021	2.570	0.034	0.011	1.28E-05	0.530
	Euro VI	0.150	0.021	0.496	0.033	0.009	1.28E-05	0.530

Surveys, energ. & emissions

Table 3-24: Tier 2 exhaust emission factors for buses, NFR 1.A.3.b.iii

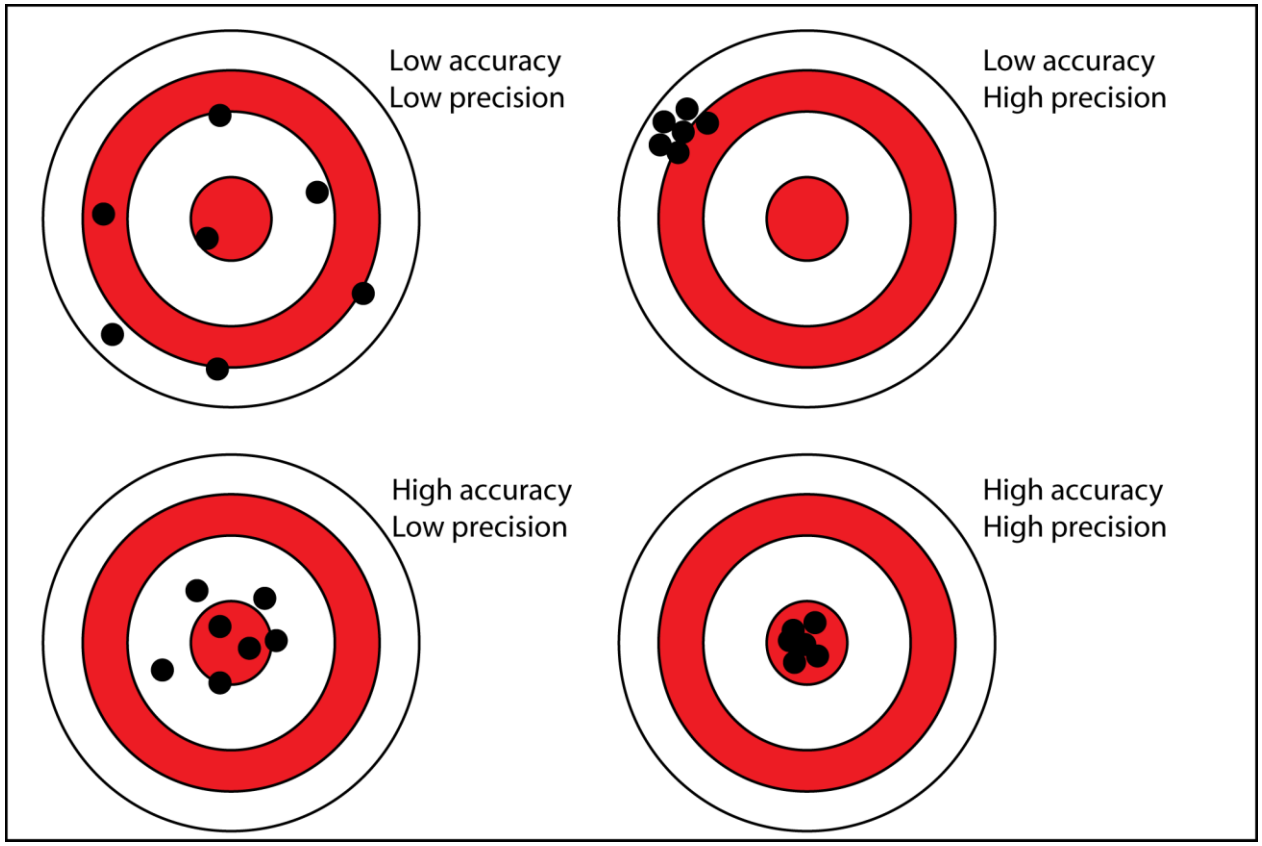
Type	Technology	PM2.5	ID(1.2.3.cd)P	B(k)F	B(b)F	B(a)F
Units		g/km	g/km	g/km	g/km	g/km
Notes		PM2.5=PM10=TSP				
Urban CNG Buses	Euro I - 91/542/EEC I	0.0200	n.a.	n.a.	n.a.	n.a.
	Euro II - 91/542/EEC II	0.0100	n.a.	n.a.	n.a.	n.a.
	Euro III - 2000	0.0100	3.00E-08	4.00E-08	8.00E-08	5.00E-08
	EEV	0.0050	1.00E-08	1.00E-08	1.00E-08	3.00E-08
Urban Buses Standard	Conventional	0.9090	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro I - 91/542/EEC I	0.4790	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro II - 91/542/EEC II	0.2200	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro III - 2000	0.2070	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro IV - 2005	0.0462	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro V - 2008	0.0462	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro VI	0.0023	1.40E-06	6.09E-06	5.45E-06	9.00E-07
Coaches Standard	Conventional	0.4700	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro I - 91/542/EEC I	0.3620	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro II - 91/542/EEC II	0.1650	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro III - 2000	0.1780	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro IV - 2005	0.0354	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro V - 2008	0.0354	1.40E-06	6.09E-06	5.45E-06	9.00E-07
	Euro VI	0.0018	1.40E-06	6.09E-06	5.45E-06	9.00E-07

Surveys, energ. & emissions

	VCA/standard	Tier 1 EEA	Tier 2 EEA	Tier 3 EEA
NOx/year				
PM/year				

Tier 3…should be more accurate

Surveys, energ. & emissions



Tier 3…should be more accurate

Surveys, energ. & emissions

Tier 3

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CONSCIOUS OF TRANSPORT'S IMPACT

EMISIA NEWSLETTER

COPERT v5.3 available for download

copert

A new version of COPERT (v5.3) has been officially released in September. The new and updated methodological elements of this new version are:

- New Emission Factors for mopeds 4-stroke.
- New Emission Factors for motorcycles.
- Revised evaporation factors for Euro 6d-temp and Euro 6d passenger cars and light commercial vehicles.
- Revised Euro 6 LCV NOx emissions factors.
- Calculation of the fossil fuel fraction in biodiesel.

Surveys, energ. & emissions

Tier 3 https://www.emisia.com/utilities/copert/download/

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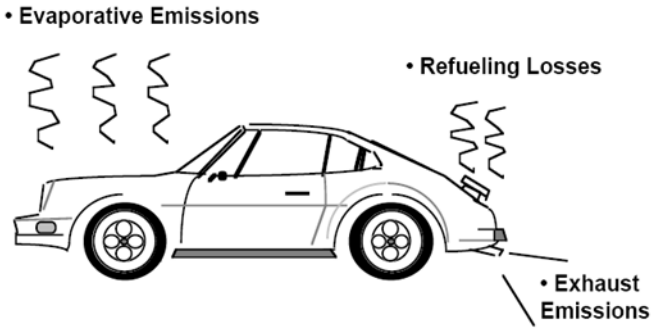

Table 4.1: Typical average speed ranges for the application of the methodology in different driving situations

Driving Situation	Typical Speed Range (km/h)
Urban	10 - 50
Rural	40 - 80
Highway	70 - 130

Surveys, energ. & emissions

Tier 3 https://www.emisia.com/utilities/copert/download/

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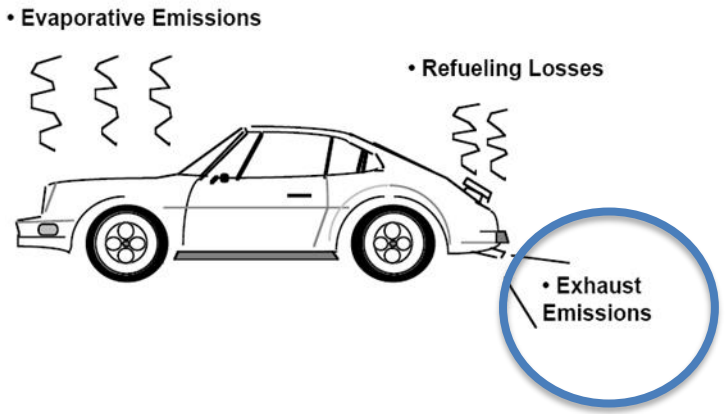

Divided in.....

$$E_{TOTAL} = E_{URBAN} + E_{RURAL} + E_{HIGHWAY}$$

$$E_{TOTAL} = E_{HOT} + E_{COLD} + E_{EVAP}$$

Surveys, energ. & emissions

Tier 3 https://www.emisia.com/utilities/copert/download/

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Table 5.5: Speed dependency of NO_x emission factors for gasoline passenger cars

Vehicle Class	Engine Capacity	Speed Range [km/h]	NO_x Emission Factor [g/km]	R^2
PRE ECE & ECE 15-00/01	CC < 1,4 l	10-130	$1,173 + 0,0225V - 0,00014V^2$	0,916
	1,4 l < CC < 2,0 l	10-130	$1,360 + 0,0217V - 0,00004V^2$	0,960
	CC > 2,0 l	10-130	$1,5 + 0,03V + 0,0001V^2$	0,972
ECE 15-02	CC < 1,4 l	10-130	$1,479 - 0,0037V + 0,00018V^2$	0,711
	1,4 l < CC < 2,0 l	10-130	$1,663 - 0,0038V + 0,00020V^2$	0,839
	CC > 2,0 l	10-130	$1,87 - 0,0039V + 0,00022V^2$	-
ECE 15-03	CC < 1,4 l	10-130	$1,616 - 0,0084V + 0,00025V^2$	0,844
	1,4 l < CC < 2,0 l	10-130	$1,29e^{0,0099V}$	0,798
	CC > 2,0 l	10-130	$2,784 - 0,0112V + 0,000294V^2$	0,577
ECE 15-04	CC < 1,4 l	10-130	$1,432 + 0,0026V + 0,000097V^2$	0,669
	1,4 l < CC < 2,0 l	10-130	$1,484 + 0,013V + 0,000074V^2$	0,722
	CC > 2,0 l	10-130	$2,427 - 0,014V + 0,000266V^2$	0,803

E_{HOT}=function (average speed in km/h)

Exercise

Tier 3 emissions factors

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Table 3-47: Values of e^{COLD} / e^{HOT} for diesel passenger cars (temperature range -10 °C to 30 °C)

Pollutant or FC	e^{COLD} / e^{HOT}
CO	$1.9 - 0.03\ t_a$
NO_x	$1.3 - 0.013\ t_a$
VOC	$3.1 - 0.09\ t_a$ (1)
PM	$3.1 - 0.1\ t_a$ (2)
Fuel consumption	$1.34 - 0.008\ t_a$

Note

(1) VOC: if ta > 29 °C then e^{COLD} / e^{HOT} > 0.5.

(2) PM: if ta > 26 °C then e^{COLD} / e^{HOT} > 0.5.

Diesel cold emissions

Exercise

Tier 3 emissions factors

copert

1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv

Passenger cars, light commercial trucks, heavy-duty vehicles including buses and motor cycles

Table 3-44: Over-emission ratios e^{COLD} / e^{HOT} for Euro 1 and later gasoline vehicles (*V*: speed in km/h, t_a: temperature in °C)

Case	Category	Speed [km/h]	Temp [°C]	$e^{COLD}/e^{HOT} = A \times V + B \times t_a + C$ A	B	C
CO	cc< 1.4 l	5– 25	-20 : 15	0.156	-0.155	3.519
		26–45	-20 : 15	0.538	-0.373	-6.24
		5–45	> 15	8.032E-02	-0.444	9.826
	1.4 l < cc < 2.0 l	5–25	-20 : 15	0.121	-0.146	3.766
		26–45	-20 : 15	0.299	-0.286	-0.58
		5–45	> 15	5.03E-02	-0.363	8.604
	cc> 2.0 l	5–25	-20 : 15	7.82E-02	-0.105	3.116
		26–45	-20 : 15	0.193	-0.194	0.305
		5–45	> 15	3.21E-02	-0.252	6.332
NOx	cc< 1.4 l	5–25	> -20	4.61E-02	7.38E-03	0.755
		26–45	> -20	5.13E-02	2.34E-02	0.616
	1.4 l < cc < 2.0 l	5–25	> -20	4.58E-02	7.47E-03	0.764
		26–45	> -20	4.84E-02	2.28E-02	0.685
	cc>2.0 l	5–25	> -20	3.43E-02	5.66E-03	0.827
		26–45	> -20	3.75E-02	1.72E-02	0.728

Diesel cold emissions

Exercise

$$FChot\ (g/km) = (a + c \times V + e \times V^2)/(1 + b \times V + d \times V^2)$$

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Table 8-9: Values for eq.(21) to calculate emissions from Euro 1 and later gasoline passenger cars

Pollutant	Emission Standard	Engine capacity	Speed Range (km/h)	R^2	a	b	c	d	e
FC	Euro 1	<1.4	10-130	0.99	1.91E+02	1.29E-01	1.17E+00	-7.23E-04	
		1.4-2.0	10-130	0.98	1.99E+02	8.92E-02	3.46E-01	-5.38E-04	
		>2.0	10-130	0.93	2.30E+02	6.94E-02	-4.26E-02	-4.46E-04	
	Euro 2	<1.4	10-130	0.99	2.08E+02	1.07E-01	-5.65E-01	-5.00E-04	1.43E-02
		1.4-2.0	10-130	0.98	3.47E+02	2.17E-01	2.73E+00	-9.11E-04	4.28E-03
		>2.0	10-130	0.98	1.54E+03	8.69E-01	1.91E+01	-3.63E-03	
	Euro 3	<1.4	10-130	0.99	1.70E+02	9.28E-02	4.18E-01	-4.52E-04	4.99E-03
		1.4-2.0	10-130	0.99	2.17E+02	9.60E-02	2.53E-01	-4.21E-04	9.65E-03
		>2.0	10-130	0.99	2.53E+02	9.02E-02	5.02E-01	-4.69E-04	
	Euro 4	<1.4	10-130	0.95	1.36E+02	2.60E-02	-1.65E+00	2.28E-04	3.12E-02
		1.4-2.0	10-130	0.96	1.74E+02	6.85E-02	3.64E-01	-2.47E-04	8.74E-03
		>2.0	10-130	0.98	2.85E+02	7.28E-02	-1.37E-01	-4.16E-04	

Table 8-11: Over-emission ratios e^{COLD} / e^{HOT} for Euro 1 and later gasoline vehicles (V: speed in km/h, t_a: temperature in °C)

Case	Category	Speed [km/h]	Temp [°C]	$e^{COLD}/e^{HOT} = A \times V + B \times t_a + C$ A	B	C
FC	All Classes	-	-10 : 30	0	-0.009	1.47

Note: e^{COLD}/e^{HOT} should be replaced with unit when it is calculated less than unit within the temperature and speed application limits

Exercise

$$FChot\ (g/km) = (a + c \times V + e \times V^2)/(1 + b \times V + d \times V^2) + f/V$$

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Table 8-15: Values for eq.(23) to calculate emissions from Euro 1 and later diesel passenger cars

Pollutant	Emission Standard	Engine capacity	Speed Range (km/h)	R^2	a	b	c	d	e	f
FC	Euro 1	<2.0	10-130	0.98	1.45E+02	6.73E-02	-1.88E-01	-3.17E-04	9.47E-03	
		>2.0	10-130	0.96	1.95E+02	7.19E-02	1.87E-01	-3.32E-04	9.99E-03	
	Euro 2	<2.0	10-130	0.97	1.42E+02	4.98E-02	-6.51E-01	-1.69E-04	1.32E-02	
		>2.0	10-130	0.96	1.95E+02	7.19E-02	1.87E-01	-3.32E-04	9.99E-03	
	Euro 3	<2.0	10-130	0.95	1.62E+02	1.23E-01	2.18E+00	-7.76E-04	-1.28E-02	
		>2.0	10-130	0.96	1.95E+02	7.19E-02	1.87E-01	-3.32E-04	9.99E-03	

Table 8-14: Over-emission ratios e^{COLD} / e^{HOT} for diesel passenger cars (temperature range -10°C to 30°C)

Pollutant	e^{COLD} / e^{HOT}
CO	$1.9 - 0.03\ t_a$
NO_x	$1.3 - 0.013\ t_a$
VOC	$3.1 - 0.09\ t_a$ (1)
PM	$3.1 - 0.1\ t_a$ (2)
Fuel Consumption	$1.34 - 0.008\ t_a$

(1) VOC: if ta > 29°C then $e^{COLD} / e^{HOT} > 0.5$

(2) PM: if ta > 26°C then $e^{COLD} / e^{HOT} > 0.5$

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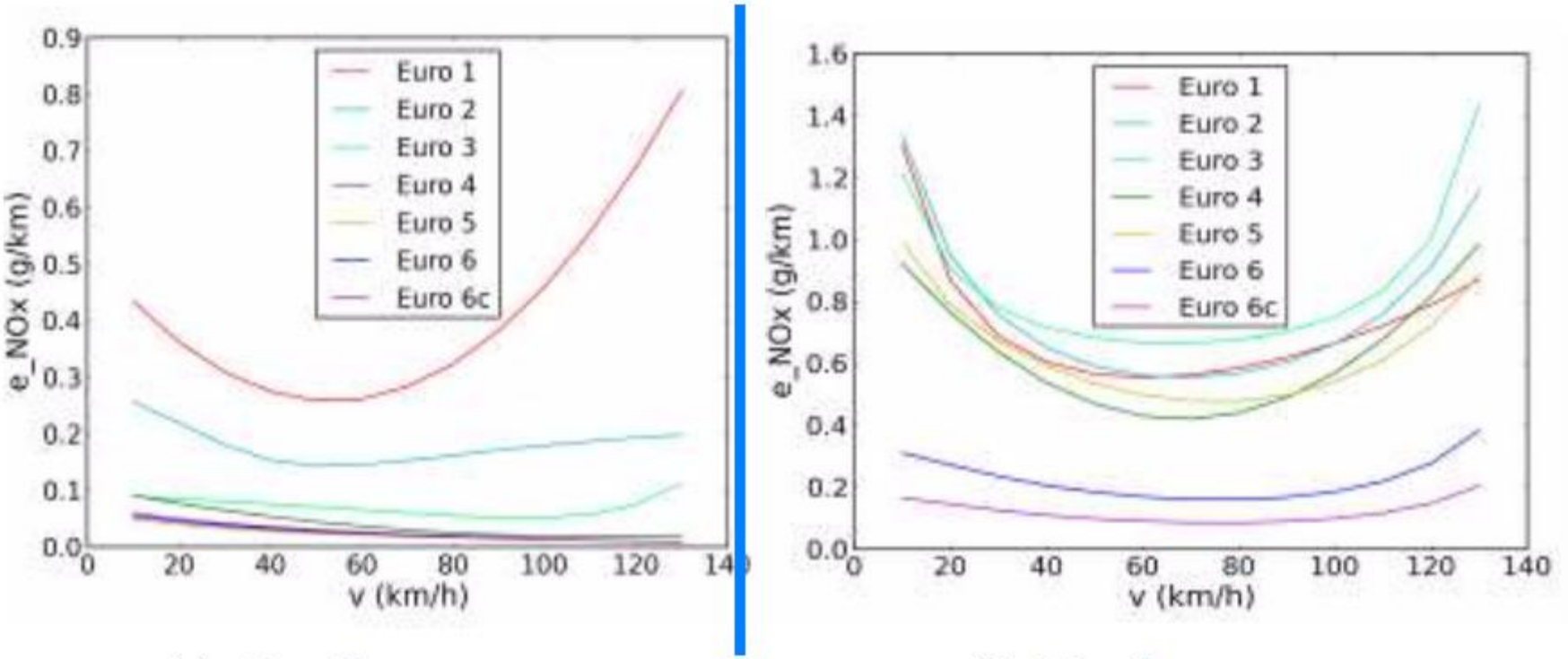

Figure 14: Sensitivity of hot emission factor of passenger cars for NO_x to the average speed.

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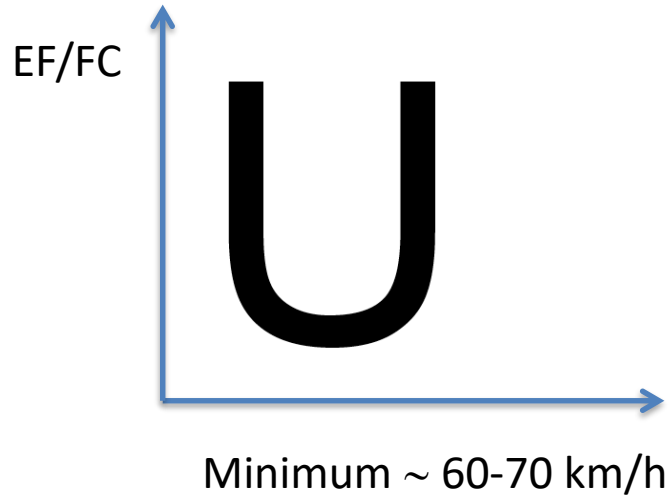
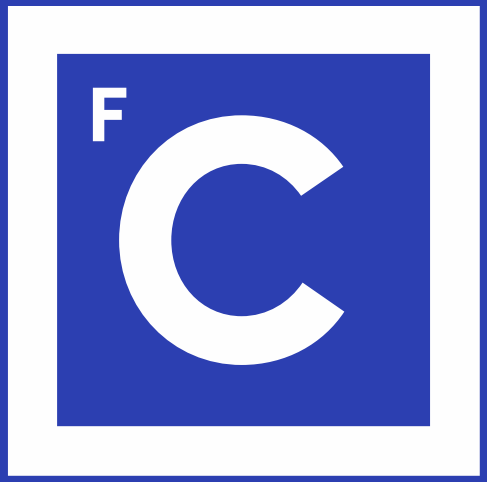


EF = Emission Factor (g/km) = f(vehicle category & standard, **average speed**, ambient temperature, A/C, Road slope, load)

You learned….

- European Environmental Agency Tier 2 approach;
- Discussing VCA(standards) vs Tier 1 EEA vs Tier 2 EEA;
- Introduction to Tier 3 EEA COPERT V;
- Precision vs accuracy.

Obrigado



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