

# COPERT and Guidebook updates

# New elements in COPERT v5.6 (Sep 2022)

- Revision of non-exhaust PM emissions
- Revision of emissions degradation methodology
- Revision of cold start methodology
- Revision of Euro 6 LPG passenger cars
- Bug corrections



# Revision of non-exhaust PM emissions



# Update fields

- Passenger Cars & Light Commercial Vehicles
  - Brake wear emissions
- Introduction of Electric Vehicles
  - Impact of vehicle weight
  - Impact of regenerative braking
  - New non-exhaust emission factors



# Brake wear emissions

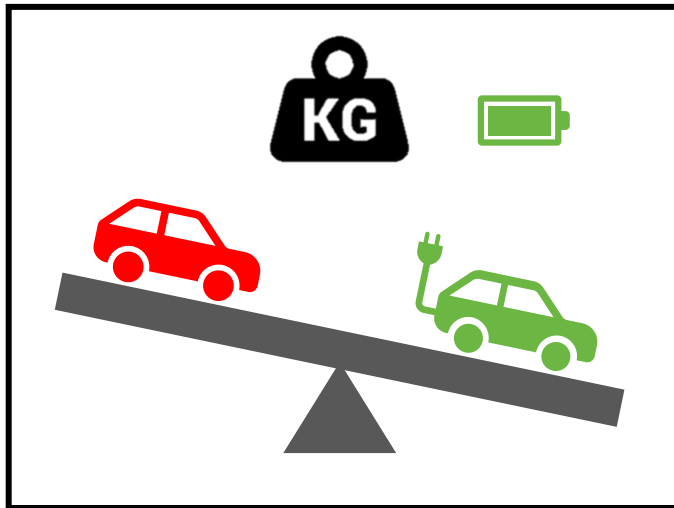
- Standardized measurement procedure from PMP Programme: WLTP brake cycle
- Measurements on WLTP brake cycle
- Revision of brake wear emission factors for PCs and LCVs

## PM10 brake wear:

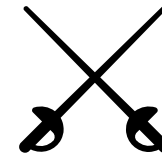
- Low-Steel (LS) pads : 12 mg/km
- Non-Asbestos Organic (NAO) pads: 3 mg/km (possibly in Euro 7?)



# Electric Vehicles – Impact of Vehicle Weight



EV

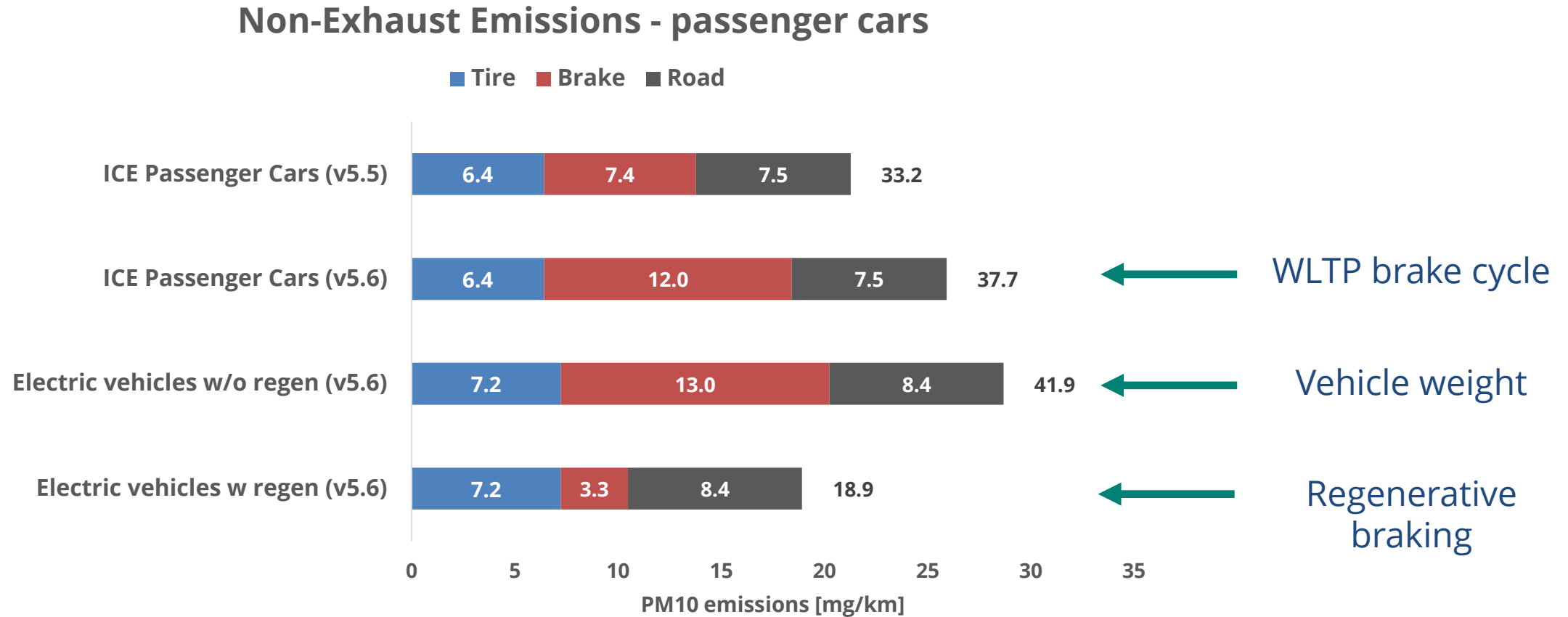


ICE

	Increase	Unit
<b>Weight</b>	257 - 318	kg
<b>Non-Exhaust emissions</b>		
<b>Brake</b>	10 – 15	[%]
<b>Tire</b>	7 – 10	[%]
<b>Road</b>	10 – 15	[%]



# Revised non-exhaust emission factors



# TSP emission factors of passenger cars

## TSP base emission factors [mg/km]

Powertrain	Tyre	Brake	Road
ICE	10.7	12.2	15.0
Hybrid	11.1	9.7	15.9
PHEV	11.2	6.6	16.1
BEV	11.6	3.4	16.9

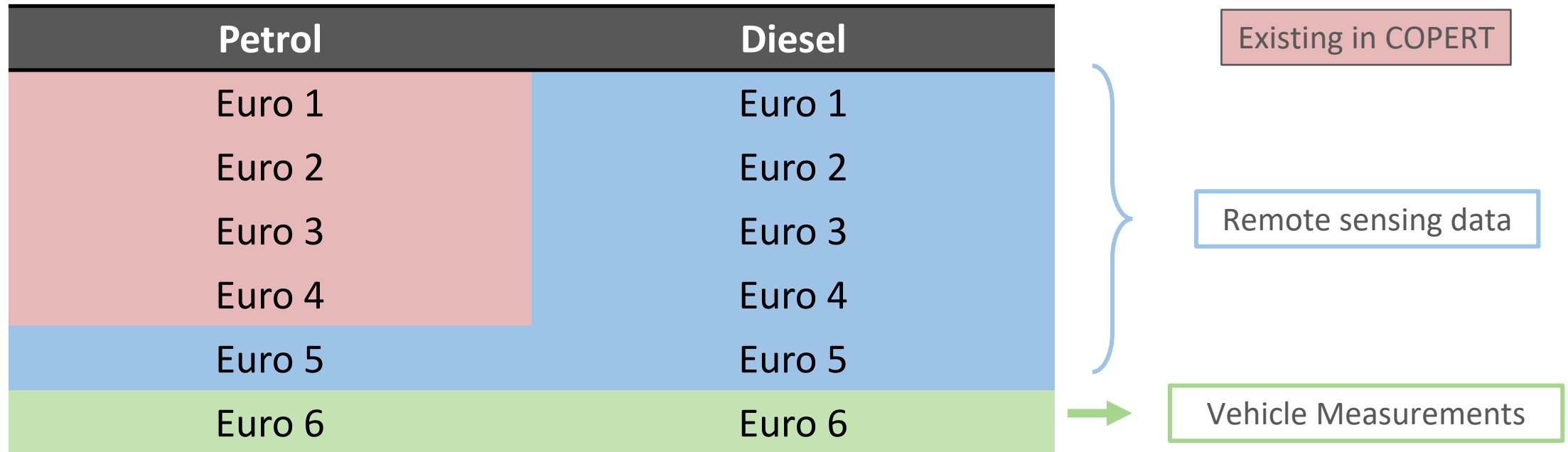




# Revision of degradation methodology

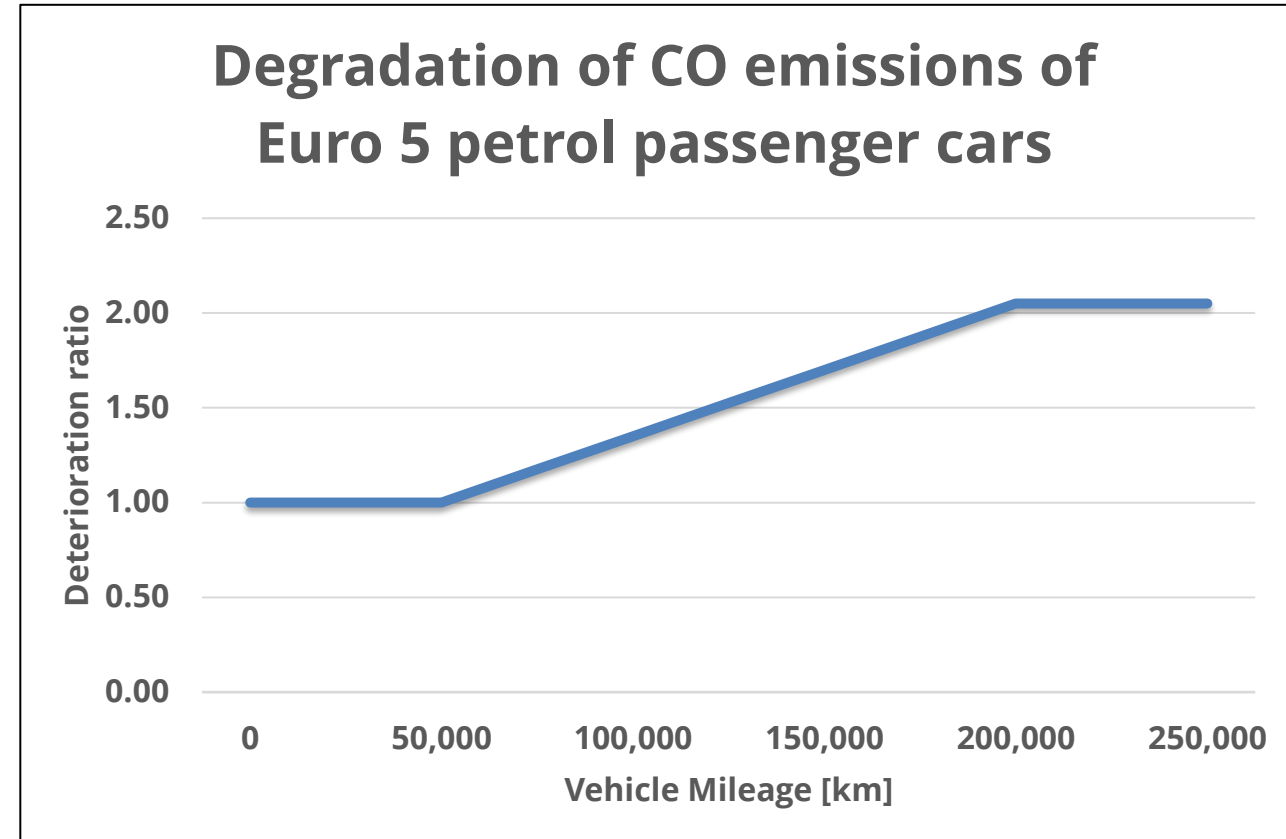


# Update fields



# Degradation equation

- Pollutants: NO<sub>x</sub>, CO, VOC
- Degradation after 50,000 km
- No further degradation after 200,000 km



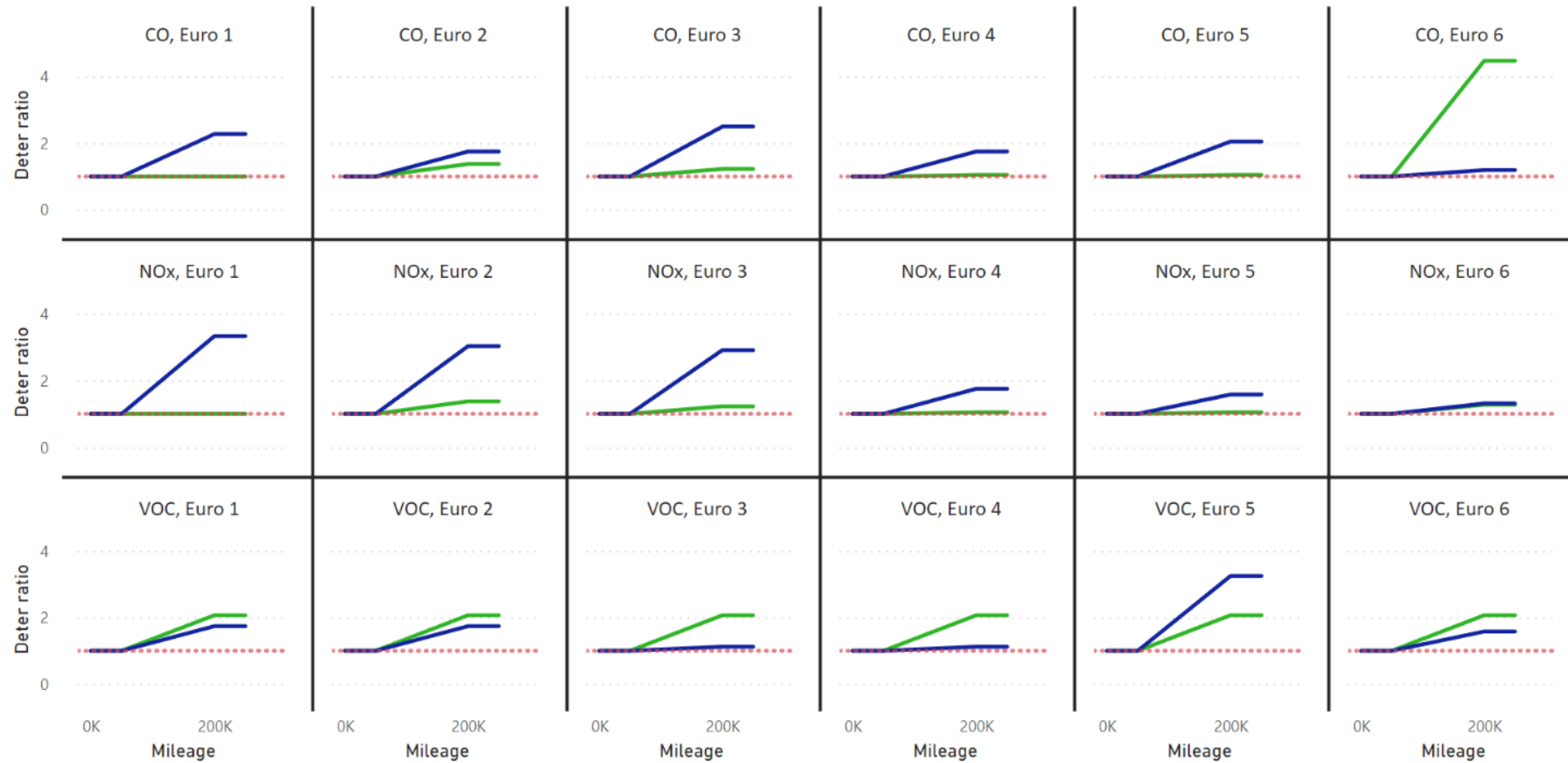
Deterioration equation example



# Degradation graphs

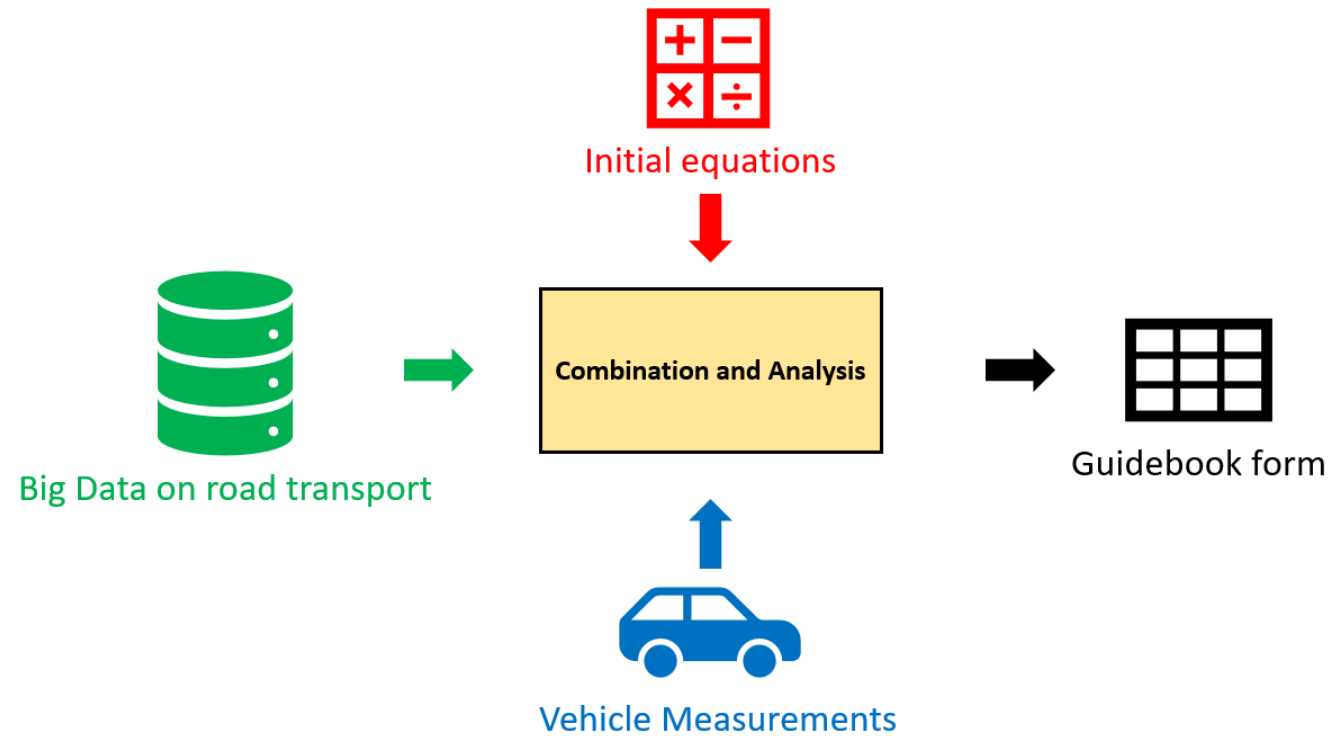
Deterioration factor by Mileage, Fuel, Pollutant and Euro Standard

Fuel ● Diesel ● Petrol



# Revision of cold start methodology

# Methodology



# Initial equations



Equations based on:

*Modelling of cold start emissions for passenger cars,*  
Joumard & Andre (1999)

Equations used:

- ✓ Impact of parking time
- ✓ Impact of travelled distance
- × Impact of speed and temperature
- × Main equation of cold excess emissions



# Big data on road transport



## Studies:

- *A pilot study to address the travel behavior and the usability of electric vehicles in two Italian provinces*, M. De Gennaro, E. Paffumi, G. Martini, H.Scholz (2014)
  - 28,000 vehicles, Italy
- *European-wide study on big data for supporting road transport policy*, E. Paffumi, G. Martini, M. De Gennaro (2018)
  - 600,000 vehicles, multiple cities in Europe

## Data used:

- Probability distribution of parking duration → *Impact of parking duration*
- Trip number per trip length → *Impact of travelled distance*





# Guidebook form – Passenger cars

Euro Standards: Euro 6  
Fuels: Petrol, Diesel  
Pollutants: NO<sub>x</sub>, CO, VOC

Calculation of cold start emissions (overemissions)

$$E_{\text{COLD}} = \beta \times bc \times N \times M \times e^{\text{hot}} \times (e^{\text{cold}} / e^{\text{hot}} - 1)$$

where,

$\beta$	:	fraction of mileage driven in cold engine (beta parameter)
$bc$	:	beta-reduction factor
$N$	:	number of vehicles (stock)
$M$	:	mileage per vehicle
$e^{\text{hot}}$	:	hot emission factor
$e^{\text{cold}} / e^{\text{hot}}$	:	cold/hot emission quotient

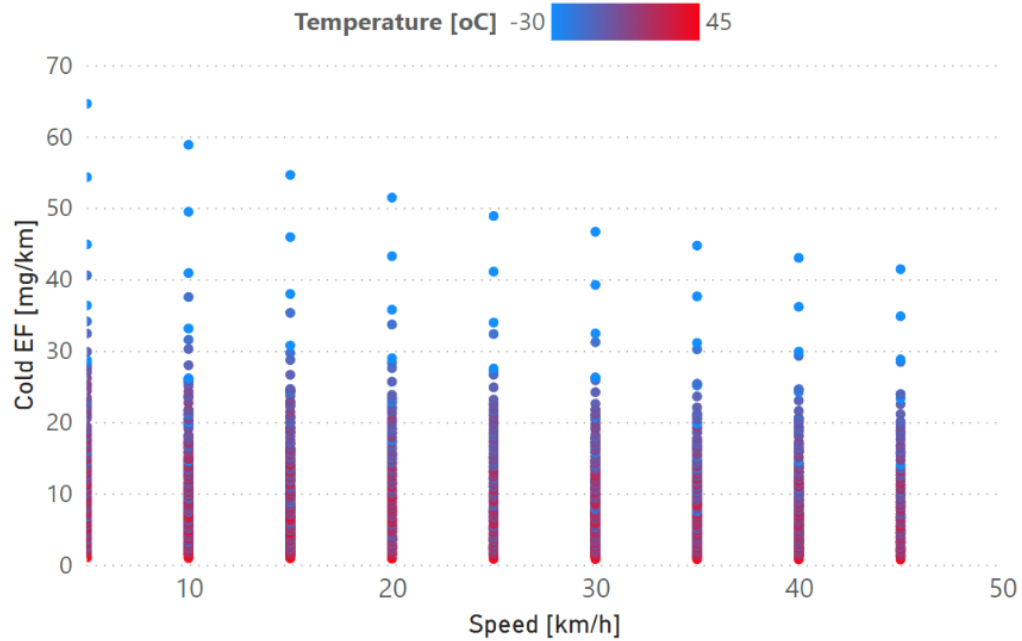
$$e^{\text{cold}} / e^{\text{hot}} = A \times v + B \times T + C$$

(*v*: vehicle speed, *T*: temperature)



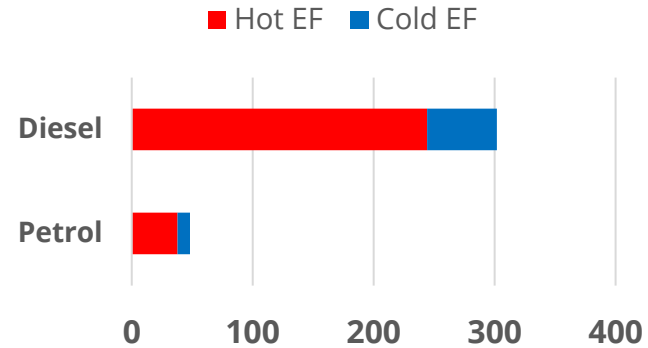
# Passenger car - example

Cold EF per speed and temperature

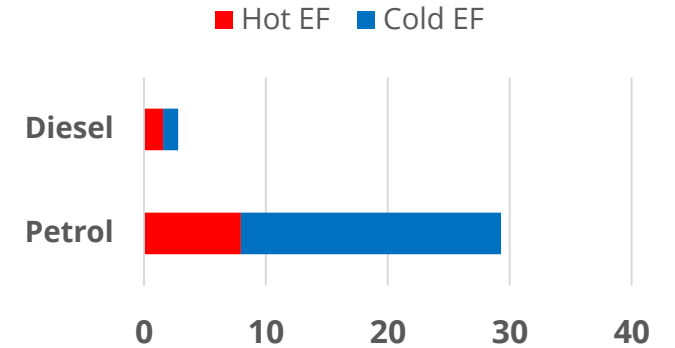


*Petrol NOx cold EF*

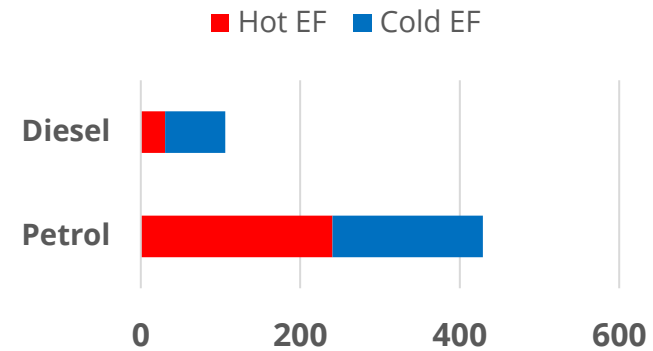
Average NOx EF [mg/km] for Euro 6 vehicles



Average VOC EF [mg/km] for Euro 6 vehicles



Average CO EF [mg/km] for Euro 6 vehicles



# Guidebook form – Heavy Duty Vehicles

<u>Vehicle Categories:</u>	Heavy Duty Trucks, Buses
<u>Euro Standards:</u>	Euro V, Euro VI
<u>Fuels:</u>	Diesel
<u>Pollutants:</u>	NOx, CO, VOC

Calculation of cold start emissions (overemissions)

$$E_{\text{COLD}} = \beta \times N \times M \times e^{\text{cold}}$$

where,

$\beta$	:	fraction of mileage driven in cold engine (beta parameter)
N	:	number of vehicles (stock)
M	:	mileage per vehicle
$e^{\text{cold}}$	:	cold overemission factor

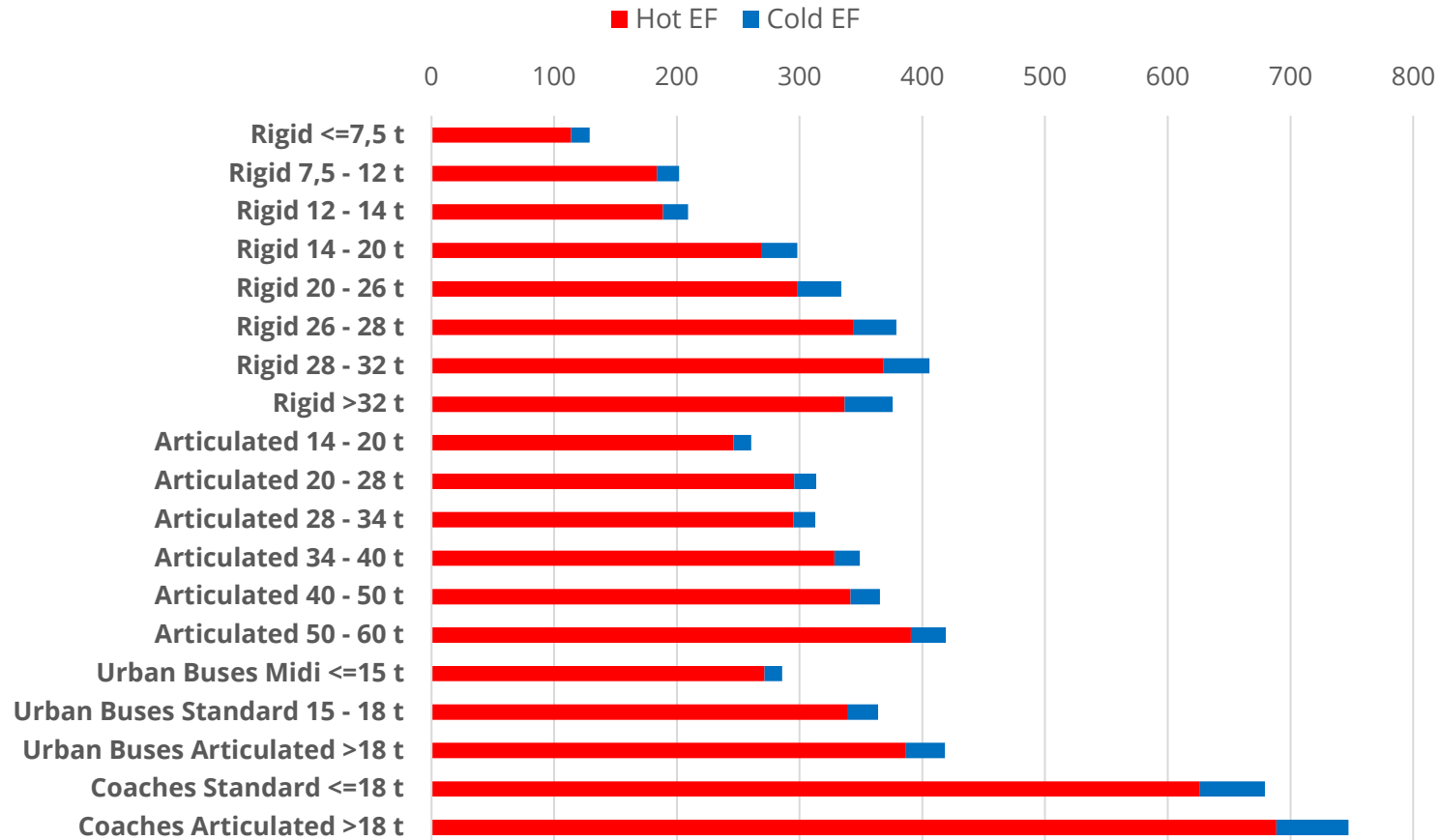
$$\beta = 8.25 / I_{\text{trip}}$$
$$e^{\text{cold}} = A \times v + B \times T + C$$

( $v$ : vehicle speed,  $T$ : temperature)



# Heavy Duty Vehicles - example

CO EF [mg/km] for Euro VI A/B/C heavy vehicles



# Revision of Euro 6 LPG passenger cars



# Vehicle measurements

- Vehicles

Categories:

4 passenger cars, 1 LCV (Euro 6b, 6c)

Euro Standards:

Euro 6b, Euro 6c

Engine size:

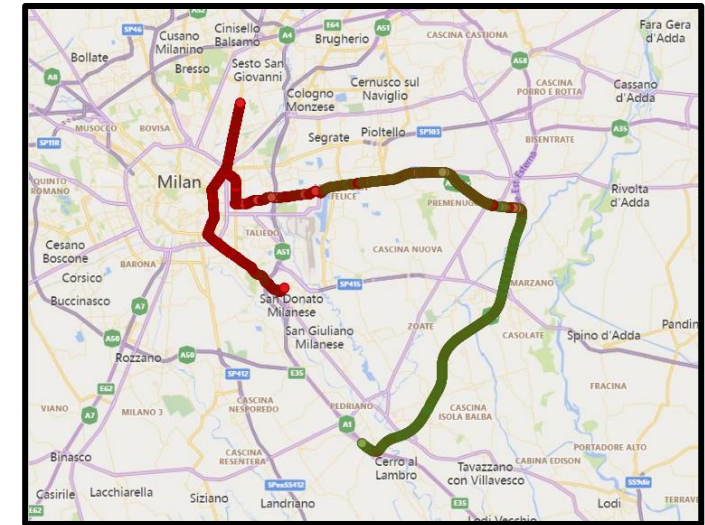
1.2 – 1.6 l

- Measurements

Laboratory and On-road cycles  
(conducted by Innovhub in Italy)

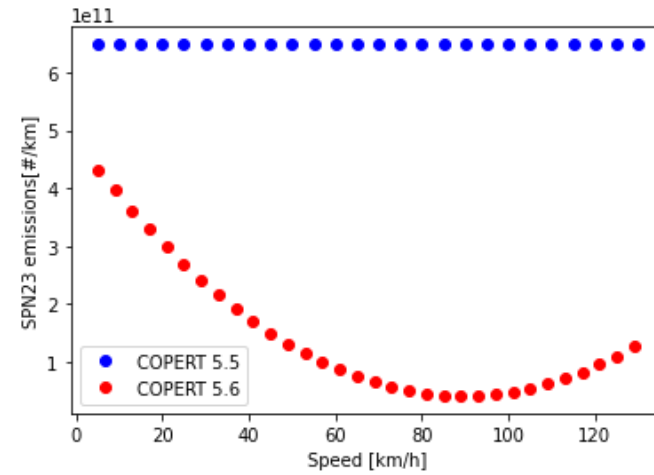
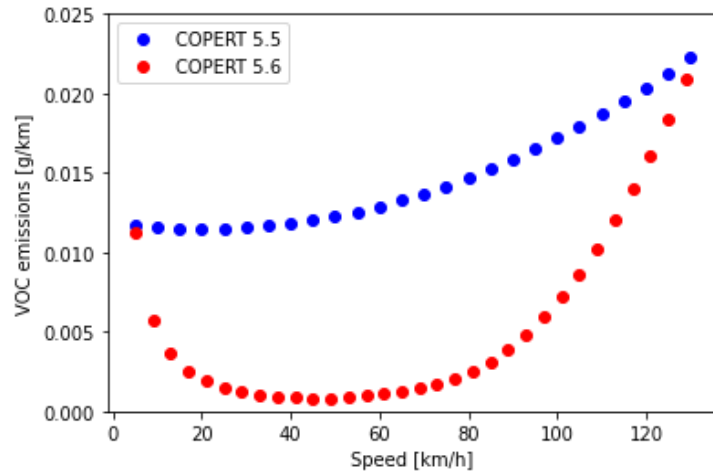
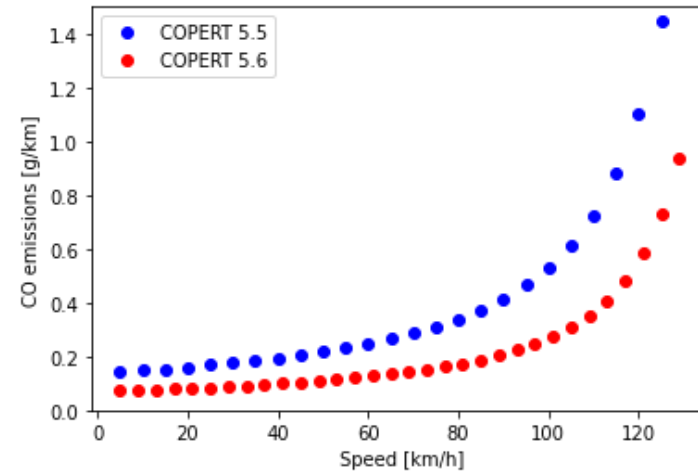
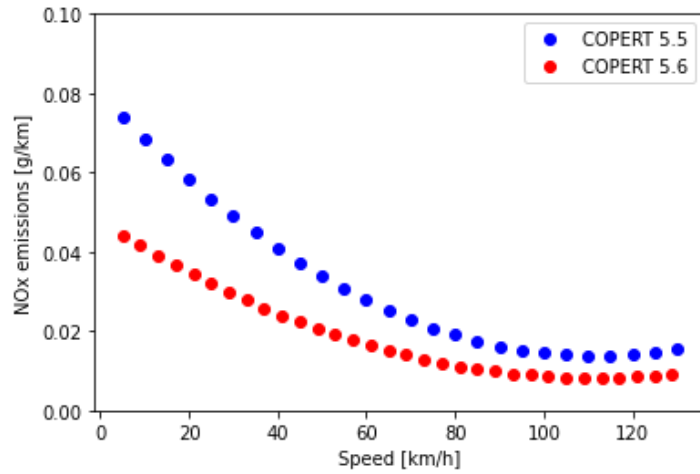
- Revised pollutant equations

NO<sub>x</sub>, CO, VOC, SPN<sub>23</sub>



RDE cycle in Milan (Low speed – High Speed)

# Revised equations



# Bugs correction

- PM and SPN23 hot emission factors of HDVs and buses
- Cold PM and SPN23 emissions of Euro 6 PCs and LCVs
- Brake and tyre non-exhaust heavy metal emissions
- Hot emission factors for LCVs N1-I
- Other minor changes





# Planned updates for next year

- Revision of Heavy-Duty Vehicles categories
- Revision of emission factors of urban buses
- Introduction of Euro 7 vehicles



**Thank you for your attention!**

