Press Conference, 07.04.2017

Evaluation of the effect of ethanol on LDVs CO_2- and particle-number-emissions within onroad-testing

Univ. Prof. Dr. Bernhard GERINGER

Dipl.-Ing. Marcus SZIKORA

Institute for Powertrains & Automotive Technology

Motivation
Fine dust alarm

☐ Media review

Fine dust: Thick air in Graz

Source: Die Presse; 17.02.2017

Fine dust in Stuttgart

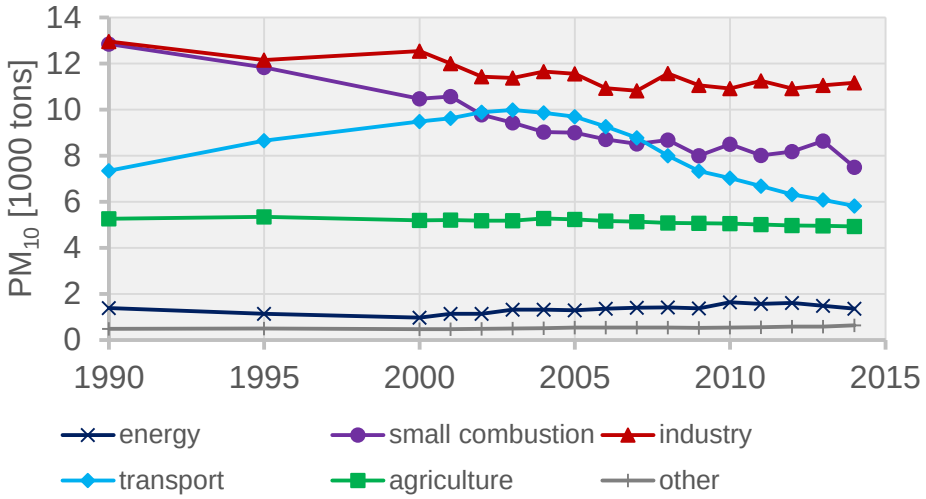
By now already 12 days exceeding the limit values

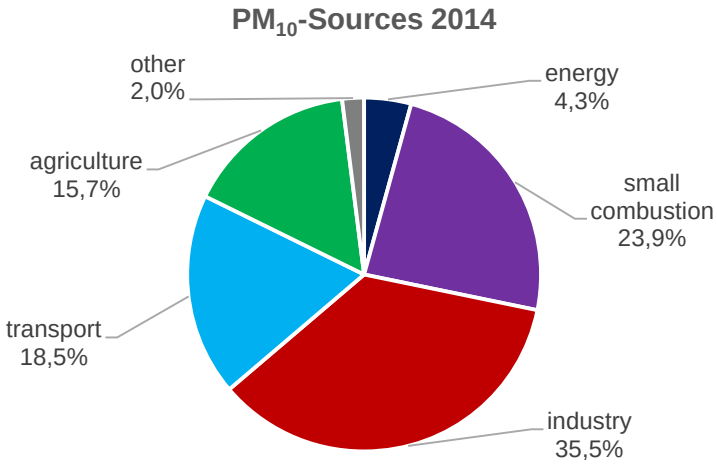
Source: Stuttgarter-Zeitung; 22.01.2017

19 fine dust alarms in Vienna by now

Source: orf.at; 21.02.2017

☐ Development of fine dust emissions in Austria



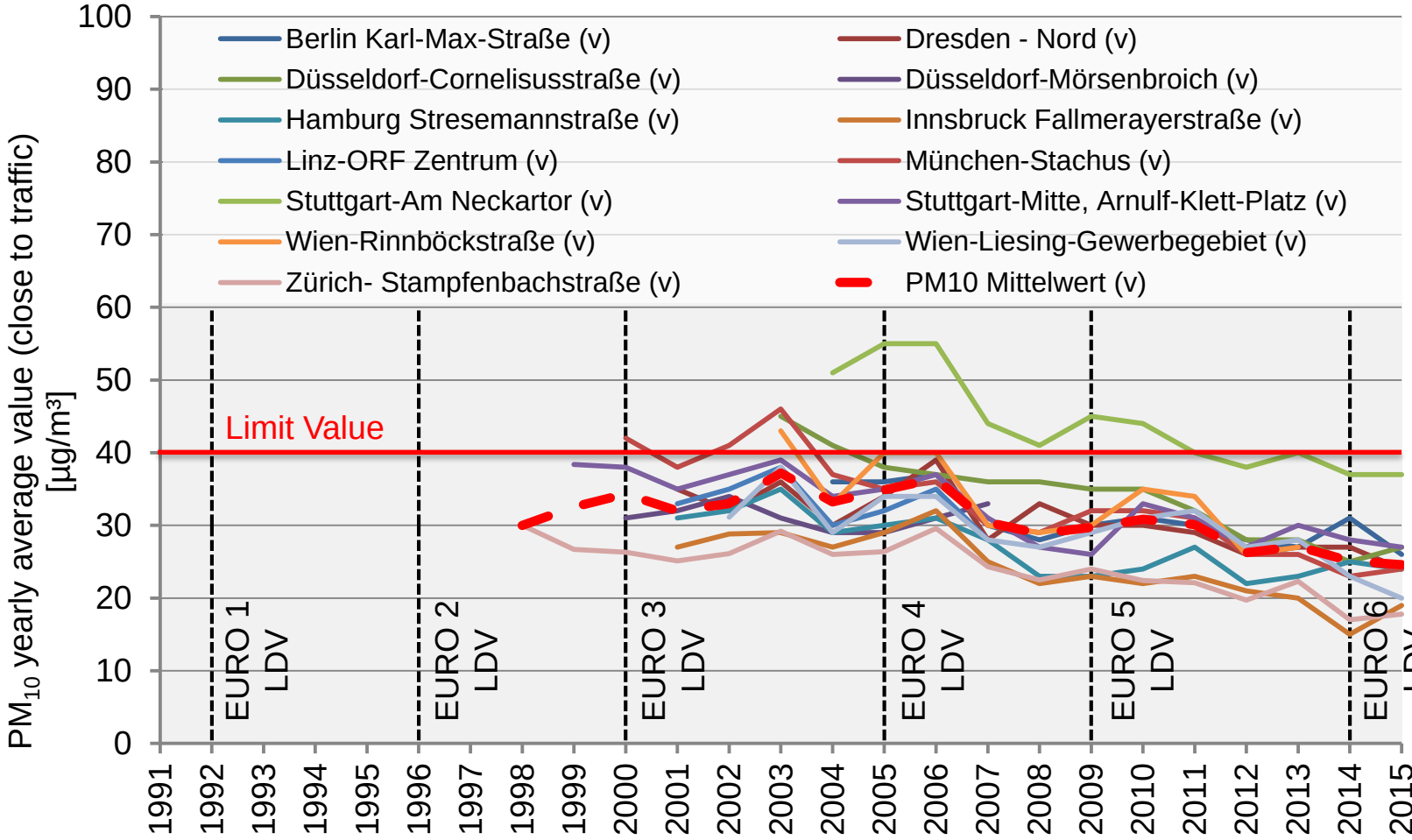


Source: Umweltbundesamt, 2016

Motivation

Fine dust alarm

☐ Development of fine dust immissions



Source: www.auto-umwelt.at, 04.2017

Motivation

Measures to reduce fine dust share of LDVs

☐ EU Emission Standards – Gasoline Vehicles

Stage	CO	HC	HC+NOx	NOx	PM	PN
	g/km					#/km
Euro 1	2.72 (3.16)	-	0.97 (1.13)	-	-	-
Euro 2	2.2	-	0.5	-	-	-
Euro 3	2.30	0.20	-	0.15	-	-
Euro 4	1.0	0.10	-	0.08	-	-
Euro 5	1.0	0.10[d]	-	0.06	0.005	-
Euro 6	1.0	0.10[d]	-	0.06	0.005	6.0×10^{11} *

* 6.0×10^{12} 1/km within first three years from Euro 6 effective dates

Source: www.dieselnet.com, 04.2017

Motivation

- Implementation of directive 2003/30/EG and the directive on promoting the use of energy from renewable sources 2009/28/EG within the Austrian fuel regulation
  - determines a yearly substitution by biogenic fuels and other renewable fuels, to reduce (amongst other) CO_2-emissions
  - rate of admixture 2013 in Austria: 5,6 Vol.-%
- Besides lower CO_2-emissions based on sustainable production, ethanol exhibits further CO_2-advantages for combustion in an ICE due to its chemical composition

- **Aim of tests** – focus on **increased ethanol share:**
  - **Evaluation of CO_2-advantages** for combustion in an ICE within normal operation conditions (real-world onroad driving)
  - **Evaluation** of expected **advantages** regarding **particle-number-emissions** for direct injection gasoline engines within real-world conditions

Scope of work

- **Three fuels** were investigated to evaluate the influence of increasing ethanol shares.

- Investigated fuels:
  - E5 (ethanol share: 5 %; basis fuel)
  - E10 (ethanol share: 10 %)
  - E20 (ethanol share: 20 %)

- LDVs with direct injection gasoline engines were utilized. To determine a possibly occurring effect of an alternative drive train concept, one out of **three vehicles** was a Plug-In Hybrid Electric Vehicle (PHEV).

- Test setup
  - **Onroad**, i.e. within real-world operating conditions (traffic, weather, etc. changeable)
  - **Chassis Dynamometer** (well defined test conditions and speed trace)

Test Campaign
Vehicles

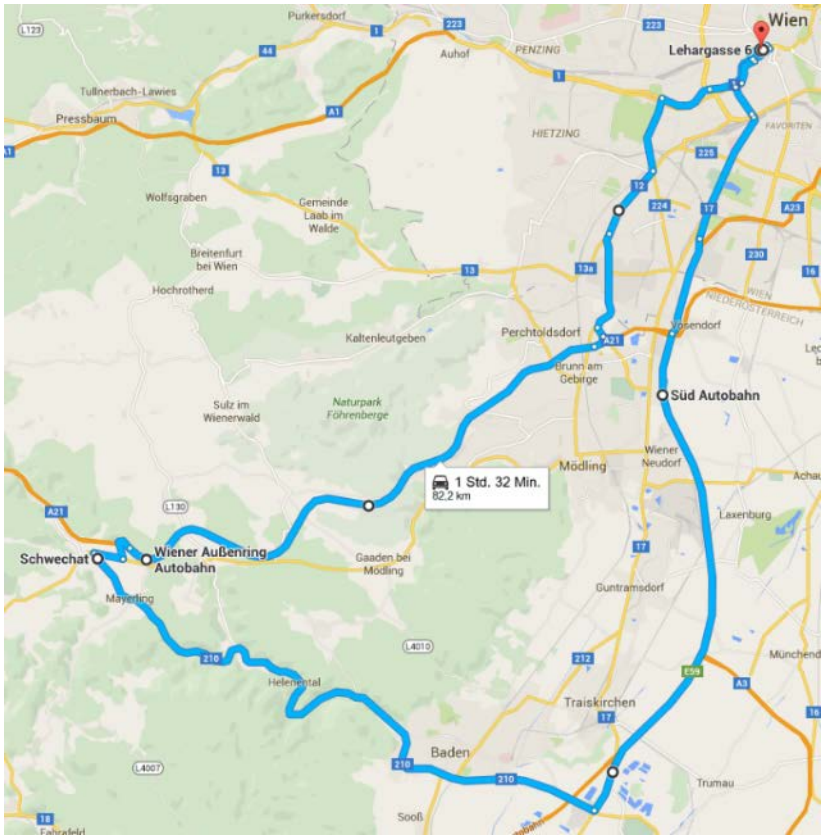
☐ Utilized vehicles for the investigations

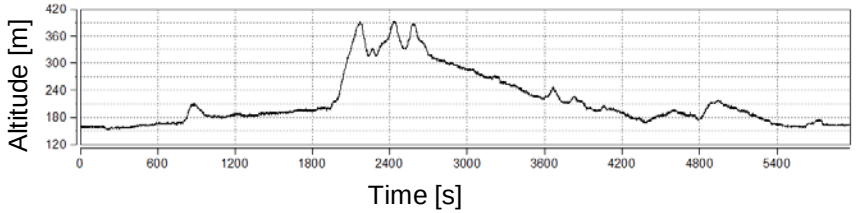
	general information		
description	vehicle 1	vehicle 2	vehicle 3
drive concept	PHEV	conventional	conventional
emissions stage	EU 6	EU 6	EU 6

	drive train		
ICE	- 4-cylinder (in-line) - 1,4 l DI-gasoline eng. /w ETC - power: 110 kW - torque: 250 Nm	- 4-cylinder (in-line) - 1,2 l DI-gasoline eng. /w ETC - power: 63 kW - torque: 160 Nm	- 4-cylinder (in-line) - 1,6 l DI-gasoline eng. /w ETC - power: 90 kW - torque: 200 Nm
electric motor	- power: 75 kW - torque: 330 Nm	-	-
HV-battery	8,8 kWh	-	-
exhaust after-treatment system	2 serial 3-way catalysts	3-way catalyst	3-way catalyst
transmission	6-speed-dual-clutch-transmission (autom.)	5-speed transmission	7-speed-dual-clutch-transmission (autom.)
drive mode	front-wheel drive	front-wheel drive	front-wheel drive
test mass	ca. 1.850 kg	ca. 1.410 kg	ca. 1.550 kg

PHEV … Plug-In Hybrid Electric Vehicle
ICE … internal combustion engine
DI … direct injection
ETC … exhaust turbo charger

Test Campaign
Onroad



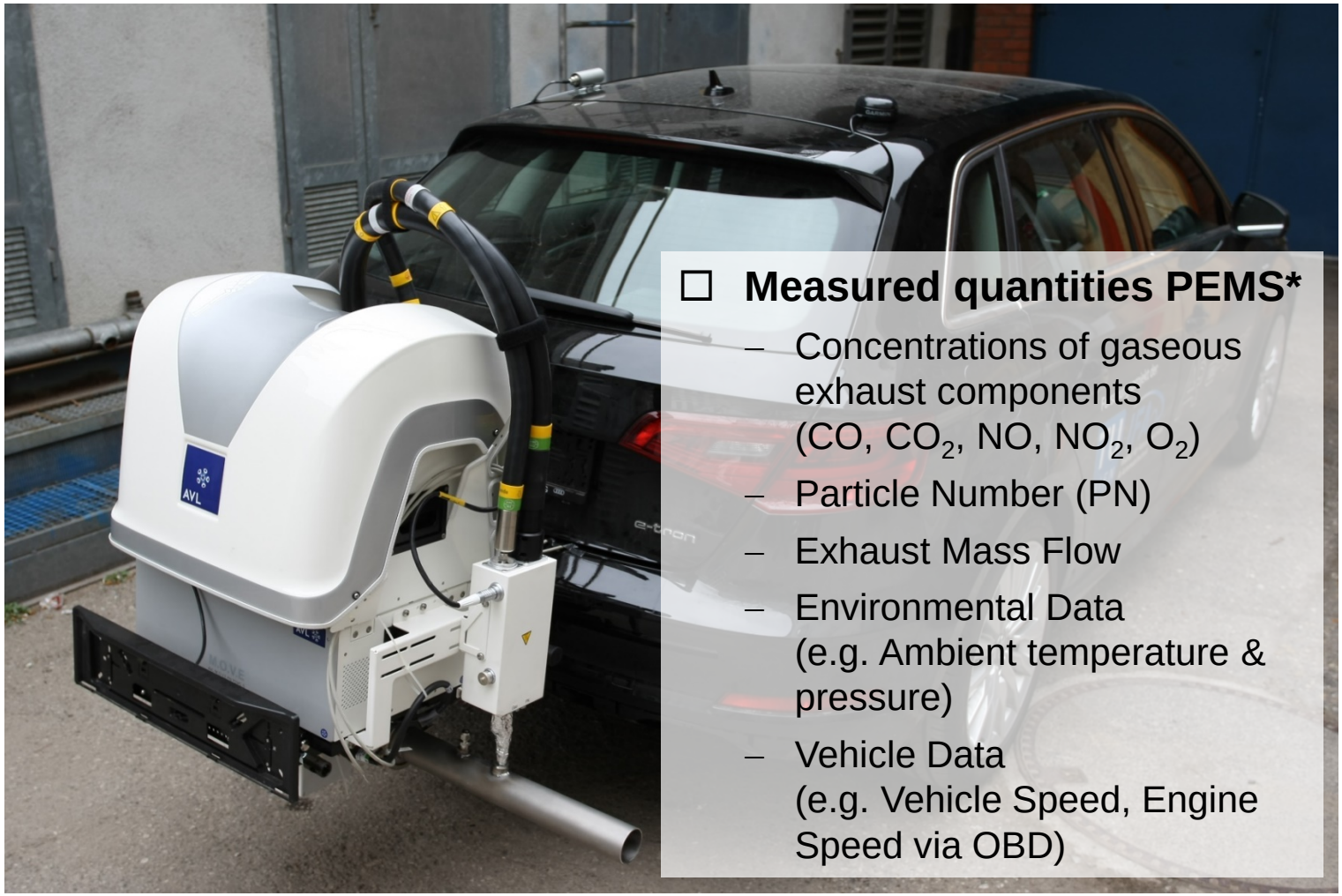


- **RDE-Route Vienna**
  - *Duration*: ca. 100 min
  - *Avg. Speed*: ca. 50 km/h
  - *Distance*: ca. 82 km
  - *Shares* (distance based):
    - *urban*: ca. 34 %
    - *rural*: ca. 33 %
    - *motorway*: ca. 33 %
  - *Cumulative pos. elevation gain*: 675 m/100 km

- 6 test runs with each fuel
  → overall 54 test runs

- Measurement of CO_2-emissions and Particle Number during the test

Test Campaign
Onroad - Setup

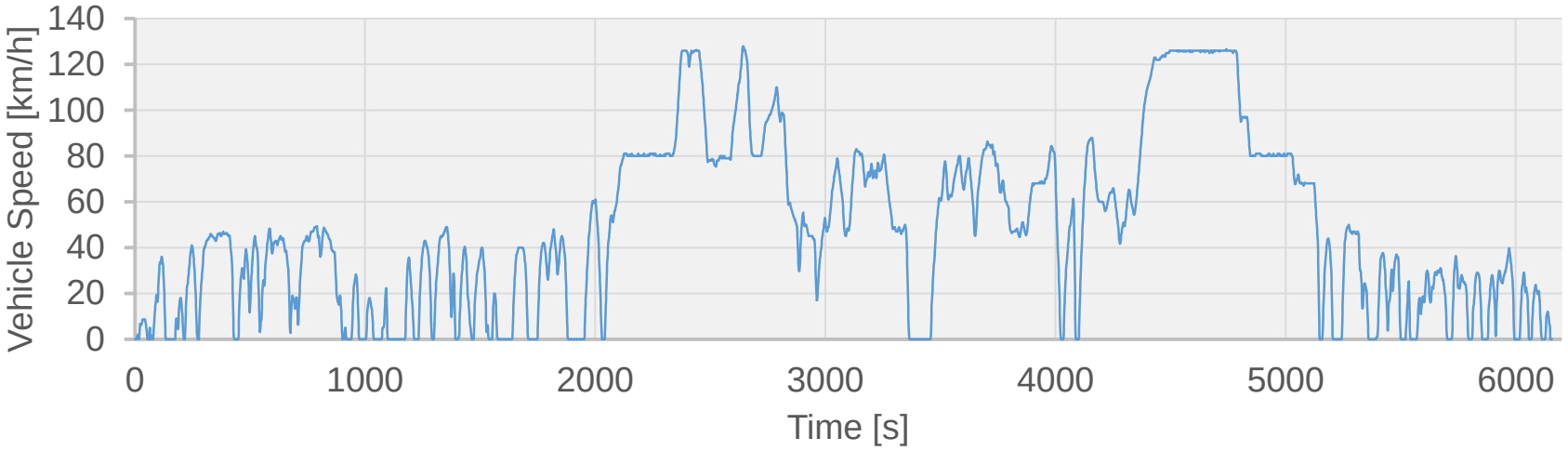


- **Measured quantities PEMS***
  - Concentrations of gaseous exhaust components (CO, CO_2, NO, NO_2, O_2)
  - Particle Number (PN)
  - Exhaust Mass Flow
  - Environmental Data (e.g. Ambient temperature & pressure)
  - Vehicle Data (e.g. Vehicle Speed, Engine Speed via OBD)

* PEMS = Portable Emission Measurement System

Test Campaign
Chassis Dynamometer

- ☐ Speed Trace from a representative onroad test



  - *Duration*: 103 min | *Avg. Speed*: 48,2 km/h
  - *Distance*: ca. 82,6 km
    - Shares: urban 32 % | rural 38 % | motorway 30 %
  - *Ambient temperature*: 21,6 °C (const.)

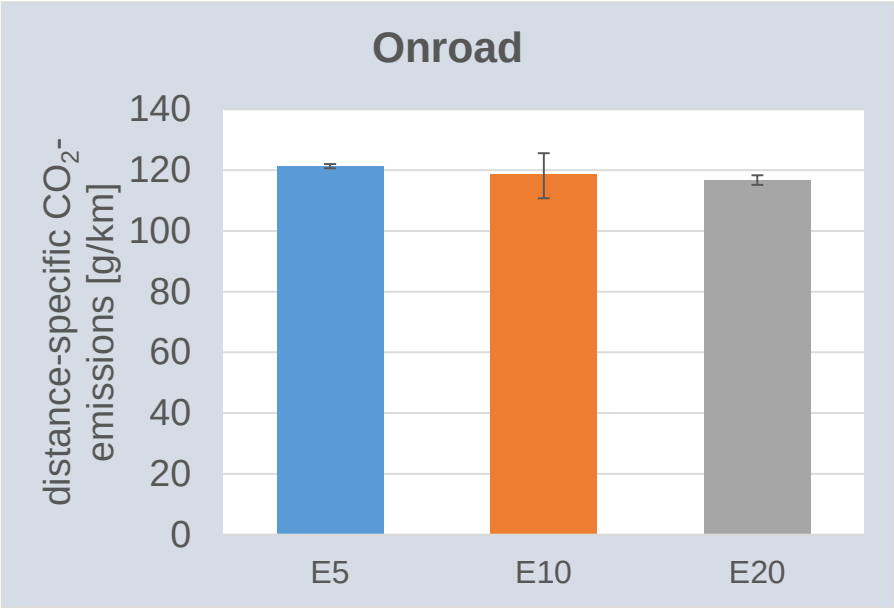
- ☐ (at least) 2 test runs with each fuel → overall 18 test runs
- ☐ Measurement of CO_2-emissions and Particle Number during the test

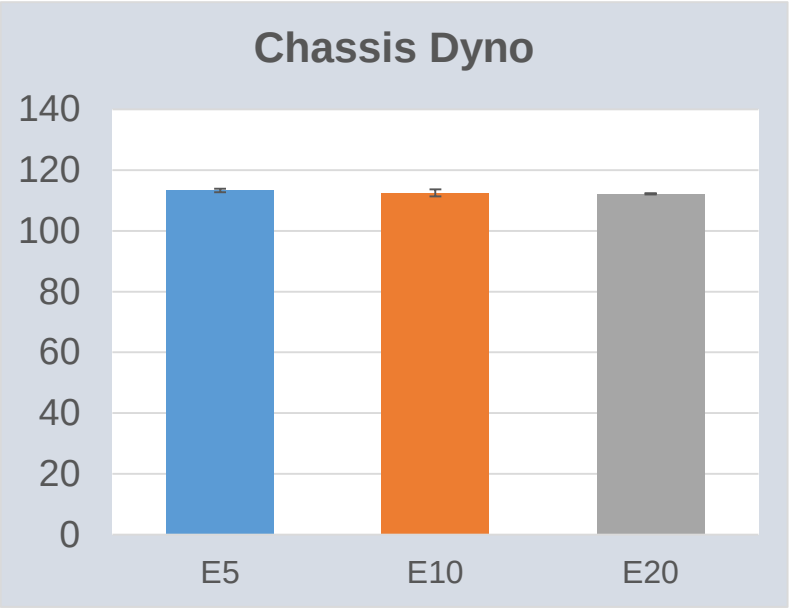
Test Campaign
Chassis Dynamometer - Setup

Results

Vehicle 1 (PHEV) – comparison of emission-results

- distance-specific CO_2-emissions in g/km





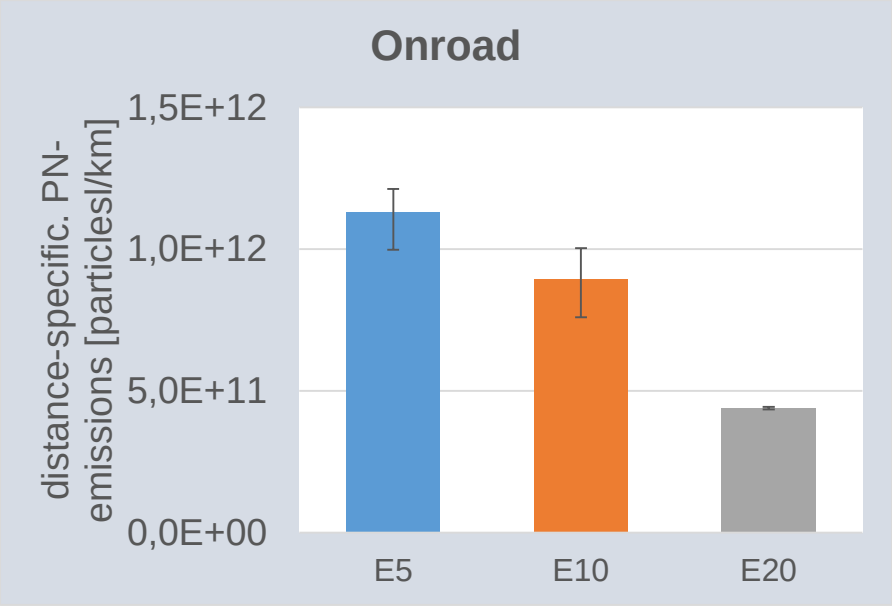
	E5	*E10*	*E20*
Mean [g/km]	**121,1**	**118,8**	**116,9**
Diff. to E5	**-**	**-1,9 %**	**-3,5 %**

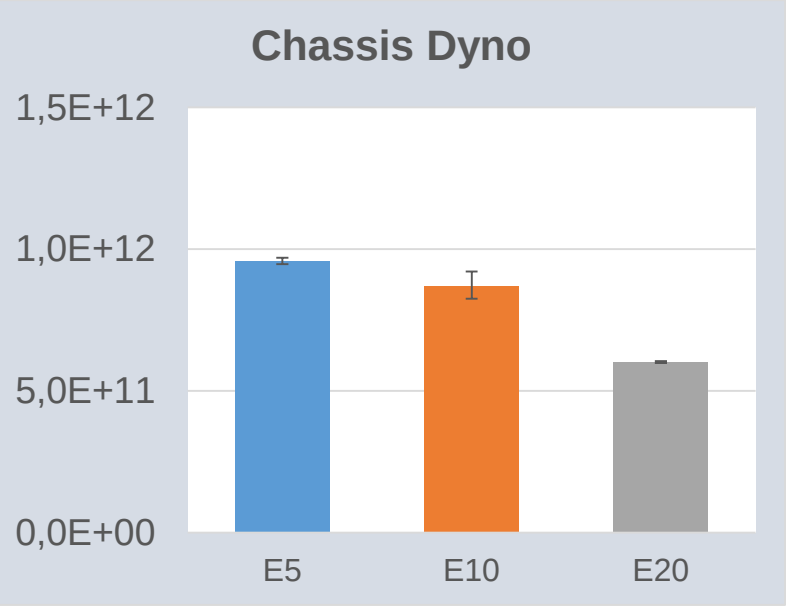
E5	*E10*	*E20*
113,3	**112,6**	**112,2**
-	**-0,7 %**	**-1,0 %**

Results

Vehicle 1 (PHEV) – comparison of emission-results

- distance-specific CO_2-emissions in particles/km



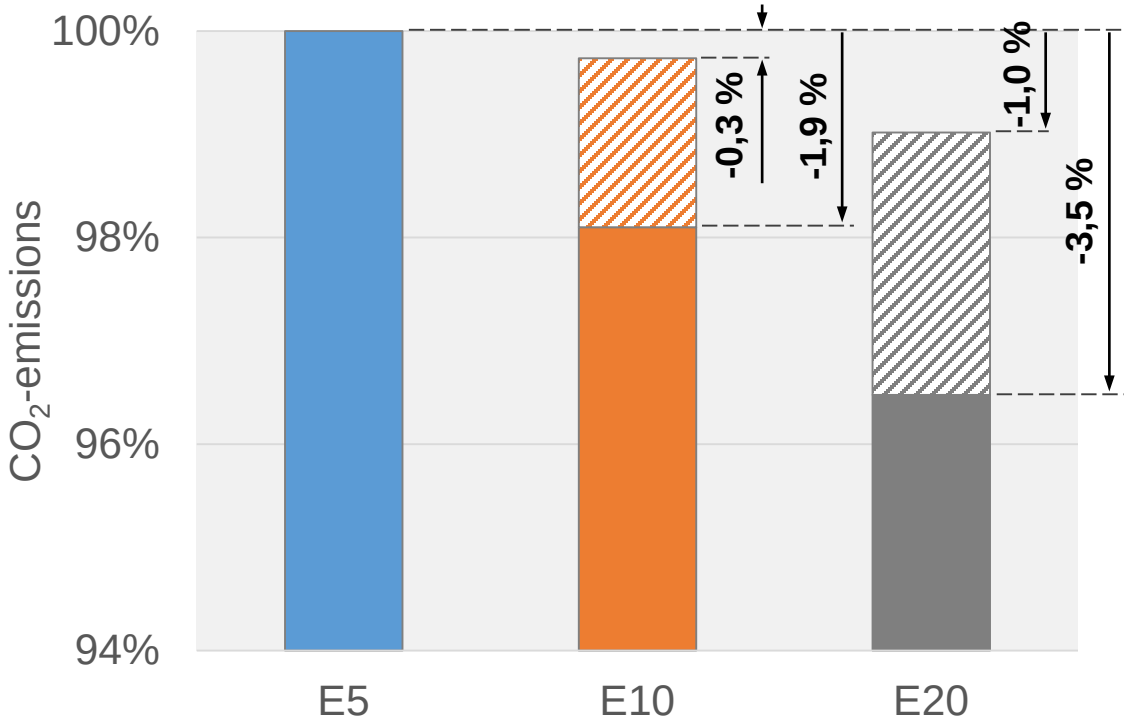


	E5	*E10*	*E20*
Mean [P/km]	**1,13E+12**	**8,93E+11**	**4,39E+11**
Diff. to E5	**-**	**-21,0 %**	**-61,2 %**

E5	*E10*	*E20*
9,58E+11	**8,70E+11**	**6,01E+11**
-	**-9,2 %**	**-37,3 %**

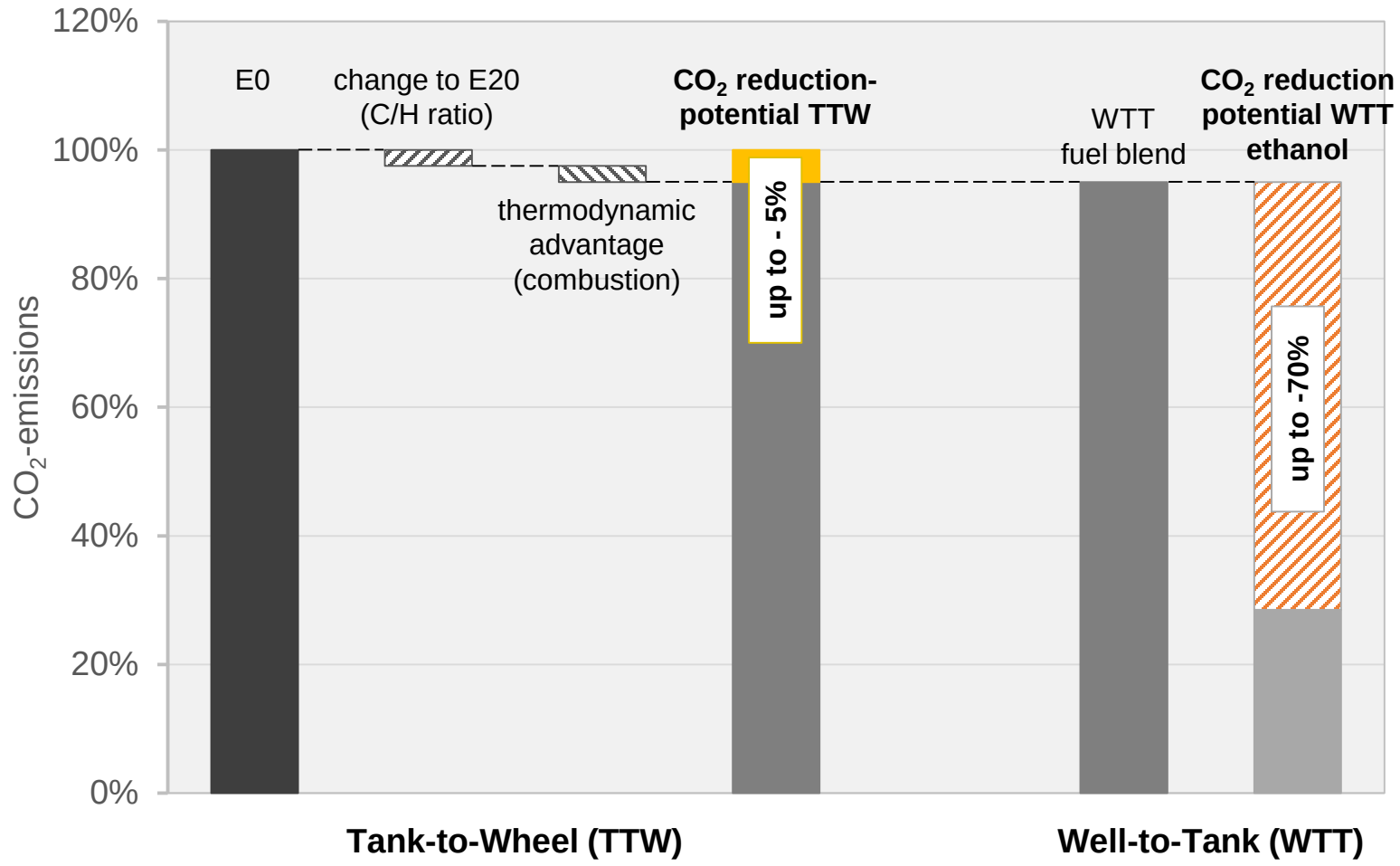
Summary
CO_2-emissions

- **CO_2-emissions** showed a **reduction** of **up to 3,5 %** (overall results of 3 vehicles – comparing E5 to E20)



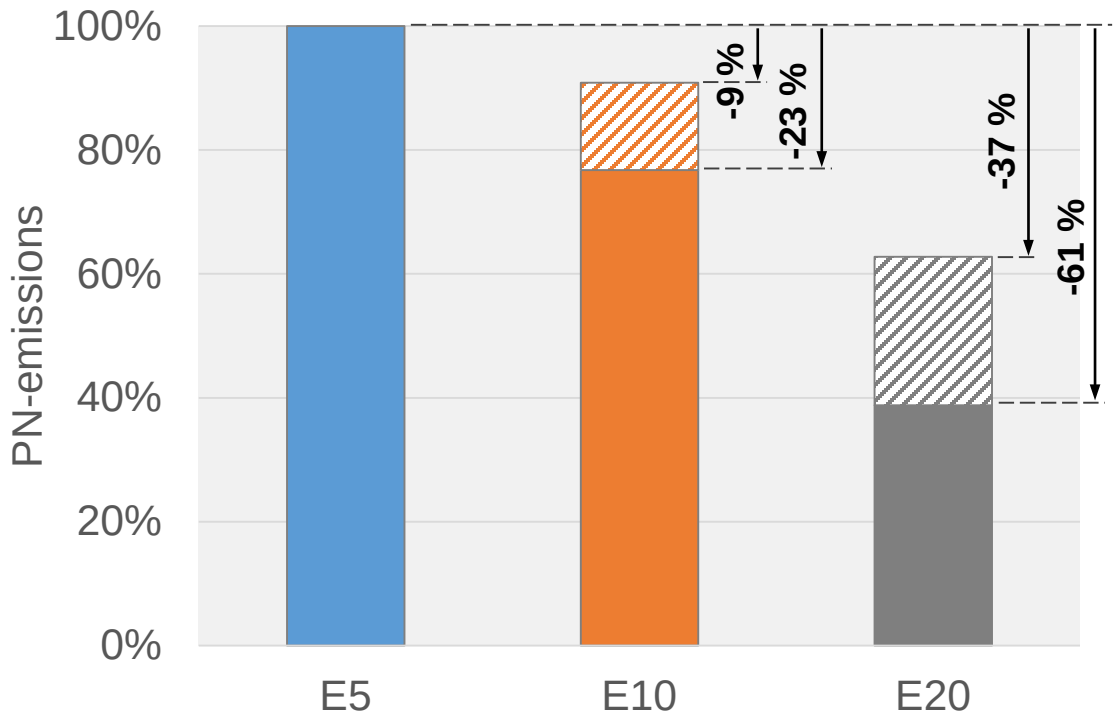
Summary
CO_2-emissions

☐ CO_2-total-balance – advantages of biogenic ethanol



Summary
Particle-number-emissions

- **Particle-number-emissions** showed a **reduction** of **up to 61 %** (overall results of 3 vehicles – comparing E5 to E20)



Conclusion

- The influence of fuel blends with different ethanol shares (E5, E10 and E20) were investigated with 3 vehicles driving onroad as well as on the chassis dynamometer. Overall 72 test runs were carried out.

- **Reduction of emissions** as a function of **ethanol share**, compared to commercially available gasoline (E5)
  - **CO_2-emissions:** **E10 up to -2,0 %**
    E20 up to -3,5 %
  - **Particle-number-emissions:** **E10 up to -23 %**
    E20 up to -61 %

- The described advantages were determined with modern EURO-6 vehicles, but would also result within older vehicle models and therefore affect the whole vehicle fleet.

Thank you for your attention!

IFA
Institute for Powertrains
& Automotive Technology

Univ. Prof. Dr. Bernhard GERINGER

Dipl.-Ing. Marcus SZIKORA

TU WIEN
TECHNISCHE
UNIVERSITÄT
WIEN
Vienna | Austria

Institute for Powertrains & Automotive Technology