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Emissions of Passenger Cars in Special Driving Situations

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TAP 31th March 2021, Graz, Austria

Motivation

Measurements of “Real Drive Emissions” (RDE) are an element of the type approval (since September 2017)

They give opportunity to collect emission data in special or non-driving situations:

- Cold start & warm-up of the engine
- Stop & Go
- Idling

These non-driving situations have a significant time share on the “urban” phase.

→ Development of automatic evaluation of the emissions from these special driving situations.

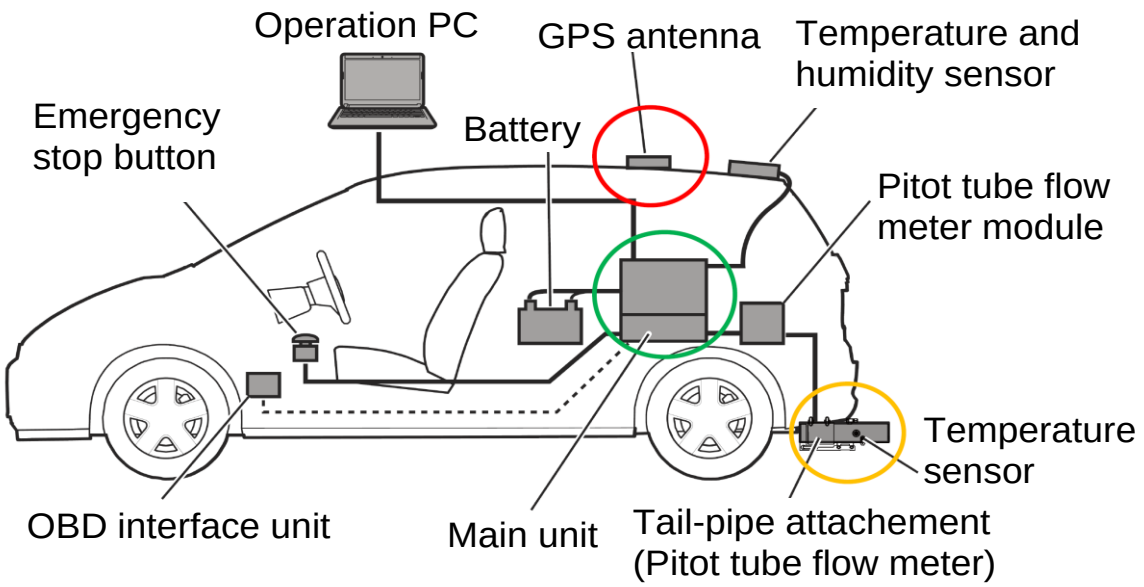
- Motivation
- Vehicle selection
- Analysis of present data
- Reproduction of non driving situations
- Results & conculsions

Vehicle selection I

Criteria for the selection of data sets

- Same RDE route
- Same measuring system
- Emission components measured (CO_2, CO, NO_x, PN, HC)
- Engine cold start measured
- Engine ignition measured
- Start-stop-system off

Set-up of Portable Emission Measuring Systems (PEMS)



Concentrations, Mass Flow, Distance ⇨g/km

Vehicle selection II

List of vehicles chosen for evaluation

Nr.	Fuel type	Displacement [L]	Exhaust Aftertreatment System	Injection
LDV01	Gasoline	1,6	TWC	PFI
LDV02	Gasoline	4,0	TWC, GPF	DI
LDV03	Gasoline	6,2	TWC	PFI
LDV04	Diesel	2,0	DOC, DPF	DI
LDV05	Diesel	2,1	DOC, DPF, SCR	DI
LDV06	Diesel	3,0	DOC, DPF, SCR	DI
LDV07	Diesel	3,0	DOC, DPF, SCR	DI

Exceptions in the data sets:

- LDV 07 “start-stop” was switched on
- PN not for all vehicles
- HC was not measured for these vehicles

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Definition of the different non-driving states

Driving distance:

- Parts with speeds <60 km/h, legal considered as “urban”
- Here 13,7 km is the shortest distance before the vehicles reached 60 km/h

Cold start & engine warm-up:

1. engine start to the instant of ECT = 70°C
2. engine start to the duration of 5 minutes

Definitions		start	end
Cold Start	state	ECT < $T_{ambient}$ +2°C OR ECT < 30°C	-
Engine in Operation	state	Engine Speed > 500 rpm	-
Warm-Up ECT 70	phase	Cold Start AND Engine in Operation	ECT > 70°C
Warm-Up 5min	phase	Cold Start AND Engine in Operation	Phase Time > 5min

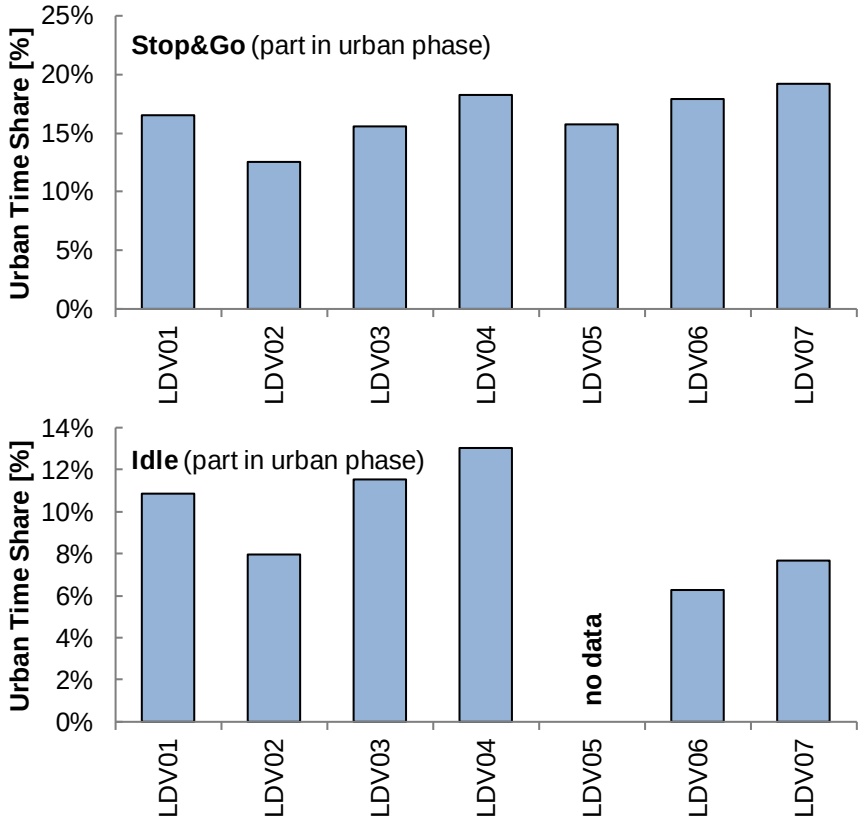
“Stop & go” & idling :

Definition		start	end
Stop&Go	phase	Vehicle Speed < 1 km/h	Vehicle Speed > 10 km/h

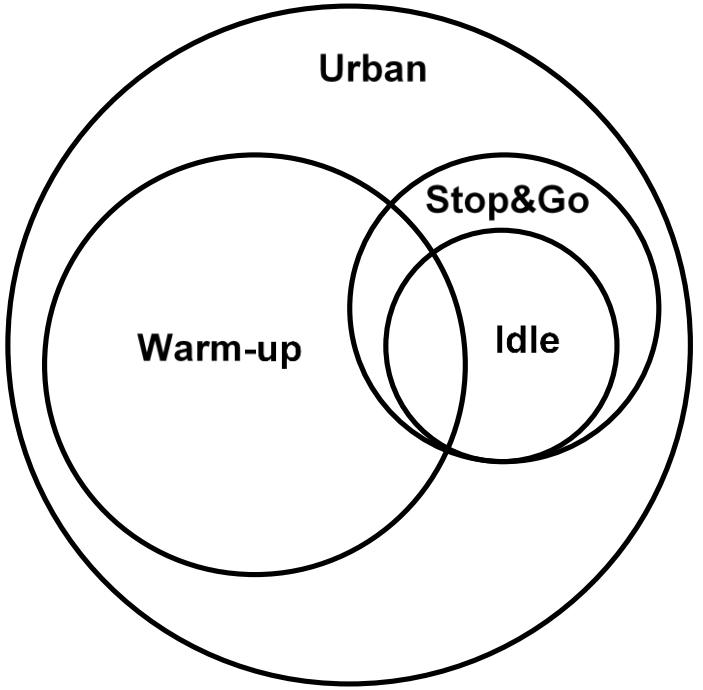
Definition		start	end
Idling	state	500 rpm < Engine Speed < 900 rpm	-
Idle	phase	Vehicle Speed < 1 km/h AND Idling	Idle Start Cond. False

Analysis of present RDE data “time share”

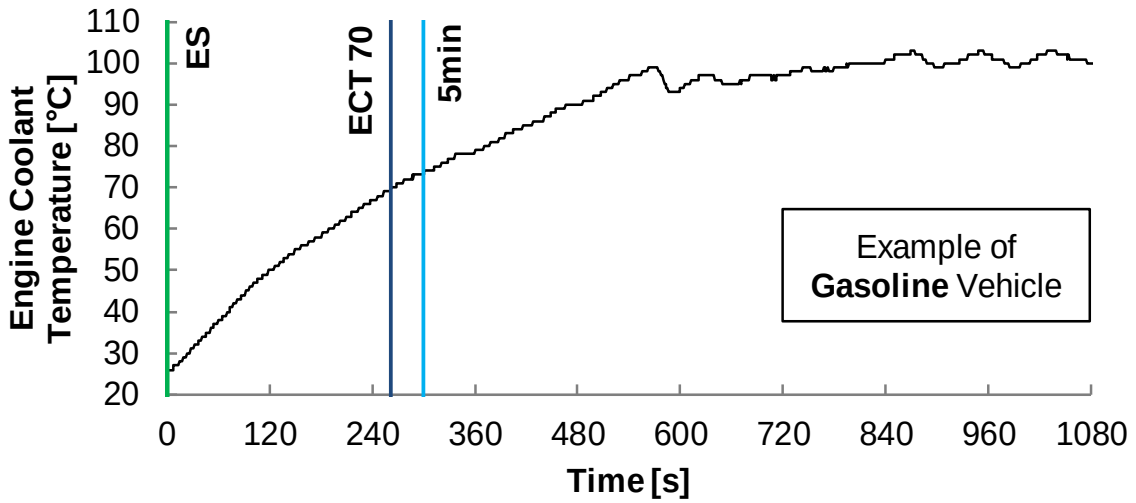
Time shares of “stop & go” and idling in RDE

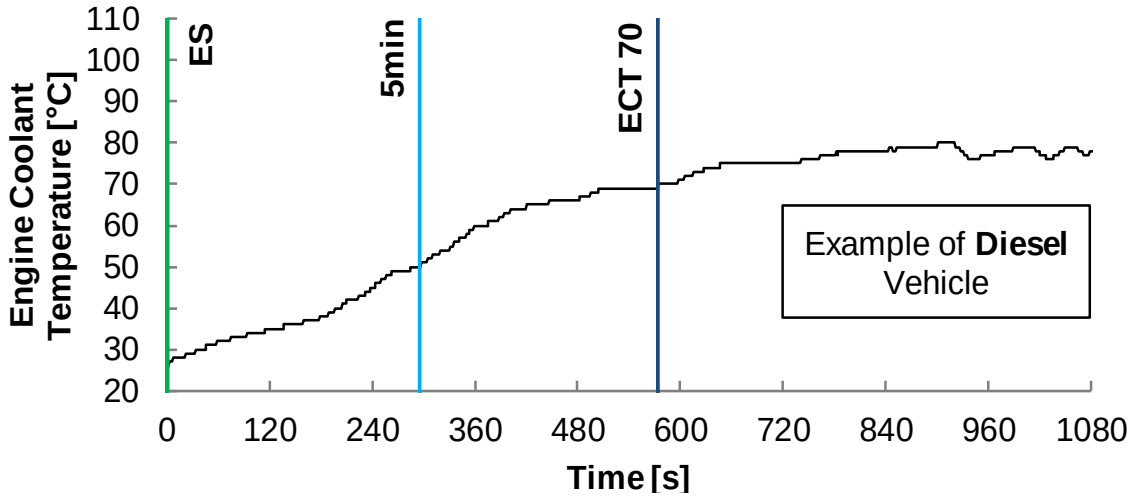


Qualitative overlapping of the analyzed data

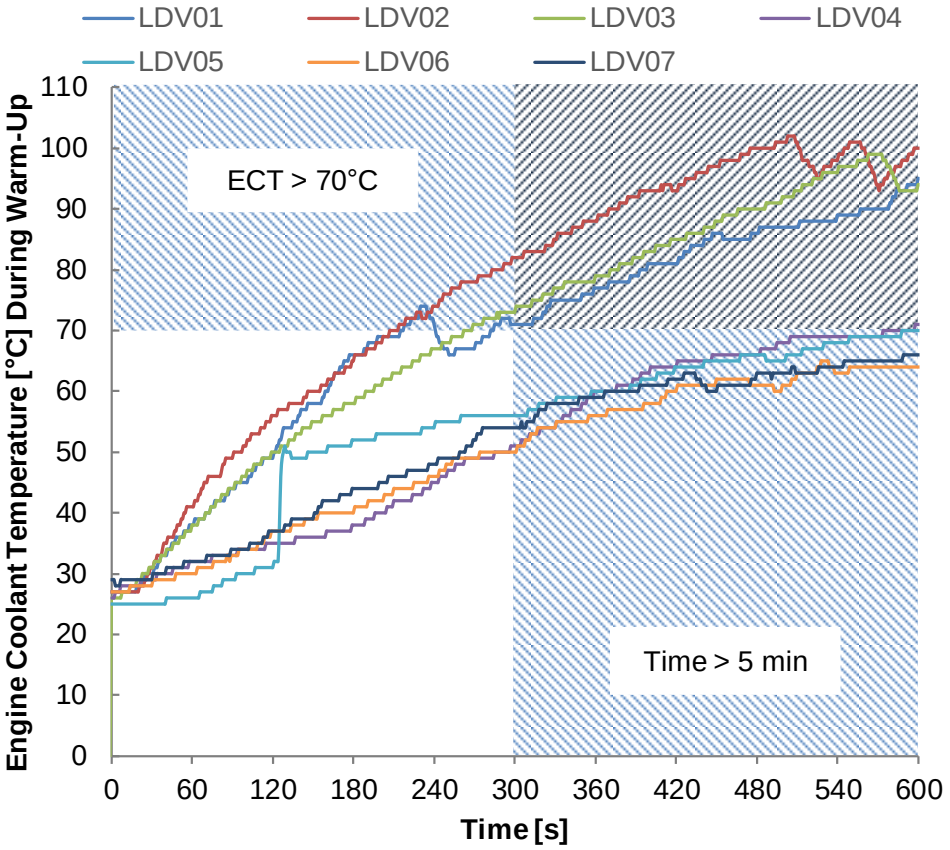


Analysis of present RDE data “warm-up”



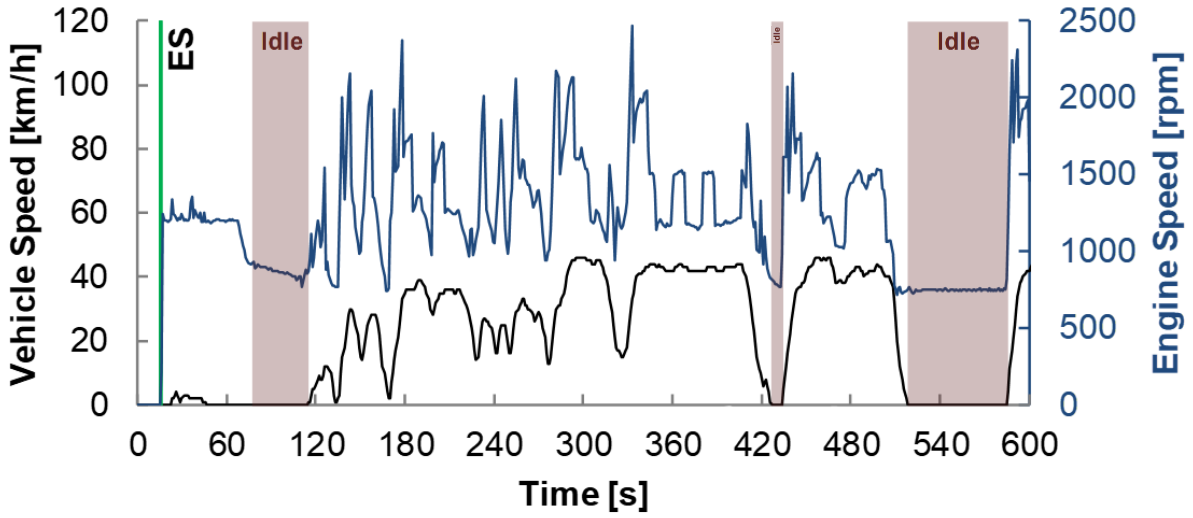


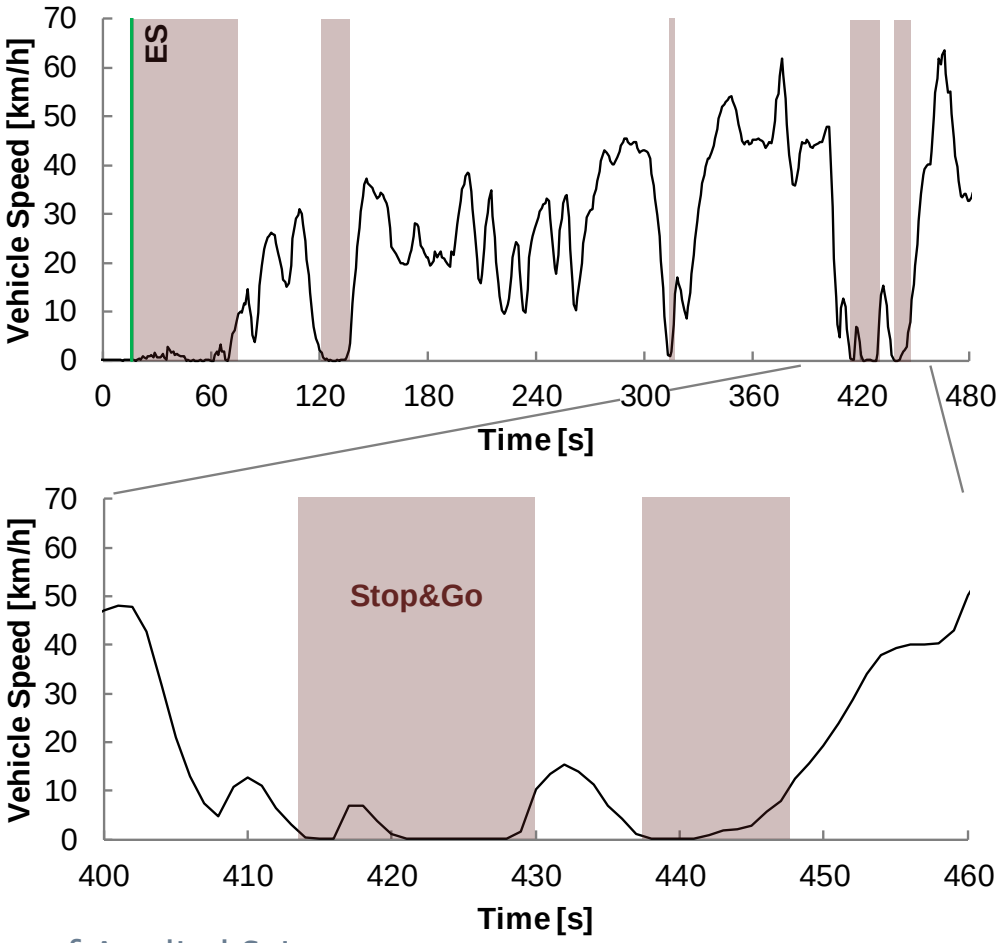
Engine coolant temperature during warm-up



Analysis of present RDE data “idling & stop & go”

Obtained recognition of phases: idle and “stop & go”





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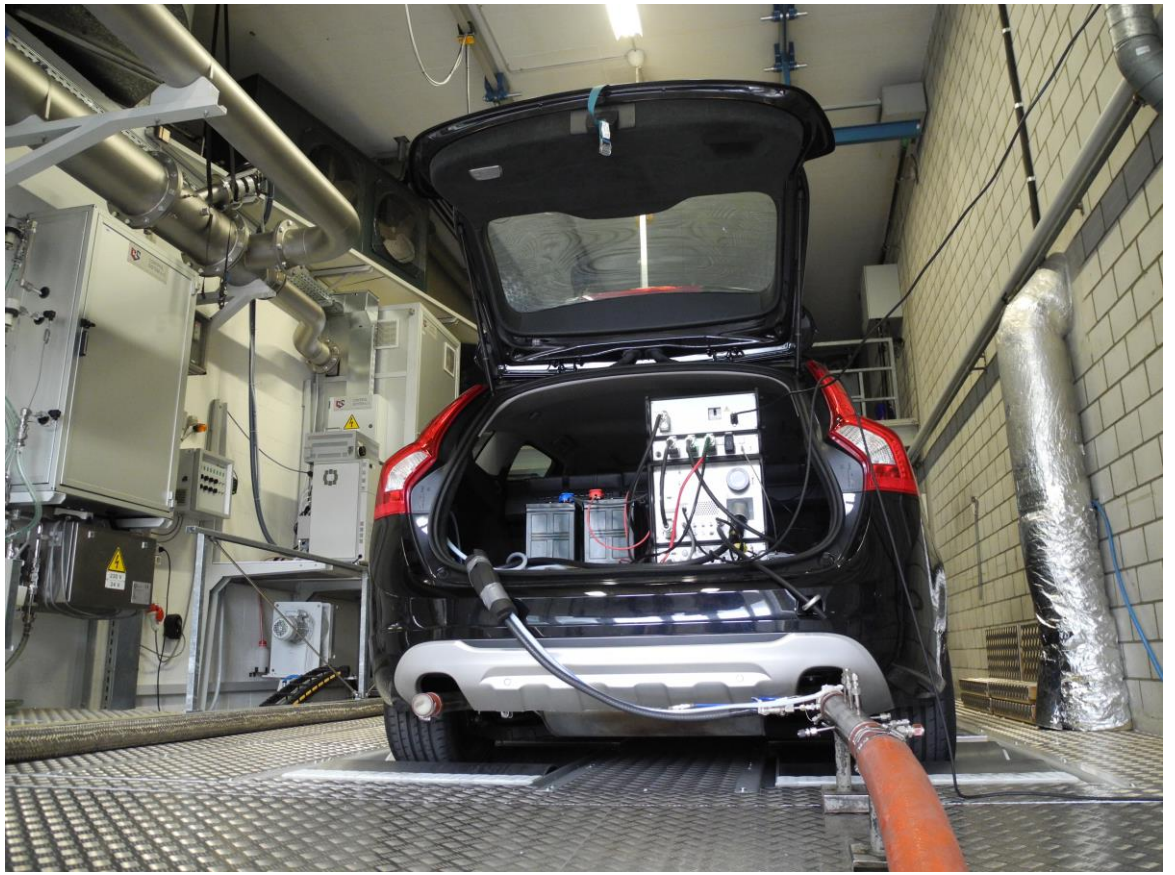
Reproduction of non driving situations

Reproduced situations:

- Cold start
  20-25° C
- Warm-up phase
  15 and 80 km/h
- “Stop & go” operation
  different portions of idling



Two groups of vehicles:

- Diesel | Gasoline
- 2 vehicles per group (1x dated/1x modern)

- Motivation
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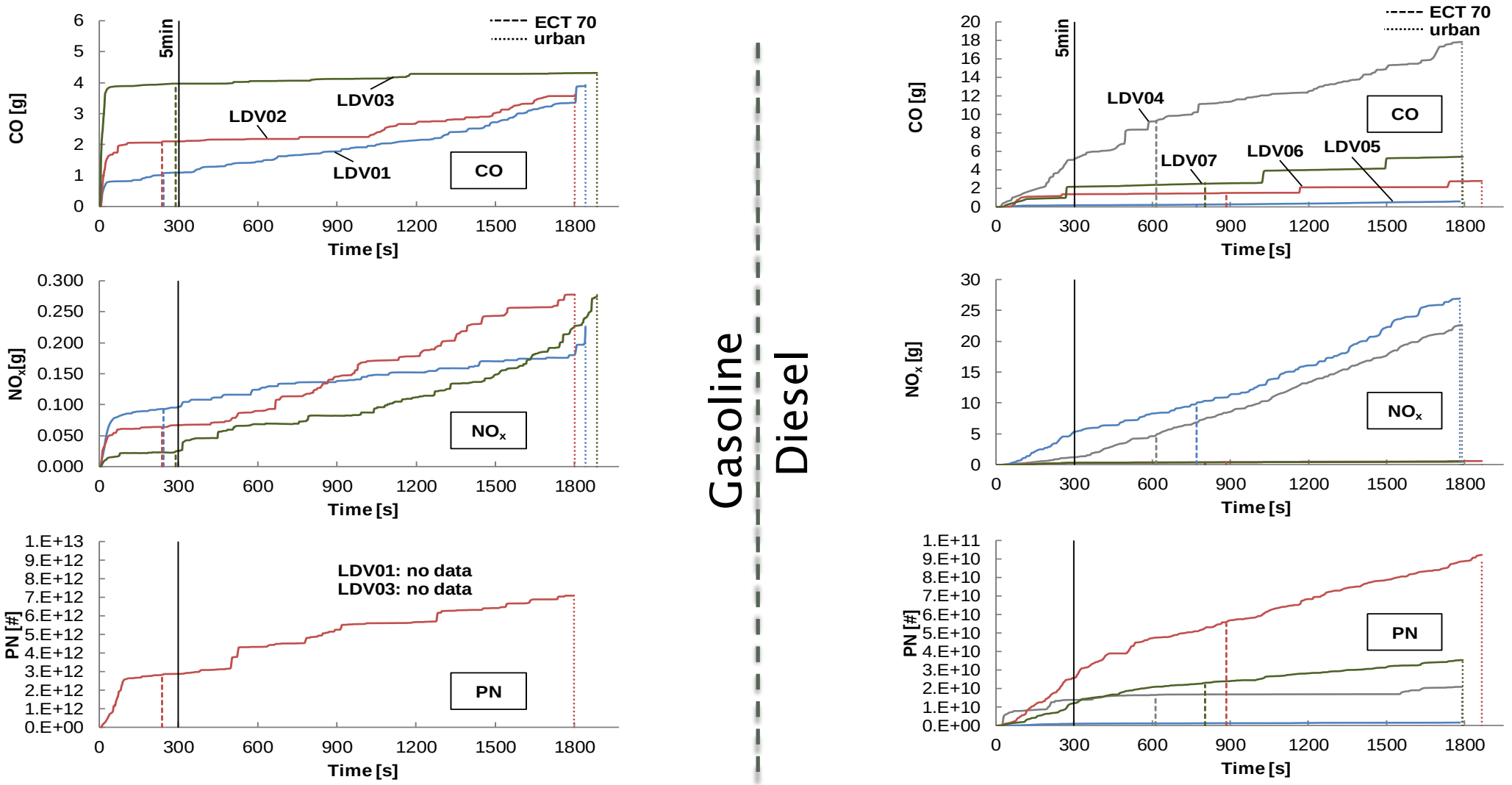
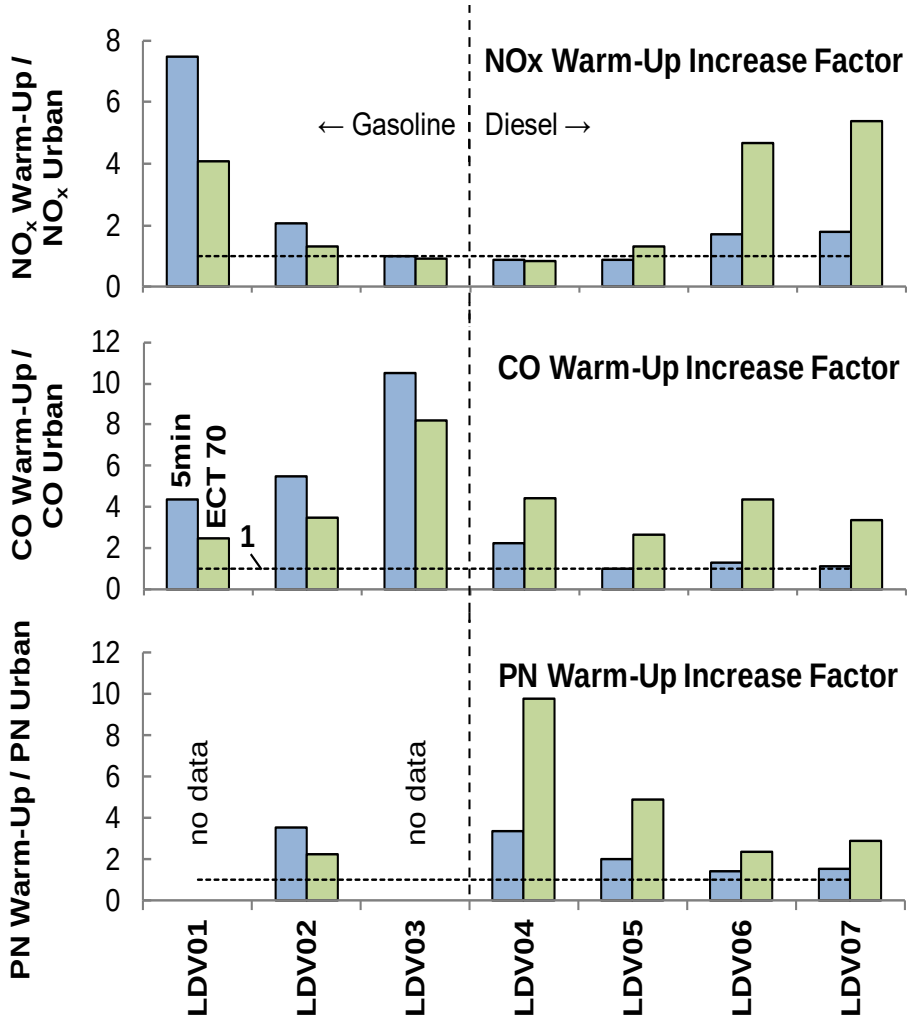
Cumulated emissions during the warm-up phase



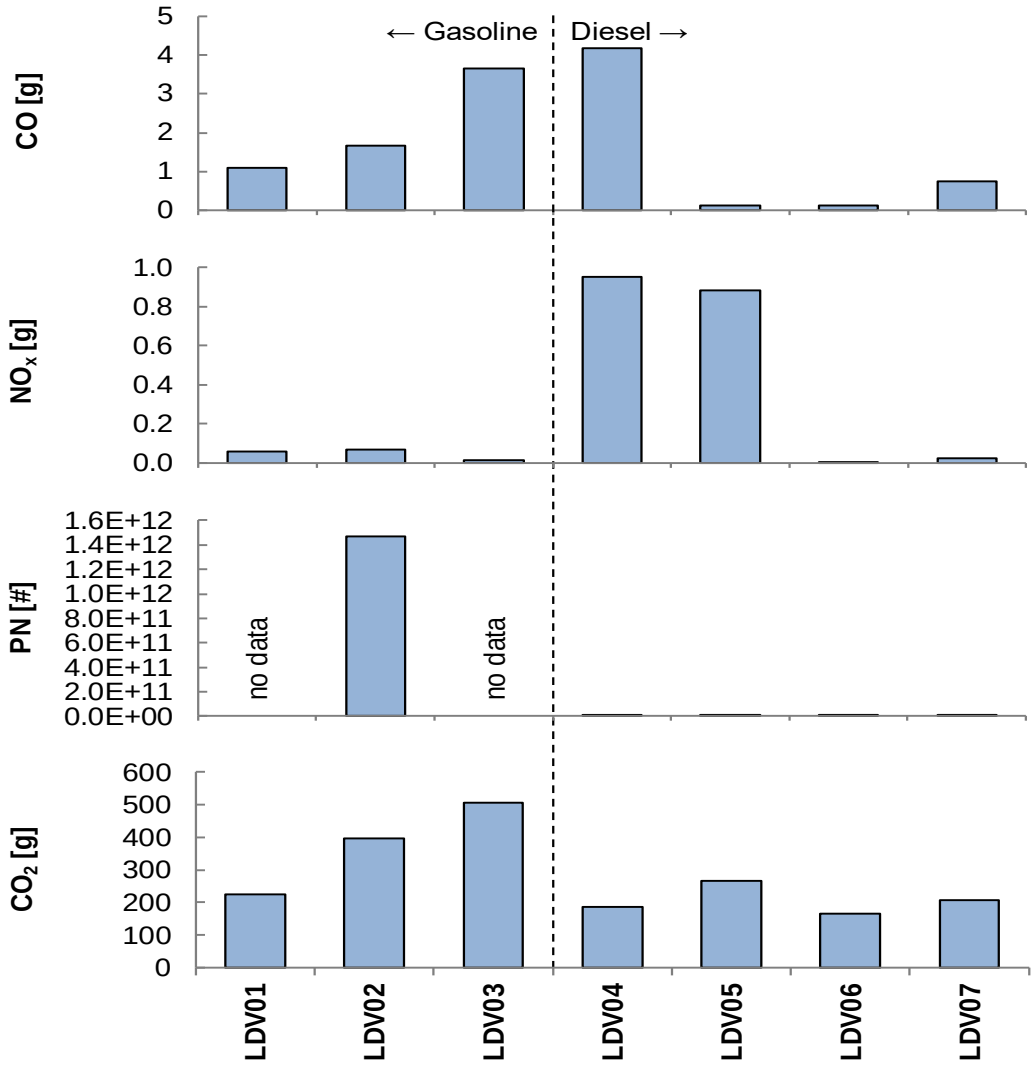
Specific emissions in warm-up



Increase factors in the warm-up phase

- NO_x:
  0,9 - 5 Gasoline | Diesel 0,9 - 5
- CO:
  2 - 11 Gasoline | Diesel 1,0 - 4
- PN:
  2 - 4 Gasoline | Diesel 1,5 - 10

Cumulated emissions in “stop & go”



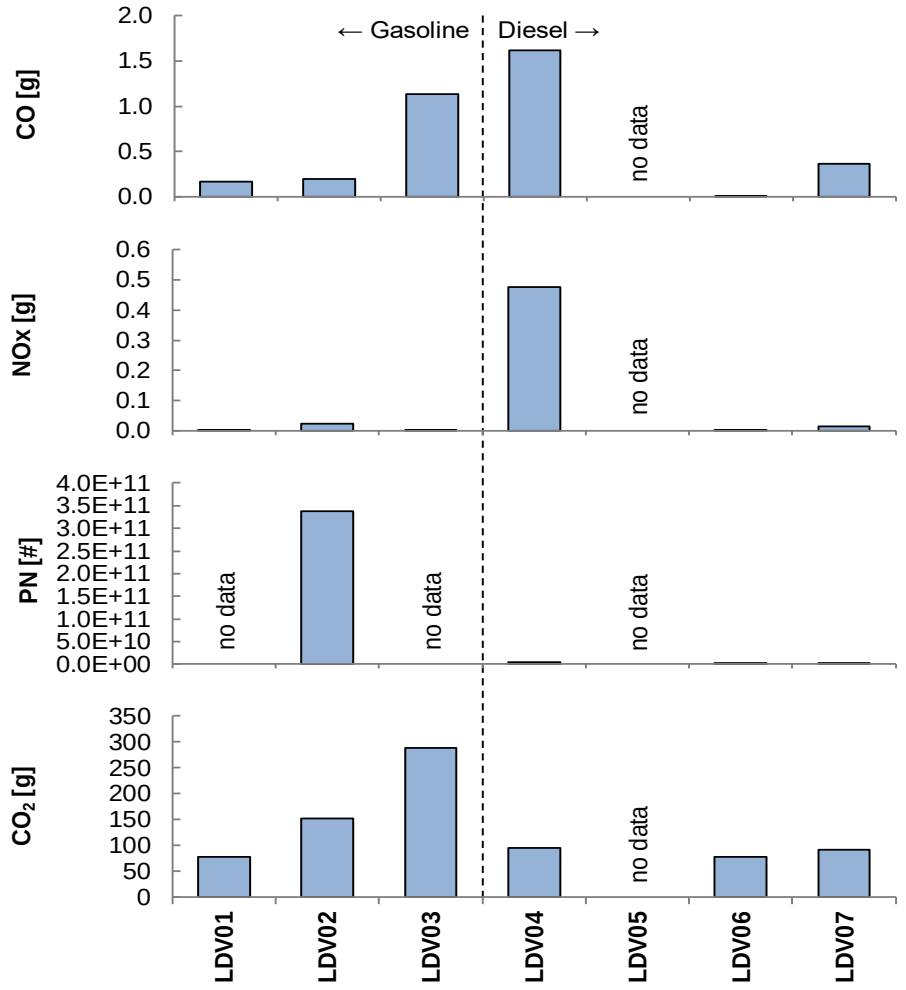
Higher CO- and NOx-emissions of LDV7 to LDV6

Both vehicles have:

- engine displacement
- nearly identical exhaust aftertreatment

for gasoline vehicles:		for Diesel vehicles:	
CO	2 - 6	CO	0.2 - 2.2
NO_x	0.7 -2.5	NO_x	0.1 - 0.4
PN	1.7 (1 vehicle)	PN	0.4 - 2.3
CO_2	0.5 - 0.7	CO_2	0.3 - 0.6

Cumulated emissions at “idling”



Increase factors at idling

for gasoline vehicles:		for Diesel vehicles:	
CO	0.5 - 2.5	CO	0.1 - 0.9
NO_x	0.3 - 1.1	NO_x	0.1 - 0.4
PN	0.7 (1 vehicle)	PN	0.5 - 1.8
CO_2	0.3 - 0.6	CO_2	0.3 - 0.4

Conclusions of the reproduction of non driving situations

Some remarkable findings are:

Gasoline group:

- Near all emissions are cumulated in the first 0.5 km of distance
- The PN-emissions of the dated vehicle (MPI) and modern vehicle (GDI) are identical
- Emissions are generally higher for the older vehicle and higher with increased load in the warm-up phase,

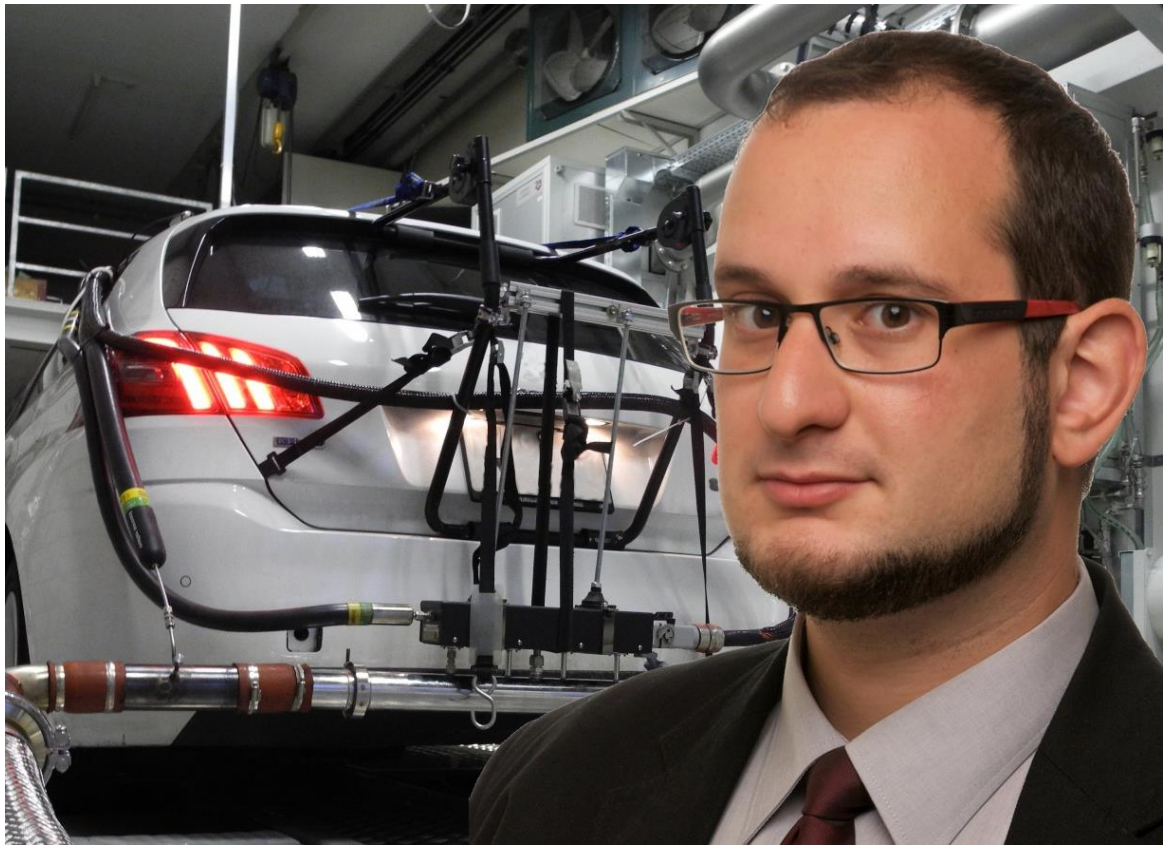
Diesel group:

- PN-emissions of both vehicles are cumulated mainly during the cold start and are essentially independent of the load
- Emissions of CO, HC and NO_x for the older vehicle, and particularly at low load, are cumulated not only at cold start but also until 4 km of driving distance

Conclusions of the analysis of present data

- The emissions in the cold start and in the first part of the warm-up phase are higher than in the rest of the urban phase
- Special situations: “stop & go” and “idling” are frequently given during the warm-up phase, i.e. with engine and exhaust treatment system not warm enough
- Specific emissions [in g/km] are in the warm-up generally significantly higher than in the investigated urban phase (13.7 km)
- Start-stop-system switched on during the warm-up is tendentially disadvantageous
- Co-evaluation works!

Thank you for your attention



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