Agenzia Regionale per la Protezione dell'Ambiente della Lombardia

TFEIP Expert Panel on Transport, Milan, March 23, 2007

Relationship between car mileage and length of service: influence on atmospheric emission assessment

Ing. Stefano Caserini[1], Cinzia Pastorello[2], Simonetta Tugnoli[3]

1- ARPA Lombardia, Settore Aria e Agenti Fisici , Viale F. Restelli, 3/1 – 20124 Milano
s.caserini@arpalombardia.it

2 - ENEA, PROT INN section – Via Martiri di Monte Sole 4 – 40129, Bologna - Italy

3- ARPA Emilia Romagna - Ingegneria Ambientale, Vicolo Carega, 3, 40121 Bologna

Aim of the work

- Assessment of cars mileage as a function of their length of service
- Importance of the relationship between mileage and age on atmospheric emission assessment.

Mileage of vehicles is important because is involved in traffic emission assessment

Emissions [g/y] =
Emission Factor [g/km] ×
Number of Vehicles [veh.]×
Mileage per Vehicle [km/veh./y]

"the authors have the impression that the distribution of mileage in driving conditions (urban, rural, highway) and the respective average travelling speeds are those variables for which most attention should be given in most of the cases."

Copert IV methodology, 2006

Relative differences in mileage for different types of vehicles are important because emission factors are highly dependent on vehicle age (legislative type: Euro 0 … euro IV, etc.).

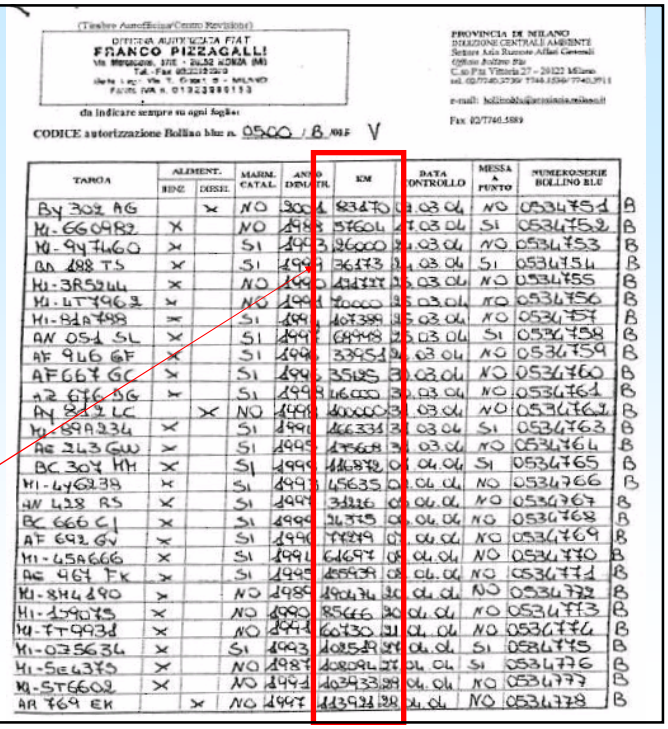
Total mileage came from fuel balance
Mileage degradation is an assumption

Data available

- Data collected during the monitoring campaign aimed at controlling the vehicle exhausted gas
- Vehicle exhausted gas control are mandatory for vehicle older than 4 years (≤ 1999)
- Are available data on:
  - **Age** (or lenght of service) - Number of years of vehicles utilization since its first registration.
  - **km driven** by the car: read on the mileometer
- QA /QC (considered mileage between the 1° and 99° percentile)
- Milan province:
  2400 data of vehicle registered between 1986 and 1999.
- Ferrara province:
  82.000 data between 1963 and 1999

Example of data collected during vehicle exhausted gas controls

km driven by the cars



OFFICINA AUTORIZZATA FIAT
FRANCO PIZZAGALLI

PROVINCIA DI MILANO
DIREZIONE CENTRALE AMBIENTE

CODICE autorizzazione Bollino blu n. 0500 / B

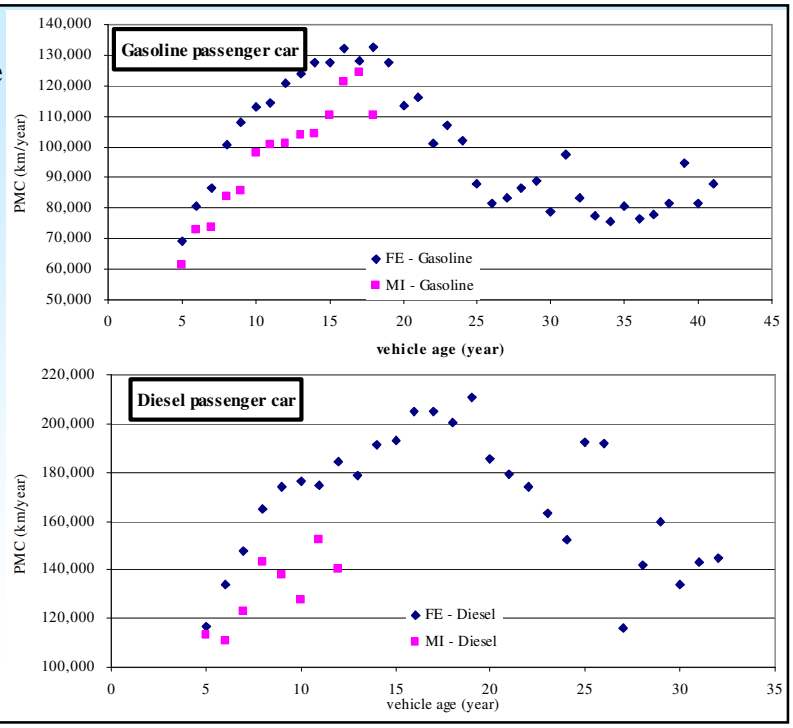
TARGA	ALIMENT. BENZ.	ALIMENT. DIESEL	MARM. CATAL.	ANNO IMMATR.	KM	DATA CONTROLLO	MESSA A PUNTO	NUMEROSERIE BOLLINO BLU	
BY 302 AG		X	NO	3004	83470	03 04	NO	0536751	B
MI-666982	X		NO	1988	57604	03 04	SI	0536752	B
MI-947460	X		SI	1993	96000	03 04	NO	0536753	B
BA 188 TS	X		SI	1994	36473	03 04	SI	0536754	B
MI-3R5244	X		NO	1990	121427	03 04	NO	0536755	B
MI-4T7963	X		NO	1991	70000	03 04	NO	0536756	B
MI-8A7488	X		SI	1994	107388	03 04	NO	0536757	B
AN 051 SL	X		SI	1997	68998	03 04	SI	0536758	B
AF 946 GF	X		SI	1998	33951	03 04	NO	0536759	B
AF667 GC	X		SI	1998	35185	03 04	NO	0536760	B
a2 676 BG	X		SI	1998	46000	03 04	NO	0536761	B
AY 847 LC		X	NO	1998	40000	03 04	NO	0536762	B
MI-899334	X		SI	1991	166334	03 04	SI	0536763	B
AE 243 GW	X		SI	1995	125608	03 04	NO	0536764	B
BC 304 MH	X		SI	1999	116878	04 04	SI	0536765	B
MI-462838	X		SI	1993	45635	04 04	NO	0536766	B
AN 428 RS	X		SI	1999	34126	04 04	NO	0536767	B
BC 666 CJ	X		SI	1999	26375	04 04	NO	0536768	B
AF 693 GV	X		SI	1999	19249	04 04	NO	0536769	B
MI-458666	X		SI	1991	61697	04 04	NO	0536770	B
AE 464 FK	X		SI	1995	105939	04 04	NO	0536771	B
MI-8H4490	X		NO	1989	190434	04 04	NO	0536772	B
MI-179075	X		NO	1990	85666	04 04	NO	0536773	B
MI-FT9934	X		NO	1994	60730	04 04	NO	0536774	B
MI-037636	X		SI	1993	108548	04 04	SI	0536775	B
MI-5E6375	X		NO	1987	108094	04 04	SI	0536776	B
MI-5T6602	X		NO	1991	103933	04 04	NO	0536777	B
AR 769 EK		X	NO	1997	113934	04 04	NO	0536778	B

Cumulative Average Mileage

Cumulative Average Mileage of vehicles with k years of service **CAM_k**, : number of km driven after k years from their first registration. This mileage could be derived from data observed in the vehicle mileometer.

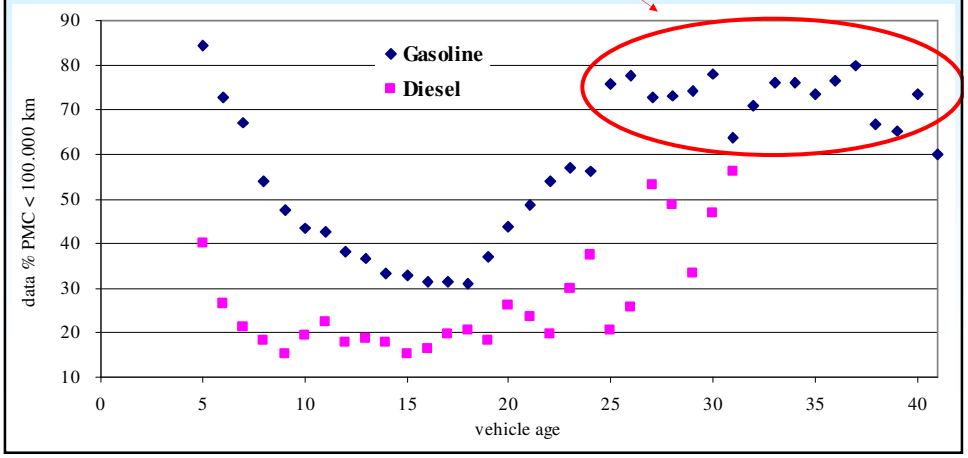
This measure is uncertain for old vehicles, due to the past use of mileometers with only 5 numerals, that measure a maximum cumulative mileage of 99.999 and then restart counting.

Cumulative Average Mileage CAM



Results: CAM

Increase in the % of mileage < 100.000 km: influence of mileometers with 5 numerals



Annual Mileage

Annual Mileage
AM, average number of km driven in a year by a vehicle.
This mileage could be assessed by the difference of two mileometer measurements, in the same day of two subsequent years.

i.e.
31/12/2003 = 152.000 km
31/12/2004 = 137.000 km

Annual Mileage = 15.000 km

Average Annual Mileage
of vehicles with k years of service

Average Annual Mileage of vehicles with k years of service
$\mathbf{AAM_k}$: Amount of km driven each year by vehicles of age k, with the hypothesis of equal mileage in every year of their service. This mileage could be assessed by the ratio between total km driven (CAM_k) and vehicle age (k):

$$AAMk = CAM_k / k$$

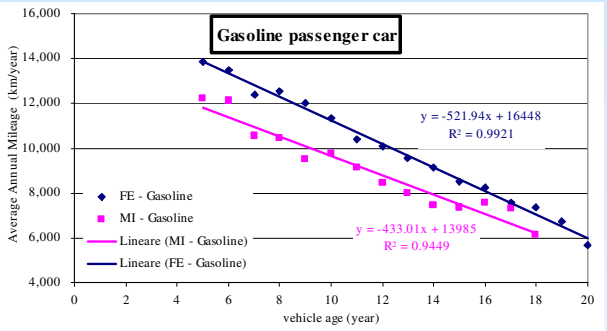
i.e.
Cumulative average mileage in 1999 = 150.000 km
Vehicle Age: = 15

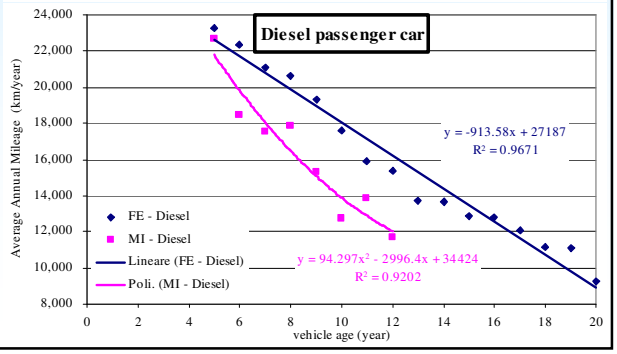
Annual Mileage = 10.000 km

Results: AAM

Annual Average Mileage AAM

With this approach Average Annual Mileage (AAM) is the same in every year of the service: this is in contrast with experimental data, that shows lower AAM for older vehicles !





Real Annual Average Mileage

of vehicle with k years of service and j years as a maximum length of service

Real Annual Average Mileage of vehicle with k years of service and j years as a maximum length of service : $\mathbf{RAAM_{jk}}$
Average number of km driven by vehicles with k years of service and j years as a maximum length of service

This is the value needed for traffic emission assessment, where we have to assign at each Euro – category their real mileage

RAAM could not be calculated by the difference between the CAM of two subsequent years: CAM (Cumulative Average Mileage) is not always growing with age.

In other words, vehicles with very higher length of service could have lower CAM than younger vehicles, because when high length of service is reached, vehicle are less used.

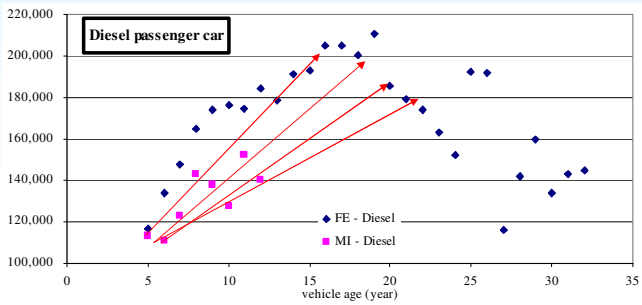
Cumulative Average Mileage

of vehicles with k years of service and j years as a maximum length of service

Cumulative Average Mileage of vehicles with k years of service and j years as a maximum length of service **CAM_{jk}**

As later explained, the variation of CAM_{jk} respect to the average value CAM_k is greater if vehicles have a different development in the growth of cumulative mileage for different maximum years of service

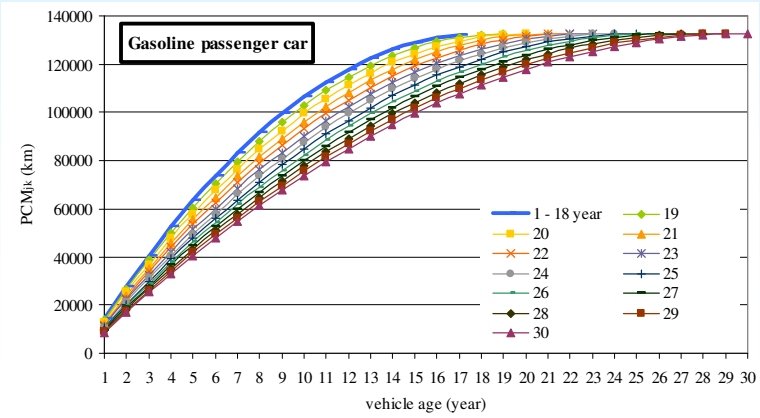
CAM_{jk}



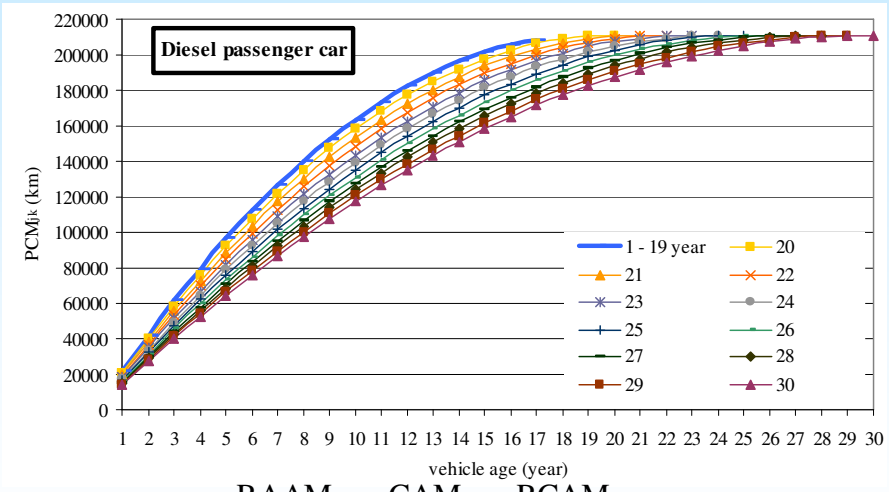
Cumulative Average Mileage - CAM_{jk}

$$CAM_{jk} = a_j \cdot k^2 + b_j \cdot k$$

CAM_{kj}, cumulative average mileage
k = vehicle age (and year in wich mileage is assessed);
j = maximum age reached by the vehicle ($j \geq k$);
a, b = coefficients ($a < 0$)



Cumulative Average Mileage - CAM_{jk}

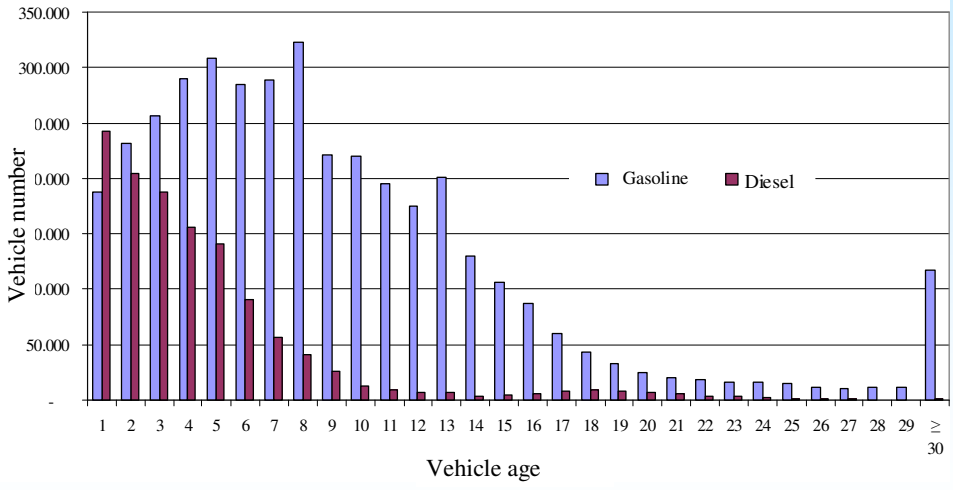


$$RAAM_{j,k} = CAM_{j,k} - RCAM_{j,k-1}$$

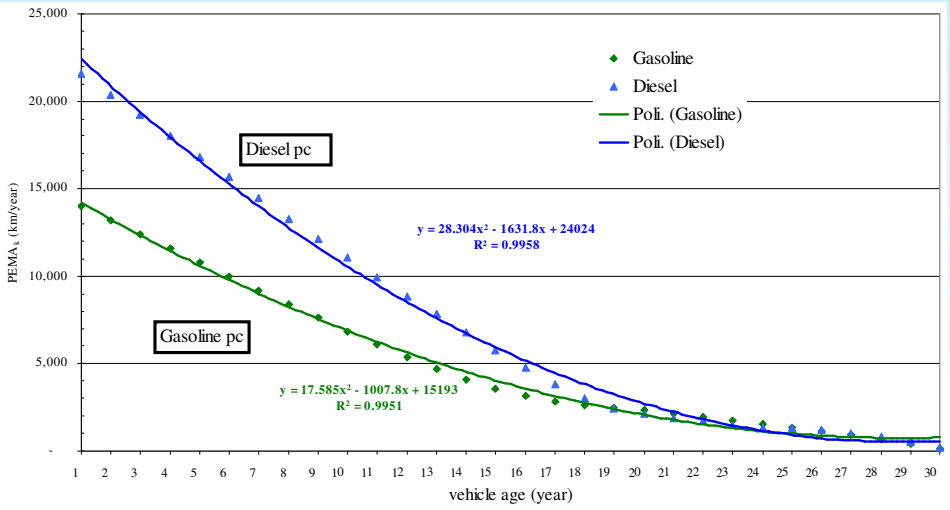
k = vehicle age (and year in wich mileage is assessed);

j = maximum age reached by the vehicle ($j \geq k$);

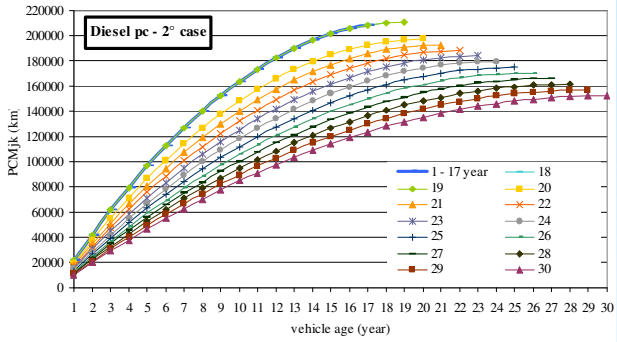
Consistence of vehicle fleet

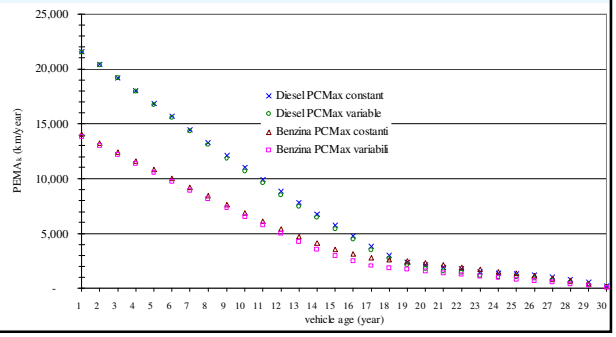


Real Annual Average Mileage RAAM

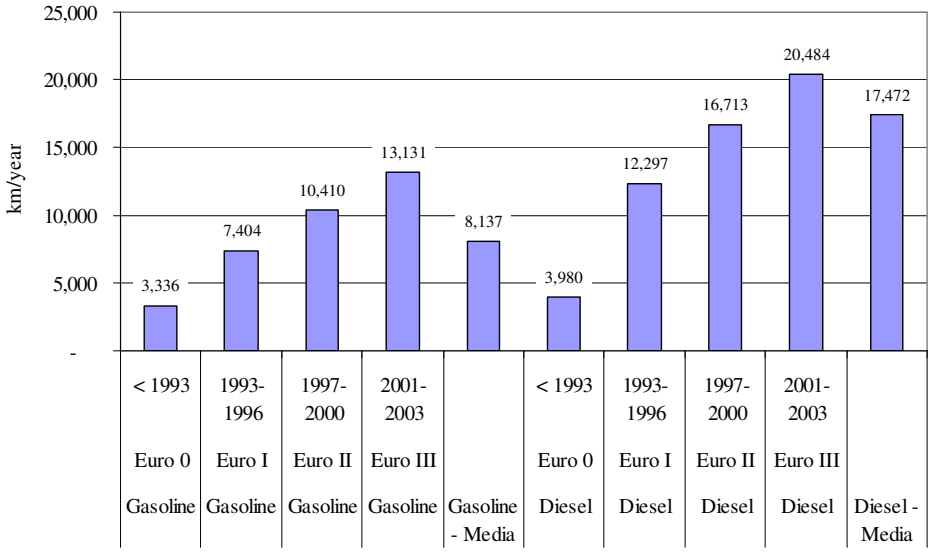


Cumulative Average Mileage - CAM$_{jk}$

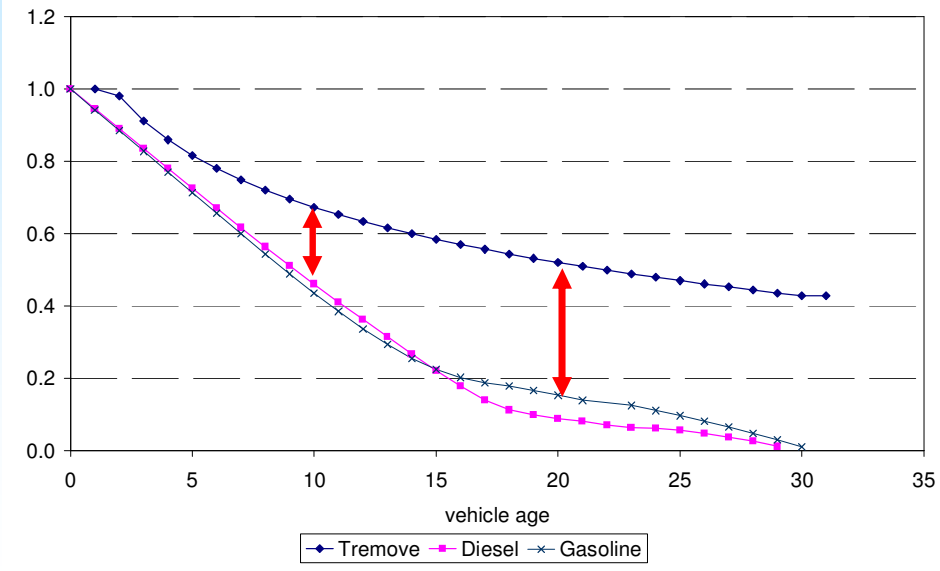




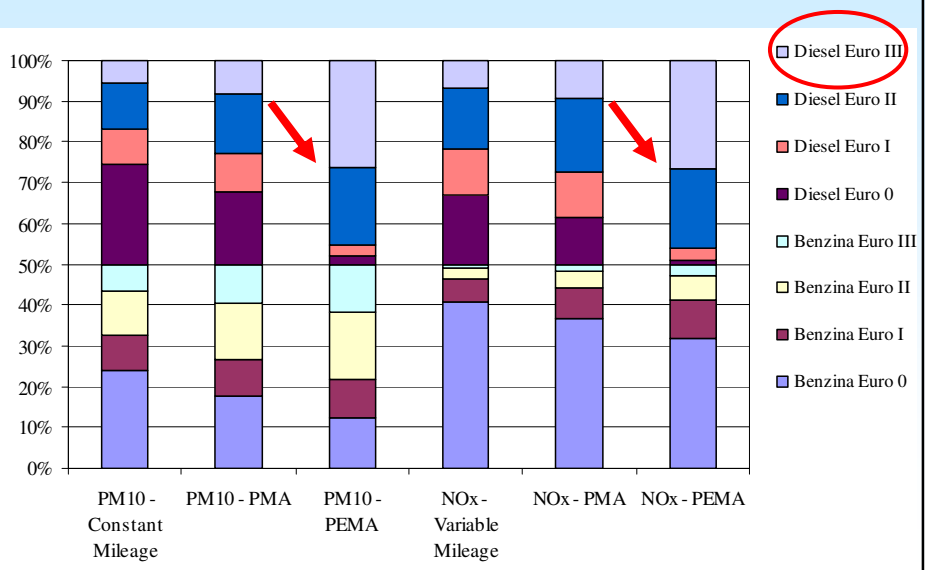
Average Mileage for Euro category



Comparison with other data



Comparison of emissions assessment with different mileage



Conclusions

The assessment of real annual mileage has an influence on emission assessment

The contribution of **Euro 0** vehicle on total PM and NOx emission **decrease**

The contribution of **Euro III** vehicle on total PM and NOx emission **increase**