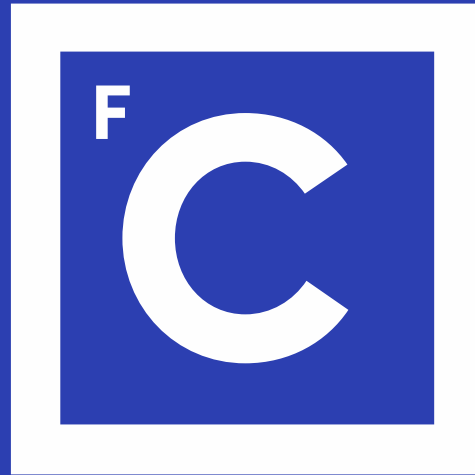




Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

DISCIPLINA MIEA 2018

move ► green



Mobilidade Sustentável

Home  Work/ University

on a regular basis

Commuting by motorized or soft modes



Emissions

Energy



Impact of people travel?

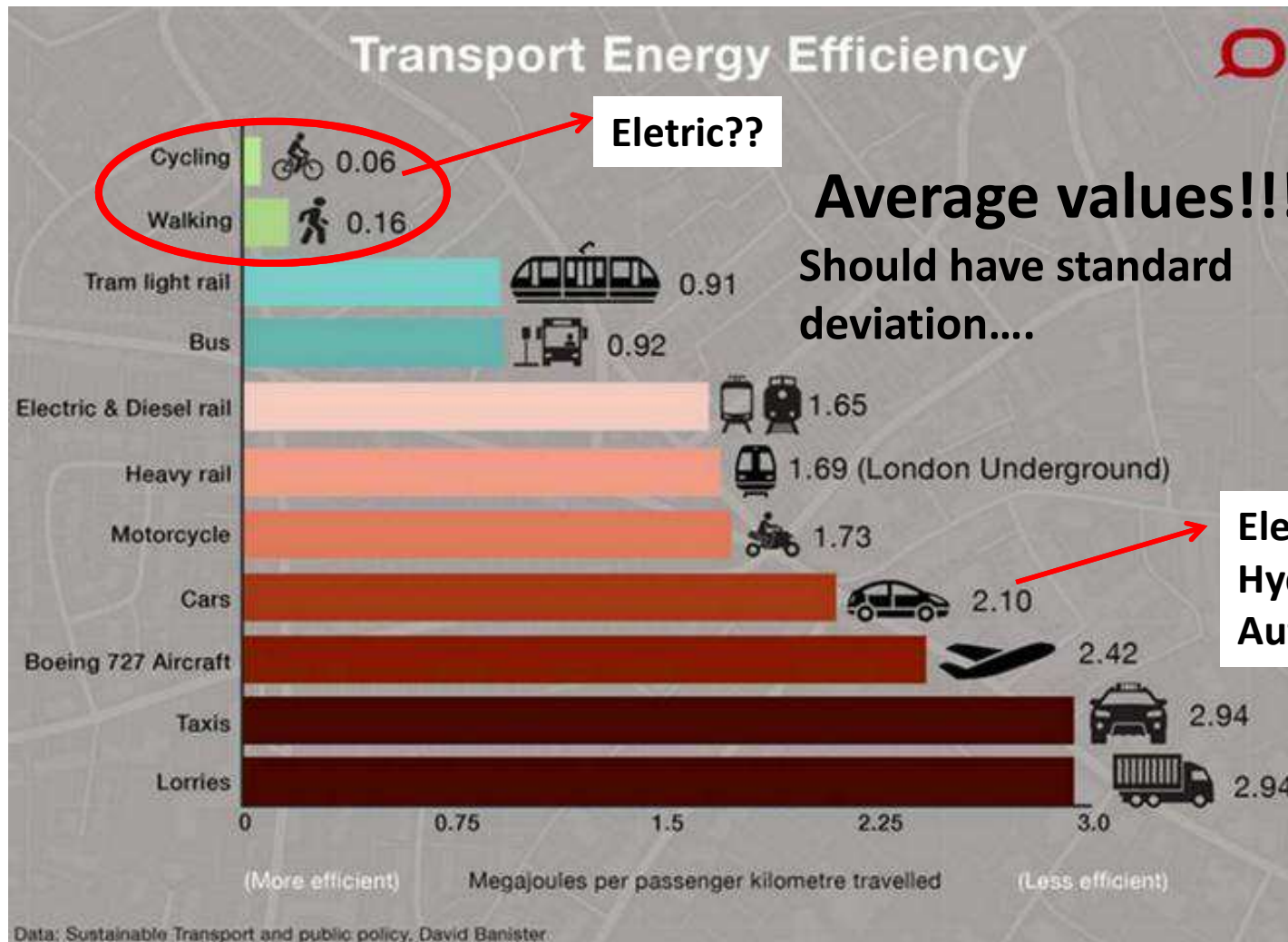
$$\sum_i (\text{Number trip}_i \times \text{km per trip}_i \times \text{EC}_i)$$

i mode of transport

EC_i final energy consumption by mode (MJ/pkm)

Or

Ef_i emission factor g/km



Average values!!!!

Should have standard deviation....

Eletric??
Hydrogen??
Autonomous??



Battery 1,12 kWh

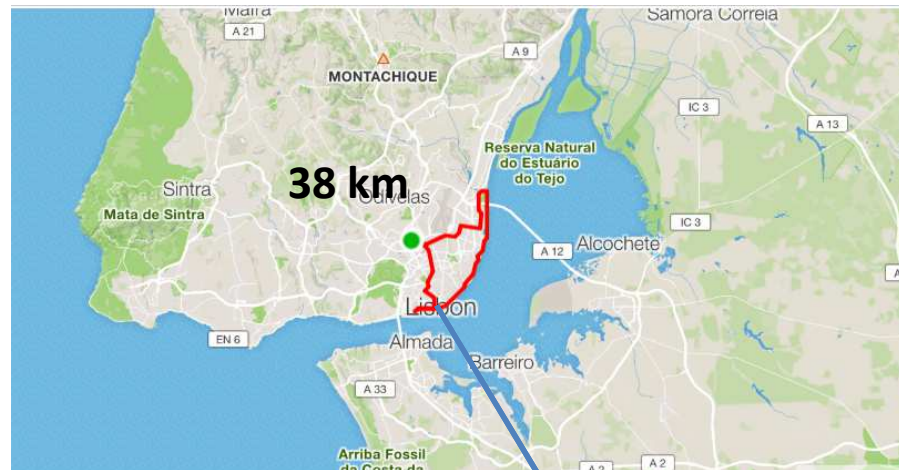
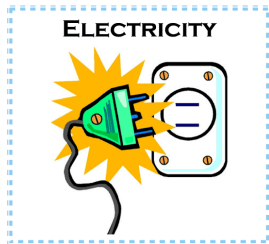
Electric motor 3 kW

Top speed 24 km/h

Final energy

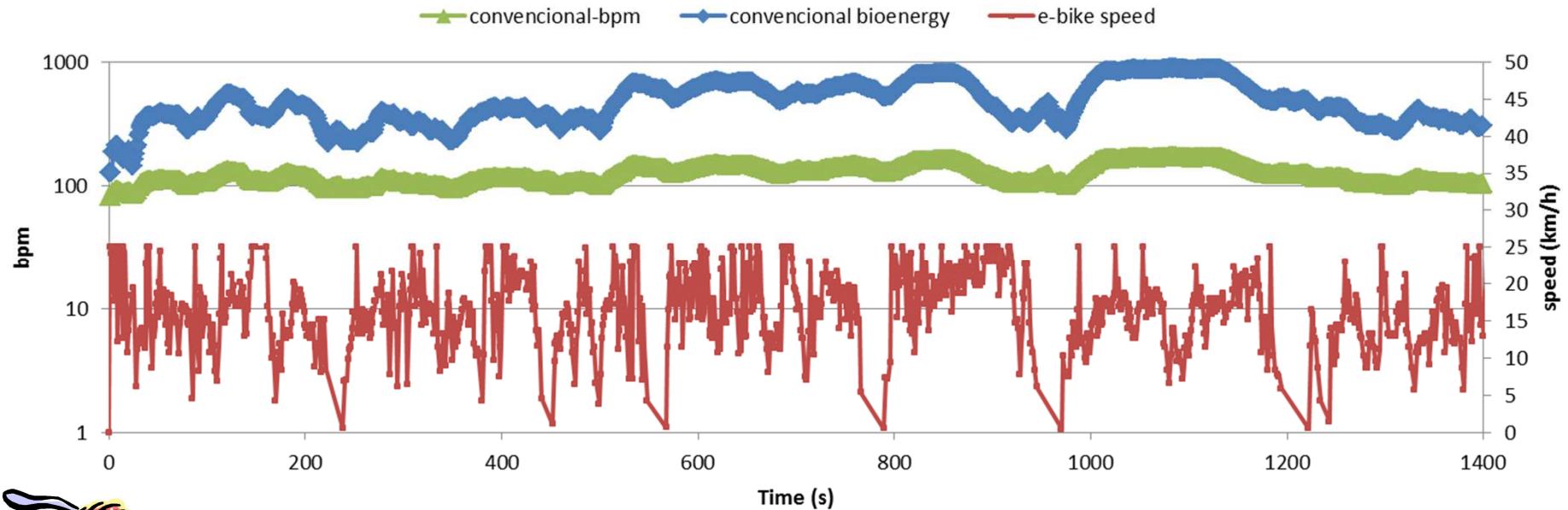
MJ/pkm???

Real use Final energy MJ/pkm???biogenic vs eletric



E-bike swap

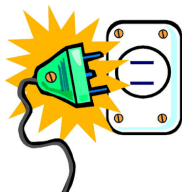
Representation first 5 km



~ 0.14 MJ/pkm

Overall 500 m elevation gain.....

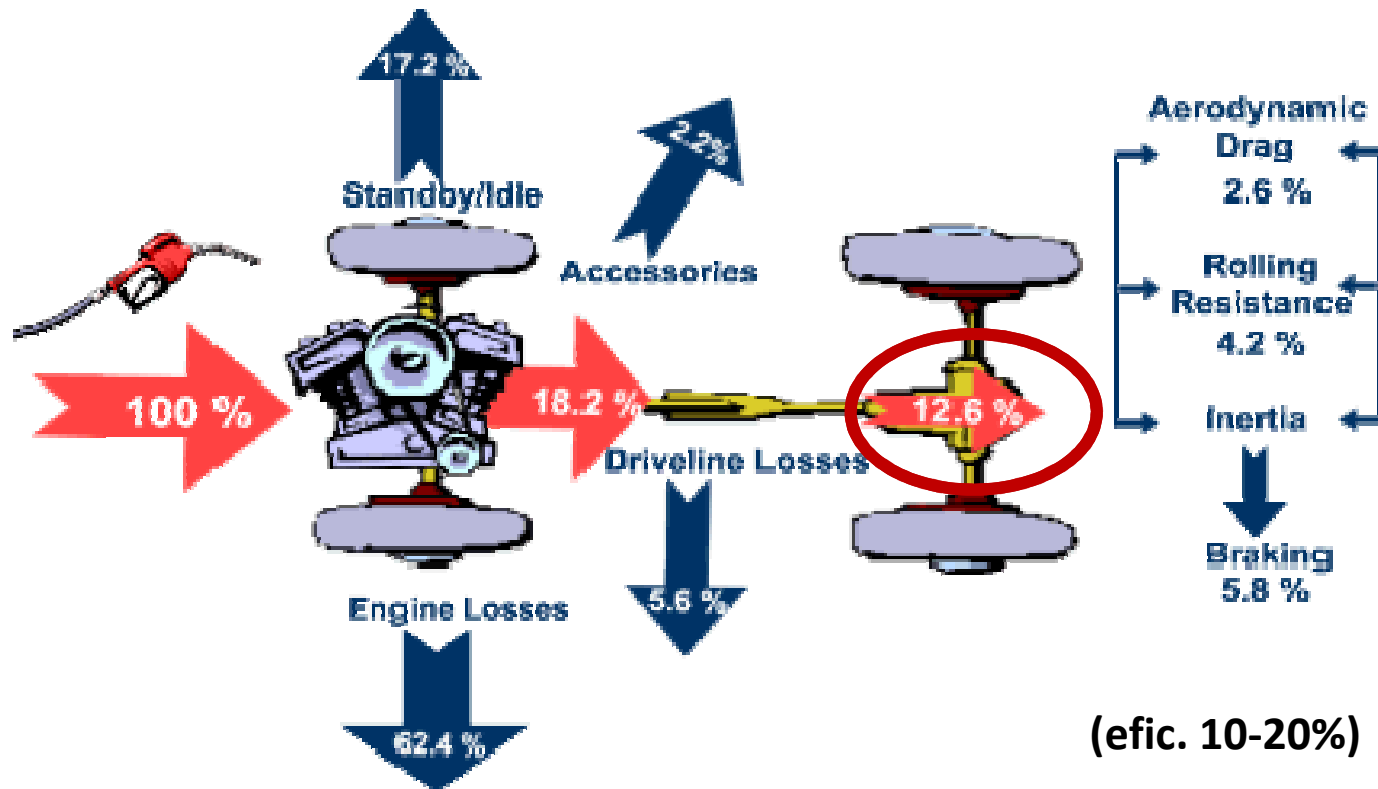
ELECTRICITY



Real range: 30 km spent 1.12 kWh → $1.12/30 * 3.6 = 0.13$ MJ/pkm
 final energy electricity

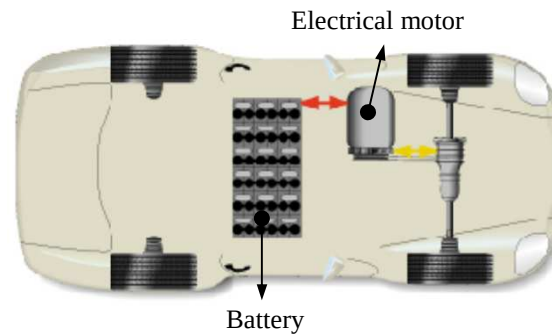
Final to useful energy

e.g. Conventional Internal Combustion Engine Car





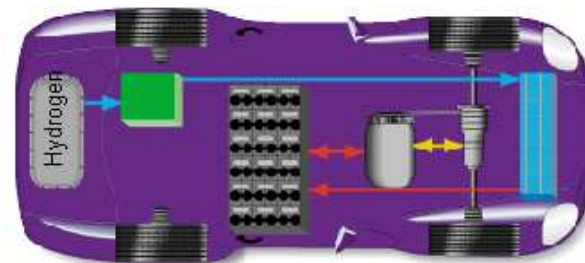
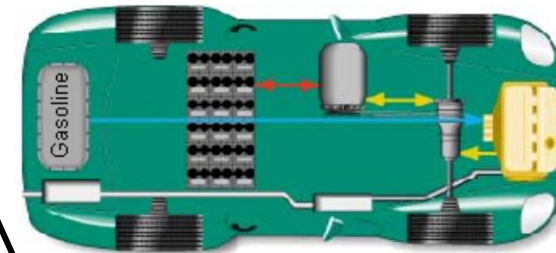
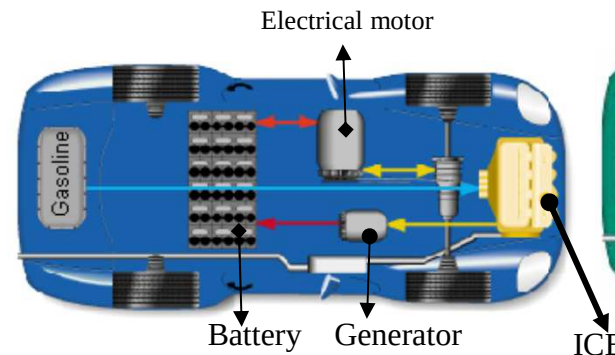
Plug-In



Final to useful energy....

Pure electric (efic. 60-70%)

Hybrids (efic. 20-30%)



Fuel cell (efic. 30-40%)

Most sold vehicle Portugal



0-100 km/h	14.5 s	
European test cycle l/100km	5.6	
1059 kg		

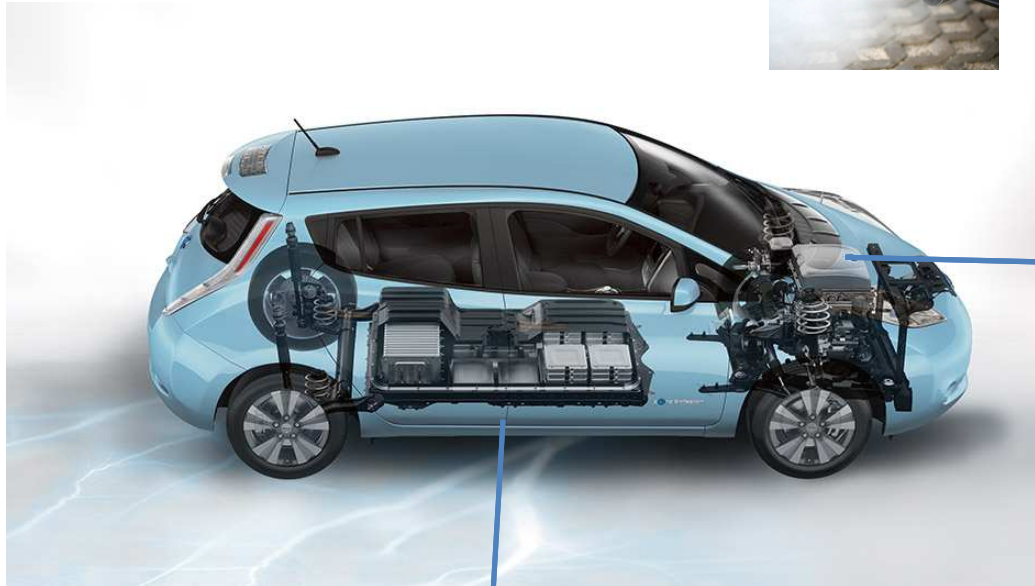
Gasoline Internal combustion engine

https://www.youtube.com/watch?v=DKF5dKo_r_Y

Leaf



No tailpipe emissions

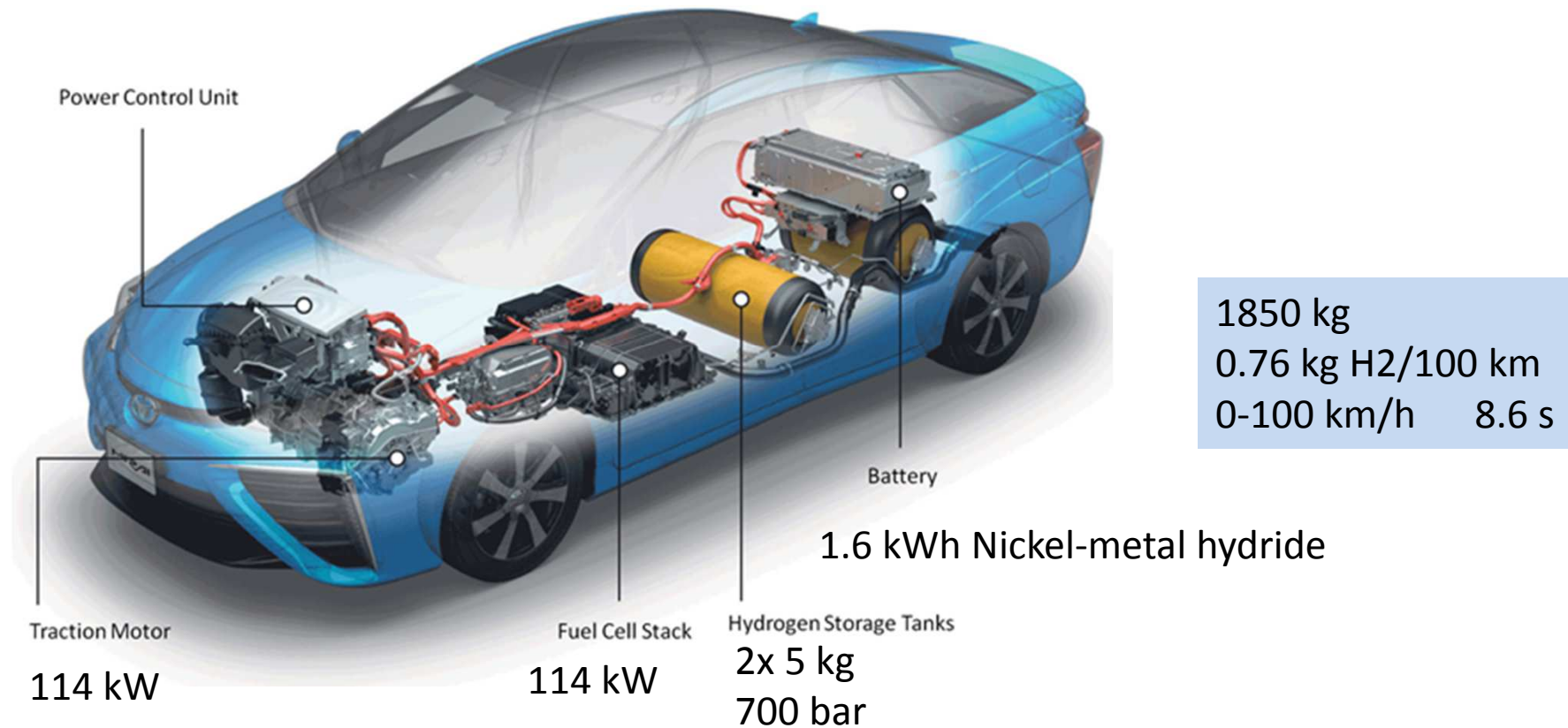


output power increased to over 110 kW (110 kW is peak power of electric motor – previously it was 80 kW)

- 192 cells (nickel manganese cobalt NMC instead lithium manganese oxide cells LMO)
- 24 modules (8 cells per module)
- 40 kWh capacity (32 kWh is available)

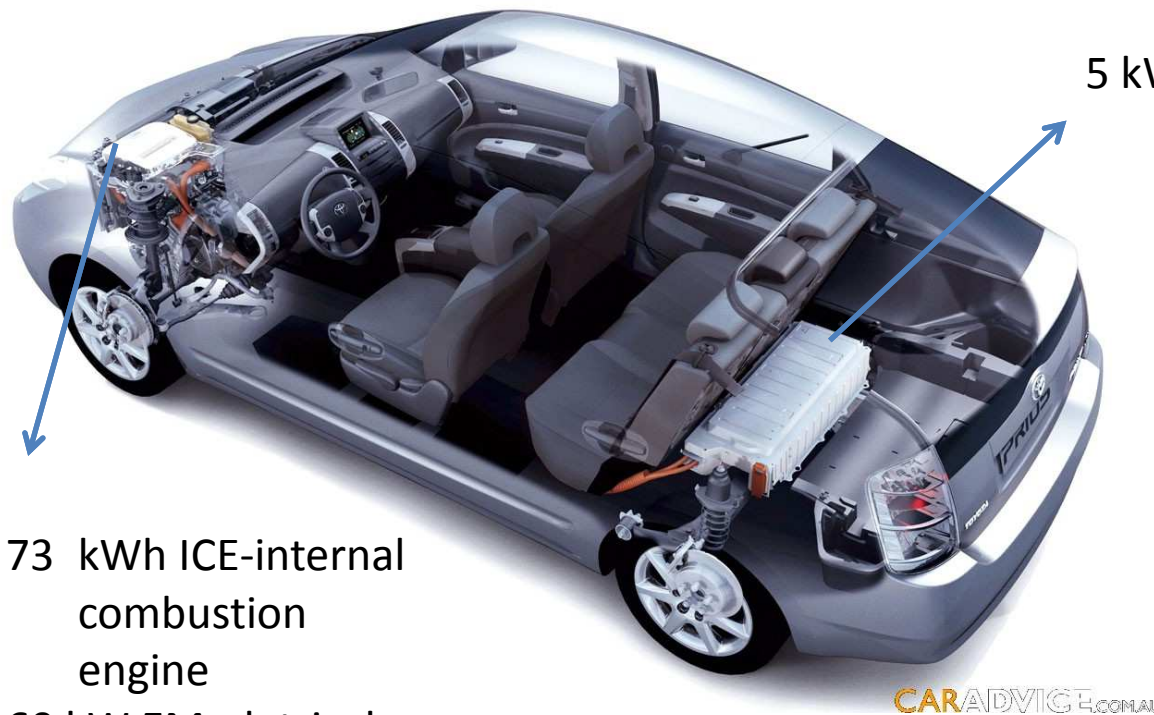
Curb weight (kg)	1570
(kWh/100km)	19.4
0-100km/h in	7.9 seconds

Mirai



<https://www.youtube.com/watch?v=eybTbwOwkec>

Prius

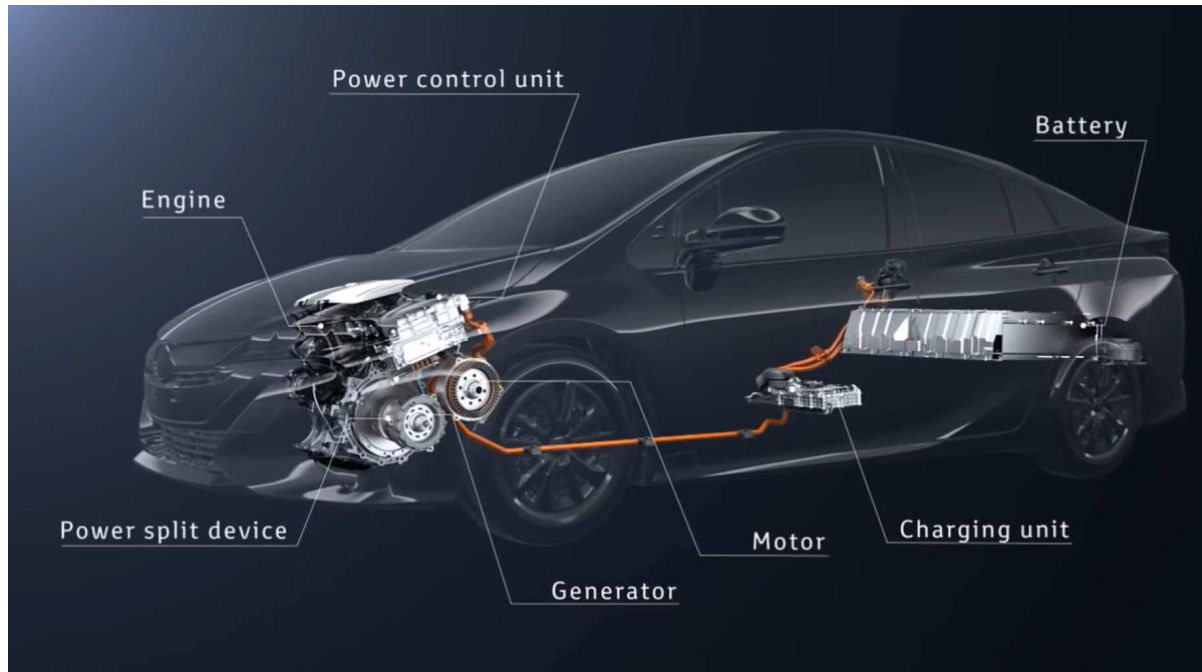


5 kWh Ni-MH

73 kWh ICE-internal
combustion
engine
60 kW EM-eletrical
motor

1475 kg
3 L/100 km
0-100 km/h 10.6 s

Prius plug-in



8.8 kWh Li-ion

1526 kg

1 L/100km

11 kWh/100km

0-100 km/h 11.1 s

100 kW EM-eletrical motor

Flex fuel

Sweden 1952 bioethanol filling pumps



0-100 km/h: 12,0 s
city consumption: 13,6 l/100km
82 kW
1282 kg



85%ethanol
15%gasoline by volume

L/100km x MJ/L = MJ/pkm
1 person (the driver)



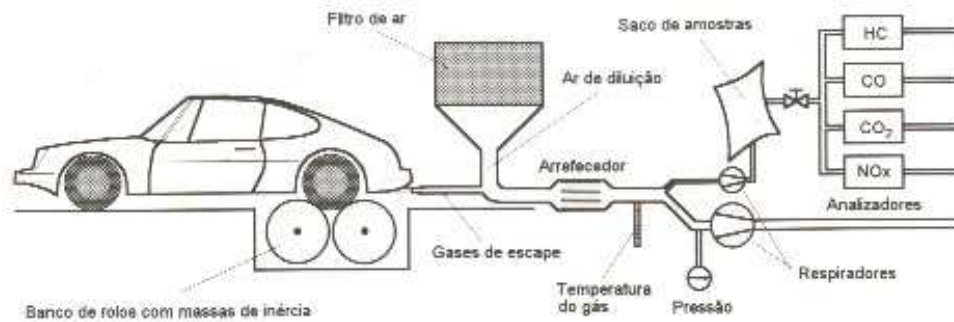
Fuel	MJ/L	Research octane number
Methanol	17.9	108.7
Ethanol	21.2	108.6
E85 (85% ethanol+ 15% gasoline)	25.2	105
Gasohol (90% gasoline + 10% ethanol)	33.7	93/94
Regular gasoline/petrol	34.8	min. 91
Premium gasoline/petrol		max. 104
Diesel	38.6	25

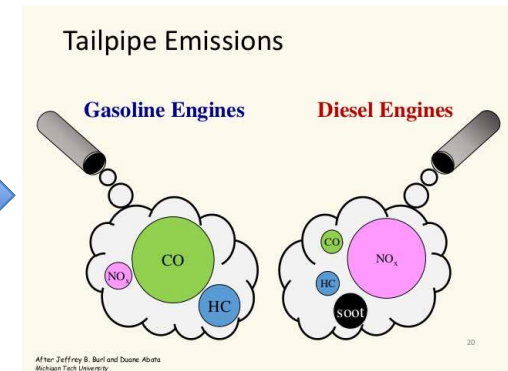
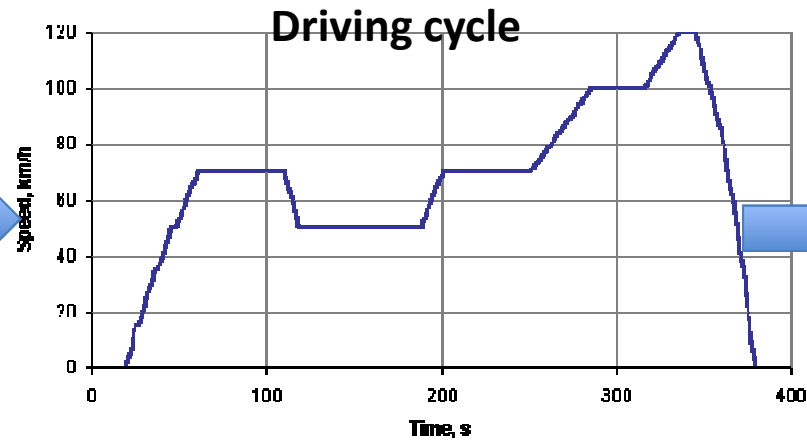
Hydrogen = 120 MJ/kg

Car magazine info.....

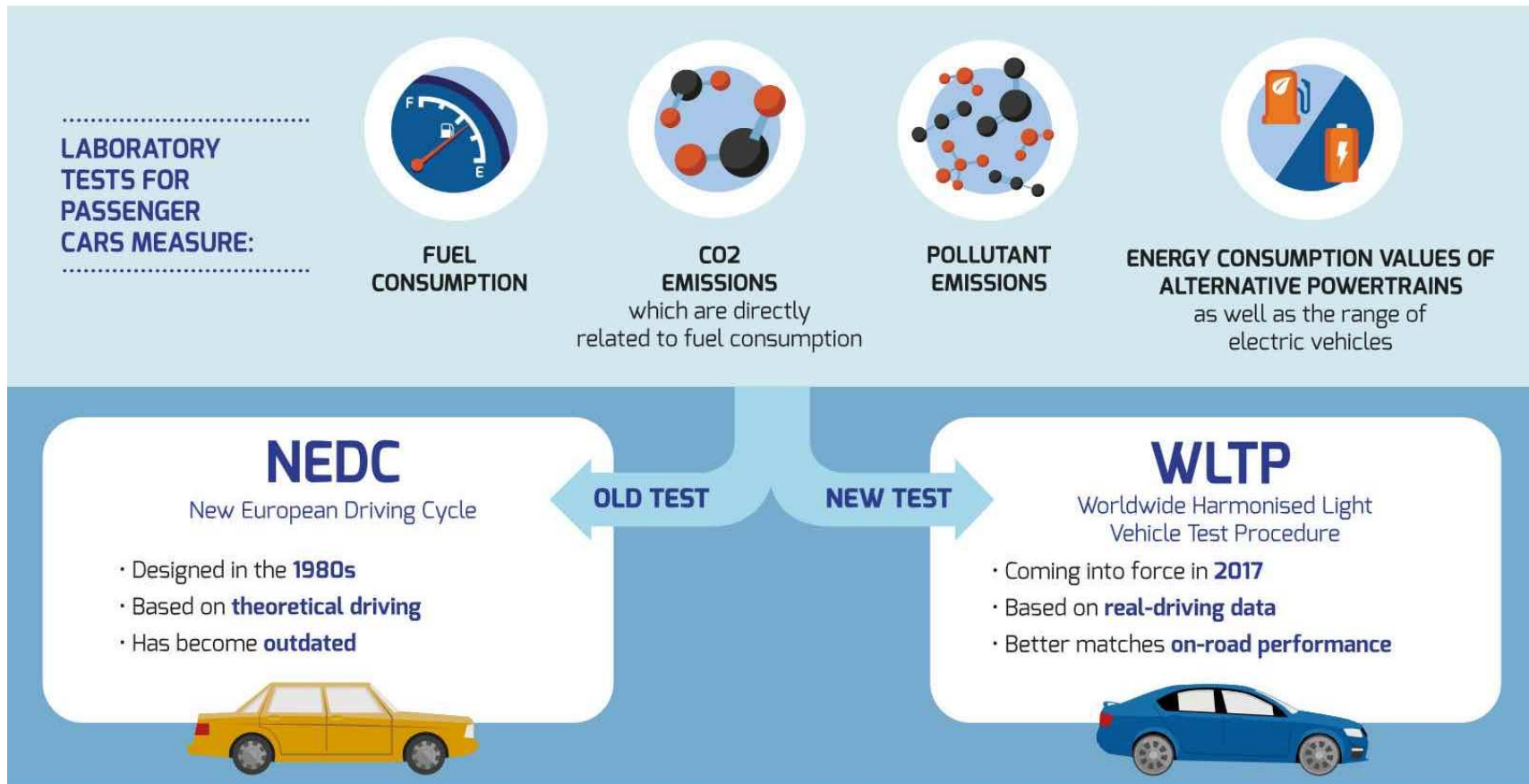


www.dieselnet.com

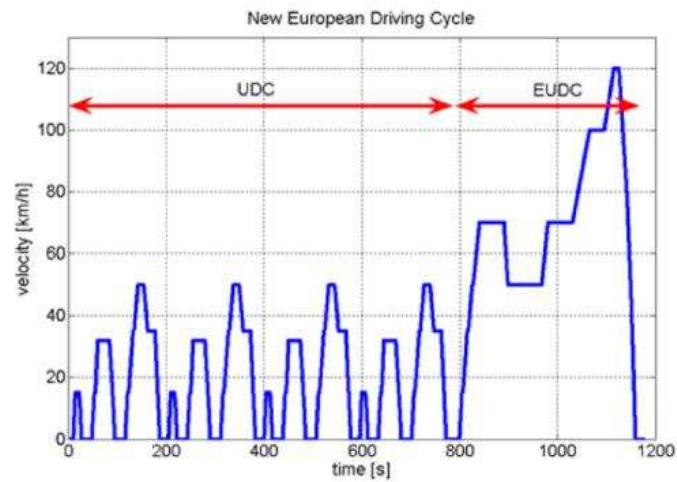




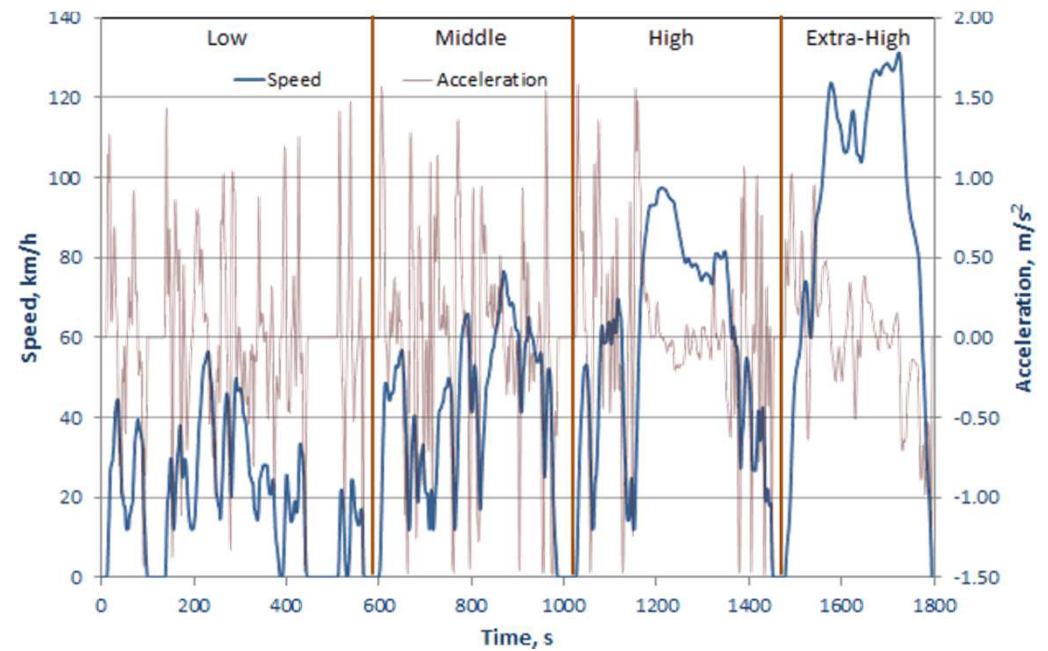
	UDC	EUDC	Artemis Urban	WLTC low*	WLTC
Duration [s]	780	400	993	589	1800
Length [km]	4.00	6.9	4.87	3.09	23.27
Average speed [km/h]	18.4	62.6	17.7	18.9	46.5
Max speed [km/h]	50	120	57.3	56.5	131.3
Idle time [%]	23.1	8.7	20.7	24.8	12.6
Cruising time [%]	25.1	49.2	9.7	15.8	25.3
Acceleration time [%]	27.2	29.8	35.9	28.4	31.9



- 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

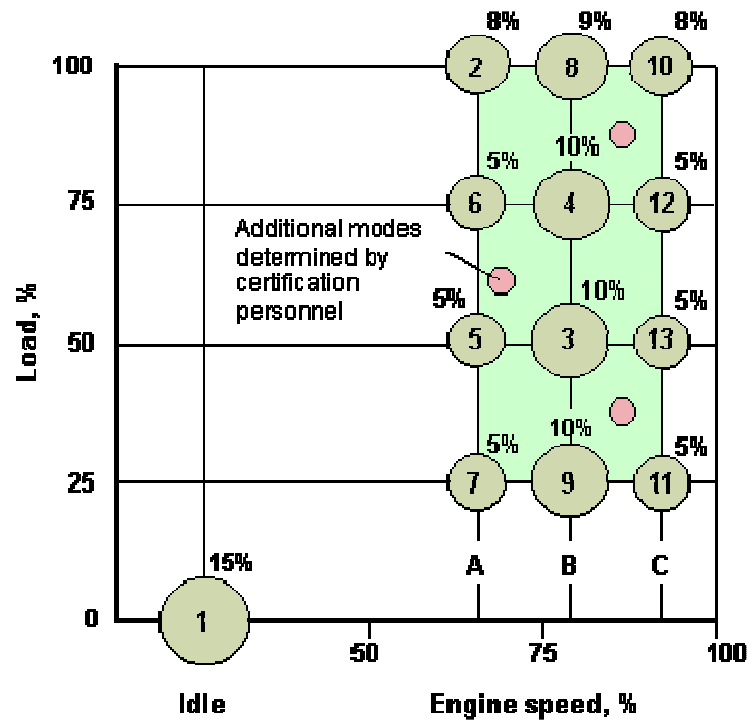
e. applicable only to vehicles using DI engines

f. 0.0045 g/km using the PMP measurement procedure

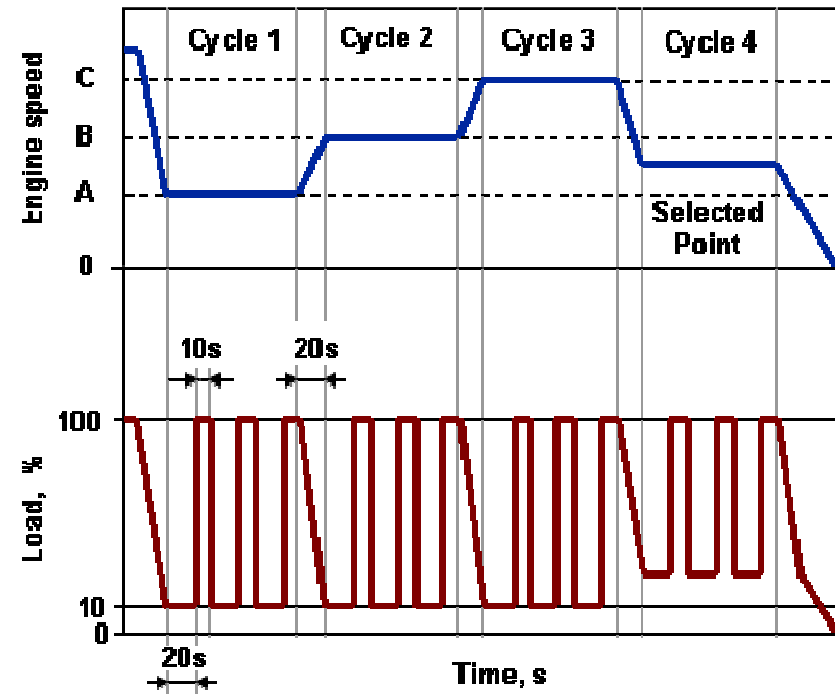
g. 6.0×10¹² 1/km within first three years from Euro 6 effective dates

Heavy-duty





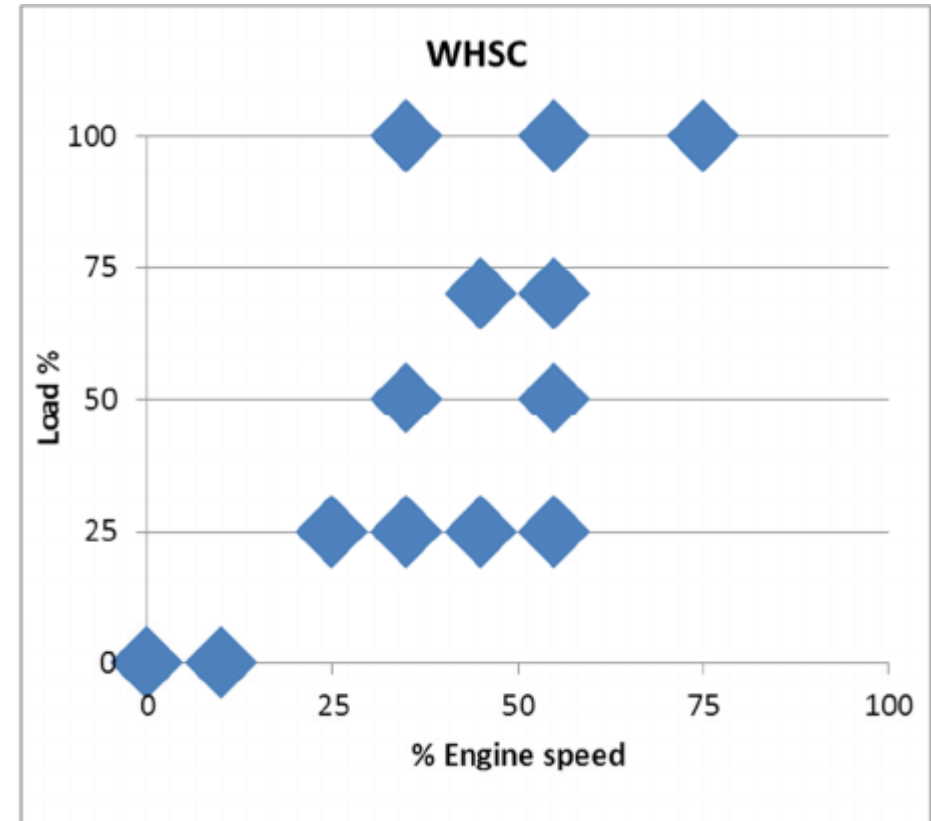
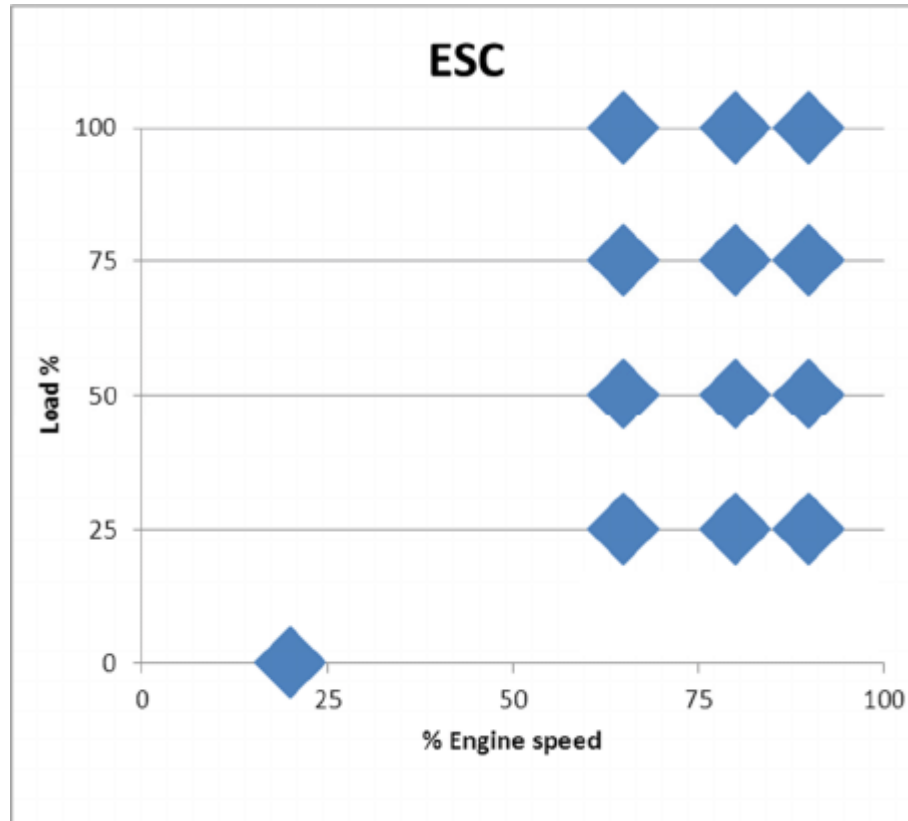
European Stationary Cycle (ESC)



European Load Response (ELR) engine tes



World Harmonized Stationary Cycle (WHSC)



World Harmonized Stationary Cycle (WHSC)

- Europe Heavy-duty

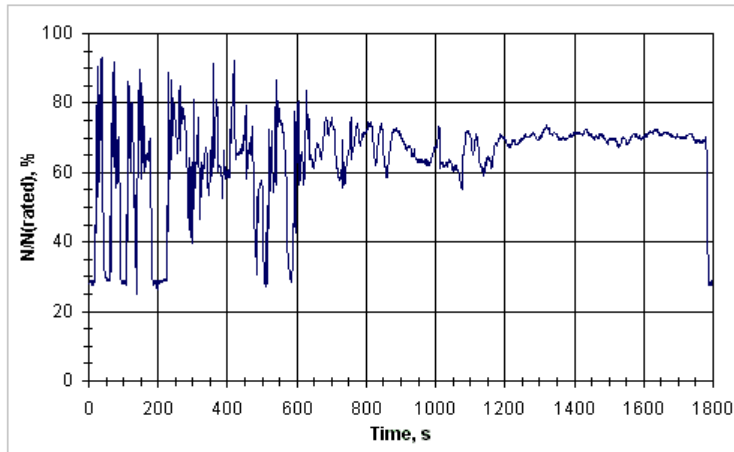
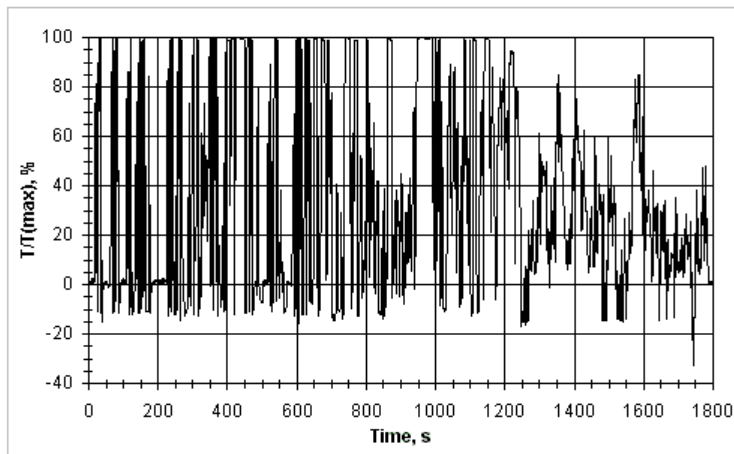
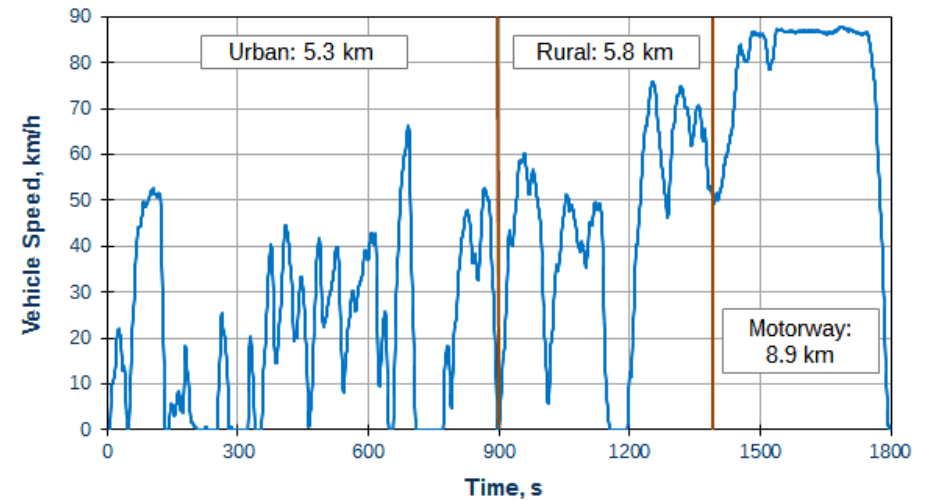


Figure 2. ETC Transient Cycle—Engine Speed



Worldwide Harmonized Heavy-duty Test Procedure (WLTP)-Class 3
P/Weight>34



- Europe Heavy-duty

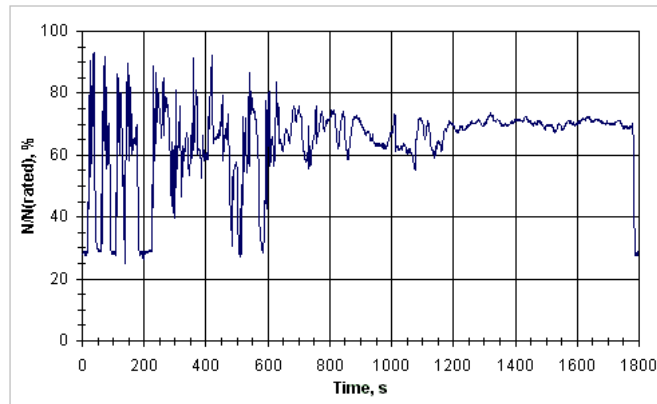


Figure 2. ETC Transient Cycle—Engine Speed

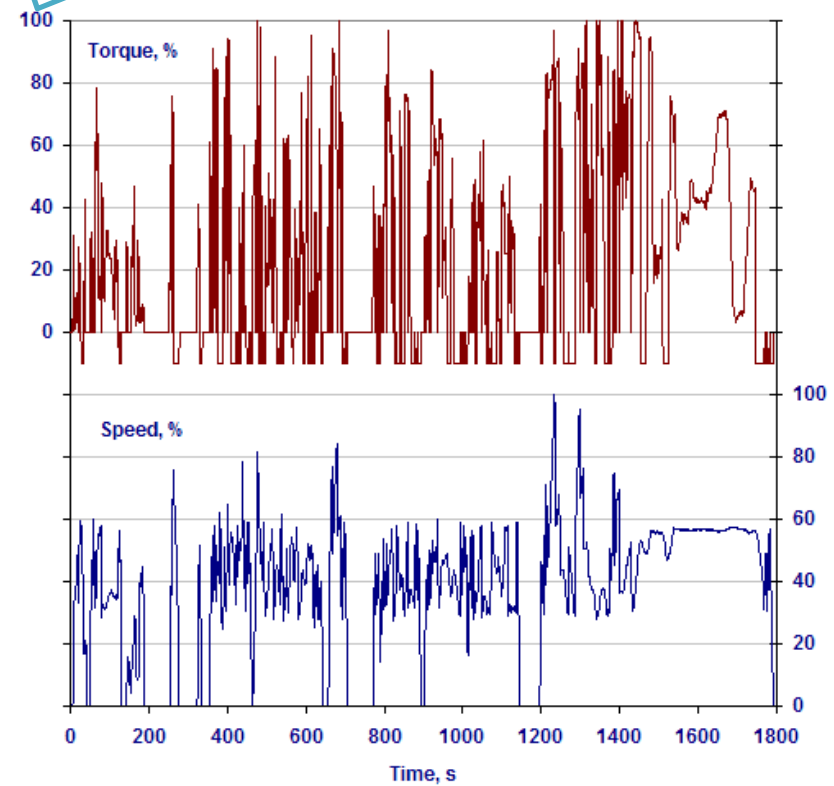
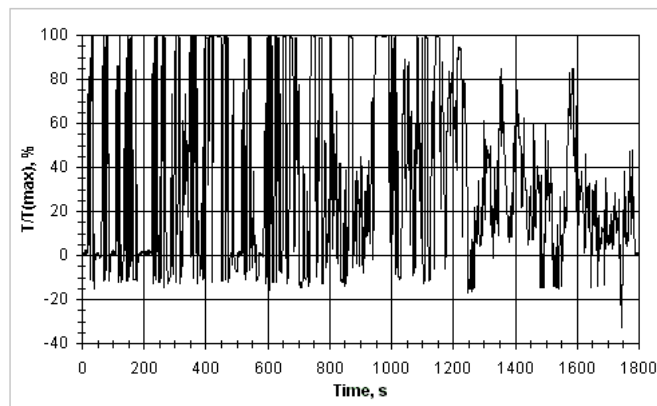


Figure 1. World Harmonized Transient Cycle (WHTC)

Table 1
EU Emission Standards for Heavy-Duty Diesel Engines: Steady-State Testing

Stage	Date	Test	CO	HC	NOx	PM	PN	Smoke
			g/kWh				1/kWh	1/m
Euro I	1992, ≤ 85 kW	ECE R-49	4.5	1.1	8.0	0.612		
	1992, > 85 kW		4.5	1.1	8.0	0.36		
Euro II	1996.10		4.0	1.1	7.0	0.25		
	1998.10		4.0	1.1	7.0	0.15		
Euro III	1999.10 <i>EEV only</i>	ESC & ELR	1.5	0.25	2.0	0.02		0.15
	2000.10		2.1	0.66	5.0	0.10 ^a		0.8
Euro IV	2005.10		1.5	0.46	3.5	0.02		0.5
Euro V	2008.10		1.5	0.46	2.0	0.02		0.5
Euro VI	2013.01	WHSC	1.5	0.13	0.40	0.01	8.0×10 ¹¹	

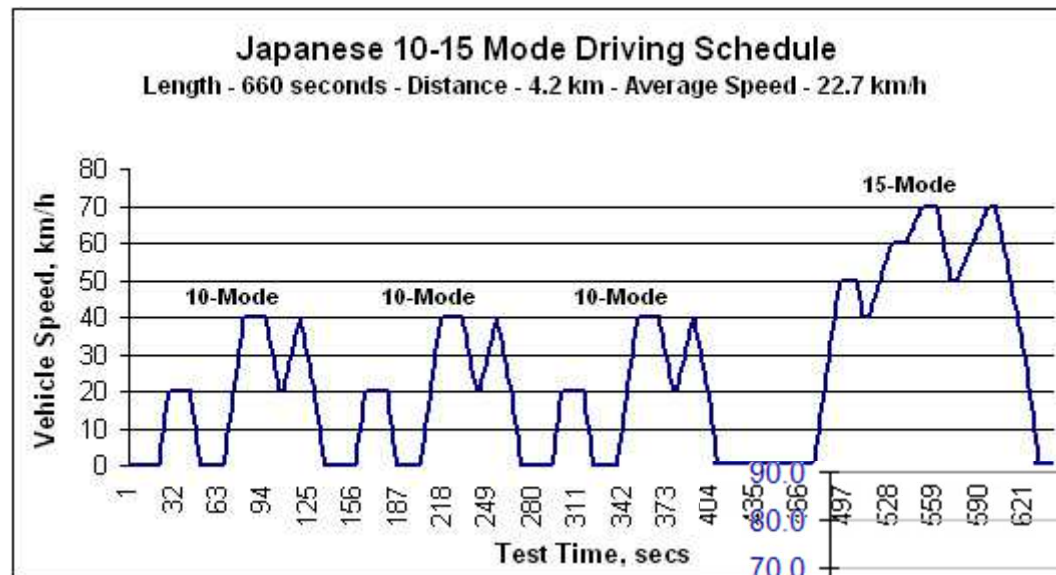
a - PM = 0.13 g/kWh for engines < 0.75 dm³ swept volume per cylinder and a rated power speed > 3000 min⁻¹

Table 2
EU Emission Standards for Heavy-Duty Diesel and Gas Engines: Transient Testing

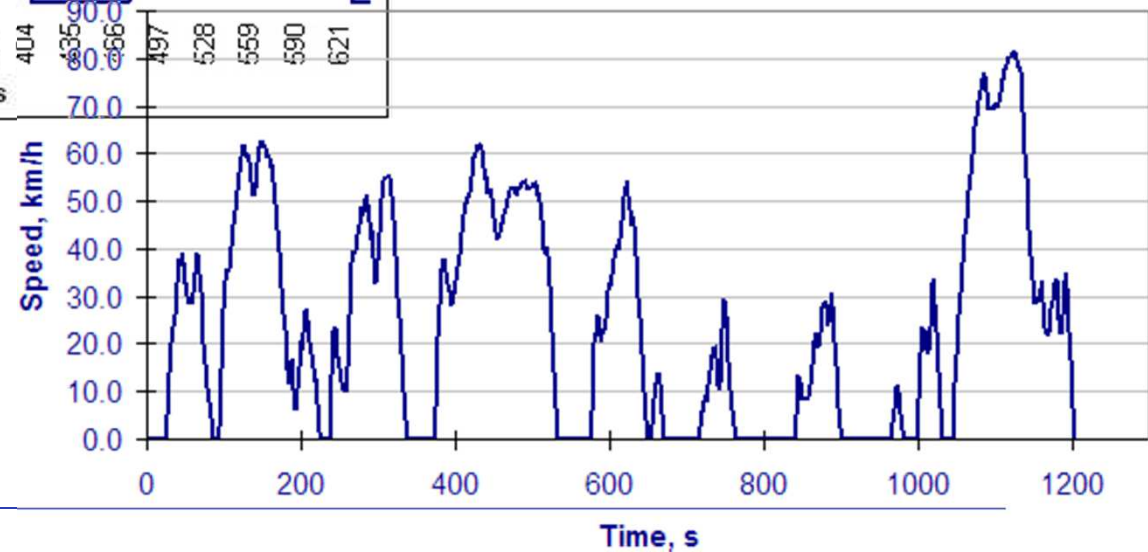
Stage	Date	Test	CO	NMHC	CH ₄ ^a	NOx	PM ^b	PN ^e
			g/kWh				1/kWh	
Euro III	1999.10 <i>EEV only</i>	ETC	3.0	0.40	0.65	2.0	0.02	
	2000.10		5.45	0.78	1.6	5.0	0.16 ^c	
Euro IV	2005.10		4.0	0.55	1.1	3.5	0.03	
Euro V	2008.10		4.0	0.55	1.1	2.0	0.03	
Euro VI	2013.01	WHTC	4.0	0.16 ^d	0.5	0.46	0.01	6.0×10 ¹¹

a - for gas engines only (Euro III-V: NG only; Euro VI: NG + LPG)
b - not applicable for gas fueled engines at the Euro III-IV stages
c - PM = 0.21 g/kWh for engines < 0.75 dm³ swept volume per cylinder and a rated power speed > 3000 min⁻¹
d - THC for diesel engines
e - for diesel engines; PN limit for positive ignition engines TBD

- Japan light-duty



JC08

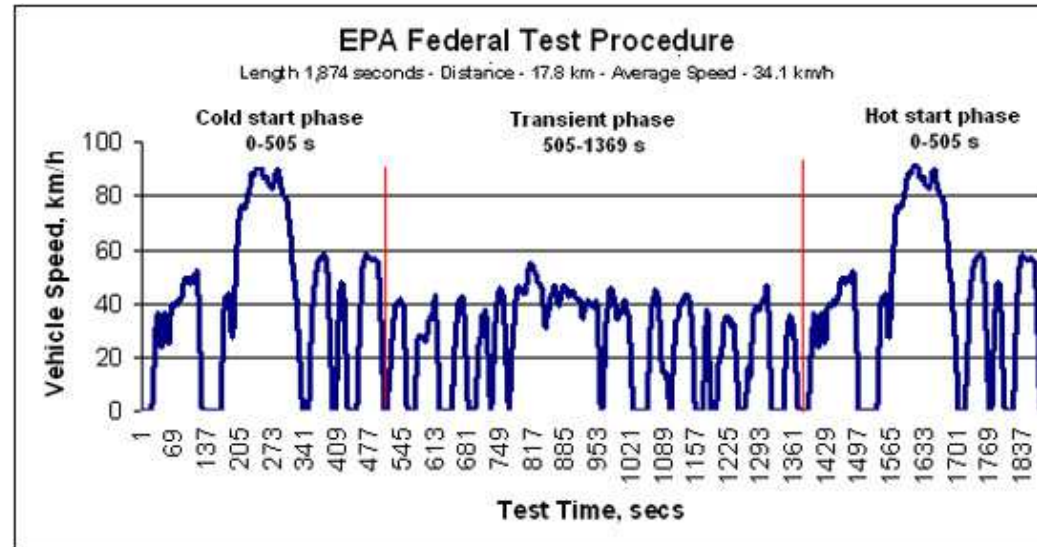


Japanese Emission Standards for Diesel Passenger Cars, g/km

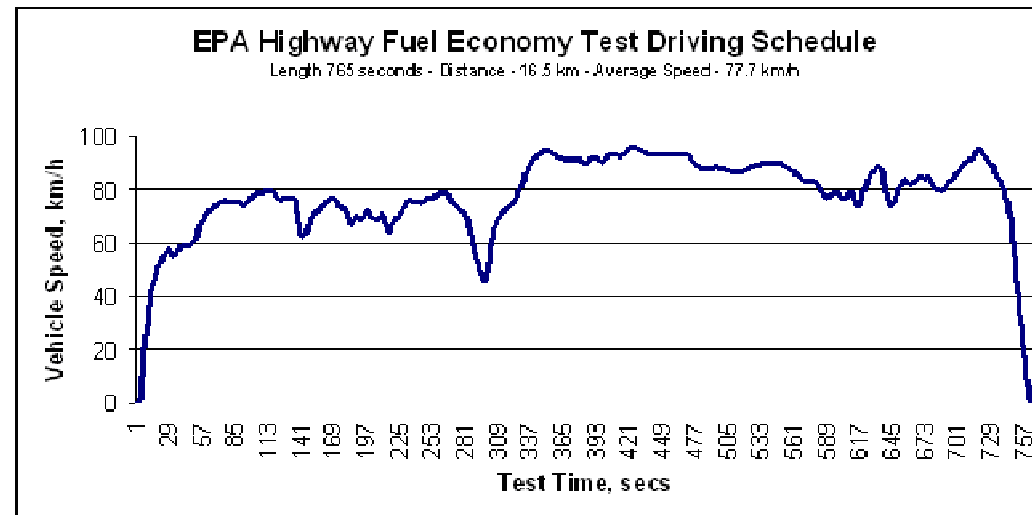
Vehicle Weight	Date	Test	CO	HC	NOx	PM
			mean (max)	mean (max)	mean (max)	mean (max)
< 1250 kg*	1986	10-15 mode	2.1 (2.7)	0.40 (0.62)	0.70 (0.98)	
	1990		2.1 (2.7)	0.40 (0.62)	0.50 (0.72)	
	1994		2.1 (2.7)	0.40 (0.62)	0.50 (0.72)	0.20 (0.34)
	1997		2.1 (2.7)	0.40 (0.62)	0.40 (0.55)	0.08 (0.14)
	2002 ^a		0.63	0.12	0.28	0.052
	2005 ^b	JC08 ^c	0.63	0.024 ^d	0.14	0.013
	2009		0.63	0.024 ^d	0.08	0.005
> 1250 kg*	1986	10-15 mode	2.1 (2.7)	0.40 (0.62)	0.90 (1.26)	
	1992		2.1 (2.7)	0.40 (0.62)	0.60 (0.84)	
	1994		2.1 (2.7)	0.40 (0.62)	0.60 (0.84)	0.20 (0.34)
	1998		2.1 (2.7)	0.40 (0.62)	0.40 (0.55)	0.08 (0.14)
	2002 ^a		0.63	0.12	0.30	0.056
	2005 ^b	JC08 ^c	0.63	0.024 ^d	0.15	0.014
	2009 ^e		0.63	0.024 ^d	0.08	0.005
* - equivalent inertia weight (EIW); vehicle weight of 1265 kg a - 2002.10 for domestic cars, 2004.09 for imports b - full implementation by the end of 2005 c - full phase-in by 2011 d - non-methane hydrocarbons e - 2009.10 for new domestic models; 2010.09 for existing models & imports						

- US-Brasil

- Urban
(55%)



- Extra Urban
(45%)



- US - California**

LEV Emission Standards for Light-Duty Vehicles, FTP-75, g/mi

Category	50,000 miles/5 years					100,000 miles/10 years				
	NMOG ^a	CO	NOx	PM	HCHO	NMOG ^a	CO	NOx	PM	HCHO
Passenger cars										
Tier 1	0.25	3.4	0.4	0.08	-	0.31	4.2	0.6	-	-
TLEV	0.125	3.4	0.4	-	0.015	0.156	4.2	0.6	0.08	0.018
LEV	0.075	3.4	0.2	-	0.015	0.090	4.2	0.3	0.08	0.018
ULEV	0.040	1.7	0.2	-	0.008	0.055	2.1	0.3	0.04	0.011
LDT1, LVW <3,750 lbs										
Tier 1	0.25	3.4	0.4	0.08	-	0.31	4.2	0.6	-	-
TLEV	0.125	3.4	0.4	-	0.015	0.156	4.2	0.6	0.08	0.018
LEV	0.075	3.4	0.2	-	0.015	0.090	4.2	0.3	0.08	0.018
ULEV	0.040	1.7	0.2	-	0.008	0.055	2.1	0.3	0.04	0.011
LDT2, LVW >3,750 lbs										
Tier 1	0.32	4.4	0.7	0.08	-	0.40	5.5	0.97	-	-
TLEV	0.160	4.4	0.7	-	0.018	0.200	5.5	0.9	0.10	0.023
LEV	0.100	4.4	0.4	-	0.018	0.130	5.5	0.5	0.10	0.023
ULEV	0.050	2.2	0.4	-	0.009	0.070	2.8	0.5	0.05	0.013
a - NMHC for all Tier 1 standards										
Abbreviations:										
LVW - loaded vehicle weight (curb weight + 300 lbs)										
LDT - light-duty truck										
NMOG - non-methane organic gases										
HCHO - formaldehyde										

• Brasil - PROCONVE

Table 1
PROCONVE Emission Standards For Passenger Vehicles
(FTP-75; Durability: 80,000 km/5 years)

Tier	Date	Idle CO	CO	THC	NMHC	NOx	HCO	PM
		% vol	g/km					
L-4	1.1.2007 ^{1,2}	0.50	2.0	0.30	0.16	0.25 ³ /0.60 ⁴	0.03	0.05
L-5	1.1.2009 ⁵	0.50	2.0	0.30	0.05	0.12 ³ /0.25 ⁴	0.02	0.05
L-6	1.1.2013 ⁶	0.20	1.3	0.30	0.05	0.08	0.02	0.025

Idle CO limits apply to Otto cycle engines only
 THC limits apply to natural gas vehicles only
 Aldehydes (HCO) limits apply to Otto cycle engines only; Natural gas vehicles exempted
 PM limits apply to Diesel cycle engines only
 (1) 1.1.2005: at least 40% of annual production (passenger vehicles + light commercial vehicles)
 (2) 1.1.2006: at least 70% of annual production (passenger vehicles + light commercial vehicles)

LEV Emission Standards for Light-Duty Vehicles, FTP-75, g/mi

EU Emission Standards for Passenger Cars (Category M₁*)

Category	50,000 miles/5 years					100,000 miles/10 years		CO	HC	HC+NOx	NOx	PM	PN
	NMOG ^a	CO	NOx	PM	HCHO	NMOG ^a	CO	g/km					
Passenger cars								2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)	-
Tier 1	0.25	3.4	0.4	0.08	-	0.31	4.2	1.0	-	0.7	-	0.08	-
TLEV	0.125	3.4	0.4	-	0.015	0.156	4.2	1.0	-	0.9	-	0.10	-
LEV	0.075	3.4	0.2	-	0.015	0.090	4.2	0.64	-	0.56	0.50	0.05	-
ULEV	0.040	1.7	0.2	-	0.008	0.055	2.1	0.50	-	0.30	0.25	0.025	-
								0.50	-	0.23	0.18	0.005 ^f	-
								0.50	-	0.23	0.18	0.005 ^f	6.0×10 ¹¹
								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

2.11 g/km
1.06 g/km

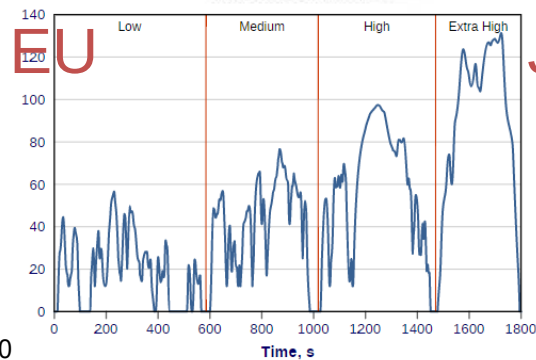
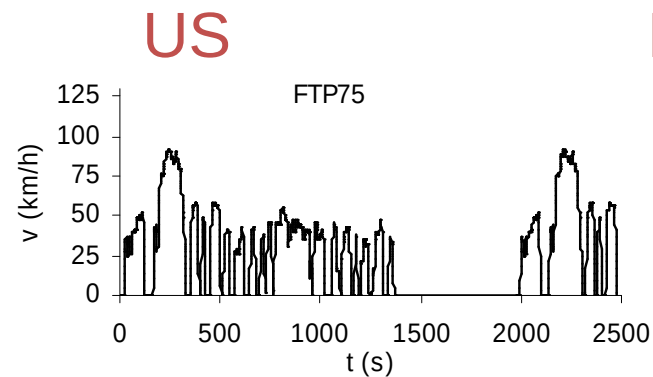
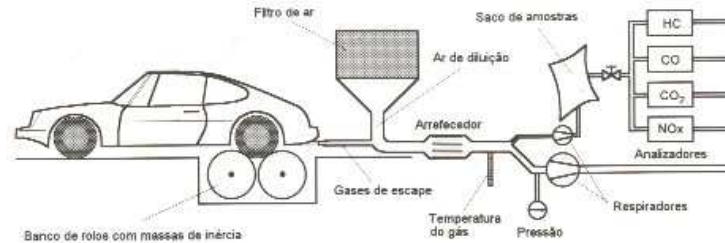


Figure 1. WLTC cycle for Class 3b vehicles

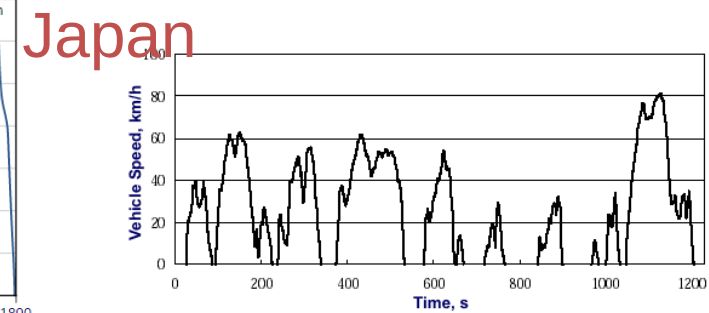
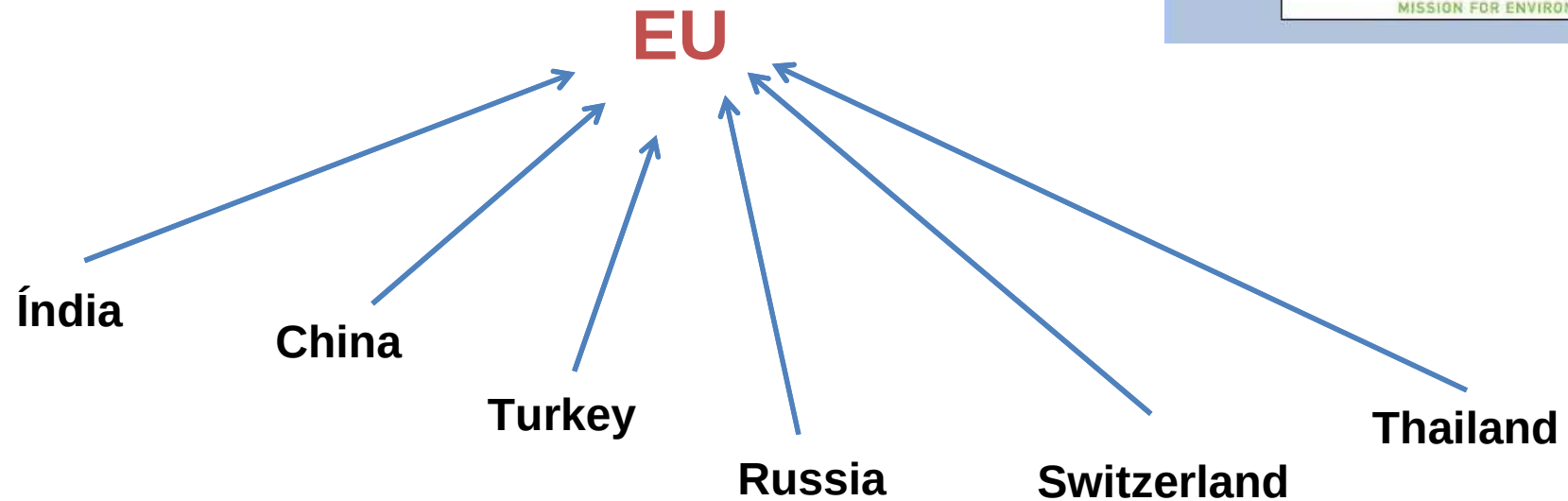
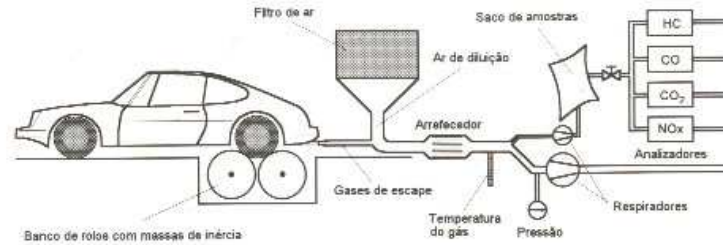


Figure 2. New Transient Mode for Vehicles < 3,500 kg GVW (proposed)

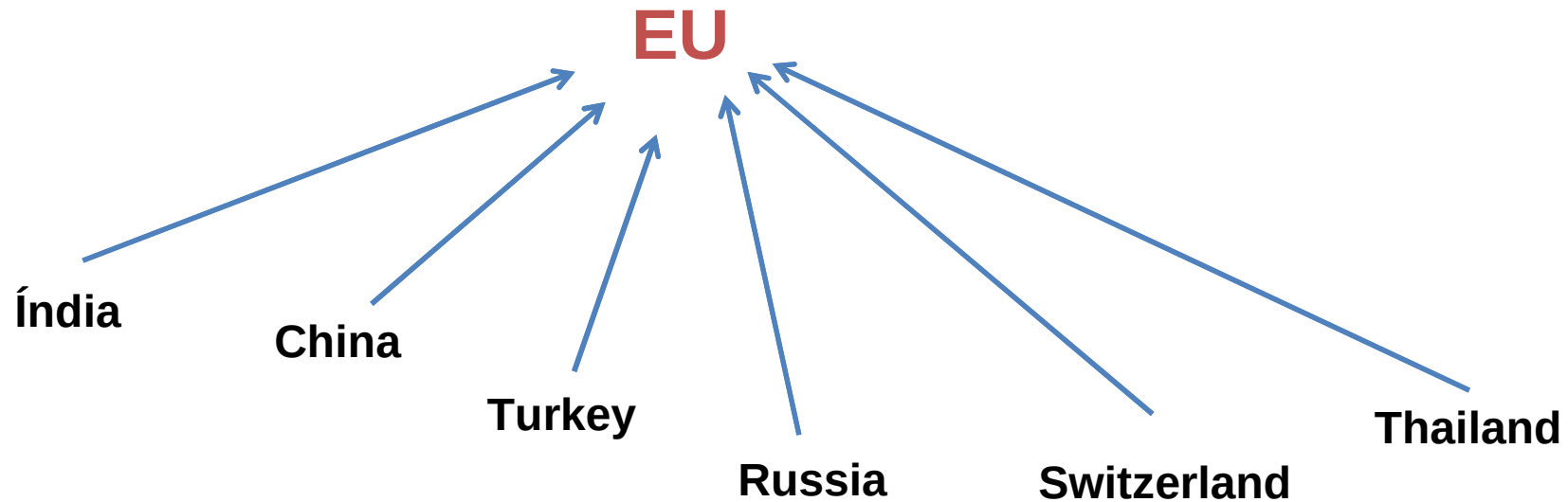
Driving cycle	FTP75	NEDC	10*15 mode
Maximum speed (km/h)	91.2	120	70
Average speed (km/h)	34.1	33.6	22.7
Distance (km)	17.8	11.05	4.16
Time (s/min.)	2479/ 41.3	1180/19.7	660/11
Maximum acceleration (m/s ²)	1.48	1.06	0.79
idle (s)	361	298	215



Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

Table 1
WLTC test cycles

Category	PMR, W/kg	v_max, km/h	Speed Phase Sequence
Class 3b	PMR > 34	v_max ≥ 120	Low 3 + Medium 3-2 + High 3-2 + Extra High 3
Class 3a		v_max < 120	Low 3 + Medium 3-1 + High 3-1 + Extra High 3
Class 2	34 ≥ PMR > 22	-	Low 2 + Medium 2 + High 2 + Extra High 2
Class 1	PMR ≤ 22	-	Low 1 + Medium 1 + Low 1



Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

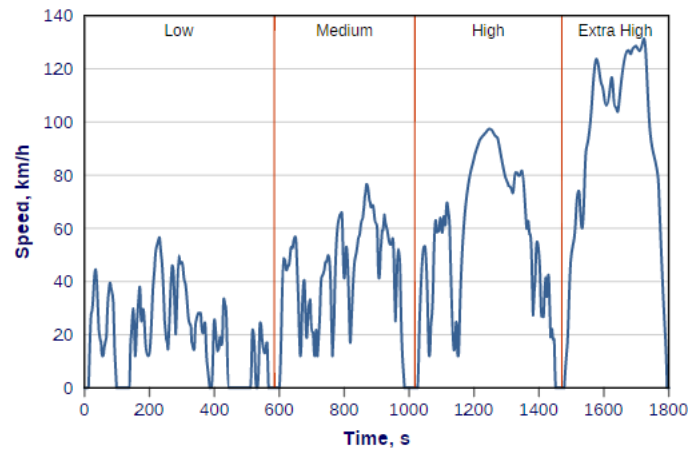


Figure 1. WLTC cycle for Class 3b vehicles

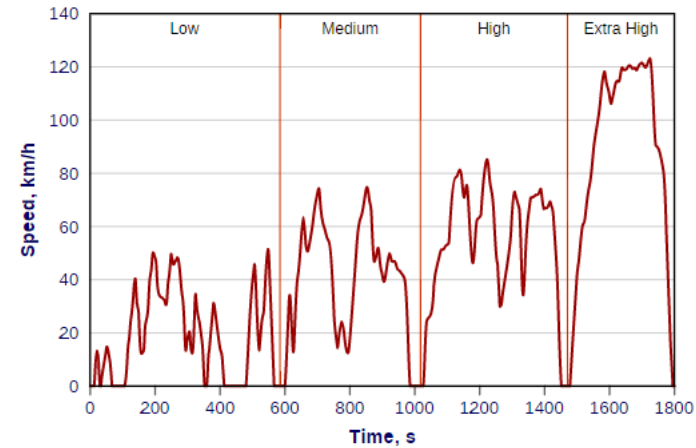


Figure 2. WLTC cycle for Class 2 vehicles

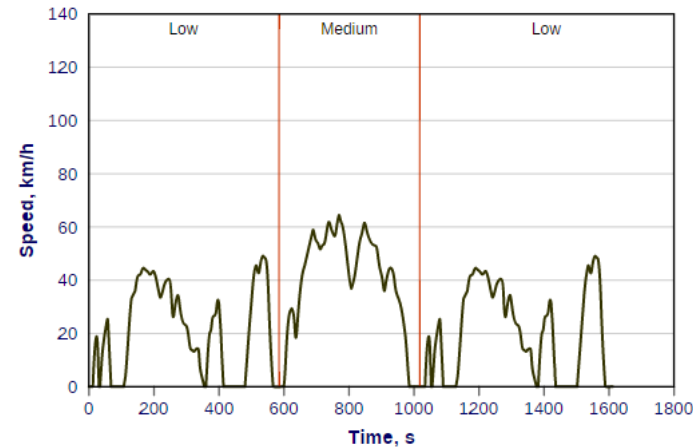
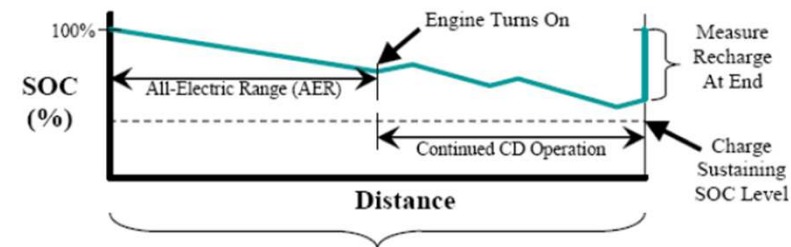


Figure 3. WLTC cycle for Class 1 vehicles

PHEV or off vehicle charging hybrid electric vehicle



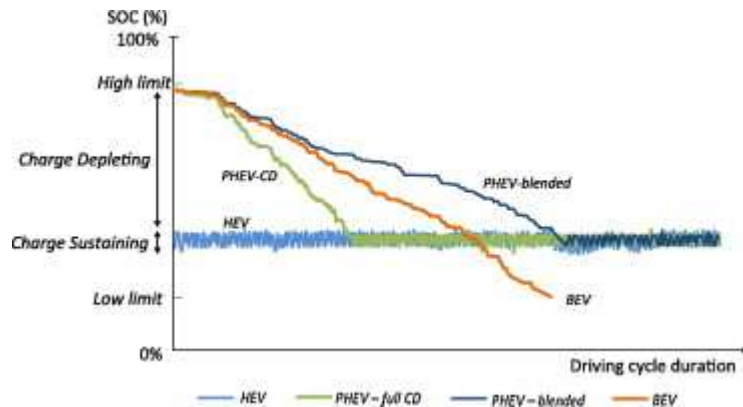
$$mpg_{CD} = \frac{D}{V_{fuel} + \frac{E_{charge}}{E_{gasoline}}}$$



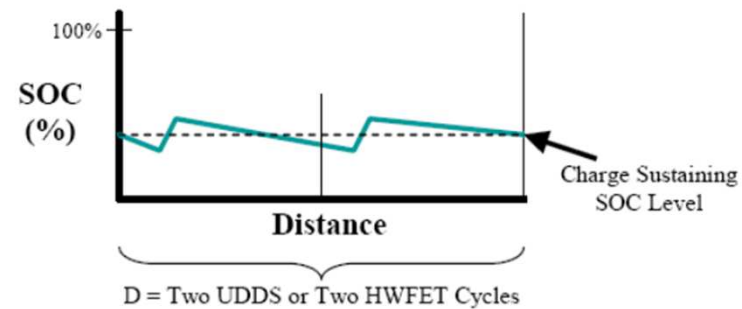
D = Four UDSS or Three HWFET Cycles (~30 miles)
(if no engine on in first 30 miles continue to run cycles until it does turn on)

Figure 3: FCT to measure Charge-Depleting (CD) fuel economy, illustrated with application to the UDSS or HWFET test cycles

SOC - STATE OF CHARGE



$$mpg_{CS} = \frac{D}{V_{fuel}}$$



D = Two UDSS or Two HWFET Cycles

Figure 2: PCT to measure Charge-Sustaining (CS) vehicle fuel economy; illustrated with application to the UDSS or HWFET test cycles

Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

CD

Table 5

WLTC test matrix for hybrid and electric vehicles

CS

		WLTP		WLTP city
		Charge-depleting	Charge-sustaining	Charge-depleting
		Criteria Emissions, FC, CO ₂ , AER, EAER, R _{CDC} , R _{CDA} , E _{AC}	Criteria Emissions, FC, CO ₂	AER _{city} , E _{AC} ^{city}
OVC-HEV	Class 3a	Low 3 + Medium 3-1 + High 3-1 + Extra High 3	Low 3 + Medium 3-1 + High 3-1 + Extra High 3	Low 3 + Medium 3-1
	Class 3b	Low 3 + Medium 3-2 + High 3-2 + Extra High 3	Low 3 + Medium 3-2 + High 3-2 + Extra High 3	Low 3 + Medium 3-2
NOVC-HEV	Class 3a	--	Low 3 + Medium 3-1 + High 3-1 + Extra High 3	--
	Class 3b	--	Low 3 + Medium 3-2 + High 3-2 + Extra High 3	--
PEV	Class 3a	Low 3 + Medium 3-1 + High 3-1 + Extra High 3	--	Low 3 + Medium 3-1
	Class 3b	Low 3 + Medium 3-2 + High 3-2 + Extra High 3	--	Low 3 + Medium 3-2

Abbreviations:
AER - All-electric range
EAER - Equivalent all-electric range
E_{AC} - Recharged energy
FC - Fuel consumption
NOVC-HEV - not off-vehicle charging hybrid electric vehicle
OVC-HEV - off-vehicle charging hybrid electric vehicle
PEV - pure electric vehicle
R_{CDA} - Charge-depleting actual range
R_{CDC} - Charge-depleting cycle range



Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

<https://carfueldata.vehicle-certificationagency.gov.uk/downloads/default.aspx>

TOYOTA	Prius Plug-in, MY2017,	1.8 VVT-i Auto	AT,	1798 cm3,	Electricity / Petrol
Euro Standard	Noise Level dB(A)	CO [mg/km]	THC [mg/km]	NOx [mg/km]	
6	67	67	17	1	
Electric energy consumption Wh/km	Maximum range (km)	Metric Combined (L/100km)	CO2 g/km		
72	63	1	22		



Vehicle Certification Agency



Worldwide Harmonized Light Vehicles Test Cycle (WLTC)



Vehicle Certification Agency

AUDI Q7 e-tron 3.0 TDI quattro (258PS) V6 8speed Tiptronic with 19" wheels QA8 2967 cm3
Electricity / Diesel

Euro Standard	Noise Level dB(A)	CO [mg/km]	THC [mg/km]	NOx [mg/km]	PM [mg/km]
6	70	53	6	22	0.34

Electric energy consumption Wh/km	Maximum range (km)	Metric Combined (L/100km)	CO2 g/km
181	56	1.8	48



Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

NISSAN Leaf, MY2016, 30 kWh Electricity

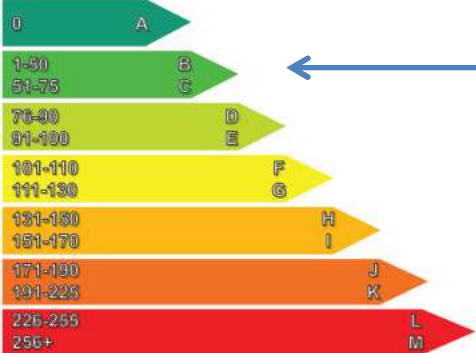
Euro Standard	Noise Level dB(A)	CO [mg/km]	THC [mg/km]	NOx [mg/km]
6	68	0	0	0

Electric energy consumption Wh/km	Maximum range (km)	Metric Combined (L/100km)	CO2 g/km
150	250	0	0



Vehicle Certification Agency



Fuel Economy		CO ₂ emissions	
CO ₂ emissions figure (g/km)			
			
Fuel and Electricity cost (estimated) for 12,000 miles A guide price for comparison purposes is calculated using the combined drive cycle (town centre and motorway) and average fuel and electricity price. Fuel consumption for plug-in hybrid vehicles is measured in two conditions, one with the battery freshly charged and another where it is significantly depleted. A weighted average of the two figures obtained is calculated based on an assumption that a vehicle is driven 16 miles (25km) beyond its maximum electric range, using the engine as required without recharging. Cost is recalculated annually. Unit Cost as at March 2018: petrol £1.19/litre, diesel £1.23/litre, electricity 15.9p/kWh.		Fuel £	Electricity £
		Total ⁽³⁾ £	
VED for 12 months Vehicle excise duty (VED) or road tax varies according to the CO ₂ emissions and fuel type of the vehicle.		1st year rate ⁽¹⁾ £	Standard rate ⁽²⁾ £
Air Quality Information Euro 6d(TEMP) includes an RDE (Real Driving Emissions) requirement to deliver greater on-road emissions reductions. Vehicles that already comply with the future requirements for RDE, Euro 6d, will be exempt from the diesel supplement. All new cars are Euro 6. Euro 6 cars meet current minimum standards for clean air zones.		Euro Standard	Diesel VED supplement
Energy consumption: Mpg and Miles/kWh ⁽³⁾		Electric range: Miles ⁽³⁾	
Environmental Information: A guide on fuel economy and CO₂ emissions which contains data for all new passenger car models is available at any point of sale free of charge. In addition to the fuel efficiency of a car, driving behaviour as well as other non-technical factors play a role in determining a car's fuel consumption and CO₂ emissions. CO₂ is the main greenhouse gas responsible for global warming.			
Make/Model:		Engine Capacity (cc):	
Fuel Type: ⁽⁴⁾		Transmission: N/A	
Fuel Consumption: Drive cycle		Litres/100km	
Urban		N/A	
Extra-urban		N/A	
Weighted Combined		⁽³⁾	
Carbon dioxide emissions (g/km) (weighted): Important note: Some specifications of this make/model may have lower CO ₂ emissions than this. Check with your dealer.			

⁽¹⁾ A new 1st year VED rate will be applied to cars registered for the first time (scheme effective from April 2010 and revised April 2017).

⁽²⁾ The standard 12 month VED rate for all registered cars in this band is shown for the purposes of comparison. Note, figures quoted reflect the current rate only, and may be subject to change in the future. Cars with a list price of over £40,000 when new pay an additional rate of £310 per year on top of the standard rate for five years.

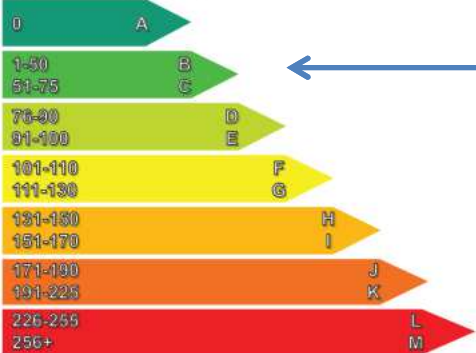
(1) A new 1st year VED rate will be applied to cars registered for the first time (scheme effective from April 2010 and revised April 2017).

(2) The standard 12 month VED rate for all registered cars in this band is shown for the purposes of comparison. Note, figures quoted reflect the current rate only, and may be subject to change in the future. Cars with a list price of over £40,000 when new pay an additional rate of £310 per year on top of the standard rate for five years.

(3) Mpg and Miles/kWh are calculated using the combined drive cycle.



<https://carfueldata.vehicle-certification-agency.gov.uk/additional/labels/2018-Electric-Hybrid-Label-Blank.pdf>

Fuel Economy		CO ₂ emissions	
CO ₂ emissions figure (g/km)			
			
Fuel and Electricity cost (estimated) for 12,000 miles A guide price for comparison purposes is calculated using the combined drive cycle (town centre and motorway) and average fuel and electricity price. Fuel consumption for plug-in hybrid vehicles is measured in two conditions, one with the battery freshly charged and another where it is significantly depleted. A weighted average of the two figures obtained is calculated based on an assumption that a vehicle is driven 16 miles (25km) beyond its maximum electric range, using the engine as required without recharging. Cost is recalculated annually. Unit Cost as at March 2018: petrol £1.19/litre, diesel £1.23/litre, electricity 15.9p/kWh.		Fuel £	Electricity £
VED for 12 months Vehicle excise duty (VED) or road tax varies according to the CO ₂ emissions and fuel type of the vehicle.		1st year rate ⁽¹⁾ £	Standard rate ⁽²⁾ £
Air Quality Information Euro 6d(TEMP) includes an RDE (Real Driving Emissions) requirement to deliver greater on-road emissions reductions. Vehicles that already comply with the future requirements for RDE, Euro 6d, will be exempt from the diesel supplement. All new cars are Euro 6. Euro 6 cars meet current minimum standards for clean air zones.		Euro Standard	Diesel VED supplement
Energy consumption: Mpg and Miles/kWh ⁽³⁾		Electric range: Miles ⁽³⁾	
Environmental Information: A guide on fuel economy and CO₂ emissions which contains data for all new passenger car models is available at any point of sale free of charge. In addition to the fuel efficiency of a car, driving behaviour as well as other non-technical factors play a role in determining a car's fuel consumption and CO₂ emissions. CO₂ is the main greenhouse gas responsible for global warming.			
Make/Model:		Engine Capacity (cc):	
Fuel Type: ⁽⁴⁾		Transmission: N/A	
Fuel Consumption:	Litres/100km	Mpg	
Drive cycle			
Urban	N/A	N/A	
Extra-urban	N/A	N/A	
Weighted Combined			
Carbon dioxide emissions (g/km) (weighted): Important note: Some specifications of this make/model may have lower CO ₂ emissions than this. Check with your dealer.			
(1) A new 1st year VED rate will be applied to cars registered for the first time (scheme effective from April 2010 and revised April 2017). (2) The standard 12 month VED rate for all registered cars in this band is shown for the purposes of comparison. Note, figures quoted reflect the current rate only, and may be subject to change in the future. Cars with a list price of over £40,000 when new pay an additional rate of £310 per year on top of the standard rate for five years. (3) (3) (4)			

⁽¹⁾ A new 1st year VED rate will be applied to cars registered for the first time (scheme effective from April 2010 and revised April 2017).

⁽²⁾ The standard 12 month VED rate for all registered cars in this band is shown for the purposes of comparison. Note, figures quoted reflect the current rate only, and may be subject to change in the future. Cars with a list price of over £40,000 when new pay an additional rate of £310 per year on top of the standard rate for five years.

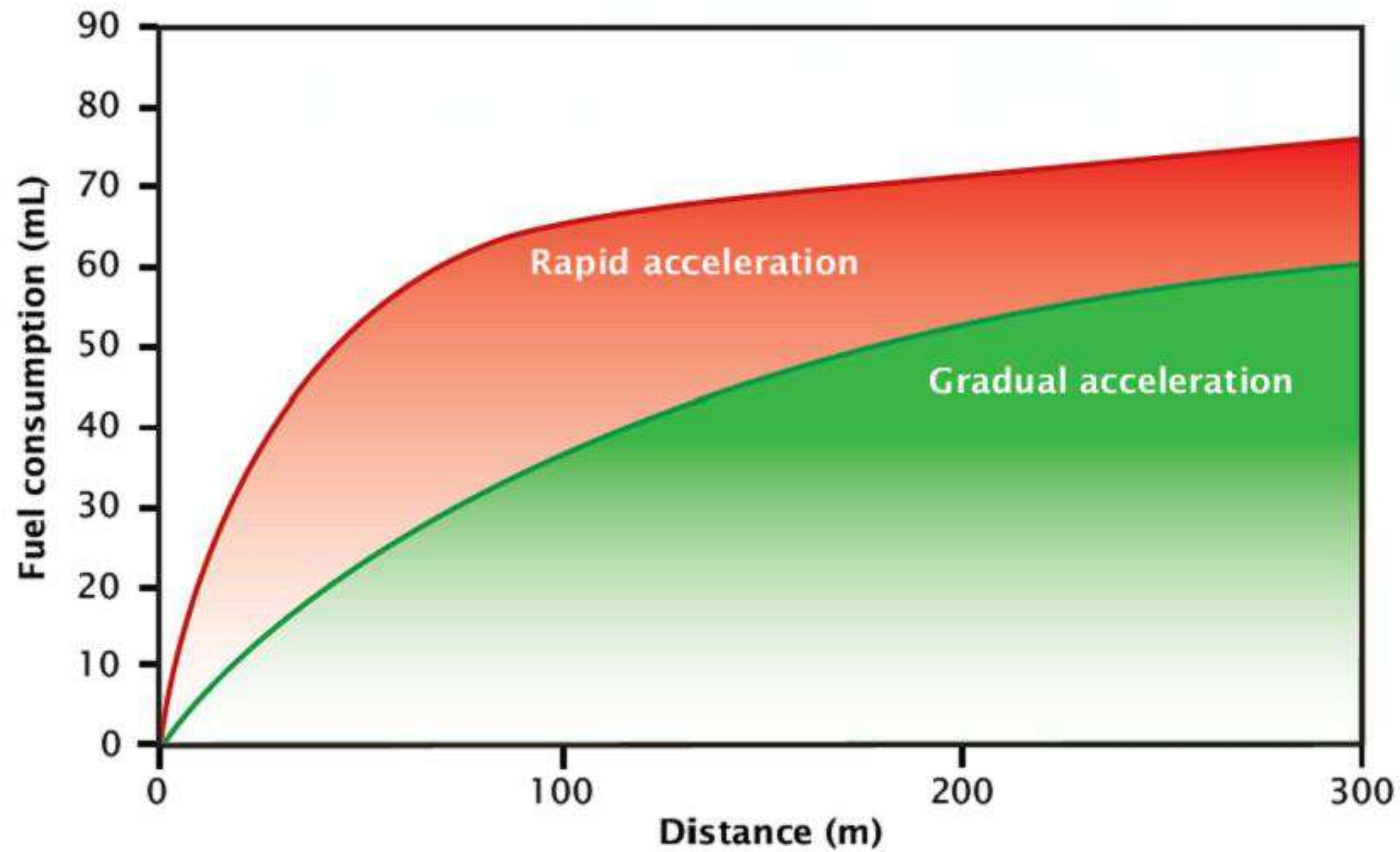
⁽³⁾ Mpg and Miles/kWh are calculated using the combined drive cycle.



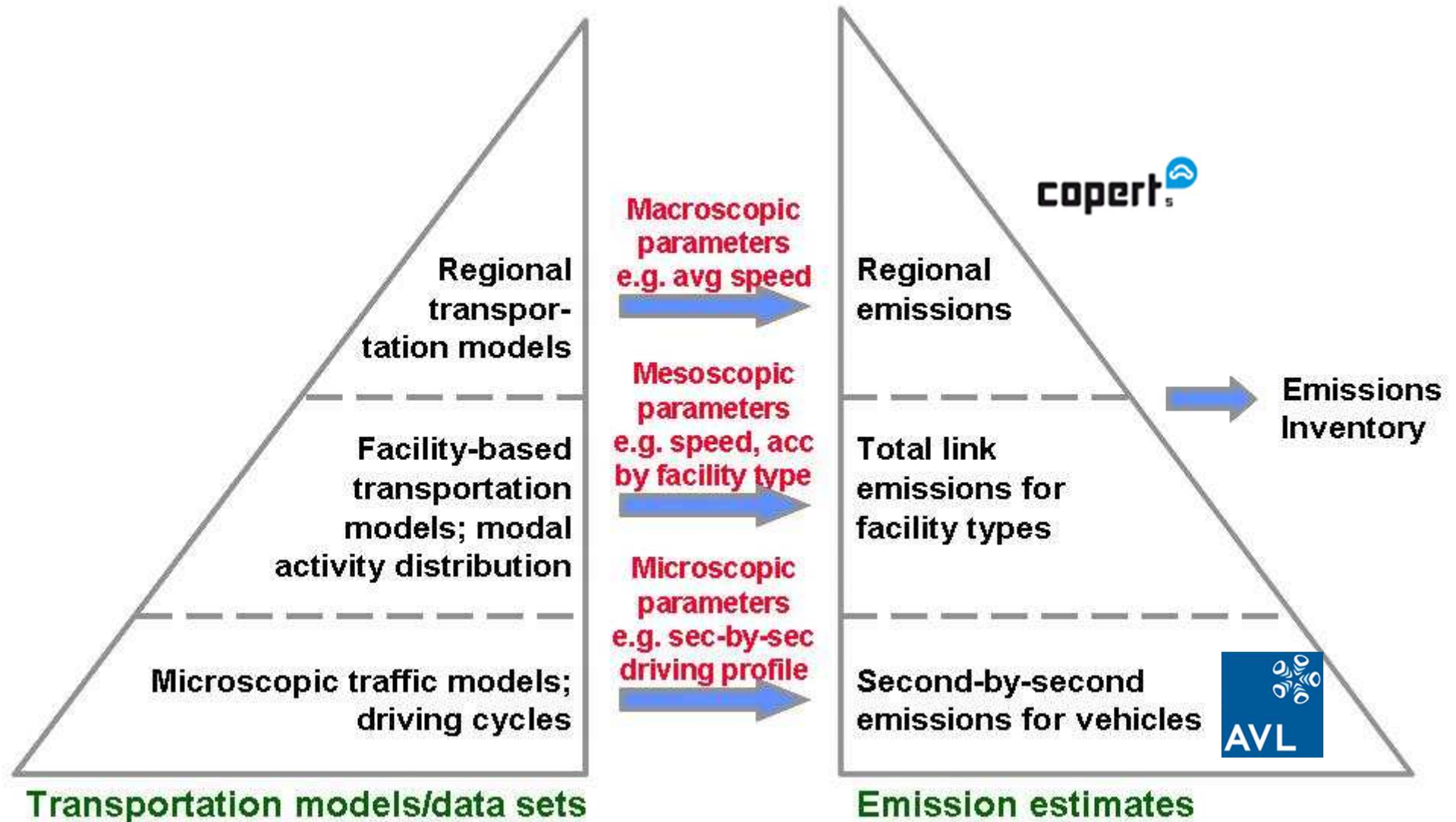
Fuel Economy		CO ₂ emissions	
CO ₂ emissions figure (g/km)		0 g/km ⁽¹⁾	
D A 1-50 B 51-75 C 76-100 D 101-130 E 131-150 F 151-170 G 171-190 H 191-225 I 226-255 J 256+ K			
		Annual energy cost ⁽³⁾	
		1st year rate ⁽¹⁾	Standard rate ⁽²⁾
		£0	£0
Electric energy consumption: Miles/kWh ⁽³⁾		Electric range: Miles ⁽³⁾	
Environmental Information: A guide on fuel economy and CO ₂ emissions which contains data for all new passenger car models is available at any point of sale free of charge. In addition to the fuel efficiency of a car, driving behaviour as well as other non-technical factors play a role in determining a car's fuel consumption and CO ₂ emissions. CO ₂ is the main greenhouse gas responsible for global warming.			
Make/Model:		Engine Capacity (cc): N/A	
Fuel Type: Electricity ⁽⁴⁾		Transmission: N/A	
Fuel Consumption:	Litres/100km ⁽⁵⁾	Mpg ⁽⁵⁾	
Drive cycle			
Urban	N/A	N/A	
Extra-urban	N/A	N/A	
Combined	N/A	N/A	
Carbon dioxide emissions (g/km): 0			
Important note: Some specifications of this make/model may have lower CO ₂ emissions than this. Check with your dealer.			
(1) A new 1st year VED rate will be applied to cars registered for the first time (scheme effective from April 2010 and revised April 2017). (2) The standard 12 month VED rate for all registered cars in this band is shown for the purposes of comparison. Note, figures quoted reflect the current rate only, and may be subject to change in the future. Cars with a list price of over £40,000 when new pay an additional rate of £310 per year on top of the standard rate for five years. (3) Please note that figures quoted are obtained under specific test conditions, they may not be achieved under 'real world' driving conditions. However, the figures serve as a means of comparing models of a similar type. (4) A list of electric vehicle charging points is available here: https://www.zap-map.com/live/ (5) Not available for electric cars			
 Department for Transport		 Vehicle Certification Agency	
Important note: The test used to establish the fuel consumption and CO ₂ figures above is changing. To find out more about this and how it might affect your purchasing decision, please read the accompanying fact sheet.			

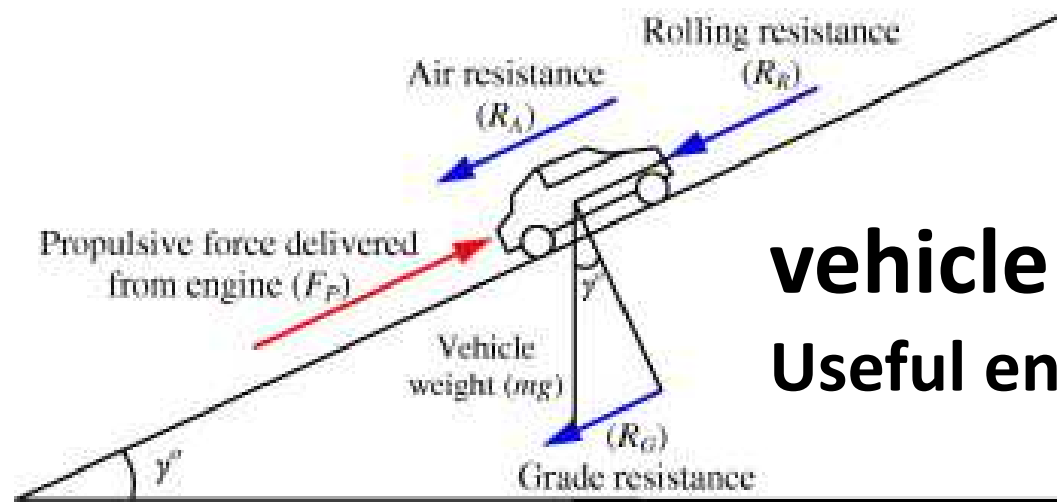


Effect of acceleration rate on fuel consumption of a Pontiac G5





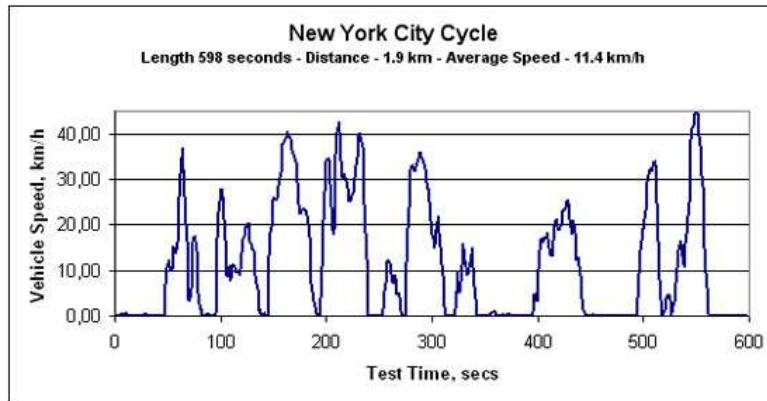




vehicle dynamics

Useful energy consumption

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



Rolling k_r
Aerodynamics $C_d A_f$
Propulsion k_m

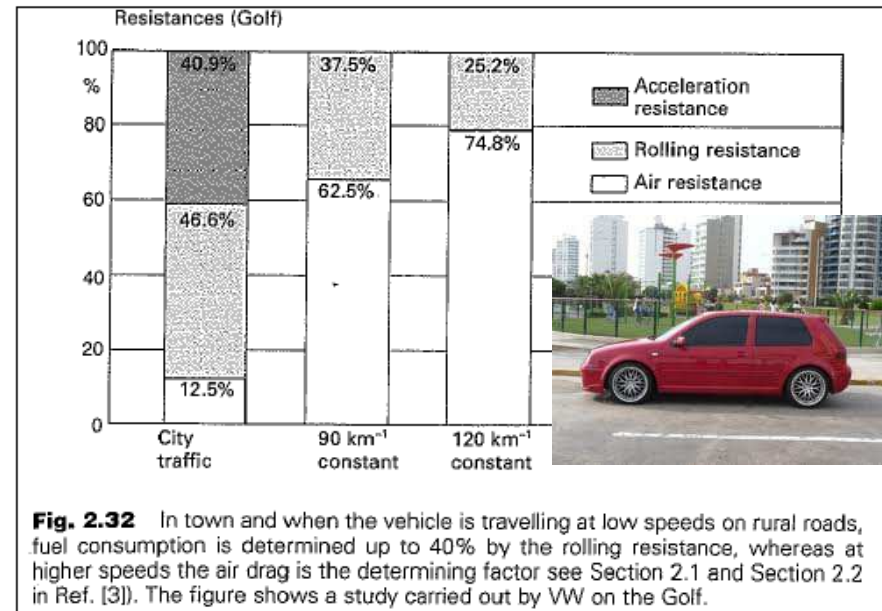
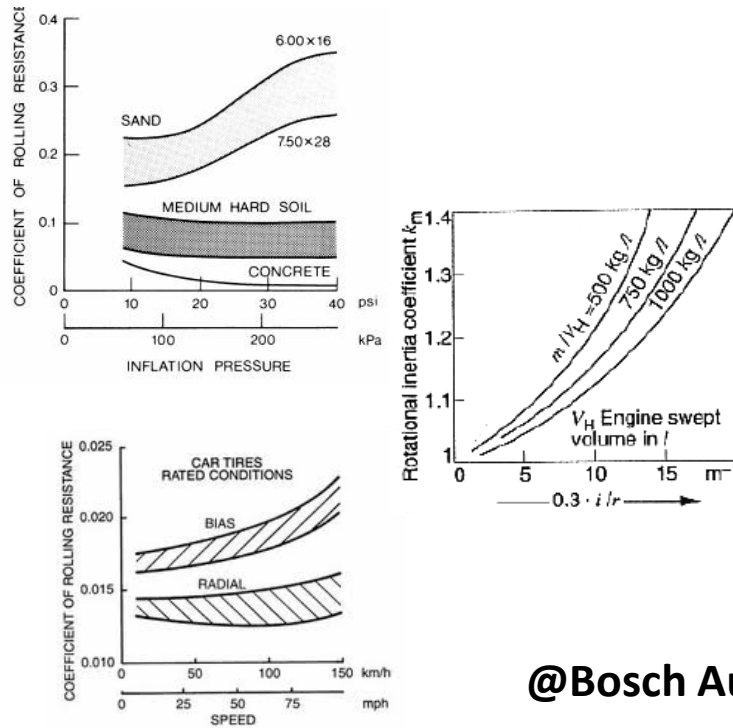


Fig. 2.32 In town and when the vehicle is travelling at low speeds on rural roads, fuel consumption is determined up to 40% by the rolling resistance, whereas at higher speeds the air drag is the determining factor see Section 2.1 and Section 2.2 in Ref. [3]). The figure shows a study carried out by VW on the Golf.

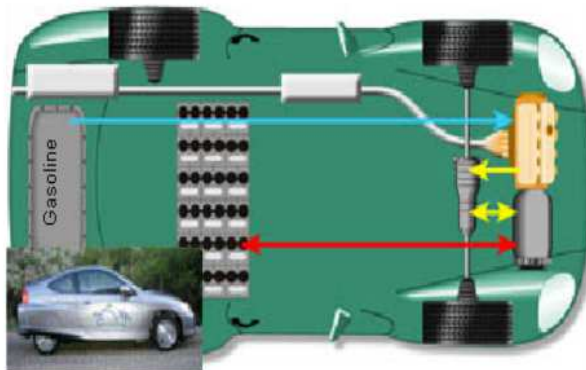
Contribution of Tire Rolling Resistance to Vehicle Fuel Economy Versus Speed
(Reprinted with permission from the Automotive Chassis: Engineering Principles, 2nd Edition, Reed Educational and Professional Publishing Ltd., 2001)



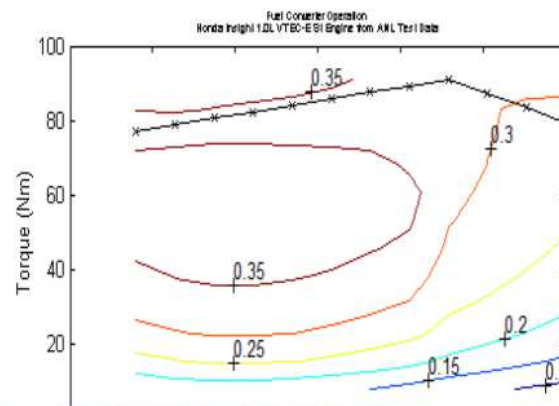
@Bosch Automotive Handbook: 8th Edition

Roling	k_r	0.013	0.01
Aerodynamics	$C_d A_f$	0.35x1.91m ²	0.6x7m ²
Propulsion	k_m	1.1	1.13

Vehicle Input



Component: **fuel_converter** Plot Selection: **fc_efficiency**



Load File: **INSIGHT_defaults_in**

Drivetrain Config: **insight**

	version	type	max pwr (kW)	peak eff	mass (kg)
☒ Vehicle	?	VEH_INSIGHT			520
☒ Fuel Converter	ic	si	50	0.4	130
☒ Exhaust Aftertreat	?	EX_SI_CC			5
☒ Energy Storage	rint	nimh	20	154	20
☐ Energy Storage 2	?	ess 2 options			
☒ Motor	?	MC_INSIGHT_draft	10	0.96	60
Motor 2	?	motor 2 options			
Starter	?	starter options			
☐ Generator	?	gc options			
☒ Transmission	man	man		1	91
Transmission 2	?	trans 2 options			
Clutch/Torq. Conv.	?	clutch/torque converter options			
☒ Torque Coupling	?	TC_INSIGHT		1	
☒ Wheel/Axle	Crr	Crr			0
☒ Accessory	Const	Const			
Acc Electrical	?	acc elec options			
☒ Powertrain Control	insight	man			

Auto-Size Scale Components

front wheel drive rear wheel drive four wheel drive ?

View Block Diagram **BD_INSIGHT**

Variable List:

Cargo Mass: 136
Calculated Mass: 962
☒ override mass: 1000

Save Help

EMEP/EEA air pollutant emission inventory guidebook

EEA Report | No 21/2016

EMEP/EEA air pollutant emission inventory guidebook 2016

Technical guidance to prepare national emission inventories

ISSN 1977-8449



EMEP/EEA air pollutant emission inventory guidebook

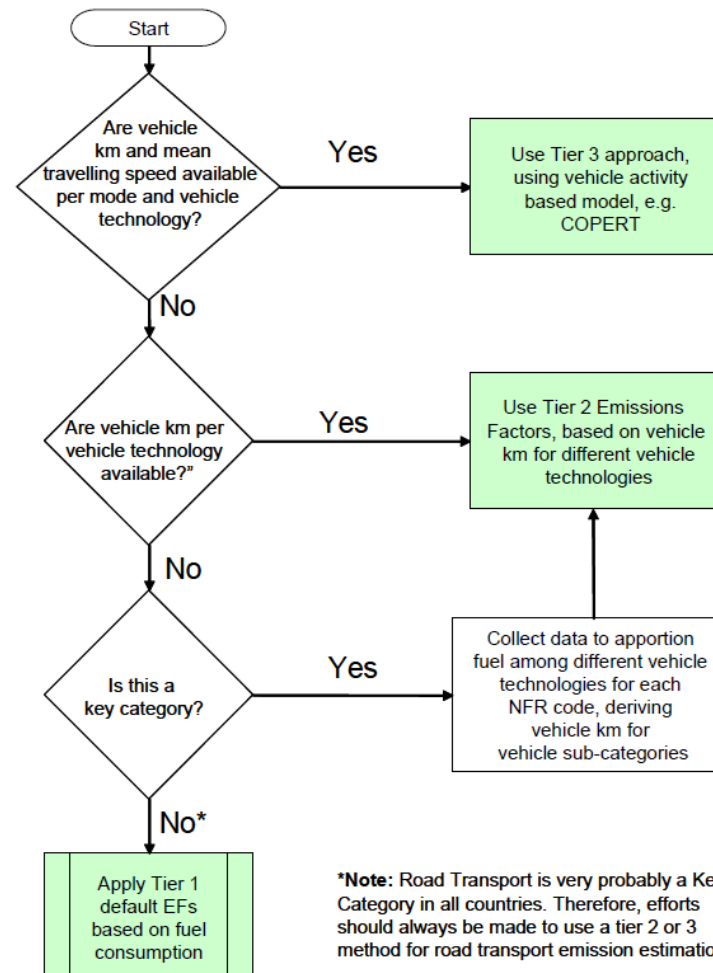
- Part B: sectoral guidance chapters
 - 1. Energy
 - 1.A Combustion
 - 1.A.1 Energy industries [2.4 MB]
 - 1.A.2 Manufacturing industries and construction [893.2 KB]
 - 1.A.3.a Aviation 2016 [1.5 MB]
 - 1.A.3.b.i-iv Road transport 2016 [3.3 MB]
 - 1.A.3.b.i-iv Road transport Annex HDVs 2016 [3.0 MB]
 - 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!

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



***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



First estimation (high uncertainty) emissions proportional to fuel consumption

$$E_x = \sum_y (\sum_m (FC_{y,m} \times EF_{x,y,m})) \quad (Eq. 1)$$

Where:

E_x = emission of pollutant x [g],

$FC_{y,m}$ = fuel consumption of vehicle category y using fuel m [kg],

$EF_{x,y,m}$ = fuel consumption-specific emission factor of pollutant x for vehicle category y

and fuel m [g/kg]

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

First estimation (high uncertainty) emissions proportional to fuel consumption

Table 3.5: Tier 1 emission factors for CO and NMVOCs

Category	Fuel	CO			NMVOC		
		(g/kg fuel)			(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

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			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

Surveys, energy & emissions

Exercise: What would be the yearly impact in biogenic and non-biogenic final energy consumption and CO₂, NO_x and PM of a community of 100 commuting people where?:

One-way trip

Weekday: 50% walk 1 km; 25% bus 5 km; 25% car 30 km

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

Surveys, energy & emissions

BUS



→ Data MJ/pkm from sustainability report

CAR



→ Most sold vehicle, VCA info

0-100 km/h	14.5 s	
European test cycle l/100km	5.6	
1059 kg		

Surveys, energy & emissions



Vehicle Certification Agency

August 2017

Manufa	Model	Description	Trans	Engine	Fuel	Metric	Metric	Metric	CO2	Emissions	Emissions	THC + NOx	Particulates
cturer			missio	Capacit	Type	Urban	Extra-	Combin	g/k	CO	NOx	Emissions	[No.]
RENAU			n	y	Dies	(Cold)	Urban	ed	m	[mg/km]	[mg/km]	[mg/km]	[mg/km]
LT	Clio Euro6, 2015	dCi 110 S/S	M6	1461	el	3.8	3.3	3.5	90	354	18	60	0.08
RENAU		Energy dCi 90			Dies								
LT	Clio Euro6, 2015	S/S	M5	1461	el	3.5	3.1	3.3	85	158	33	60	0.08
RENAU		Energy dCi 90			Dies								
LT	Clio Euro6, 2015	S/S ECO	M5	1461	el	3.3	3.1	3.2	82	158	33	60	0.08
RENAU	Clio Sport Tourer				Dies								
LT	Euro6, 2015	dCi 90 S/S	M5	1461	el	3.5	3.1	3.3	85	158	33	60	0.08
RENAU	Clio Sport Tourer	Energy dCi 90			Dies								
LT	Euro6, 2015	S/S ECO	M5	1461	el	3.4	3.1	3.2	84	158	33	60	0.08
RENAUL		Energy TCe 90											
T	Clio Euro6, 2015	S/S	M5	898	Petrol	5.7	4.1	4.7	105	327	28		
RENAUL	Clio Sport Tourer	Energy TCe 90											
T	Euro6, 2015	S/S	M5	898	Petrol	5.7	4	4.6	104	327	28		



Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

Surveys, energy & emissions

Fuel energy density MJ/L and Lower heating value MJ/kg.....average gasoline-diesel

Using data from

Bus (MJ/pkm)	1.6 carris sust.report		EEA Tier 1				
Car (L/100km)	4.45 most sold vehicle	1.6465 MJ/pkm	240 g/km	9.6 MJ/km	80 Lugares	0.24 MJ/pkm	50% occupancy
			65 g/km	2.6 MJ/km	5 Lugares	2.6 MJ/pkm	only the driver

$4.5 \text{ L/100km} * 37 \text{ MJ/L}$

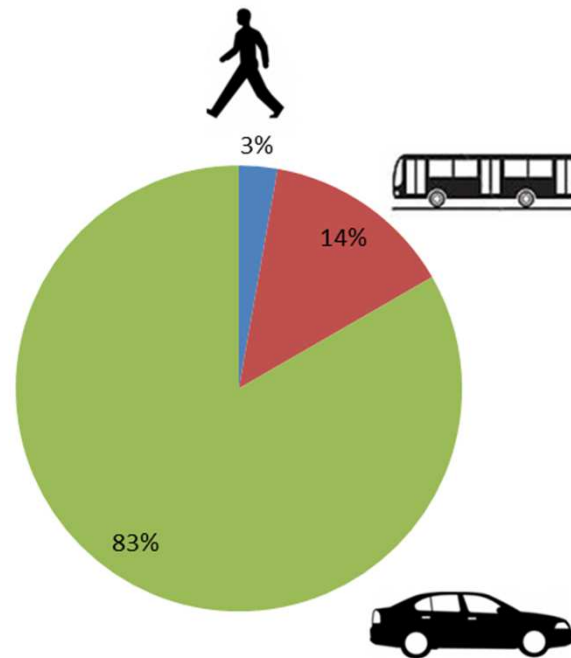
$* 42 \text{ MJ/kg}$

Data from class #4
And Tier 1 emission factors

EEA Tier 1			
	CO2 (g/g)	NOx (mg/kg)	PM2.5 (mg/kg)
bus	3.2	33.37	0.94
car	3.2	10.845	0.565
g/MJ			
bus	76.19048	0.79452381	0.022381
car	76.19048	0.25821429	0.013452
ton/year			
bus	7.314286	0.07627429	0.002149
car	45.16114	0.15305394	0.007974

$\text{g/MJ} * \text{MJ/year}$

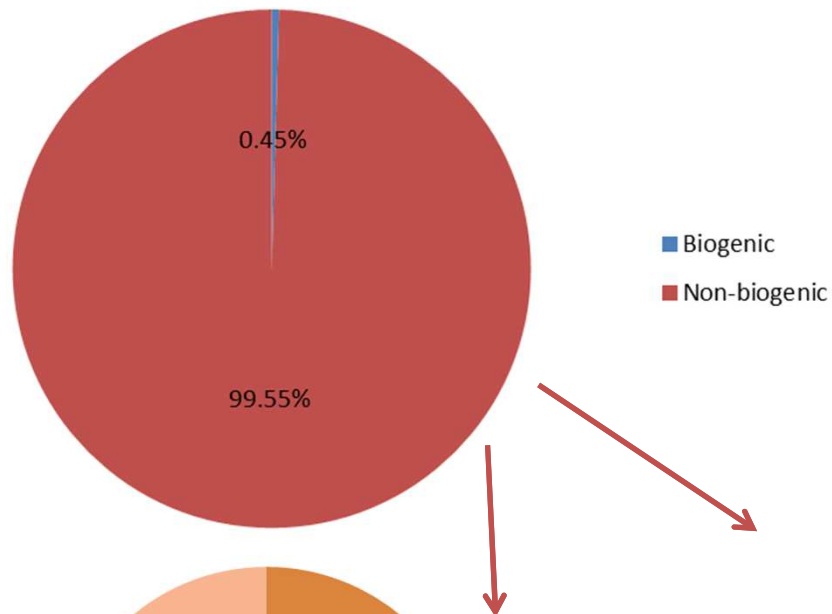
Travel to work by transport mode (km basis)



100% = 360 km/week

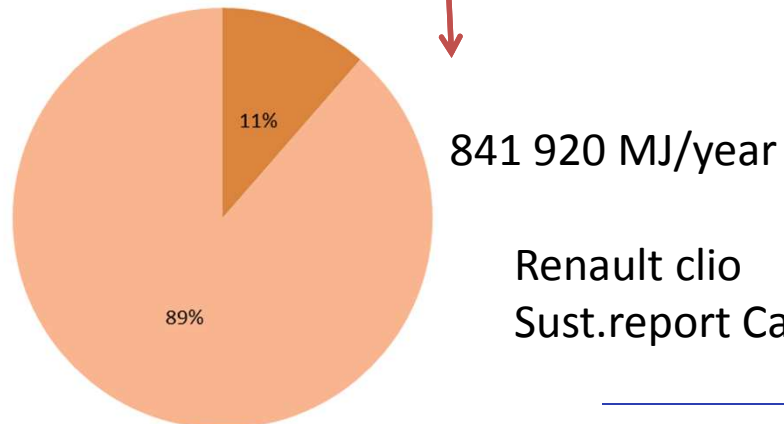
48 week/year = 17 280 km

(MJ/year) and CO₂, NO_x and PM_{2.5} (g/year)

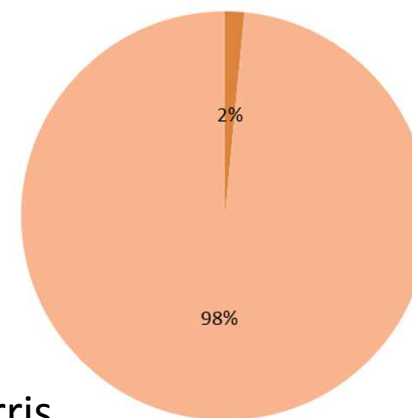


100% = 360 MJ/week

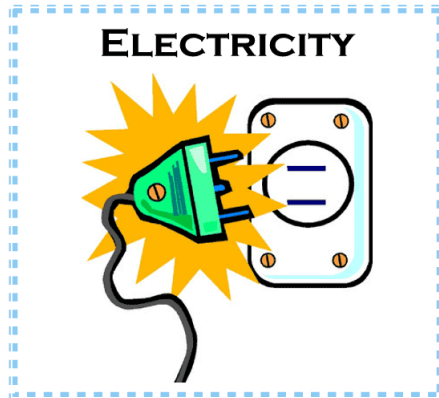
48 week/year = 845 760 MJ/year



Renault clio
Sust.report Carris

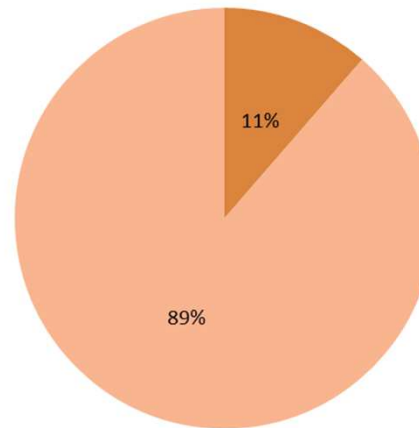


EEA Tier 1
950 400 MJ/year



$$841\,920 * 0.2 / 0.7 = 240\,548 \text{ MJ/year}$$

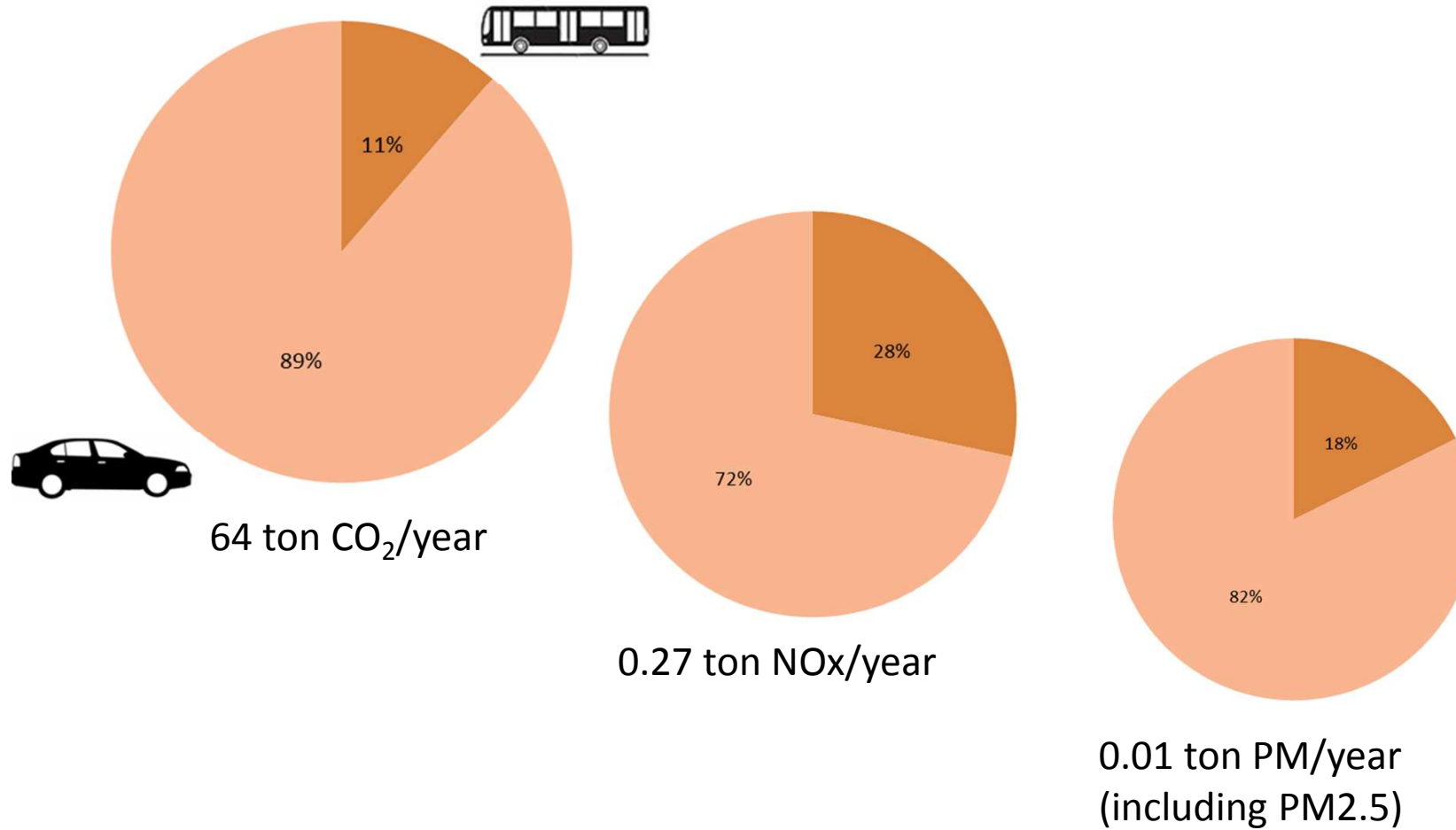
Using final to useful
efficiencies..... or choose
Nissan Leaf and Mirai
data but for bus.....



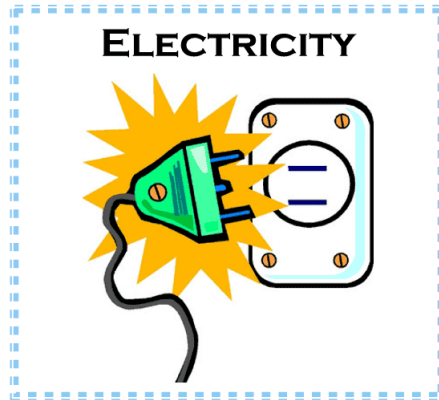
Renault Clio
Sust.report Carris

$$841\,920 * 0.2 / 0.4 = 420\,960 \text{ MJ/year}$$

CO₂, NO_x and PM_{2.5} (ton/year)



CO₂, NO_x and PM_{2.5} (ton/year)



0 ton CO₂/year



0 ton NO_x/year

0 ton PM/year
(including PM_{2.5})

Lisbon AML case study

P#2 AML – Metropolitan area of Lisbon. From the AML 2017 survey results (shown below) estimate the final energy consumption (MJ/year) and CO₂, NO_x and PM2.5 (ton/year) and do a pie chart by transportation mode, and bar graphs for the scenarios. Assume a year with 48 weeks (except holidays).

Reference ; Scenario electric e-bike e-cars e-bus; Scenario Hydrogen all H₂

what would be the overall mobility related final energy consumption (biogenic and non biogenic)? What scenario would you advise? A more electrified one or a more hydrogen based one?

Deadline 5 November

Recent mobility survey 2017 Porto and Lisbon

Impact of people travel?

Quadro 9

Tempo e distância por deslocação, segundo o principal meio de transporte das deslocações

AM Lisboa

km per trip



		Duração média (minutos)	Distância média (km)
	AM Lisboa	24.3	10.3
car	Automóvel - condutor	21.7	12.7
	Automóvel - passageiro	20.8	13.3
motorbike	Motociclo/ciclomotor	18.0	11.7
bus	Autocarro (transporte público)	45.7	12.1
train	Comboio	53.4	19.1
subway	Metropolitano	39.7	8.5
boat	Barco	58.1	19.5
	Táxi	19.6	6.4
van	Transporte escolar / empresa	32.6	17.2
walk	A pé	17.0	1.5
bike	Bicicleta	36.2	8.8
	Outro/desconhecido	31.7	24.2

Nota: Exclui as deslocações internacionais

Recent mobility survey 2017 Porto and Lisbon

Impact of people travel?

Quadro 6

[Voltar ao Índice](#)

Deslocações por tipo de dia e meio de transporte principal da deslocação

AM Lisboa

Unidade: 10³

		Deslocações		
		Total semanal	Dias úteis	SDF a)
AM Lisboa		37,697.1	27,439.7	10,257.4
Transporte individual		22,542.4	15,715.5	6,826.9
car	Automóvel - condutor	17,326.3	12,334.4	4,992.0
	Automóvel - passageiro	4,884.7	3,110.2	1,774.5
motorbike	Motociclo/ciclomotor	331.3	270.9	60.4
Transporte público ou coletivo		5,939.5	5,056.6	882.9
<i>Dos quais:</i>				
bus	Autocarro	2,945.9	2,476.0	469.9
train	Comboio	1,215.7	1,032.0	183.7
subway	Metropolitano	1,167.8	1,014.6	153.2
Walk and bike	Modos suaves (a pé e bicicleta)	8,857.7	6,404.3	2,453.4
Outro/desconhecido		357.4	263.4	94.1

a) SDF - Sábados, domingos e Feriados

Number trips Per mode

Vehicle activity x N^{er} Trips x Factor x days/year

Km/week/
mode/trip

trips/mode

e.g. 48
weeks/year

Energy and Emission factors

MJ/pkm and g/pkm

MJ/year and g/year

Control point Fuel sales

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Base de Dados Portugal Contemporâneo

A selecção não foi alterada.

Pordata > Municípios > Ambiente, Energia e Território > Energia > Venda de combustíveis para consumo > Consulta Avançada

Início Glossário Retratos Destaques Academia

Venda de combustíveis para consumo

Tabela | Mapa | Gráfico

Indicadores (4/15)

Filtro: Inserir Palavra

- ☒ Gás auto (GPL)
- ☐ Gasolina normal
- ☐ Gasolina super
- ☐ Gasolina aditivada
- ☒ Gasolina sem chumbo 95
- ☒ Gasolina sem chumbo 98
- ☒ Gasóleo rodoviário
- ☐ Gasóleo colorido
- ☐ Gasóleo para aquecimento
- ☐ Biodiesel

Territórios (1/353)

Anos (1/13)

Venda de combustíveis para consumo
Onde é vendido mais e menos gás, gasolina, gasóleo, biodiesel, fuel, coque ou outros produtos petrolíferos?
t (tonelada)

Venda de combustíveis para consumo				
	Gás auto (GPL)	Gasolina sem chumbo 95	Gasolina sem chumbo 98	Gasóleo rodoviário
Anos	2015	2015	2015	2015
Área Metropolitana de Lisboa	7.035	253.331	11.233	888.838

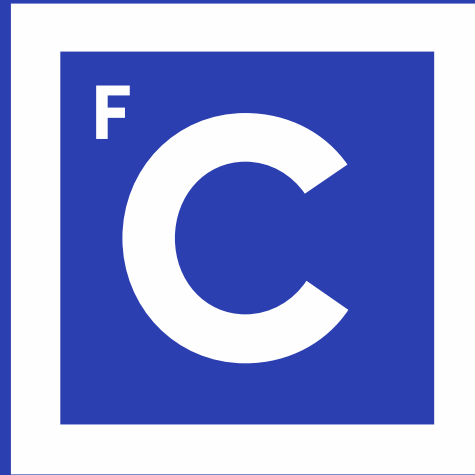
Venda de combustíveis para consumo
Fontes de Dados: DGE/MEC
Fonte: PORDATA
Última actualização: 2018-03-02



-
- Final energy consumption factors, first approach;
 - Emission modelling, macro to micro scale;
 - European Environmental Agency Tier 1 approach;
 - Fuel sales as a control point.

The image consists of a large blue square. Inside this square is a white square, which is further enclosed by a smaller blue square. The word "Obrigado" is written in white, bold, sans-serif font in the center of the innermost blue square.

Obrigado



Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa