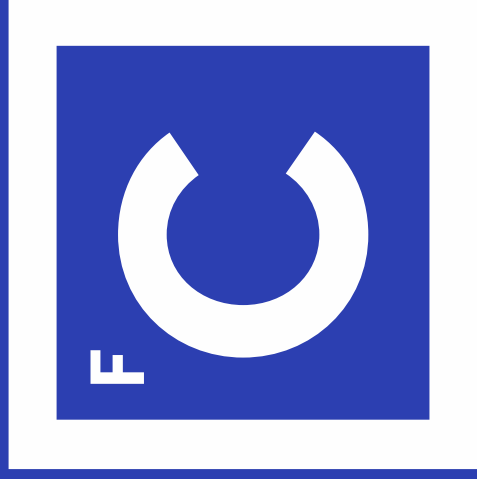




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Sustainable Mobility

European Environment Agency



EEA Report | No 21/2016

EMEP/EEA air pollutant emission inventory guidebook 2016

Technical guidance to prepare national emission inventories

ISSN 1977-8449





Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

EU

September
2017

September
2018

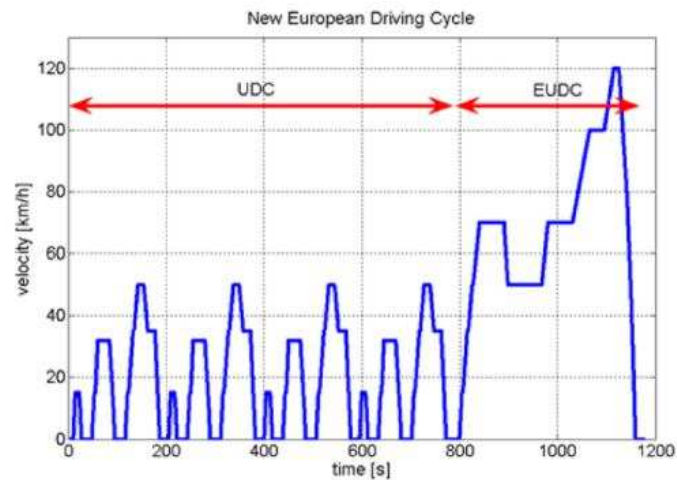
January
2019

WLTP/NEDC

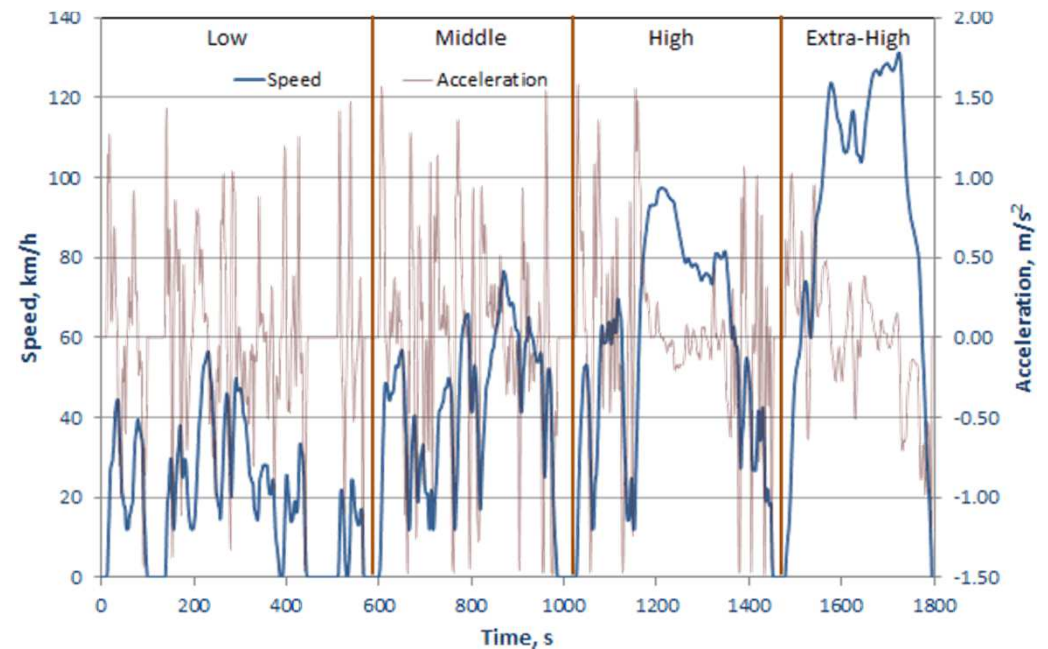
WLTP all new vehicles

WLTP-CO₂ values only

- Europe – Light-duty



Worldwide Harmonized Light Vehicles Test Procedure (WLTP)-Class 3
P/Weight>34



EU Emission Standards for Passenger Cars (Category M₁*)

Stage	Date	CO	HC	HC+NOx	NOx	PM	PN
		g/km					#/km
Compression Ignition (Diesel)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)	-
Euro 2, IDI	1996.01	1.0	-	0.7	-	0.08	-
Euro 2, DI	1996.01 ^a	1.0	-	0.9	-	0.10	-
Euro 3	2000.01	0.64	-	0.56	0.50	0.05	-
Euro 4	2005.01	0.50	-	0.30	0.25	0.025	-
Euro 5a	2009.09 ^b	0.50	-	0.23	0.18	0.005 ^f	-
Euro 5b	2011.09 ^c	0.50	-	0.23	0.18	0.005 ^f	6.0×10 ¹¹
Euro 6	2014.09	0.50	-	0.17	0.08	0.005 ^f	6.0×10 ¹¹
Positive Ignition (Gasoline)							
Euro 1†	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	-	-
Euro 2	1996.01	2.2	-	0.5	-	-	-
Euro 3	2000.01	2.30	0.20	-	0.15	-	-
Euro 4	2005.01	1.0	0.10	-	0.08	-	-
Euro 5	2009.09 ^b	1.0	0.10 ^d	-	0.06	0.005 ^{e,f}	-
Euro 6	2014.09	1.0	0.10 ^d	-	0.06	0.005 ^{e,f}	6.0×10 ¹¹ e,g

* At the Euro 1..4 stages, passenger vehicles > 2,500 kg were type approved as Category N₁ vehicles

† Values in brackets are conformity of production (COP) limits

a. until 1999.09.30 (after that date DI engines must meet the IDI limits)

b. 2011.01 for all models

c. 2013.01 for all models

d. and NMHC = 0.068 g/km

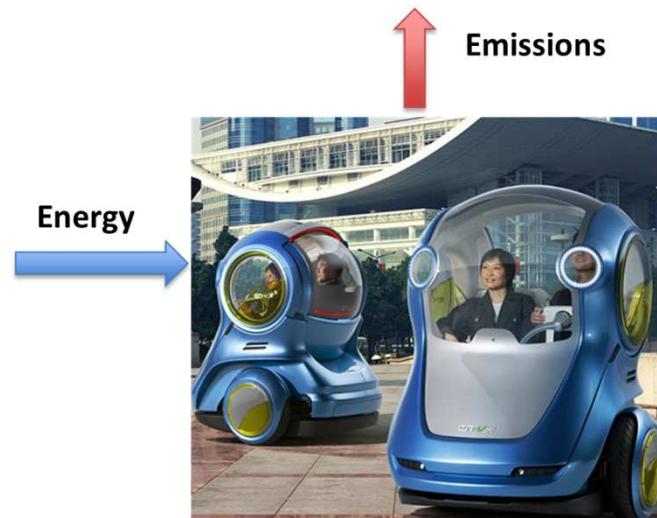
e. applicable only to vehicles using DI engines

f. 0.0045 g/km using the PMP measurement procedure

g. 6.0×10¹² 1/km within first three years from Euro 6 effective dates

Conclusions P#4 and P#5: Total emissions per year

Emissions/Fleet	Lisbon-Porto TAP	SofLusa Lisboa-Barreiro
		
CO ₂ (ton/year)	19 000	16 580
NOx (ton/year)	32	415
PM2.5 (ton/year)	6.5	7.4



Estimate the energy consumption in MJ/pkm of a fleet of 5 motorized cars that travels roundtrip Lisbon –Porto (~300 km). Temp. 20°C.

CO₂, NO_x and PM2.5 in g/pkm.

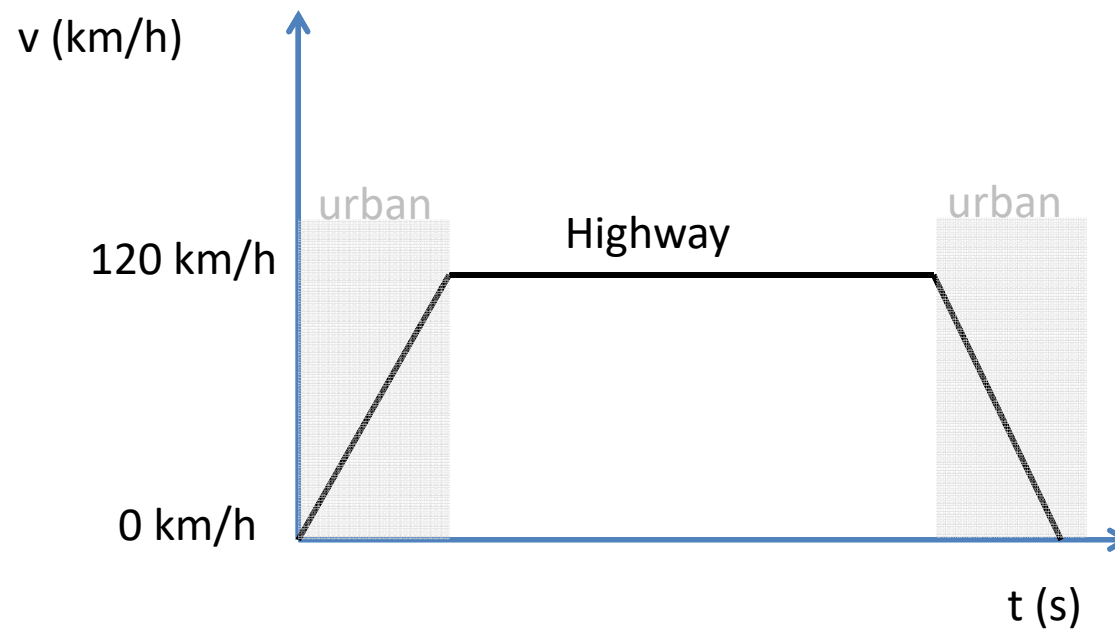
a) Use refuelling info;

b) Use EEA Tier1/2/3;

c) Discuss results.



	Gasoline (2x) Euro4	Diesel (2x) Euro3	HEV (1x) Euro4
Tank begin (l)	50	60	45
Tank end round-trip (l)	14	33	15
Speed	See driving cycle		
Curb weight	1200	1500	1400
Passengers	1	1	1
CD*AF (m2)	0.6	0.6	0.4
t (s) 0-100km/h	10.2	10.3	10
Engine efficiency	25	30	35
Transmission efficiency	95	95	95
A/C	off	off	off
A/C (kW)	2	2	2

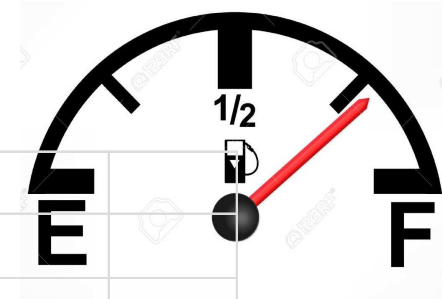


Driving cycle

	Gasoline (2x)	Diesel (2x)	HEV (1x)					
						Roundtrip distance (km)	600	
Tank begin (l)	50	60	45			Gasoline (LHV)	30 MJ/l	
Tank end roundtrip (l)	14	33	15					
Macrosimulation approach								
Number of vehicle*(Tank begin (L)-Tank end roundtrip (L))*30 MJ/L								
Overall MJ	2160	1620	900			SUM	4680	
						pkm	3000	
						MJ/pkm	1.56	



CO₂, NO_x and PM2.5????



Gasoline (2x) Euro4	Diesel (2x) Euro3	HEV (1x) Euro4			
	NO _x		PM		
Euro3 diesel	0.5 g/km		0.05 g/km		
Euro 4 gasoline	0.08 g/km		0 g/km		
CO ₂	3.14kgCO ₂ /kgfuel/40MJ/kg		78.5 gCO ₂ /MJ		
CO ₂	1.56MJ/pkm*78.5gCO ₂ /MJ		122.46 gCO ₂ /pkm		
NO _x	(3*0.08+2*0.5)/5		0.248 gNO _x /pkm		
PM ₁₀	2*0.05/5		0.02 gPM/pkm		

European Environment Agency



TIER 1 ?

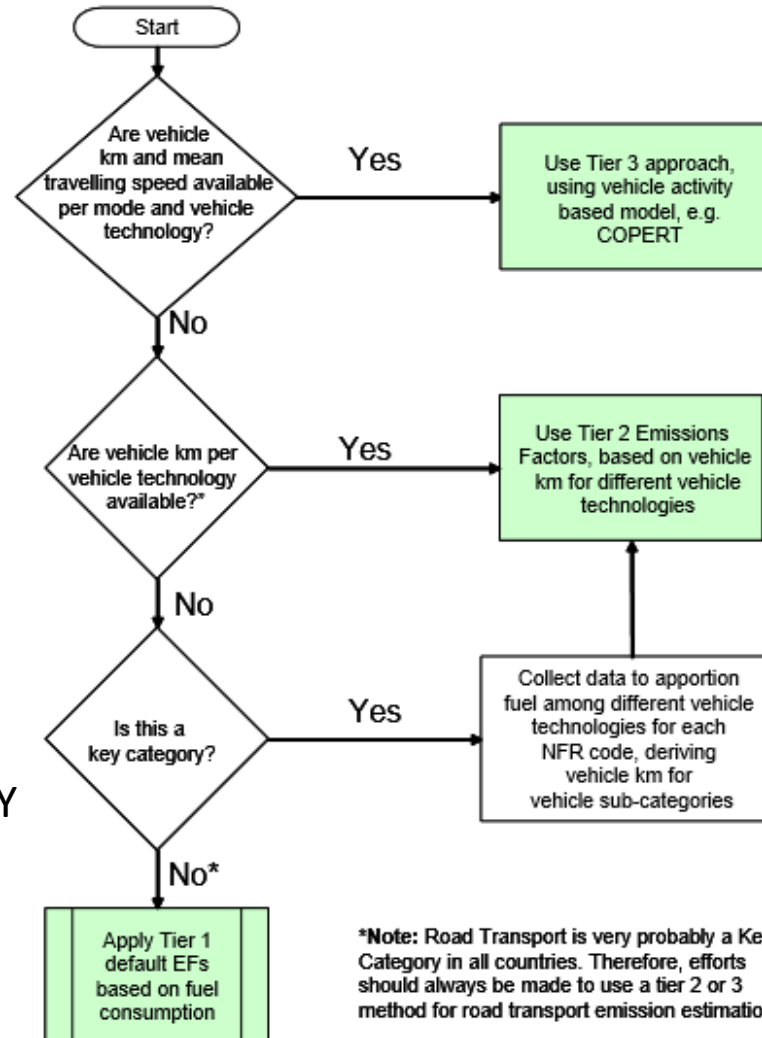
TIER 2 ?

TIER 3 ?

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

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

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



***Note:** Road Transport is very probably a Key Category in all countries. Therefore, efforts should always be made to use a tier 2 or 3 method for road transport emission estimation

European Environment Agency



TIER 1 ?

Table 3.12: Tier 1 CO₂ emission factors for different road transport fossil fuels

Subsector units	Fuel	kg CO ₂ per kg of fuel ¹
All vehicle types	Petrol	3.180
All vehicle types	Diesel	3.140
All vehicle types	LPG ²	3.017
All vehicle types	CNG ³ (or LNG)	2.750
All vehicle types	E5 ⁴	3.125
All vehicle types	E10 ⁴	3.061
All vehicle types	E85 ⁴	2.104

Notes:

¹ CO₂ emission factors are based on an assumed 100% oxidation of the fuel carbon (ultimate CO₂).

² LPG assumed to be 50% propane + 50% butane.

³ CNG and LNG assumed to be 100% methane.

European Environment Agency



TIER 1 ?

Table 3.6: Tier 1 emission factors for NO_x and PM

Category	Fuel	NO _x			PM		
		(g/kg fuel)			(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

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TIER 1 ?

Table 3.13: Tier 1 CO₂ emission factors from combustion of lubricant oil¹

Category	Fuel	CO ₂ from lubricant		
		(g/kg fuel)		
		Mean	Min	Max
PC	Petrol	8.84	7.83	9.89
	Diesel	8.74	8.01	11.3
	LPG	8.84	7.83	9.89
LCV	Petrol	6.07	4.76	7.28
	Diesel	6.41	5.41	7.72
HDV	Diesel	2.54	1.99	3.32
	CNG (Buses)	3.31	3.09	3.50
Two-wheel	Petrol	53.8	33.3	110

Note:

¹ These emission factors assume typical consumption values for lubricant oil used in automotive applications.

European Environment Agency



TIER 1 ?

Gasoline 0.745 kg/L

Diesel 0.845 kg/L

pkm=5*600

gasoline (kg)	75.99		
	mean	min	max
Nox (g)	663.3927	340.4352	2271.341
PM2.5 (g)	2.2797	1.5198	3.0396
CO2 (g)	241648.2		
CO2 (g) lube	671.7516	595.0017	751.5411
diesel (kg)	45.63		
	mean	min	max
Nox (g)	591.3648	511.056	633.3444
PM2.5 (g)	50.193	36.504	120.4632
CO2 (g)	143278.2		
CO2 (g) lube	398.8062	365.4963	515.619
Total g/pkm			
NOx	0.4182525	0.2838304	0.968229
PM2.5	0.0174909	0.0126746	0.041168
CO2	128.3088		
CO2 lube	0.3568526	0.320166	0.422387

European Environment Agency



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 ₂ O	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-CH ₄	Given as NO ₂ equivalent				due to lube oil
Petrol Small	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
	Euro 6 2020+	0.69	0.048	0.056	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

European Environment Agency



TIER 2 ?

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
	Euro 6 2020+	0.0016	3.90E-07	2.60E-07	3.60E-07	3.20E-07
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



European Environment Agency



TIER 2 ?

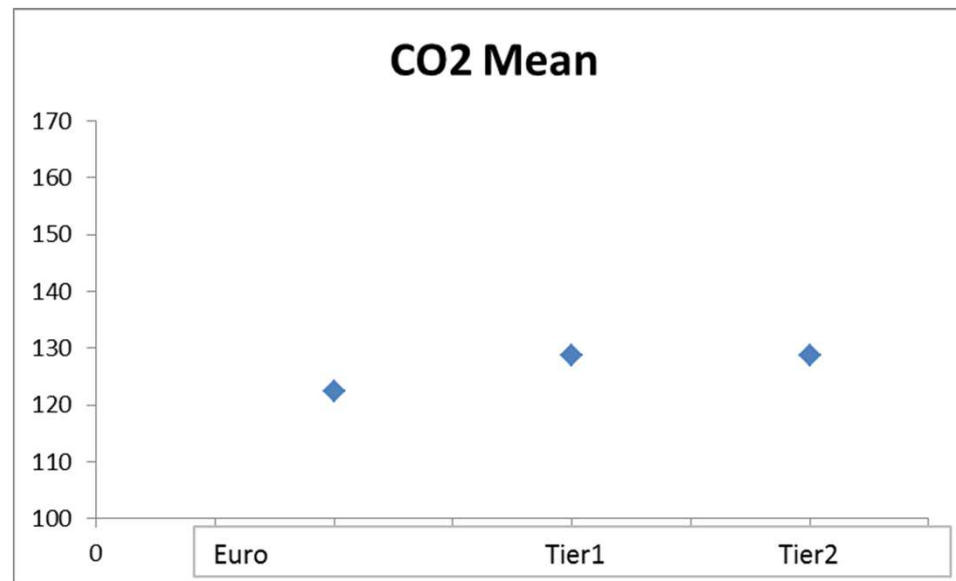
Petro SMALL EURO4	NOx (g/km)	0.056	
	PM2.5 (g/km)	0.0011	
	CO2 lube (g/km)	0.398	
Diesel Euro3	NOx (g/km)	0.58	
	PM2.5 (g/km)	0.0314	
	CO2 lube (g/km)	0.398	
	Total g/pkm		
	NOx	0.2656	
	PM2.5	0.01322	
	CO2	128.3088	
	CO2 lube	0.398	

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Euro/TIER 1/TIER 2 ?

g/pkm

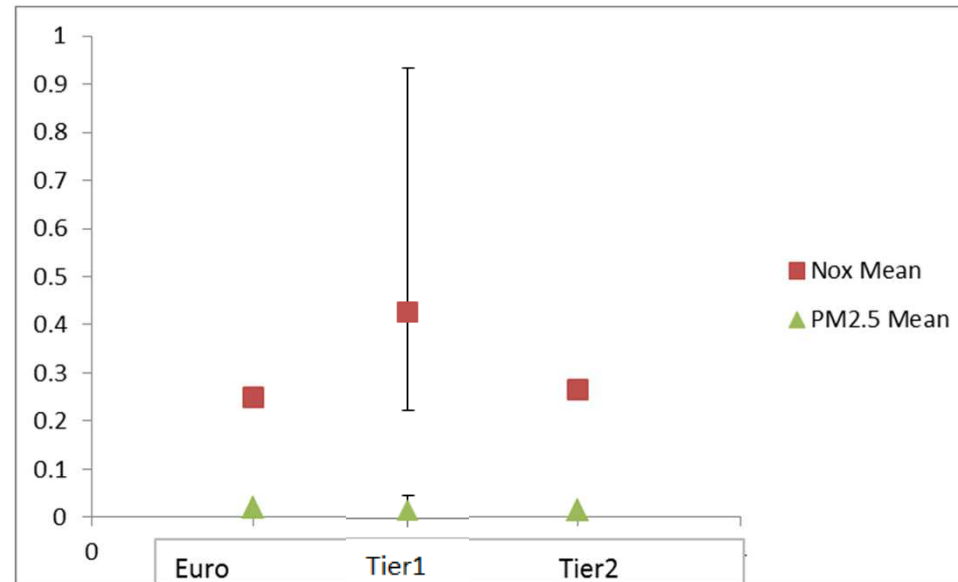


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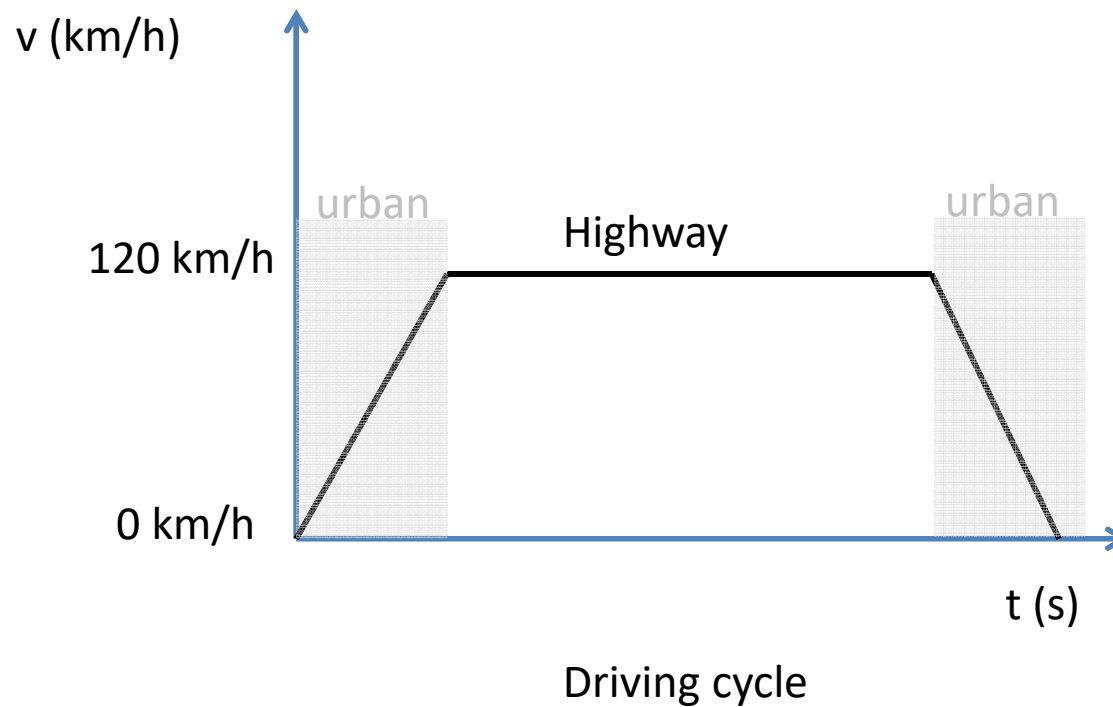


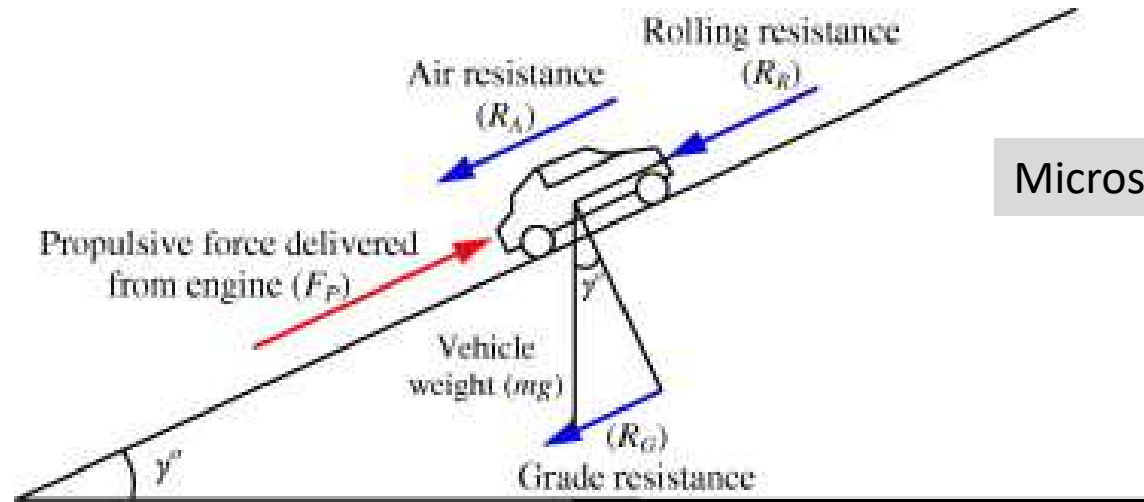
Euro/TIER 1/TIER 2 ?

g/pkm



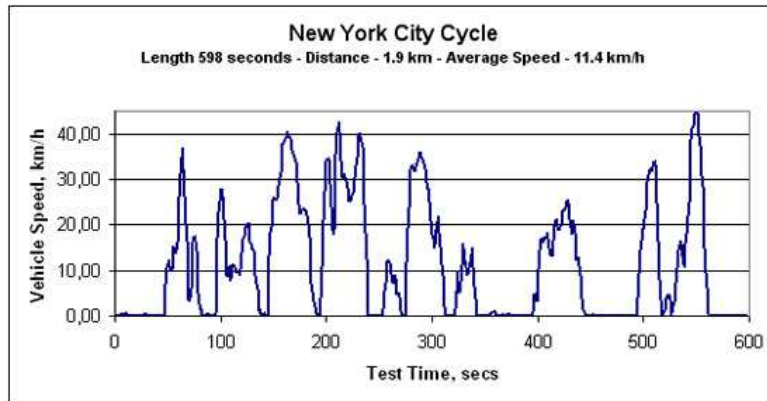
Without refueling info? With GPS info....



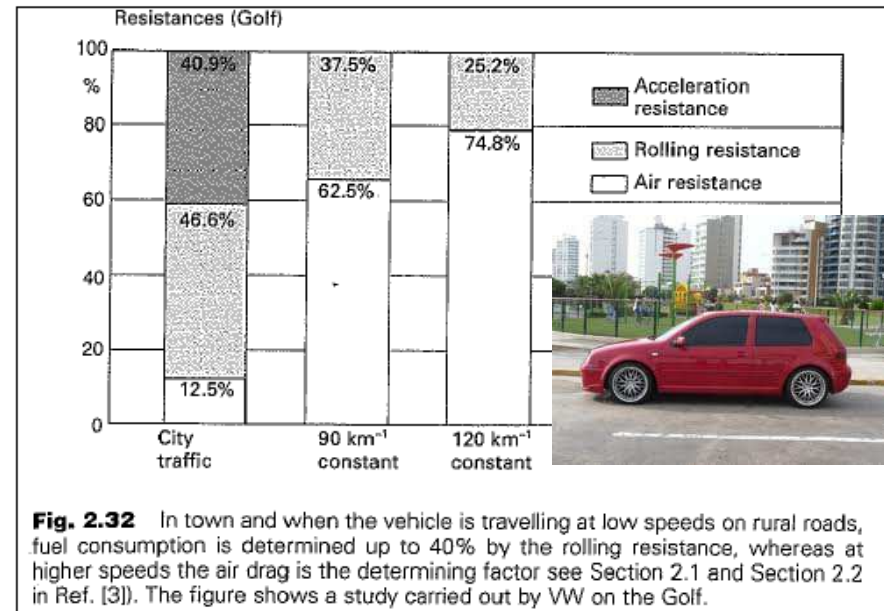


Microsimulation approach

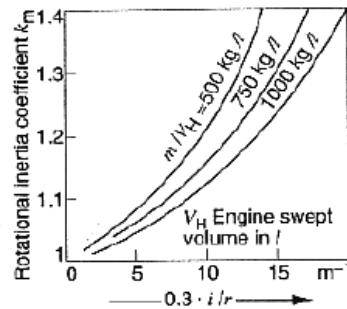
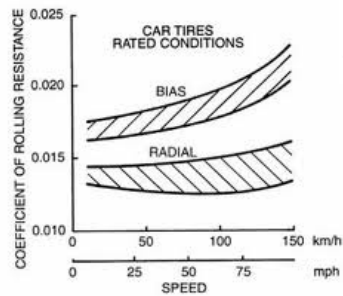
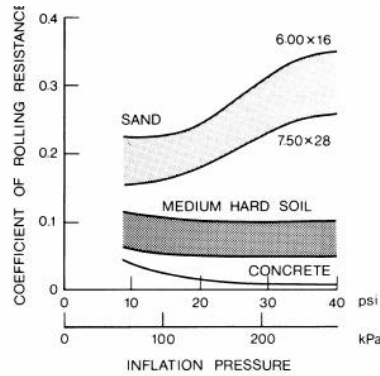
Rolling	$R_r = k_r(m+m_p)g \cdot \cos \gamma$
Road gradient	$F_w = (m+m_p)g \cdot \sin \gamma$
Aerodynamics	$R_a = 1/2 \cdot \rho C_d A_f v^2$
Propulsion	$F_p = (k_m \cdot m + m_p) \cdot dv/dt$



Rolling k_r
Aerodynamics $C_d A_f$
Propulsion k_m

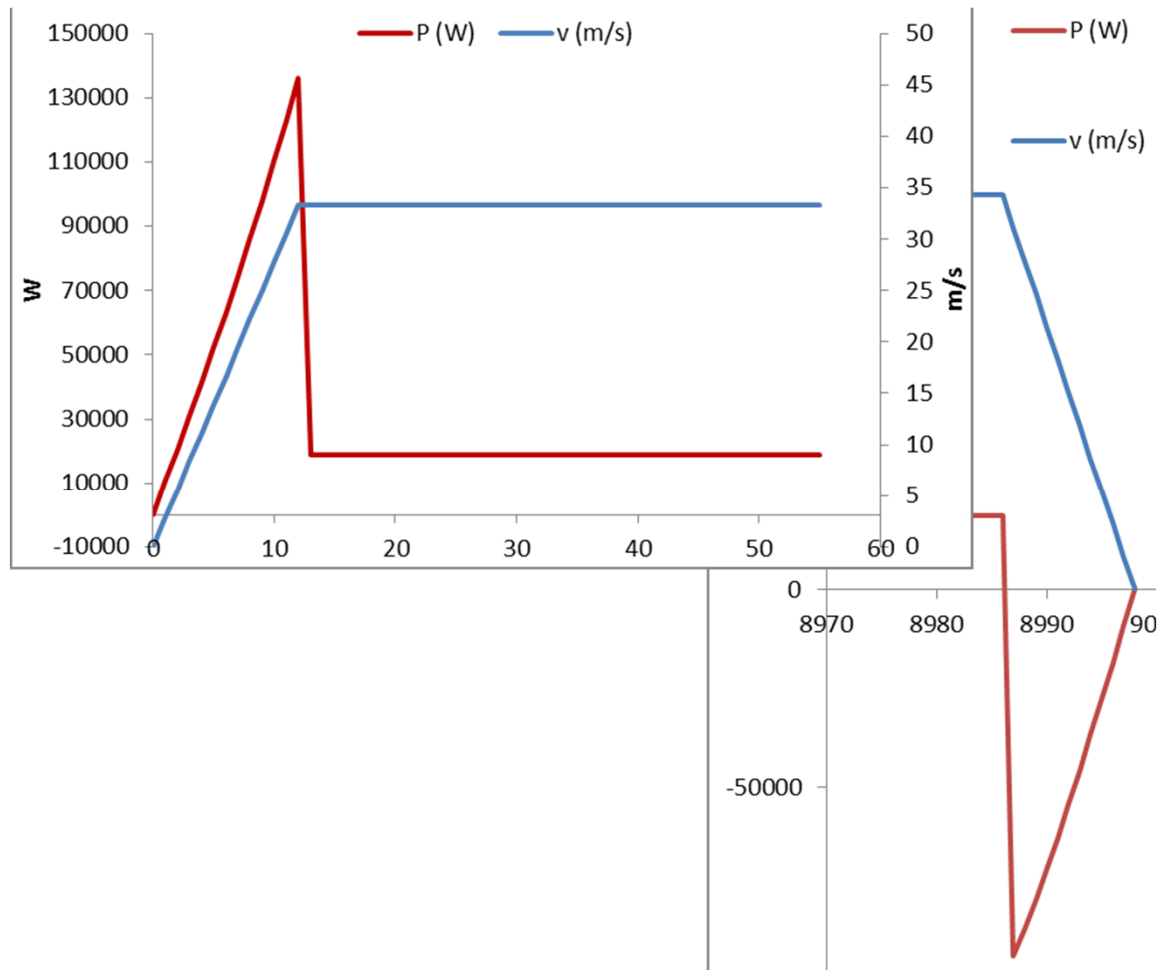


Contribution of Tire Rolling Resistance to Vehicle Fuel Economy Versus Speed
(Reprinted with permission from the Automotive Chassis: Engineering Principles, 2nd Edition, Reed Educational and Professional Publishing Ltd., 2001)

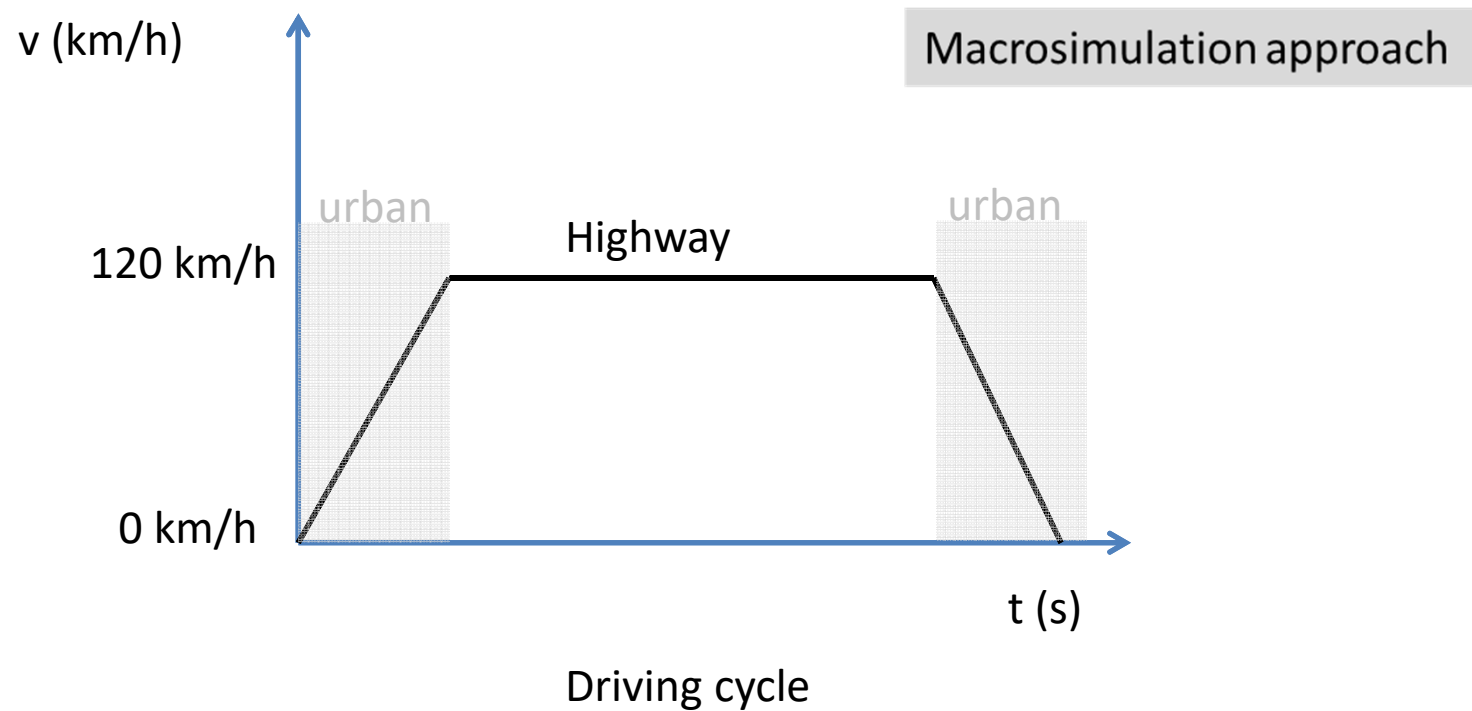


@Bosch Automotive Handbook: 8th Edition

Rolling	k_r	0.013	0.01
Aerodynamics	$C_d A_f$	$0.35 \times 1.91 \text{ m}^2$	$0.6 \times 7 \text{ m}^2$
Propulsion	k_m	1.1	1.13



Without refueling info? With GPS info...EEA Tier 3





l_{trip} average trip length [km] Europe 12.4 km
T_a °C

Table 8-8: Cold mileage percentage β

Calculations based on	β -parameter (Beta parameter)
Estimated l_{trip}	$0.6474 - 0.02545 \times l_{trip} - (0.00974 - 0.000385 \times l_{trip}) \times t_a$



$$F_{\text{Hot}} (\text{g/km}) = (a + c \times V + e \times V^2) / (1 + b \times V + d \times V^2)$$

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 $e^{\text{COLD}} / e^{\text{HOT}}$ for Euro 1 and later gasoline vehicles (V: speed in km/h, t_a : temperature in °C)

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

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



$$F_{\text{hot}} (\text{g/km}) = (a + c \times V + e \times V^2) / (1 + b \times V + d \times V^2) + f/V$$

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 $e^{\text{COLD}} / e^{\text{HOT}}$ for diesel passenger cars (temperature range -10°C to 30°C)

Pollutant	$e^{\text{COLD}} / e^{\text{HOT}}$
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 $t_a > 29^\circ\text{C}$ then $e^{\text{COLD}} / e^{\text{HOT}} > 0.5$

⁽²⁾ PM: if $t_a > 26^\circ\text{C}$ then $e^{\text{COLD}} / e^{\text{HOT}} > 0.5$



$$EF = a + c \times V + e \times V^2$$

Table 8-23: Values for eq.(26) to calculate emissions from hybrid gasoline passenger cars

Pollutant	Emission Standard	Engine capacity	Speed Range (km/h)	R ²	a	c	e
FC		All capacities	10-130	1	1.94E+01	6.06E-02	7.54E-04

NOx and PM2.5?

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



Euro 3	All >0.8 l	10-130	0.80	9.29E-02	-1.22E-02	-1.49E-03	3.97E-05	6.53E-06
Euro 4	All	10-130	0.71	1.06E-01		-1.58E-03		7.10E-06

Table 3-43: PM emission factors for Euro 1 to Euro 4 gasoline passenger cars

Pollutant	Emission standard	Fuel specs (EN590)	Urban [g/km]	Rural [g/km]	Highway [g/km]
PM	Euro 1 and 2	2000-2009	3.22E-03	1.84E-03	1.90E-03
	Euro 3 and 4	2000-2009	1.28E-03	8.36E-04	1.19E-03
	Euro 3 GDI	2000-2009	6.60E-03	2.96E-03	6.95E-03

Gasoline hot emissions g/km

i) Could you estimate NOx and PM2.5?

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

Tier 3 emissions factors



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

Gasoline cold emissions

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

Tier 3 emissions factors



Table 3-48: Values for equations (26), (27), (30) and (31) to calculate emissions and fuel consumption from Euro 1 and later diesel passenger cars

Pollutant or FC	Emission standard	Engine capacity	Eq. Nb.	Speed range (km/h)	R ²	a	b	c	d	e	f
NO _x	Euro 1	All > 1.4 l	(30)	10-130	0.96	3.10E+00	1.41E-01	-6.18E-03	-5.03E-04	4.22E-04	
	Euro 2	All > 1.4 l		10-130	0.94	2.40E+00	7.67E-02	-1.16E-02	-5.00E-04	1.20E-04	
	Euro 3	All > 1.4 l		10-130	0.92	2.82E+00	1.98E-01	6.69E-02	-1.43E-03	-4.63E-04	
	Euro 4	All		10-130		1.11E+00		-2.02E-02		1.48E-04	
	Euro 5	All		10-130	0.923	9.46E-01	4.26E-03	-1.14E-02	-5.15E-05	6.67E-05	1.92E+00

Diesel hot emissions

Tier 3 emissions factors



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

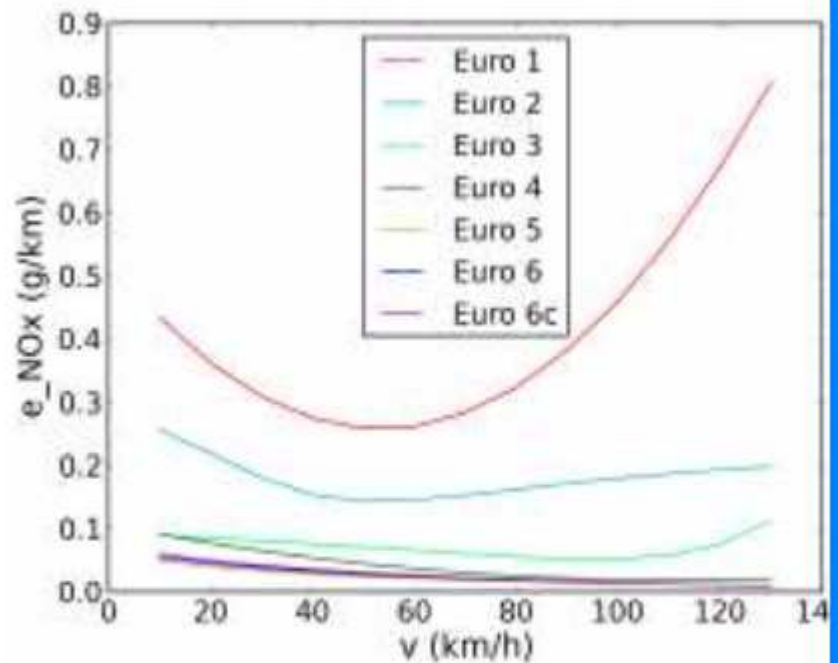
Pollutant or FC	$e^{\text{COLD}} / e^{\text{HOT}}$
CO	$1.9 - 0.03 \ t_a$
NO _x	$1.3 - 0.013 \ t_a$
VOC	$3.1 - 0.09 \ t_a^{(1)}$
PM	$3.1 - 0.1 \ t_a^{(2)}$
Fuel consumption	$1.34 - 0.008 \ t_a$

Note

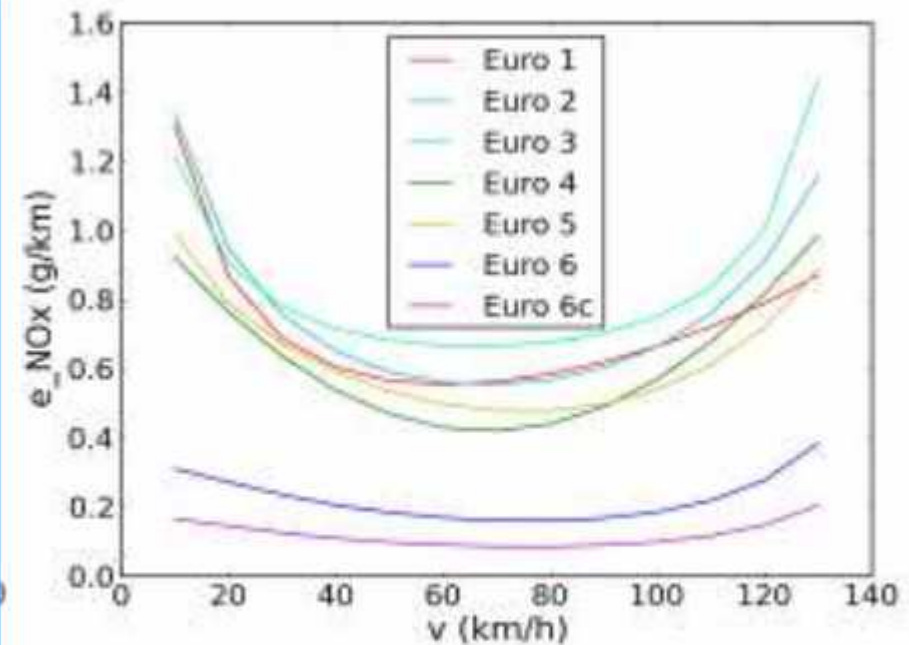
(1) VOC: if $t_a > 29 \text{ °C}$ then $e^{\text{COLD}} / e^{\text{HOT}} > 0.5$.

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

Diesel cold emissions



(a) Gasoline passenger car

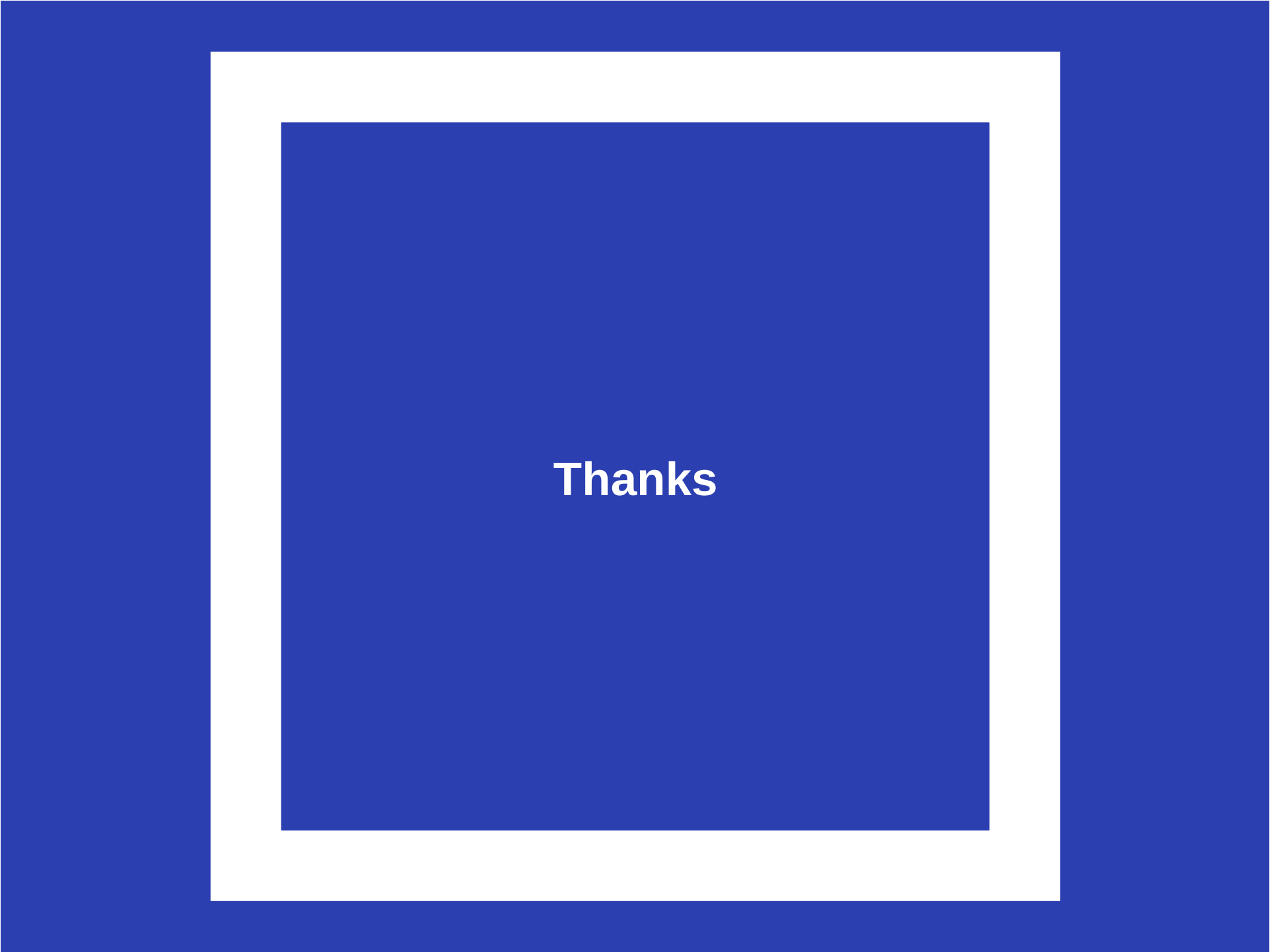


(b) Diesel passenger car

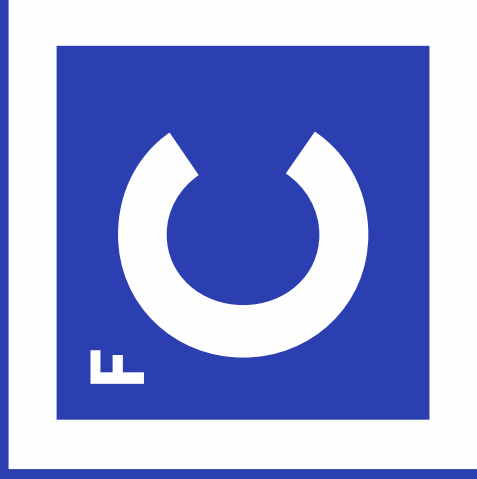
Figure 14: Sensitivity of hot emission factor of passenger cars for NO_x to the average speed.

**Homework estimate Tier 3 results with
copert and with excel.....with no
A/C....Then...try with A/C.....**

Diesel cold emissions

The image consists of a large blue square. Inside this square is a white border, which is itself a square. In the center of the white square is the word "Thanks" in a white, sans-serif font.

Thanks



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