Guidebook updates

Chapters 1.A.3.b.i-iv / Road Transport

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New elements in 2022

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

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Revision of non-exhaust PM emissions

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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

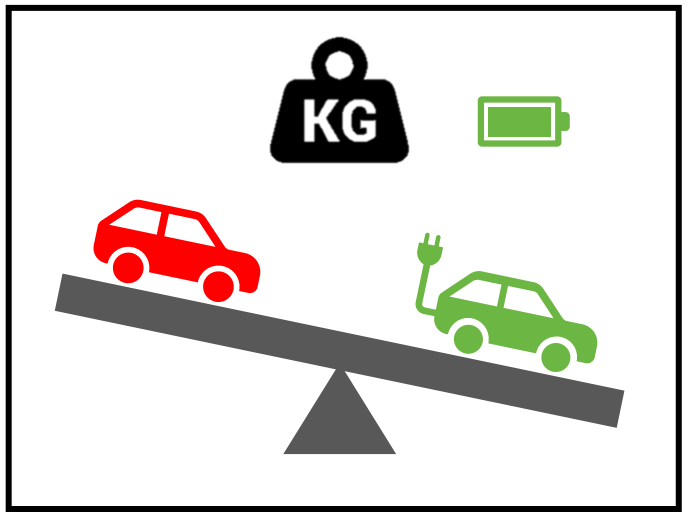
Brake wear emissions

- 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



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

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Electric Vehicles – Impact of Regenerative braking

Regenerative braking

- Energy recovery mechanism
- Braking energy → Electricity → Driving/acceleration
- Brake emission reduction potential

Measurement data show ~75 % reduction of brake emissions

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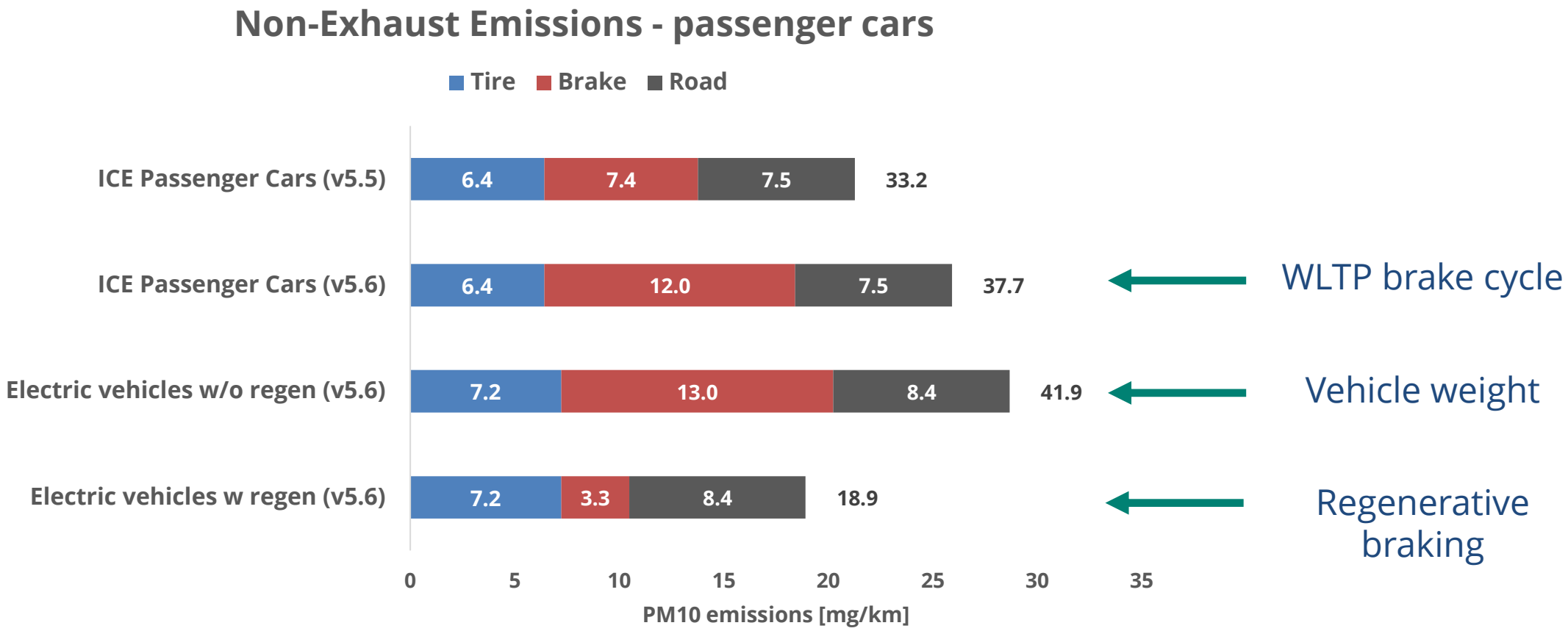
Revised non-exhaust emission factors



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Revision of degradation methodology

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Update fields

Petrol	Diesel
Euro 1	Euro 1
Euro 2	Euro 2
Euro 3	Euro 3
Euro 4	Euro 4
Euro 5	Euro 5
Euro 6	Euro 6

Existing in COPERT

Remote sensing data

Vehicle Measurements

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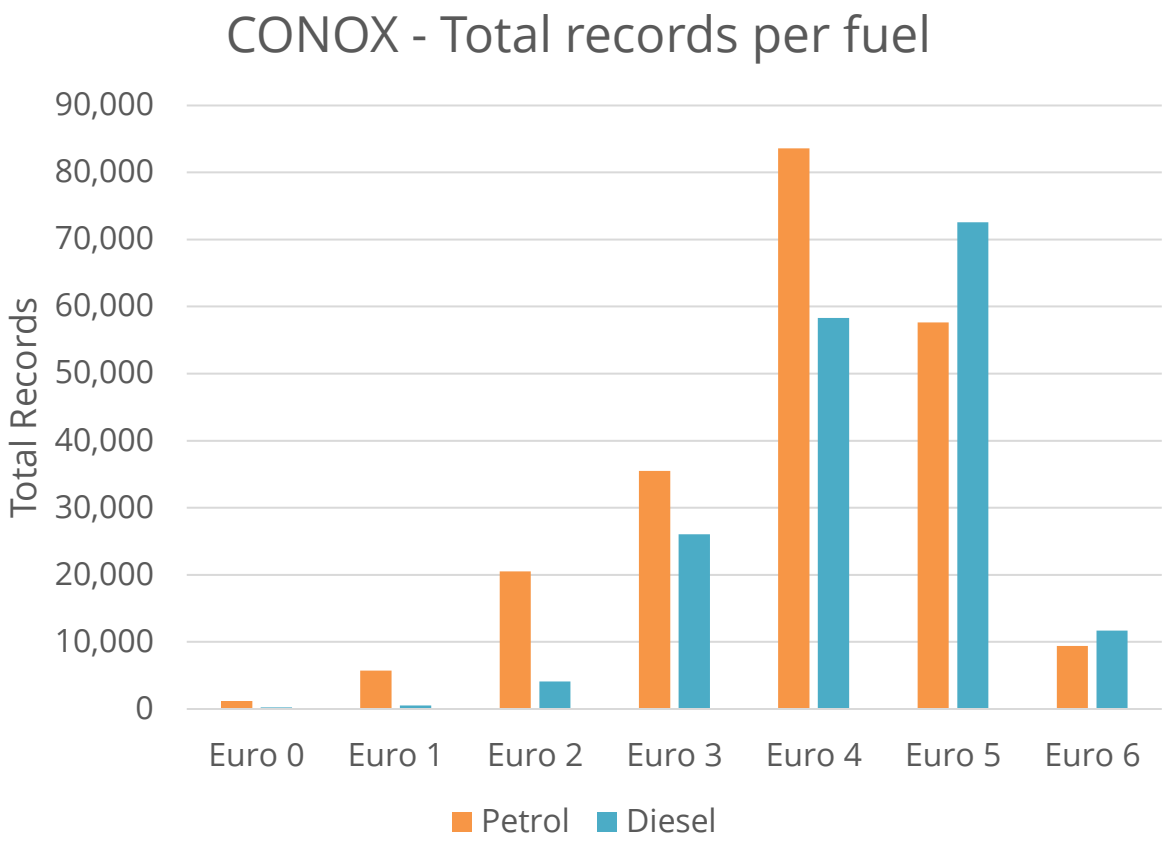
Remote sensing data

CONOX database

- Largest database of remote sensing measurements in Europe
- Multiple campaigns (France, Spain, Sweden, Switzerland, United Kingdom)
- Duration: 2011 – 2017
- More than 700,000 records



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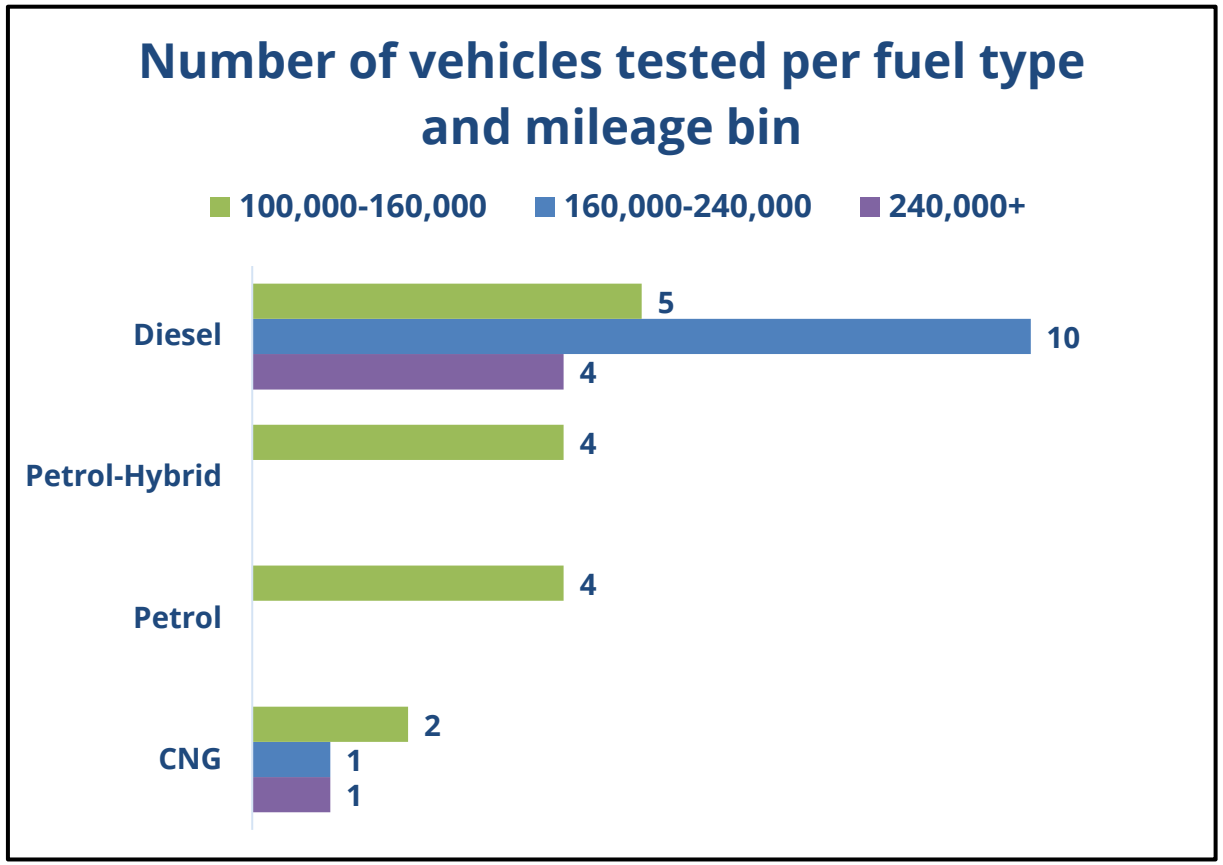
Vehicle measurements

- 35 Euro 6 vehicles tested
- Measurements
  - WLTC
  - RDE
  - Non-RDE
- Deterioration trends over mileage



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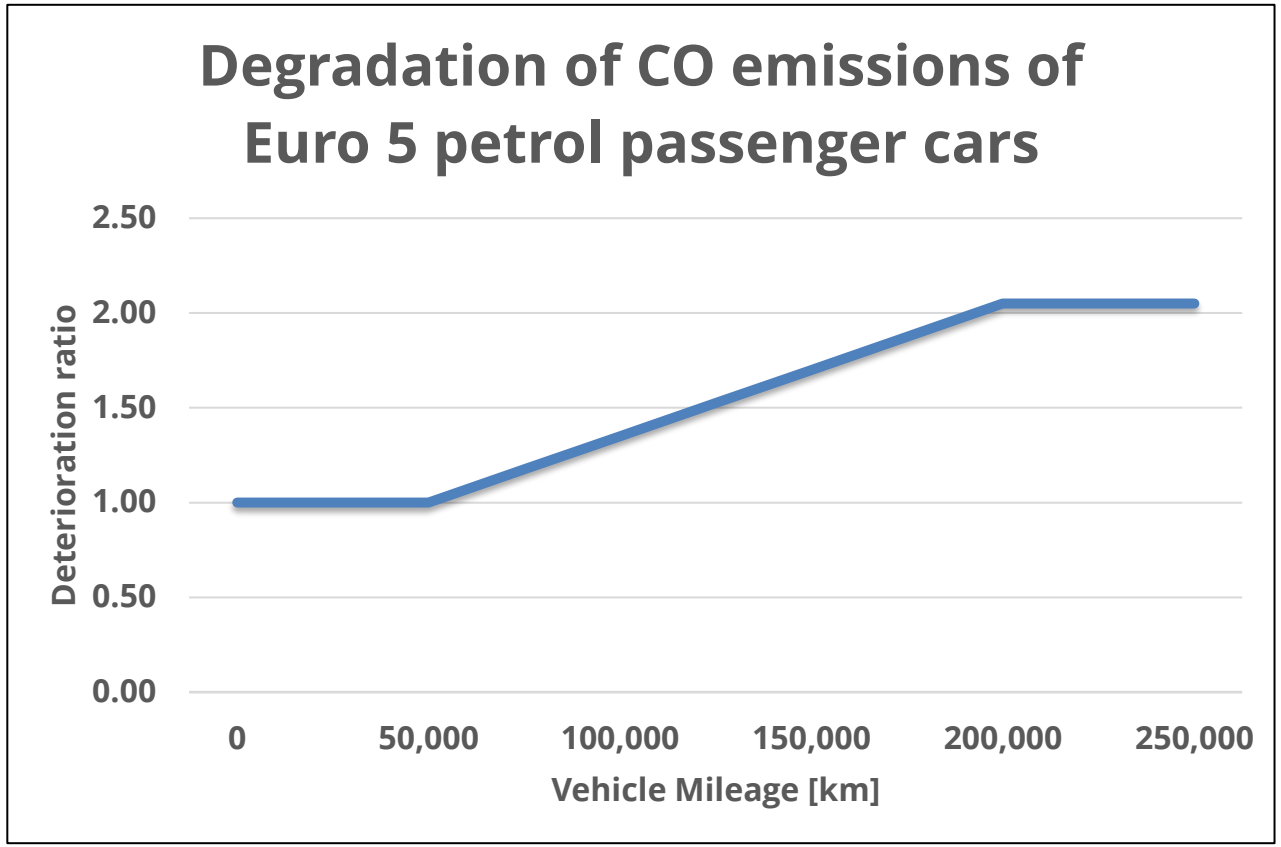
Degradation equation

- Pollutants: NOx, CO, VOC
- Degradation after 50,000 km
- No further degradation after 200,000 km



Deterioration equation example

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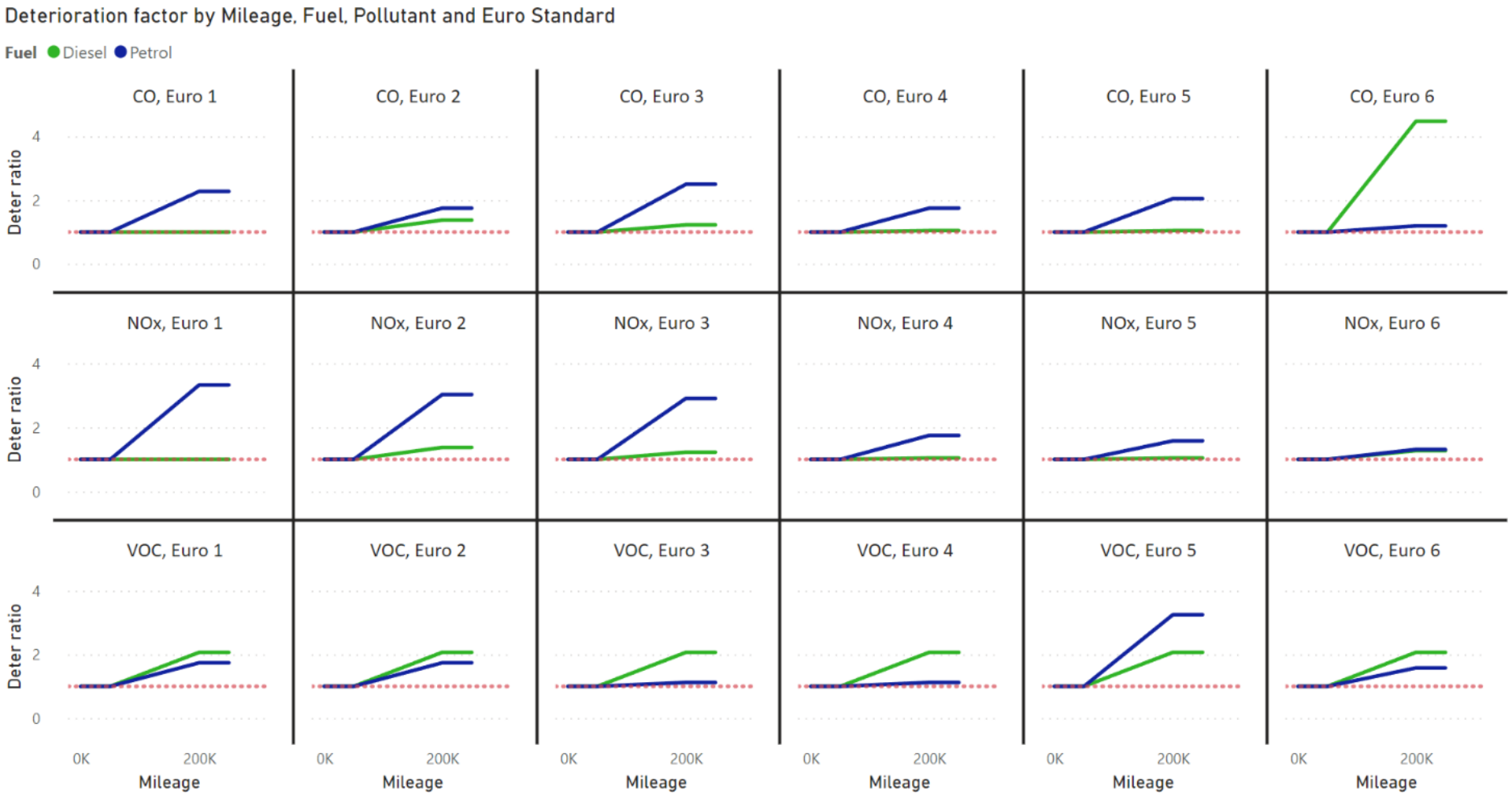
Degradation graphs



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Revision of cold start methodology

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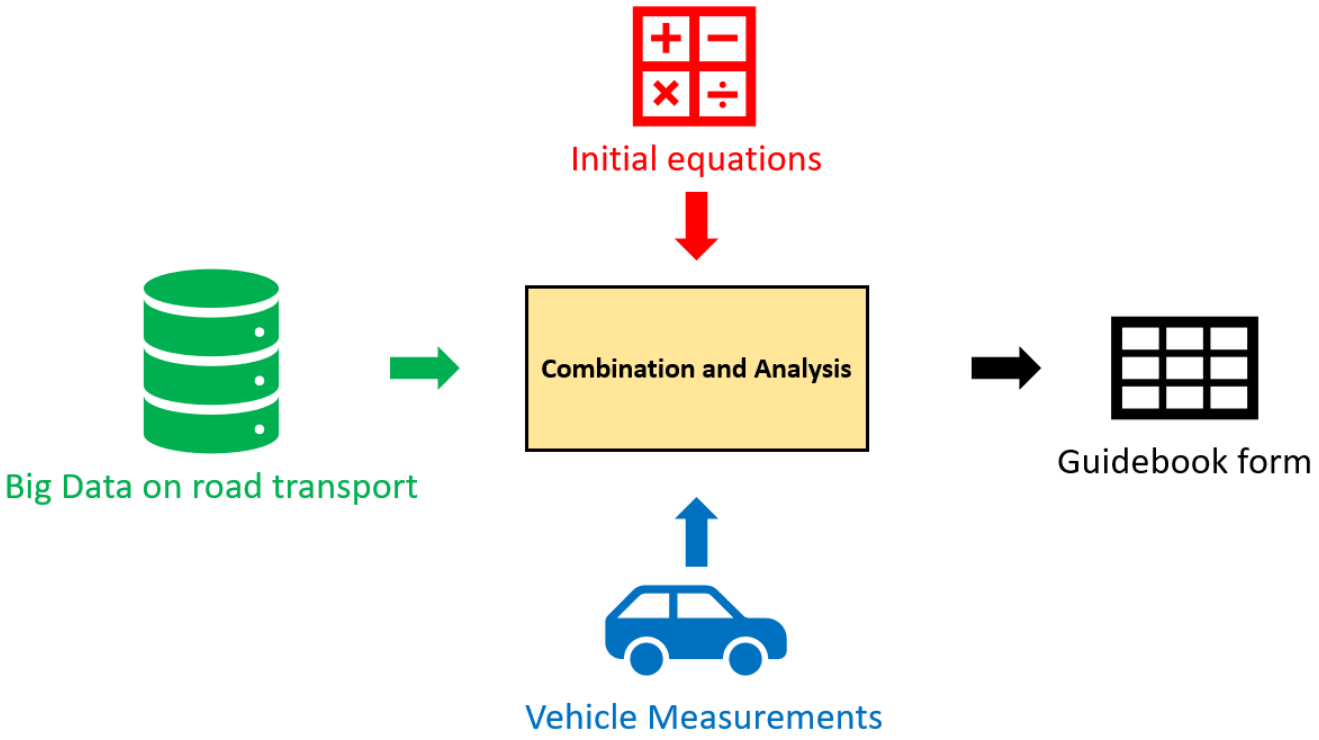
Methodology



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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

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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*

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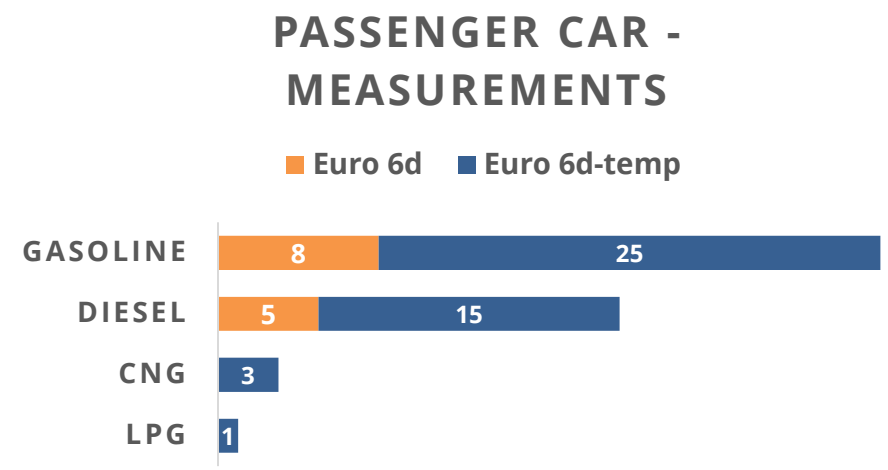
Vehicle measurements



HEAVY DUTY VEHICLES MEASUREMENTS

Euro Standard	Fuel	Categories
Euro V	Diesel	Heavy Duty Trucks, Buses
Euro VI-ABC	Diesel	Heavy Duty Trucks, Buses
Euro VI-DE	Diesel	Heavy Duty Trucks, Buses

Measurements

- hot conditions
- cold conditions

Cold start excess emission [mg per trip]

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Guidebook form – Passenger cars

Guidebook form

Euro Standards: Euro 6
Fuels: Petrol, Diesel
Pollutants: NOx, CO, VOC

Calculation of cold start emissions (overemissions)

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

where,

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

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

(v: vehicle speed, T: temperature)

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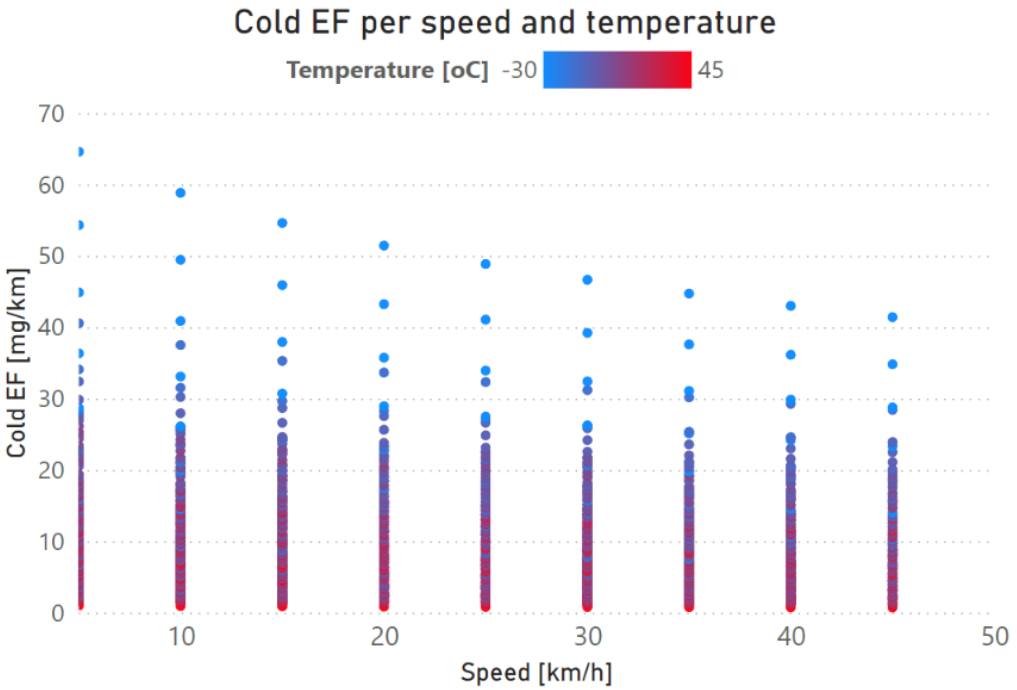
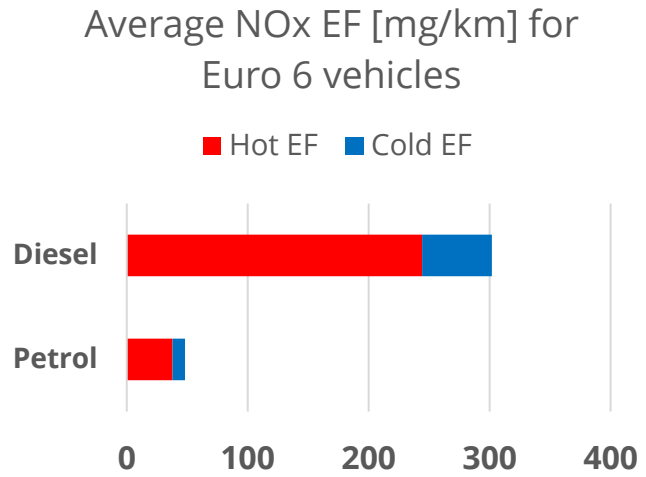
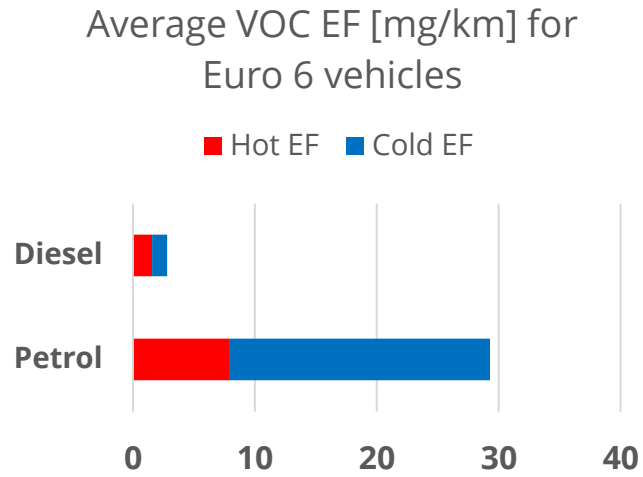
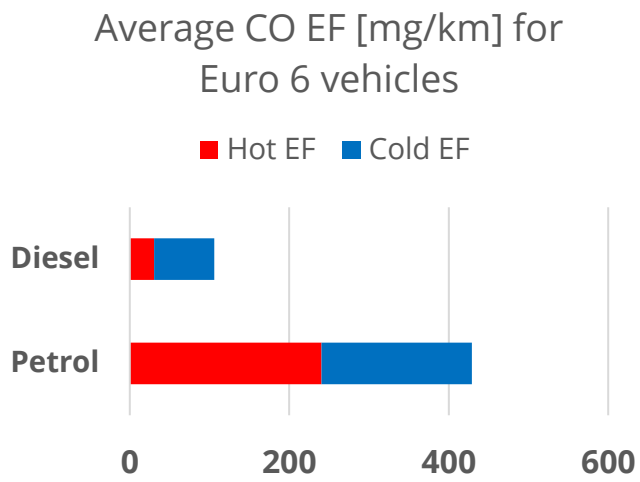
Passenger car - example



Petrol NOx cold EF







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Guidebook form – Heavy Duty Vehicles

Guidebook form

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

Calculation of cold start emissions (overemissions)

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

where,

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

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

(v: vehicle speed, T: temperature)

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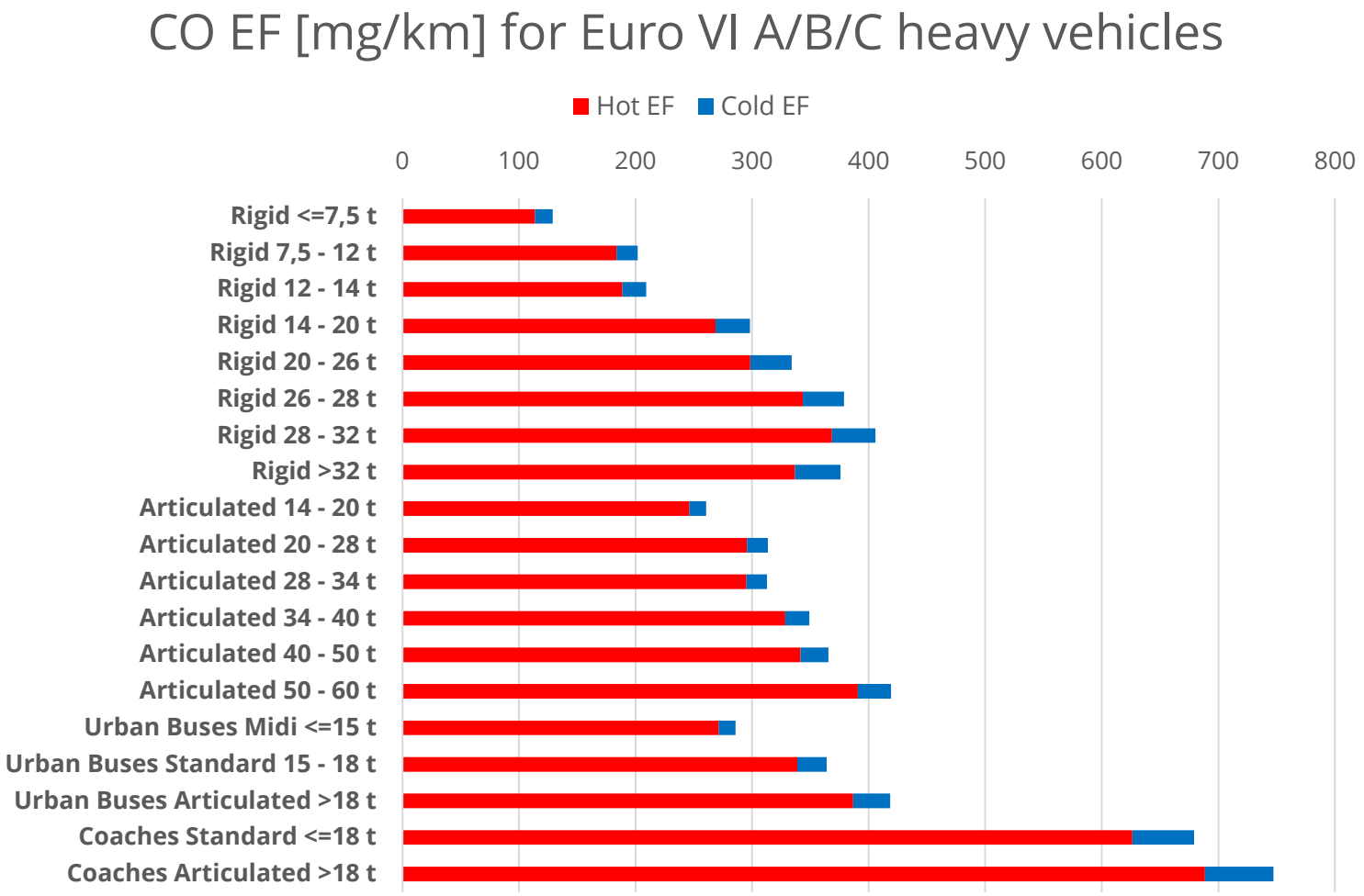
Heavy Duty Vehicles - example



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Revision of Euro 6 LPG passenger cars

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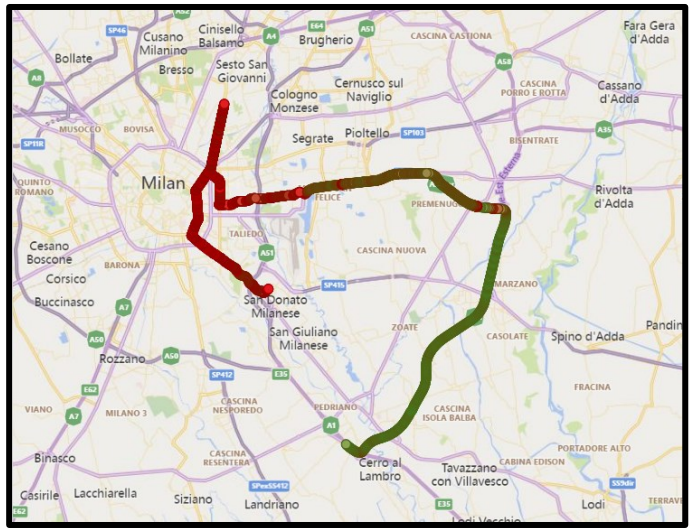
Vehicle measurements

- 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
  - NOx, CO, VOC, SPN23



RDE cycle in Milan (Low speed – High Speed)

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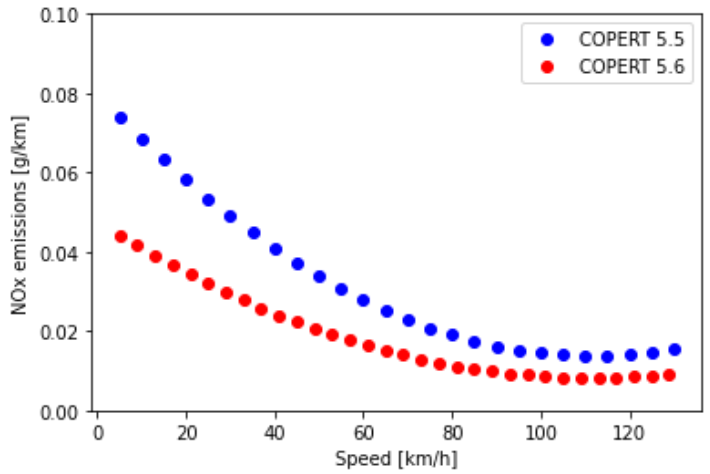
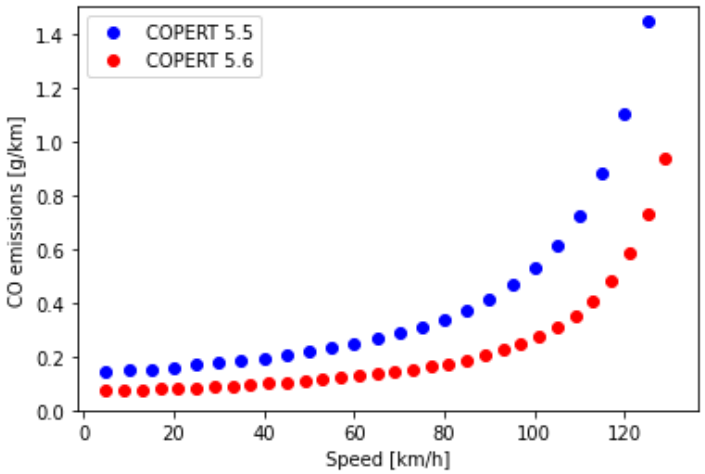
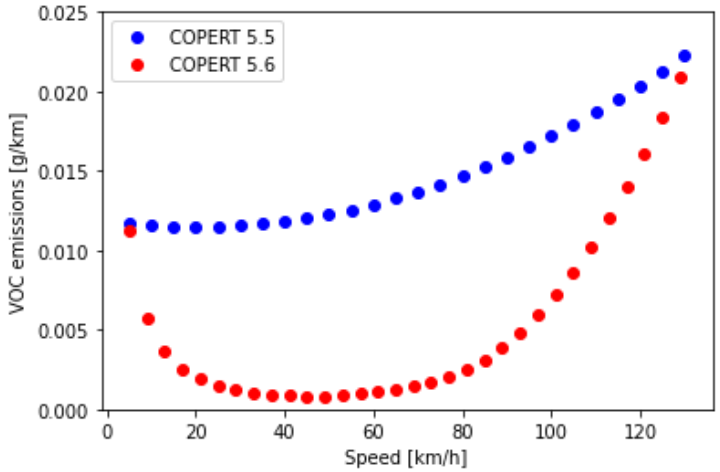
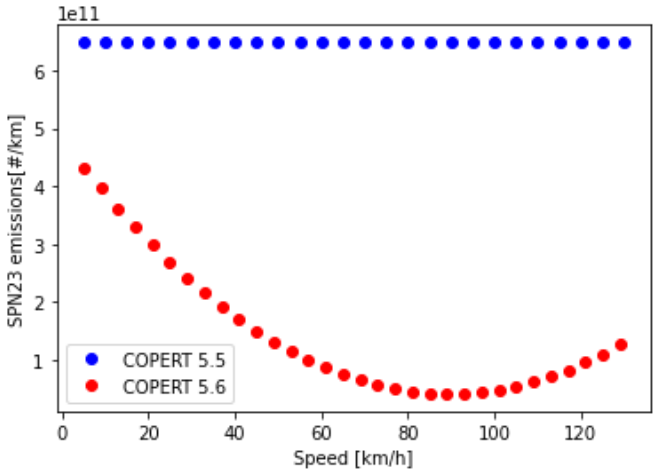
Revised equations









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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!

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