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HBEFA: Outlook on Version 5.1

ERMES Plenary, November 20, 2023

Agenda

1. Overview of the HBEFA 5.1 work program
2. Migrated HBEFA API preview
3. Method for assessing the emission factors
    1. Overview
    2. New non-exhaust particle model
    3. Non regulated exhaust gas components
    4. New cold start model
4. Summary

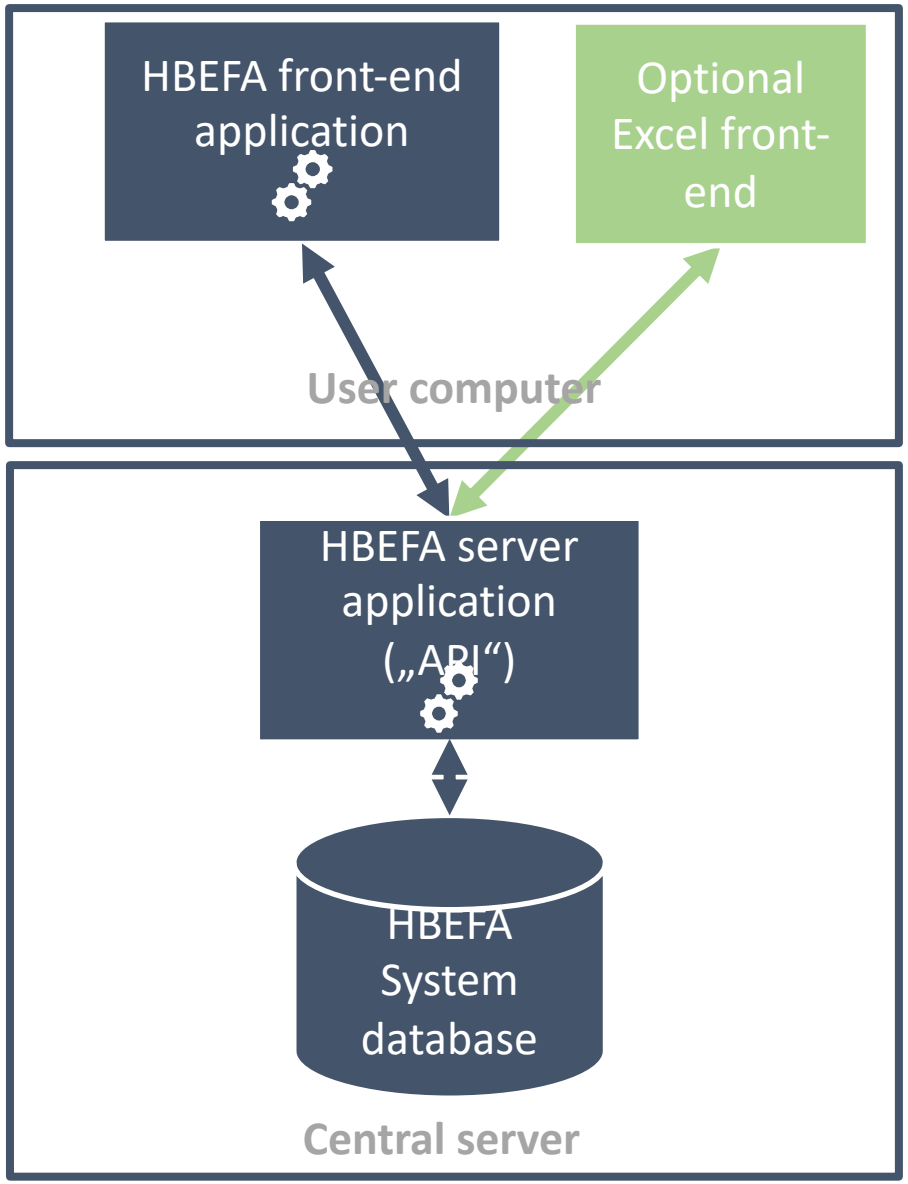
Work program for HBEFA 5.1

Work package	Task	Executed by
Preparation of measurement data	Single vehicle measurements (lab, on-road)	TU Graz
	Remote sensing	TU Dresden
Driving behaviour	Publication of traffic situation classification guidelines	INFRAS, ifeu, WSP
	Improvement of pre-conditioning methodology (SCR temperature, SOC)	TU Graz, INFRAS
Hot exhaust EF	Comprehensive hot EF update	TU Graz, INFRAS
	Mileage and temperature correction factors update	TU Graz, INFRAS
	Euro-7/VII EF	TU Graz, INFRAS
	Euro VI SCR heating strategies	TU Graz, INFRAS
	HGV size classes of alternative drivetrains at same degree of detail as Diesel	TU Graz, INFRAS
	Tampered HGV emission factors and mileage shares	TU Graz, INFRAS
	New moped EF from PHEM	TU Graz, INFRAS
	Additional L-cat. EF from PHEM	TU Graz, INFRAS
Cold start	Cold start EF based on new model; new cold start EF for HDV	TU Graz, INFRAS
Evap.	Evaporation update based on latest COPERT methodology	INFRAS
Non-exh.	PM/PN non-exhaust by processes (brake, tyre, road abrasion, resuspension) and by subsegment/traffic situation	TU Graz, INFRAS
Non-reg.	Update of existing (N2O, NH3, CH4, C6H6) and possibly new pollutants (e.g. aldehydes) from FTIR measurements	TU Graz, INFRAS
	N2O and NH3 cold start EF	TU Graz, INFRAS
	Update other pollutants from EMEP/EEA	INFRAS
Country data	Ccomprehensive country data update (fleet compositions, mileages etc.)	INFRAS + country data providers (ifeu, TU Graz, UGE, IVL, SSB)
	Harmonization of mopeds	INFRAS
Software, API	EF API: Additional aggregation levels (e.g. aggregated size classes)	INFRAS
	EF API: Differentiate by base energy (e.g. petrol vs. bioethanol)	INFRAS
	EF API: EF of new registrations or age groups	INFRAS
	EF API: EF by static TS (based on average LOS distribution in respective country)	INFRAS
	EF API: EF in additional units (e.g. FC in litres, EF in g/MJ, etc.)	INFRAS
Review, QC	More systematic and in-depth review and QC	ifeu, INFRAS, TU Graz, country data providers

Components of the migrated HBEFA

- A server application (running on a central server) presents an API and carries out calculations.
- The front-end is a GUI application running on the user's computer, sending requests to API and displaying/saving result. Will have similar functionality as the current application.
- Optionally, additional front-ends (or third-party applications) can use the API.
  E.g. an Excel front-end for easy extraction of emission factors into Excel is planned

The migrated application is planned to become available with the HBEFA 5.1 update, i.e. mid-2025



Migrated HBEFA API

- Migrated HBEFA API will allow more flexible emission factor queries, e.g.:
  - Selection of single vehicle types at all aggregation levels – e.g. single (sub)segments
  - Choice of output units; EF of different emission categories (e.g. hot and cold start) in same unit
  - Query EF by multiple aggregation levels that can be flexibly combined, e.g. by technology and size class
  - Differentiate by „base energy“ (i.e. components of a fuel mix)

efrequest.py > EFRequest > __init__

```
def __init__(self, pollutant: List[str], country: str, wgt: bool, emcat: List[str],
        agglevel_fleet: List[str] =['vehcat'], agglevel_ts: str ='aggregate_ts', agglevel_energy: str='none',
        yearref: List[int]=[2020], idvehcat: List[int]=None, idtechnology: List[int]=None, idsizeclass: List[int]=None,
        idemconc: List[int]=None, idsegment: List[int]=None, idsubsegment: List[int]=None,
        idts: List[int]=None, idgrad: List[int]=None, idload: List[int]=None,
        idtraffic_scen: List[int]=None, idtsgrad: List[int]=None, idpatternambientcond: List[int]=None,
        nocorr: bool=False,
        lang: str='en',
        col_selection: str='standard', col_titles: str='speaking',
        load_in_rows: bool=False,
        verbose: bool=False, test_outputs: bool=False, **kwargs):
```

Overview on method for assessing the emission factors

For all “new” emission classes, i.e. Euro 6d-TEMP /VI C up to 6d / VI E and for L-category

Input from all partners highly welcome!

DBEFA test database

EU 6 emission test data of
- 68 LDVs
- 32 Euro VI HDVs
- 11 L-category

Chassis dyno and PEMS
- Test data from brake and tires

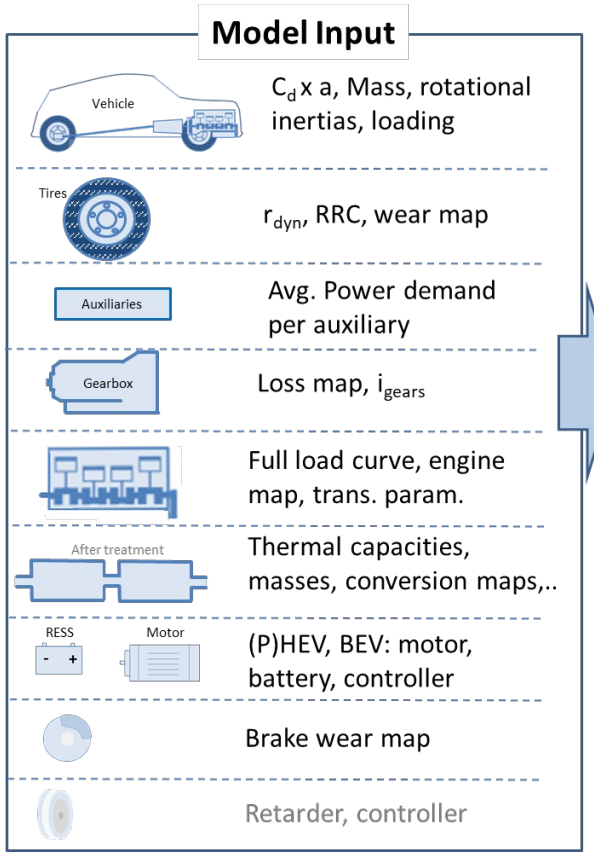
More expected in 2024 data collection campaign.

> 270 HBEFA driving cycles

PHEM input data base

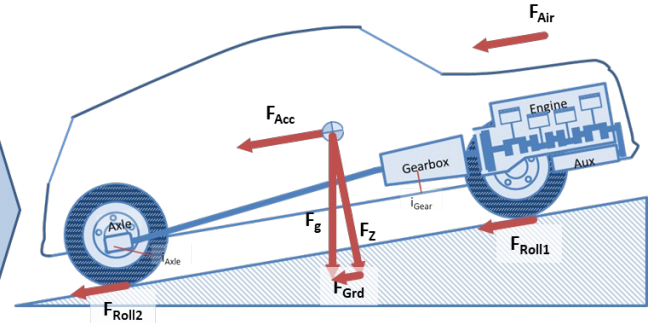
- Engine hot emission maps and EAS efficiencies
- Cold start polygons
- Vehicle data
- Brake- & tire emission polygons

Per vehicle and weighted average for EU fleet



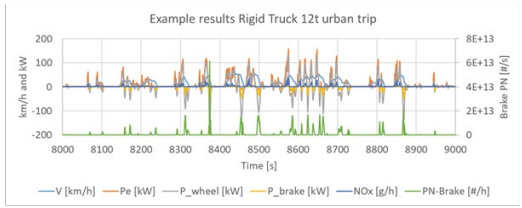
PHEM

Passenger car and Heavy duty Emission Model



$$P_e = P_{Air} + P_{Roll} + P_{Acc} + P_{Grd} + P_{Loss} + P_{Aux}$$

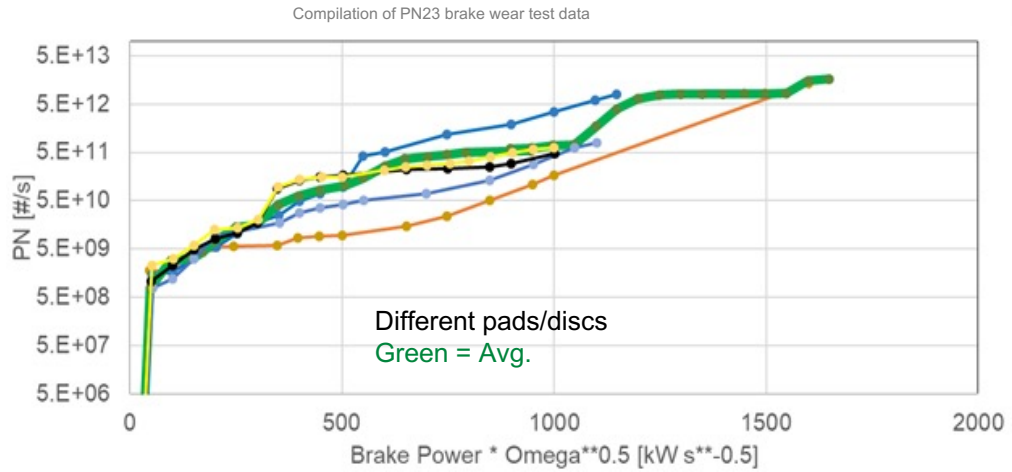
Simulation in 1 Hz for: wheel power, engine power and speed, brake power, fuel consumption, emissions, etc.



New non-exhaust particle model

Brake wear calculated based on brake power and disc speed simulated by model PHEM
Tire- & Road wear simulated based on wheel power simulated by model PHEM

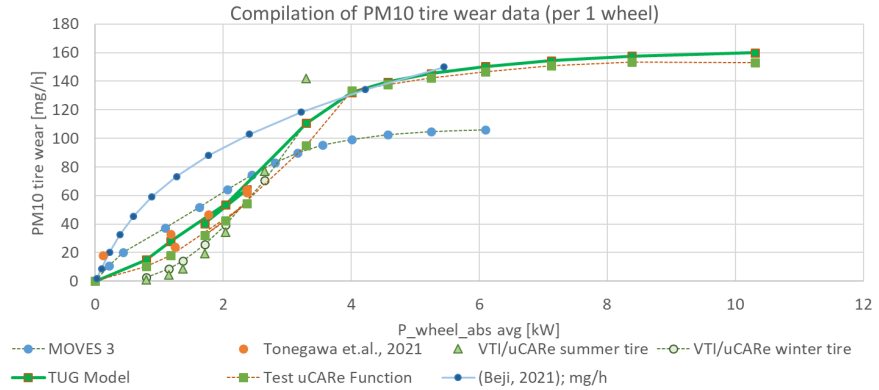
Brake wear: PN/brake event from test data
→ characteristic curves; PM from density function



To do's in 2024:

- More pad/disc data to be added
  (TPM, PM10, PM2.5, PN)
  also for representative density functions
- Temperature effect may be added
- Representative retarder model for HDVs

Tire wear: PM & PN from test data and literature
→ characteristic curves; PN from density function



To do's in 2024

- Add test data of more tires, especially HDVs
  (PM10, PM2.5, PN also for density f.)
- Add other effects if relevant
- Adjust road wear model if data available

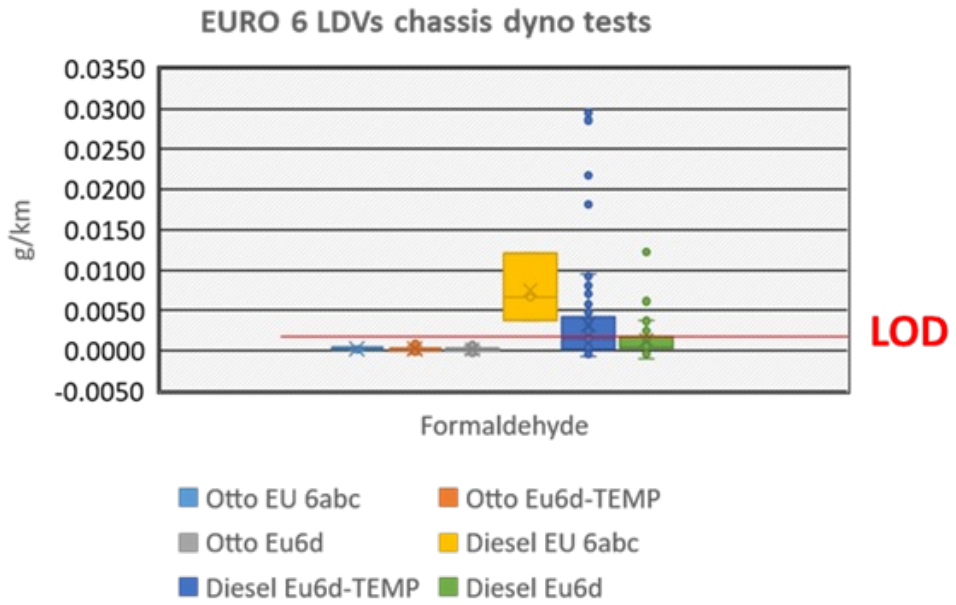
Non regulated exhaust gas components

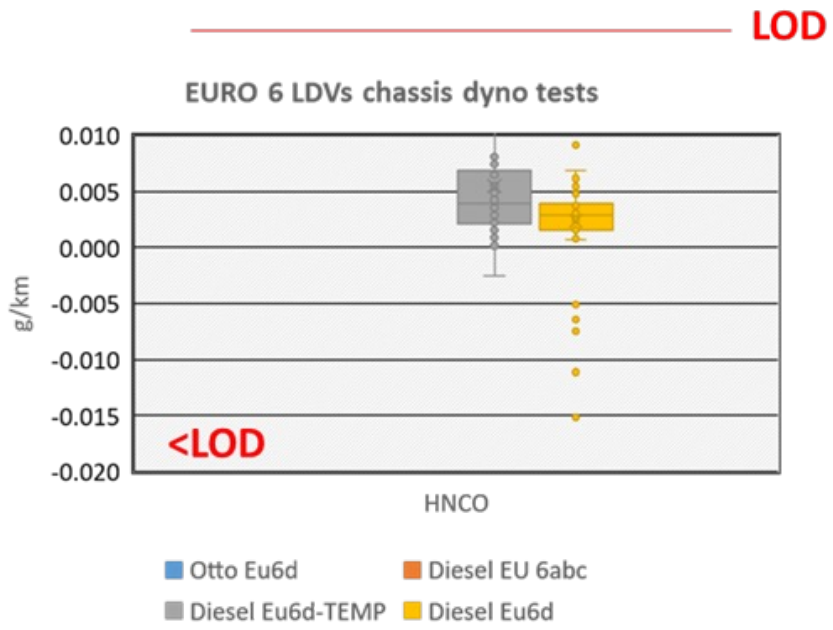
Most vehicles in DBEFA measured with FTIR (also PEMS) → Huge data set used for update of emission factors

Where reasonable, the new components will be added in PHEM emission maps for automatic handling.

Emission levels of many components are below LOD of the FTIRs
(example Euro 6 diesel cars below)

Discussion, which components to consider, is ongoing
(NO/NO2, NH3, N2O, Formaldehyde + more?)





New cold start model

Up to HBEFA 4.2. cold start extra emissions (CSEE) were calculated from IUFC tests (cold – warm sub-cycles)

Needed tests at different start temperatures on chassis dyno → very limited data set.

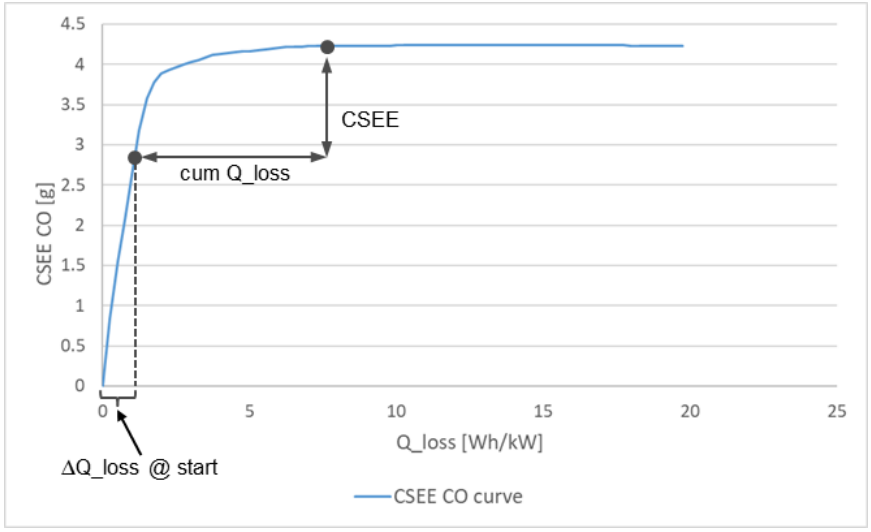
CSEE dominate emissions from Euro 6/VI vehicles → larger vehicle sample to be covered by new method.

PHEM produces cold start polygons" CSEE by simulating hot emissions for tested cycle as usual.

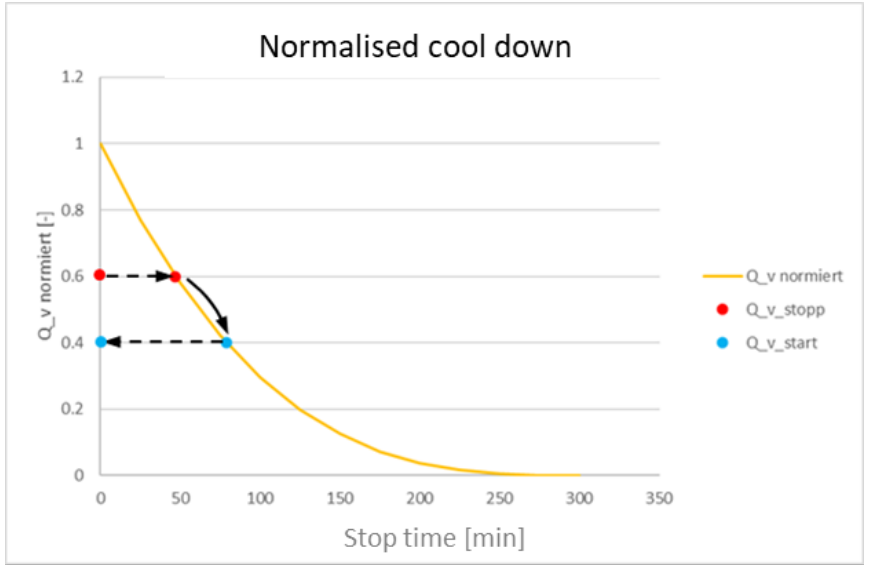
CSEE [g/start] = measured cold emissions – simulated hot emissions.

CSEE plotted as function of heat loss (fuel energy – engine work) I correction function for engine power in cold phase

From single vehicle polygons average ones per emission concept are produced to model CSEE for any cycle.



Effects of stops considered by cool-down curve →



Summary

HBEFA software set up in a modern and future proofed way for V 5.1

All emission factors for newer EURO 6 generations to be updated

Updates based on large and high quality data base (more contribution highly welcome)

New non-exhaust emission factors will be based on physical simulation approach and component test data

Test data includes non-regulated exhaust gas components from FTIR analysers

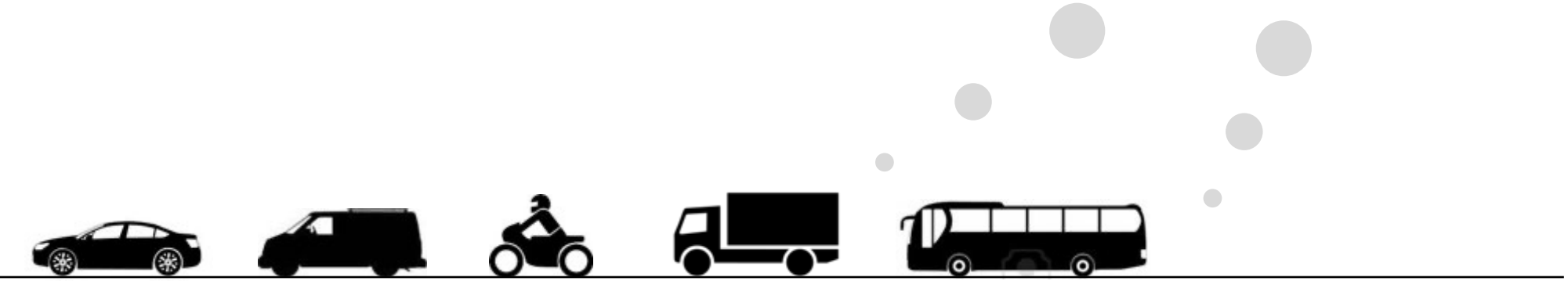
New cold start model can use all cold start tests as input → representative data base

Many thanks to the funding countries for enabling such a major step forward in of road transport emission monitoring!

INFRAS THINKING FOR TOMORROW

TU Graz

Thank you for your attention!



Example for model results (backup slide)

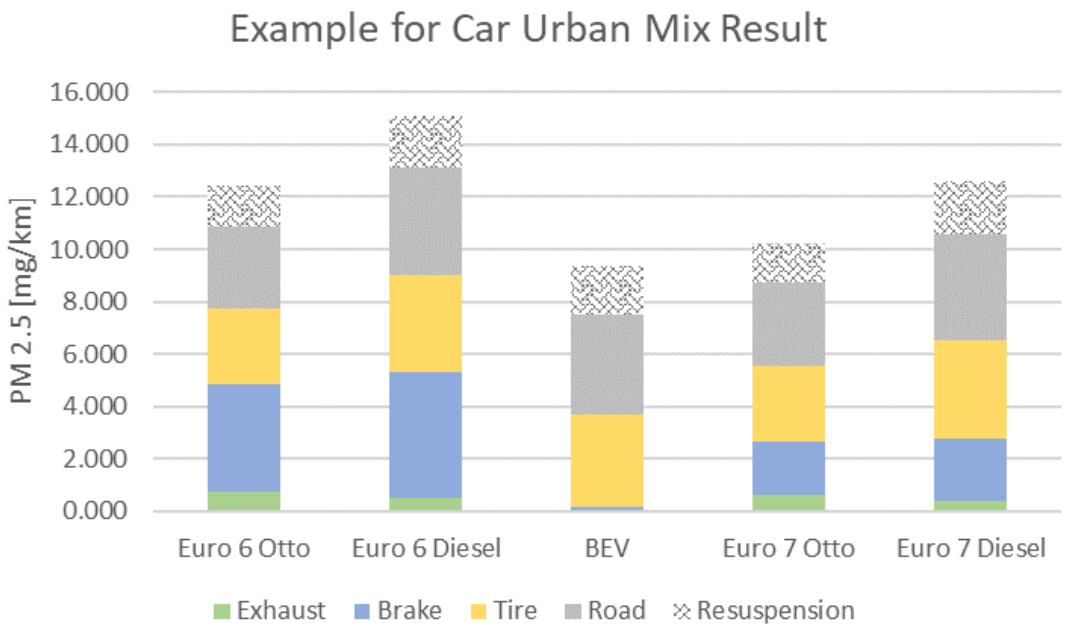
Version and data from $PHEM_{13.06.2}$

Different propulsion systems:

PM2.5 for cars

EU average new registration vehicle masses

EU7 with limit of 7mg/km in WLTP brake cycle



Different driving cycles:

PM10 for generic articulated truck

Reasonable resolution for uphill (higher tire and road wear, less brake wear) and downhill (vice versa) and for cycles with low/high shares of brake events