EU7 Standards
Insights and 1st Interpretations

Webinar, 18th of November 2022

K. Engeljehringer, C. Martin, M. Weissbaeck, M. Wieser

Today’s Moderator

Alan Forrest
Sales Manager
AVL Powertrain UK Limited

- 12 years with AVL
  - ~13 years AVL UK
  - ~1 year AVL Austria
  - ~2 years AVL Turkey
- Powertrain Calibration Engineer ~10 years
  - Diesel Engine
  - Focus on Aftertreatment (DPF)
  - Passenger Car and HDD
- Manager of AVL Powertrain UK Sales Team

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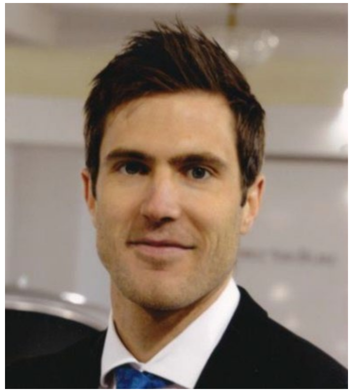
Today’s Presenters



Christian Martin

christian.martin@avl.com

Since 2016
Product Manager
PC Powertrain Systems Gasoline

Michael Weissbaeck

michael.weissbaeck@avl.com

Since 1997
Business Field Leader
PC & LDT Diesel

Kurt Engeljehringer

Kurt.Engeljehringer@avl.com

Since 1986
Principal Business Development Manager Emission, Energy and Analytic measurement systems
A member of AVGES groupe

Martin Wieser

martin.wieser@avl.com

Since 2004

Manager Development Commercial Engines

Content

Content

Euro-7/VII - Timeline

9,5 years = app. 170 Million vehicles in EU
(more BEV share but maybe an ICE boom before 2035)

18.11.2022

2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2034 2035

Start
24 Oct 18
Stakeholder event
Preparing for the
future European
Emission Standards
"Post-Euro-6"

AGVES and CLOVE
2 years, 12 meetings
90 Documents,
2125 pages

17.07.19 – 1st AGVES meeting
18.10.19 – 2nd AGVES meeting
04.02.20 - 3rd AGVES meeting
09.07.20 – 4th AGVES meeting
10.09.20 – 5th AGVES meeting
27.10.20 - 6th AGVES meeting
1st CLOVE proposal
16.11.20 – WS simplification
26.11.20 – 7th AGVES meeting
10.12.20 – PEMS Workshop
24.02.21 – 8th AGVES meeting
30.03.21 – InS electr. platform
08.04.21 – 9th AGVES meeting
27.04.21- 10th AGVES meeting
2nd CLOVE proposal

EU Commission
- Internal discussions and impact assessments.
- Official EC proposal was continuously shifted.
- Published 10.11.2022

AGVES
Implementing regulation meetings

30.11.22
18.01.23
08.02.23
15.03.23
19.04.23

Euro-6e
- CF reduced
- Reference to UNR-154

EU Commission
Report on tire abrasion about measurement methods and limit proposal.

Euro-7
Light-Duty

Euro-VII
Heavy-Duty

Zero $CO2_{Tailpipe}$ vehicles

Lower brake
wear limit
7 to 3mg/km

AGVES = Advisory Group on Vehicle Emission Standards
CLOVE = Consortium for Low Vehicle Emissions

"European Green Deal" Targets for Euro-7

EU Emission

European Commission, Picture Engeljehringer 2015

	Euro-7/VII Targets	EC proposals
1	• as clean as possible (Best Available Technology)	O
	• under "all EU" driving conditions	✓
2	• Significant reduction of limits	O
	• New emission components	✓
3	• Fuel and technology independent	✓
	• Harmonization between Light- and Heavy Duty	O
4	• New EVAP procedure	✓
	• Brake- and tire wear	✓
5	• On-Board Measurements (OBM)	✓
	• Simplification of type approval	✓

Based on the AVGES meetings and CLOVE proposal (2019 … 2021).
EC Proposal Explanatory Memorandum (10.11.2022)

EC proposals (10.11.2022)

Criteria Emissions – Light Duty Euro-7 limits

ANNEX I

EURO 7 EMISSION LIMITS

Table 1: Euro 7 exhaust emission limits for M_1, N_1 vehicles with internal combustion engine

Pollutant emissions	M_1, N_1 vehicles	Only for N_1 vehicles with power to mass ratio[1] less than 35 kW/t	Emission budget for all trips less than 10 km for M_1, N_1 vehicles	Emission budget for all trips less than 10 km only for N_1 vehicles with power to mass ratio less than 35 kW/t
	per km	*per km*	*per trip*	*per trip*
NO_x in mg	60	75	600	750
PM in mg	4.5	4.5	45	45
PN_{10} in #	6×10^{11}	6×10^{11}	6×10^{12}	6×10^{12}
CO in mg	500	630	5000	6300
THC in mg	100	130	1000	1300
NMHC in mg	68	90	680	900
NH_3 in mg	20	20	200	200

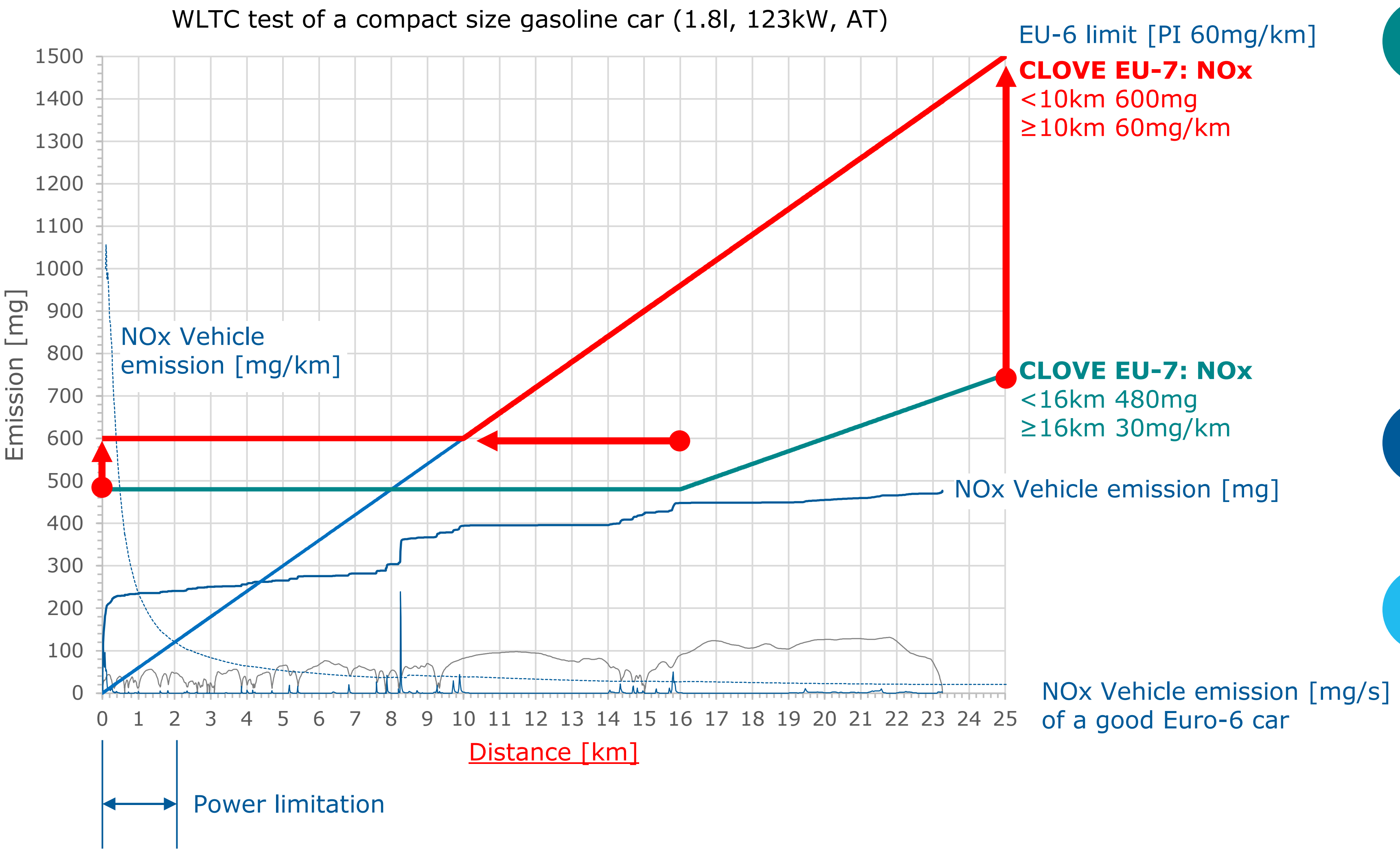
[1] Measured in accordance with paragraph 5.3.2. of UN/ECE Regulation No 85 in the case of ICEVs and PEVs, or, in all other cases, measured in accordance with one of the test procedures laid down in paragraph 6 of UN Global Technical Regulation 21

Original Document of EU Commission proposal for Euro-7, 10.11.2022

1
- **Borderline between Light-Duty and Heavy-Duty for N1/N2 is a power to mass ratio of 35kW/t**

2
- **Emission Budget for the first 10km in mg/trip.**
- **Above 10km a limit in mg/km**

Emission Budget: mg/trip and mg/km



1 **CLOVE proposal:** Emission Budget is a fixed absolute emission mass limit of 480mg for any test below 16km and 30mg/km above 16km.

EC proposal: Emission Budget is a fixed absolute emission mass limit of 600mg for any test below 10km and 60mg/km above 10km.

2 **Power limitation**, for the first 2km for normal driving conditions, above extended driving conditions.

3 **For extended RDE driving conditions an "Extended Driving Divider" of 1,6.**

Criteria Emissions – Light-Duty Euro-7 limits

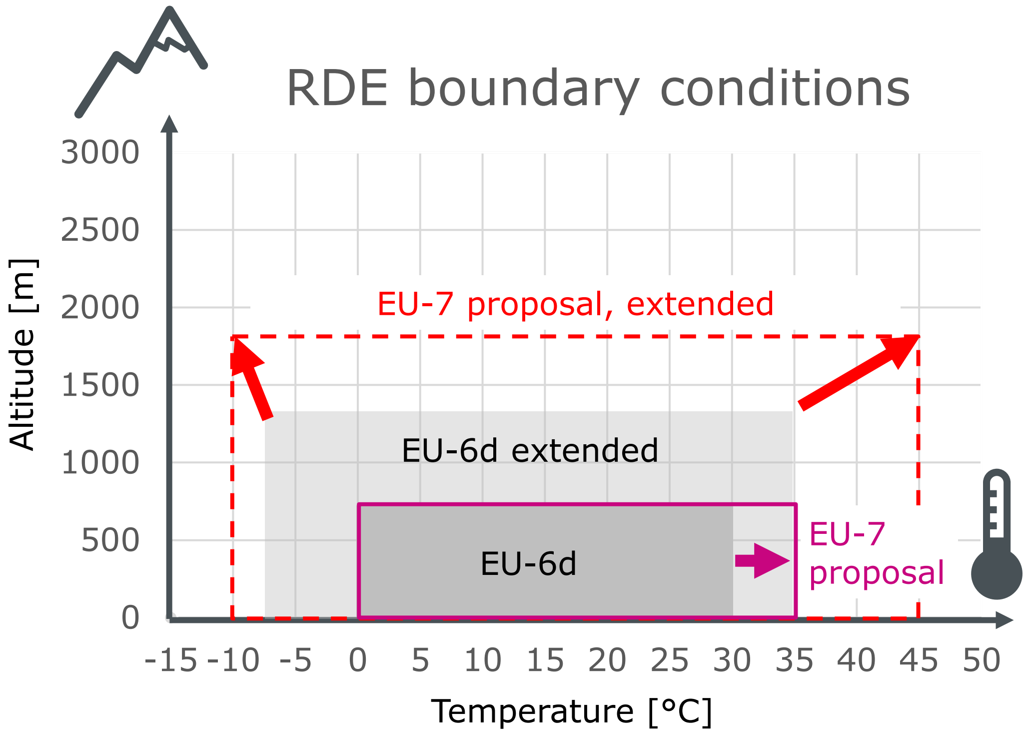
Component Candidates	Unit	EU-6d (M1)			**Clove proposal** 27.04.2021		**EU Commission proposal** 10.11.2022			Notes
		PI	CI	Testing	EU-7 (M1)		EU-7 (M1)		Testing	
CO_2	mg/km	✓	✓	Lab + RDE	✓	-	✓		Lab	Needed for calculation, validation and for GHG legislation
$CH_4 + N_2O$	mg/km	-	-	-					-	
CO	mg/km	1000	500	Lab + RDE	400	-20%	500	0%	(Lab) + RDE	
NOx	mg/km	60	80	Lab + RDE	20…30	-50%	60	-30% (1)	(Lab) + RDE	CF 1,43 down to 1
THC	mg/km	100	-	Lab	25…45	-65%	100	0%	(Lab) + RDE	
NOx + THC		-	170	-					-	
CH_4	mg/km	-	-	Lab	10	-	✓		-	No limit only needed for if there is a NMHC limit
NMHC	mg/km	68	-	-			68	0%	(Lab) + RDE	
Alcohols	mg/km	-	-	-					-	
NMOG	mg/km	-	-	-					-	
PM	mg/km	4,5	4,5	Lab	2	-55%	4,5	0%	Lab	
PN	#/km	6E+11	6E+11	Lab + RDE	1E+11	-89%	6E+11	-55% (1)	(Lab) + RDE	CF 1,43 to 1. PN_{23nm} → PN_{10nm} results in app. 50% higher results
N_2O	mg/km	-	-	-	10	New			-	New pollutant - stratospheric ozone depletion
NH_3	mg/km	-	-	-	10	New	20	New	(Lab) + RDE	New pollutant - secondary PM formation
HCHO	mg/km	-	-	-	5	New			-	No limit only needed if there is a NMOG limit
		EC 715/2007 as amended EC 692/2008			% lowest EU-6 to highest proposal					

Note (1) (x%) represents the nominal limit number, (0%) -30% considers the also measurement modifications like Conformity Factor (CF) reduction and/or measuring more particle due to PN_{10nm}. A wider range of RDE test conditions is not considered, since it can hardly be quantified.

Criteria Emissions – Heavy-Duty Euro-VII limits

Component Candidates	Light-Duty	Unit	EU-VI Heavy-Duty M2, M3, N2 and N3			
			Cold emissions 100th percentile	**Hot emissions** 90th percentile	**Emission Budget < 3xWHTC**	**Idle emission** if no 5min automatic engine shut off
CO_2	✓	mg/kWh	✓	✓		
CH_4 + N_2O		mg/kWh	-	-		
CO	✓	mg/kWh	3500	200	2700	
NO_x	✓	mg/kWh	350	90	150	5000 mg/h
THC	✓	mg/kWh	-	-		
NO_x + THC		mg/kWh	-	-		
CH_4	✓	mg/kWh	500	350	500	
NMHC	✓	mg/kWh	-	-		
Alcohols		mg/kWh	Needed for NMOG	Needed for NMOG	Needed for NMOG	
NMOG		mg/kWh	200	50	75	
PM	✓	mg/kWh	12	8	10	
PN_{10nm}	✓	#/kWh	5E+11	2E+11	3E+11	
N_2O		mg/kWh	160	100	140	
NH_3	✓	mg/kWh	65	65	70	
HCHO		mg/kWh	30	30		

Criteria Emissions: RDE testing Euo-7/VII proposals



	EU-6d	EU-7 EC proposal	EU-VII EC proposal
CF	CF_{NOx} = 1,43 CF_{PN23nm} = 1,5	CF=1	
	CO_2, CO, NOx, PN_{23nm}	CO_2, CO, NOx, THC, NMHC (CH_4), NH_3, PN_{10nm}	CO_2, NOx, CO, THC, NMOG, CH_4, N_2O, NH_3, HCHO, PN_{10nm}, PM
max	Max. Speed ≤145km/h ≤ 160km/h extended	Max. Speed ≤145km/h ≤ 160km/h extended	
23.3	Duration, min distance	any	
	34% 33% 33%	as per normal use	
max. pos. a	Avg, max accel., ...	as per normal use	

Towing is extended RDE

Payload ≥ 10%
<10% is extended

For all extended RDE driving conditions an “Extended Driving Divider” of 1,6.

Euro-7/VII – European Proposal

ANNEX V

APPLICATION OF TEST REQUIREMENTS AND DECLARATIONS

Table 1: Application of test requirements and declarations for M_1, N_1 vehicles for vehicle manufacturers

Test requirements	Tests and requirements at initial emission type approval	Tests at conformity of	Tests at in-service
Gaseous pollutants and PN in road testing (RDE)	Required demonstration test for all fuels for which the type approval is granted and declaration of compliance for all fuels, all payloads and all applicable vehicle types	Not requ	
Gaseous pollutants, PM and PN in RDE cycles in the laboratory and CO_2 emissions, fuel consumption (OBFCM), electric energy consumption and electric range (Battery Durability) (WLTP at 23 °C)	Required where all pollutants cannot be measured on the road	Required	Required where all pollutants cannot be measured on the
CO_2 ambient temperature correction (WLTP at 14°C)	Declaration[6]	Not requ	
Crankcase emissions	Declaration that a closed crankcase system or routing to the tailpipe is installed [6]	Required	

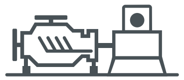
- More clarification is needed and will be part of the implementing regulation work shops.
- RDE Cycle could be:
  - Standardized RDE cycle, like RTS95
  - Random cycle generator, like from TNO
  - Road-to-Lab reproduction of the RDE test

- Using only RDE for emission validation is questionable.
- Laboratory instrumentation is unmatched in accuracy, robustness and has the highest level of quality control (PI check).
- It is also the backbone of any PEMS test (PEMS to Lab validation)

Original Document of EU Commission proposal for Euro-7, 10.11.2022

Euro-7/VII – European Proposal

Table 6: Application of test requirements and declarations for type-approval and extensions of engines intended for M_2, M_3, N_2 and N_3 vehicles for Member States and recognised third parties/Commission



Test requirements for each fuel	Tests and requirements at initial emission type approval	Tests at conformity of production	Tests at in service conformity	Tests at market surveillance
Relevant actor	*Type approval authority for issuing the type approval*	*Type approval authority*	-	-
Gaseous pollutants, PM and PN and CO_2 emissions, fuel consumption on transient cycle (WHTC Cold and Hot)	Required on the parent engine and a declaration for all family members**	Audit or optional testing		

Table 3: Application of tests, declarations and other requirements for type-approval and extensions for M_2, M_3, N_2 and N_3 vehicles for manufacturers

Test requirements	Tests and requirements at initial emission type approval	Tests at conformity of production	Tests at in-service conformity
Gaseous pollutants, PM and PN in road testing (RDE) for each fuel and for the applicable vehicle categories (M_2, M_3, N_2 and N_3) and low load test (if applicable)	Required demonstration tests for all fuels for which the type approval is granted per vehicle type and a declaration of compliance for all fuels, all payloads and all applicable vehicle types	Conformity of production performed at engine level only	Required test on a vehicle with any fuel and on any vehicle category and any payload for all engine types every two year
CO_2 and fuel/energy consumption, zero emission/electric range determination of a vehicle	VECTO licence	For components	Not required

Evaporative Emission (EVAP) (Gasoline only)

Annex I, Table 3: **Euro 7 evaporative emission limits** for petrol fuelled M_1, N_1 vehicles

Evaporative pollutant emissions (only gasoline)	**M_1, N_1** with maximum mass up to 2650 kg	**N_1** with maximum mass equal or more than 2650 kg
1. Hot soak + 2 day diurnal test	0.50 g at worst day + hot soak	0.70 g at worst day + hot soak
2. Refueling emissions	0.05 g/L of fuel	0.05 g/L of fuel

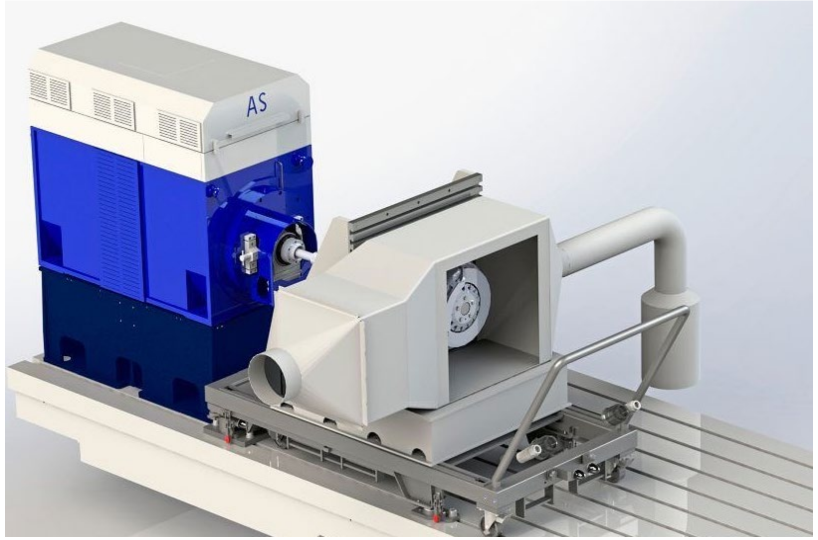
Challenges:

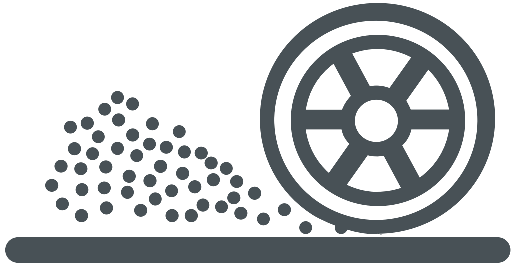
1. Reduced Hot-Soak and Diurnal limits might require app. 2 times larger canisters. For conditioning drive cycle, a climatic chassis dyno for 38°C. Modified calculations

2. Refueling emission will require new test systems.

Test and measurement systems are already existing in the AVL EVAP product portfolio (see picture).

Brake- and tire wear





Annex I, Table 4/5: Euro 7 brake Particle Emission limits in standard driving cycle

Brake particle emissions	M_1, N_1	M2, M3	N_2, N_3
Brake particle (PM_{10}) emissions per vehicle	7 mg/km 2035: 3 mg/km	-	
Brake particle (PN) emissions per vehicle	-	-	

Current vehicles are 2 to 3+ times above the limit (Round robin results)

AVL Test and measurement systems are already available

Annex I, Table 6: Euro 7 tyre Abrasion limits

Tyre Abrasion	M_1, N_1	M2, M3	N_2, N_3
Tyre Mass lost in g/1000km	-	-	-

Test procedure will be developed by UN-ECE, EU Commission to report on measurement method and limit proposal until end 2024

Battery durability and performance

Battery Durability of OVC-HEV and PEV		5 years or 100-000 km whichever comes first	Vehicles more than 5 years or 100 000 km, and up to whichever comes first of 8 years or 160 000 km	Vehicles up to additional lifetime
	Energy based battery capacity	80% (M1) / 75% (N1)	70% (M1) 65% (N1)	
	Electric Drive Range	?	-	

AVL Test and measurement systems are already available

Testing and Measurement: Can we test and measure it?

Application	Notes	Status	AVL Systems
Chassis dyno	• Some improvement required • Analyzers with appropriate accuracy available • Analyzers for new components available. • NH3 measurement needs to be defined • Automation systems needs an up-date	✓	
Engine test bed	• Some improvement required. Important is zero calibration, drift and time alignment. • Low NOx analyzer available, mainly for US and China. • Analyzers for new components available • Automation systems needs an up-date	✓	
RDE PEMS	• Up to 10.11.2022 unclear requirements. Which components must be tested N2O, NH3, THC, CH4 and Aldehyde? • Most likely different set-ups for Light- and Heavy-Duty (FTIR) • High accuracy requirement due to CF=1. • New improved PEMS and mobile FTIR under development.	!	
EVAP	• No issues for SHED and analyzer itself. • 38°C Chassis dyno preconditioning capability required • ORVR (Onboard Refueling Vapor Recovery) test systems available.	✓	
Brake wear	• EU-7 is now a vehicle and component legislation • New test and measurement systems are available • Little practical experience up to now in the industry	✓	

Ready for Carbon-Free Fuels, like H2

Testing and Measurement: New emission components

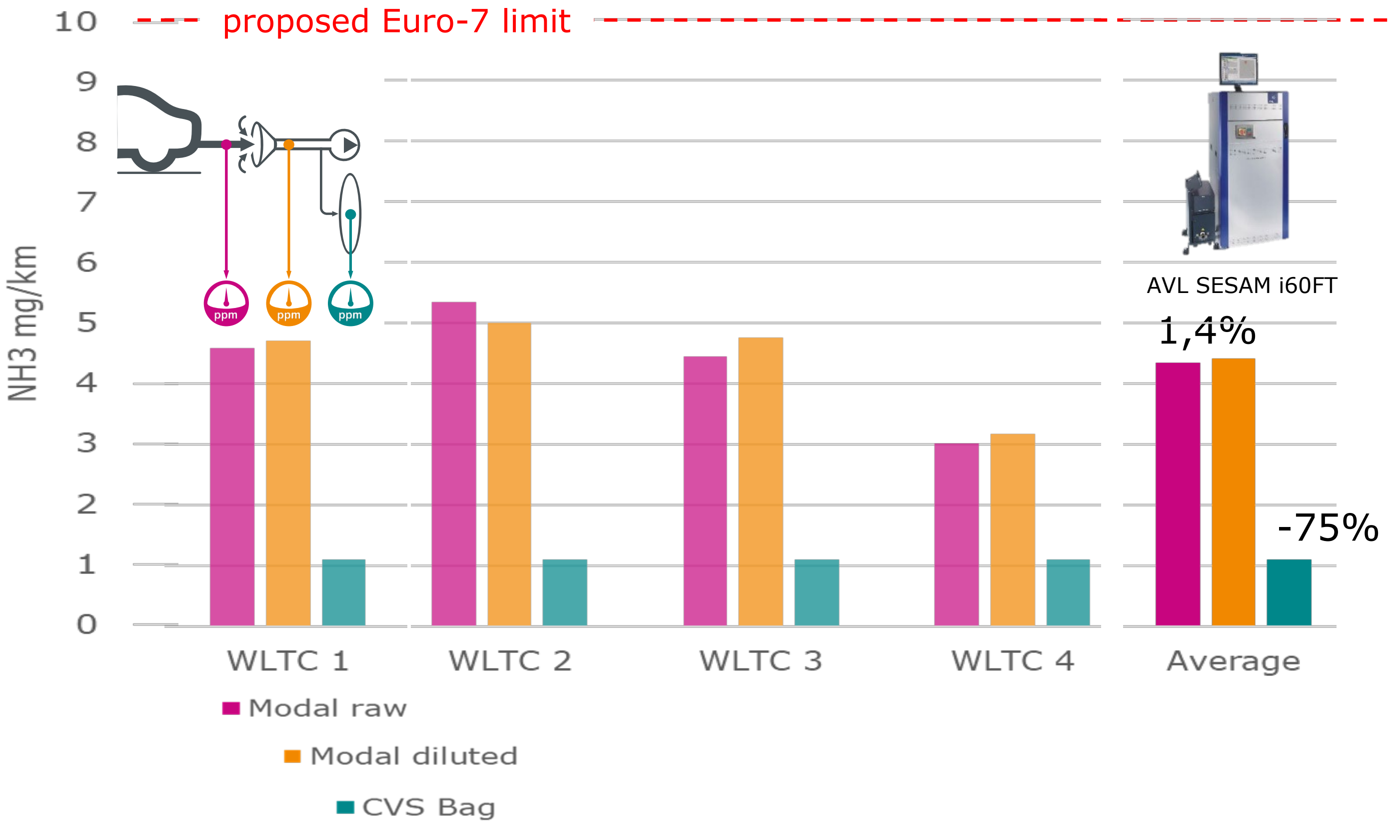
Gas component	**Accepted analyzer types,** as defined in GTR-15 (WLTP)													Notes
	FTIR	NDIR	QCL	LDS	GC-ECD	PAS	Impinger	DNPH Catr.	PTR-MS	Direct GC	FID	NMC-FID	GC-FID	
N_2O Nitrous oxide	✓	✓	✓		✓									• Batch sample for GC-ECD
NH_3 average conc. Ammonia	✓		✓	✓										• raw sample for average NH_3 concentration.
NH_3 mass Ammonia	✓		✓	✓										• sampling method to be defined
HCHO Formaldehyde Acetaldehyde	✓							✓						• cont. diluted or • cartridge sample
Alcohols	✓					✓	✓		✓	✓				• only when the HC limit will be based on NMOG
NMOG	✓					✓	✓		✓	✓	✓	✓	✓	• NMOG = THC + Aldehydes + Alcohols − CH_4

+ others

AVL SESAM i60FT D1

NMOG = Non-Methane Organic Gases
FTIR = Fourier Transform Infra-Red multi component analyzer
NDIR = Non-Dispersive Infra-Red analyzer
QCL = Quantum Cascade Lasers analyzer
LDS = Laser Diode Spectrometer
GC-ECD = Gas Chromatograph Electron-Capture Detector
PAS = Photo-Acoustic analyzer
Impinger = Alcohol sampler with High-Pressure Liquid Chromatography (HPLC)
DNPH Cart. = Dinitrophenylhydrazine impregnated cartridges with Gas Chromatography
PTR-MS = Proton Transfer Reaction - Mass Spectrometry
Direct GC = direct measuring Gas Chromatograph
FID = Flame Ionization Detector
NMC-FID = Non-Methane Cutter - Flame Ionization Detector
GC-FID = Gas Chromatograph - Flame Ionization Detector

How to measure NH3 as mass



Our recommendation is "Continuous Diluted"

NH3 Analyzer		
Analyzer	AVL SESAM i60FT raw and D1 for diluted	✓
Accuracy	good	✓
Dynamic	for raw and cont. dil. very good	✓
Calibration gas	3% accepted by GTR-15, no better available	?
Raw Exhaust measurement method		✓
Raw modal	works well	✓
Requirements	Time alignment Modal raw calculation Clean sample lines	✓
Regulation	would need to accept raw modal and add the calculations	?
Continuous Diluted measurement method		✓
Contin. Diluted	works well	✓
Requirements	Heated transfer lines between tailpipe and CVS inlet.	✓
Regulation	already included	✓
Continuous Diluted measurement method		X
CVS Bag	Bag is not possible, due to the "sticky" nature of NH3	X

Conclusion of Part-1

EC EU-7 Proposal	• The current proposal gives us more details to improve test and measurement systems end develop new ones where needed.
Can we measure it?	• for most parts yes • PEMS RDE testing will be the most challenging task
Concerns	• Using mainly RDE for emission validation is questionable • Lab testing is unmatched in accuracy, robustness and has the highest level of quality control (PI check). It is the backbone of any PEMS test (PEMS to Lab validation)
AVL is fully Committed to	• to supply the industry with all needed test and measurement systems for Euro-7

Content

1

Review of EU7/VII Commission Proposal

- Proposal Summary • Comparison to EU6d Standard & former EU7/VII Proposals
- Implications for testing

2

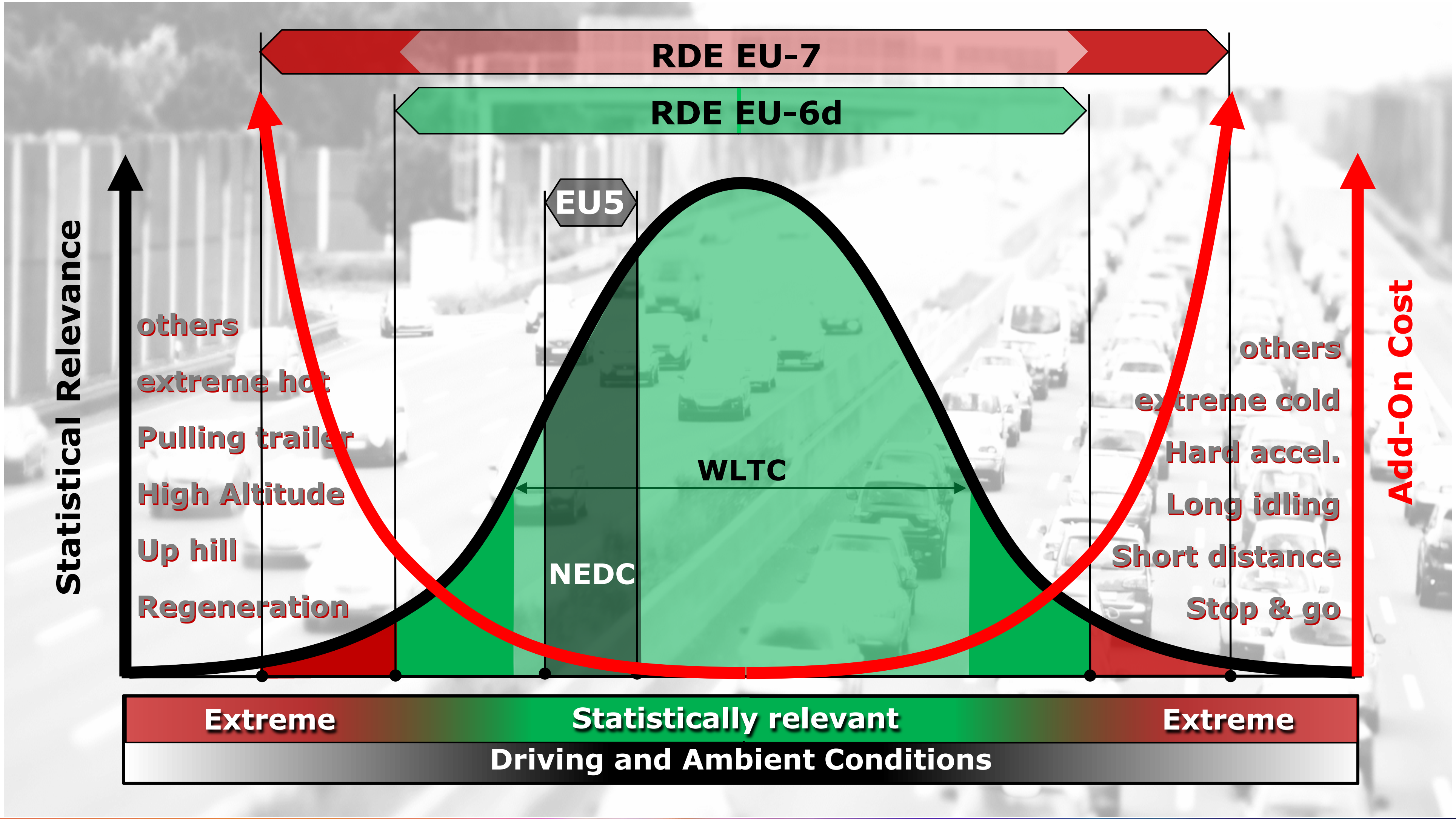
Implications on Emission Concepts

- PC/LD Segment - 1st evaluation/interpretation
- HD Segment - 1st evaluation/interpretation

3

Q&A

Driving Profiles
Focus on Statistical relevant areas required

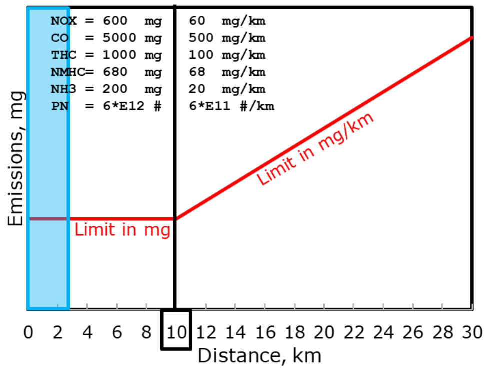


EU7 Emission Challenges Overview

AVL Interpretation - Main upcoming EU7 pollutant emission challenges

RDE Boundaries

- Wider RDE conditions
- Any RDE composition allowed
  → e.g. highway first
  → high load drive-offs
- Emission "budget" for the first 10km



Emission limits

- CO reduced to 50%
- NH3 introduction
- PN 10nm limit
- All Emissions limited in RDE
- New EVAP requirements
- Brake / Tyre wear

CO
reduced

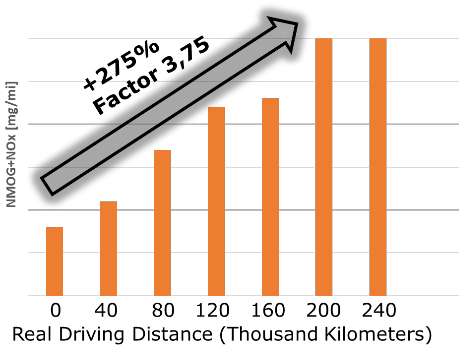
PN
(>10nm)

NH_3

Aging Robustness

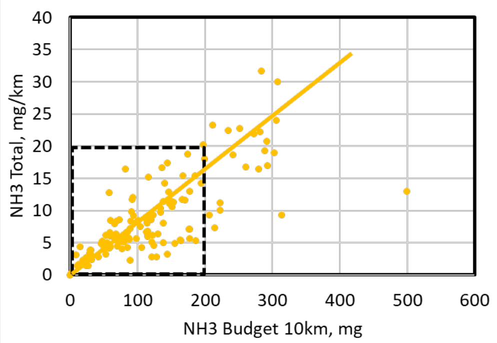
- Aging and Lifetime robustness
- Durability up to 200.000km or 10 years

Impact of lifetime Aging (example)
NMOG + NOx



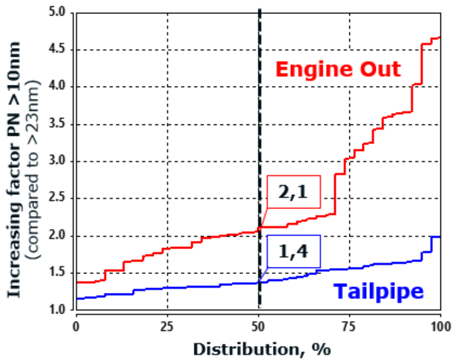
NH_3

- NH_3 produced in TWC
- 20mg/km limit discussed
- Optimization by Calibration for most cases sufficient



PN >10nm

- 40-60% PN Tailpipe increase
- Limit as in EU6d
- ICE limitation, cold PN Optimization and high GPF efficiency needed

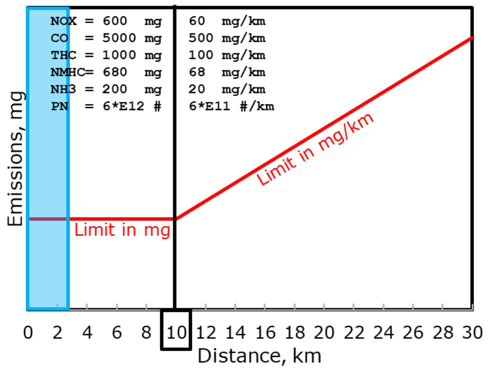


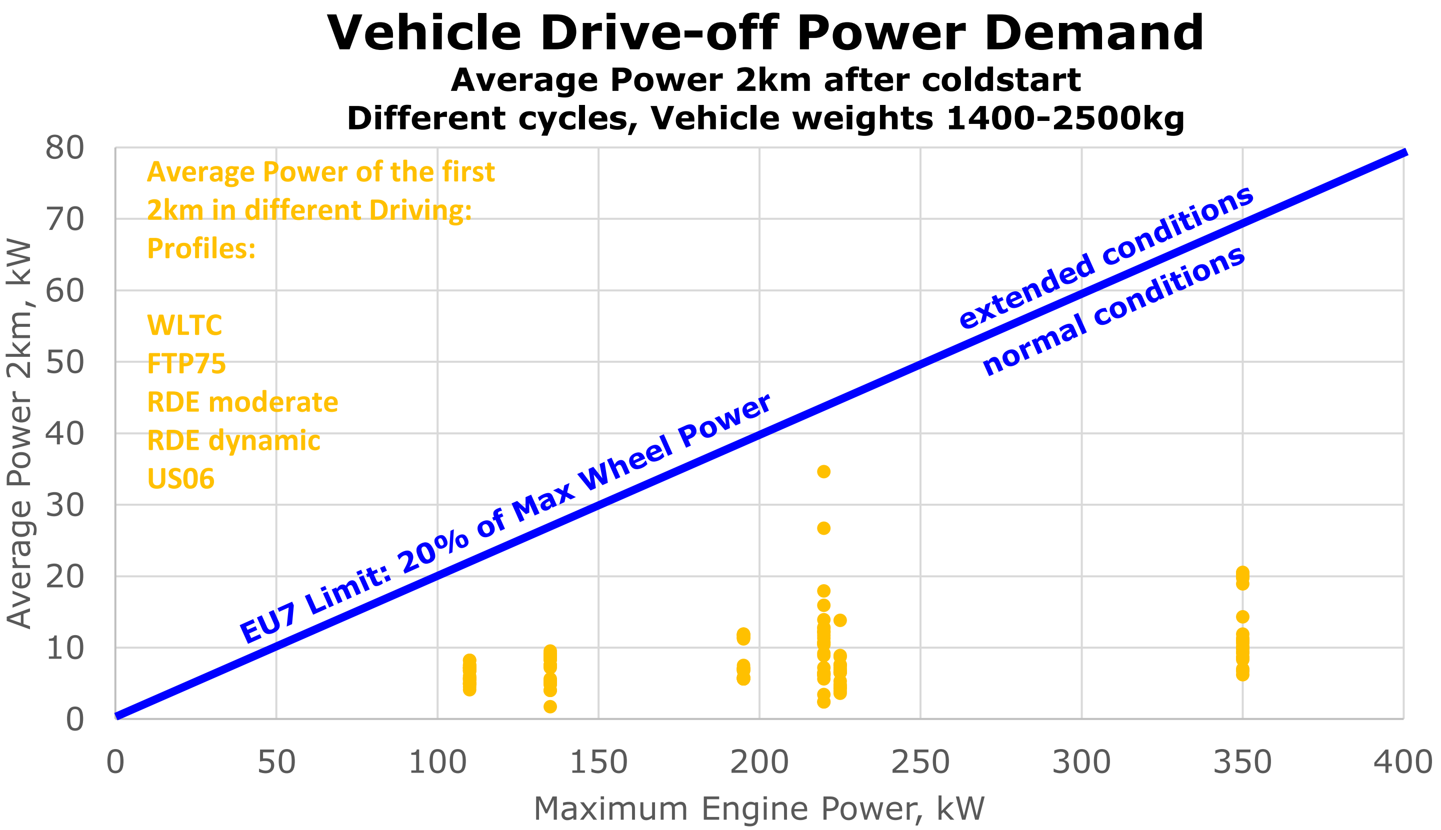
EU7 Emission Challenges
Drive-off Scenarios

AVL Interpretation - Main upcoming EU7 pollutant emission challenges

RDE Boundaries

- Wider RDE conditions
- Any RDE composition allowed
  → e.g. highway first
  → high load drive-offs
- Emission "budget" for the first 10km





Most gasoline passenger cars below extended even in aggressive driving profiles

Focus Cycles

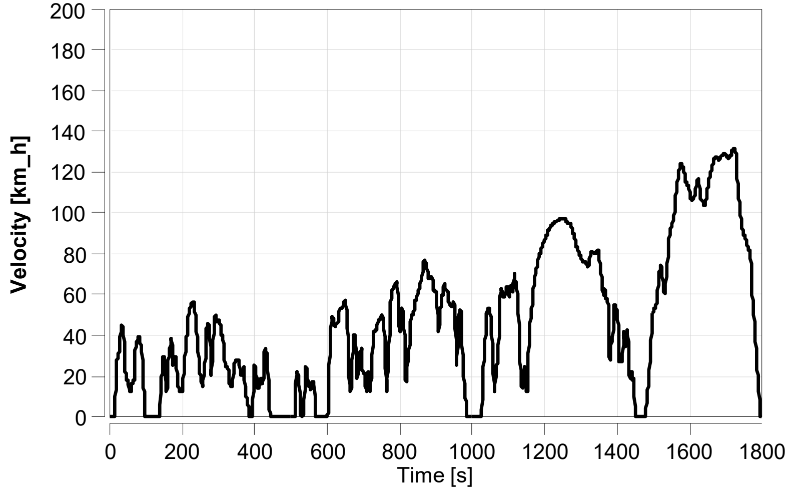
Main Challenges:

Inner City Delivery
Low speed stop & go
→ TFL

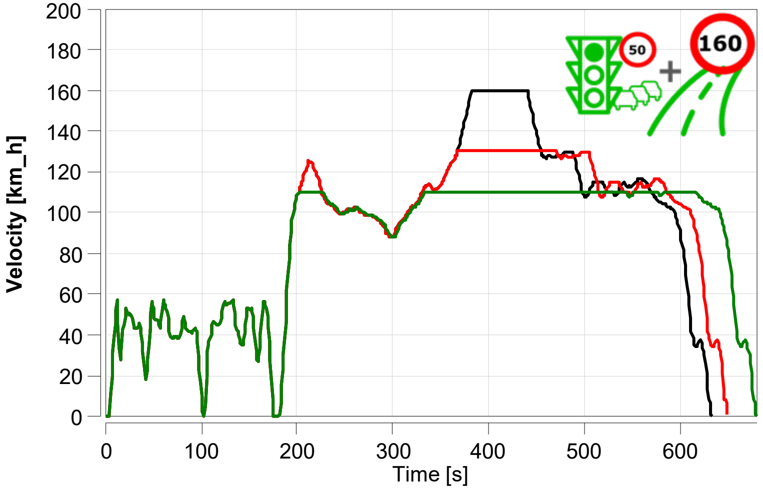
City & immediate high speed
Slow warm-up + immediate high massflow for EAS
→ RDE City + Highway

Cold start + high massflow
Standstill + immediate high massflow for EAS
→ RDE highway

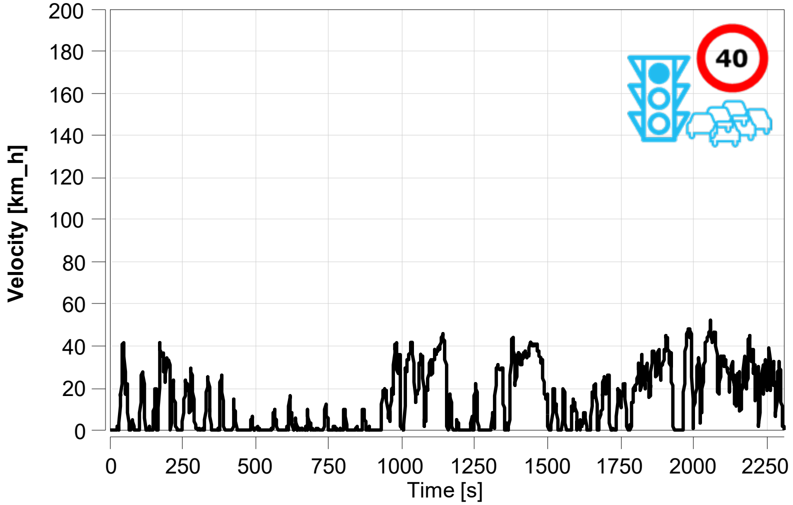
WLTC



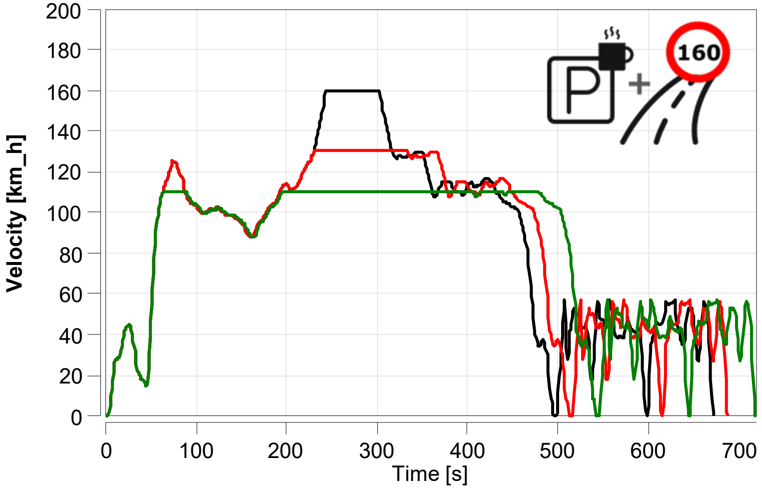
RDE City+Highway



TFL

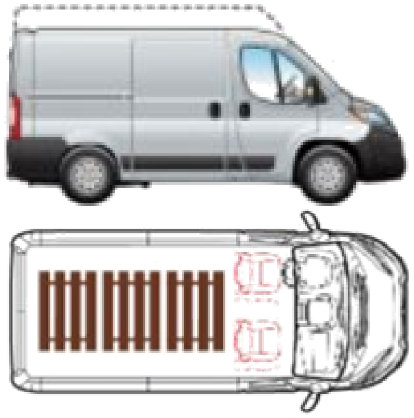


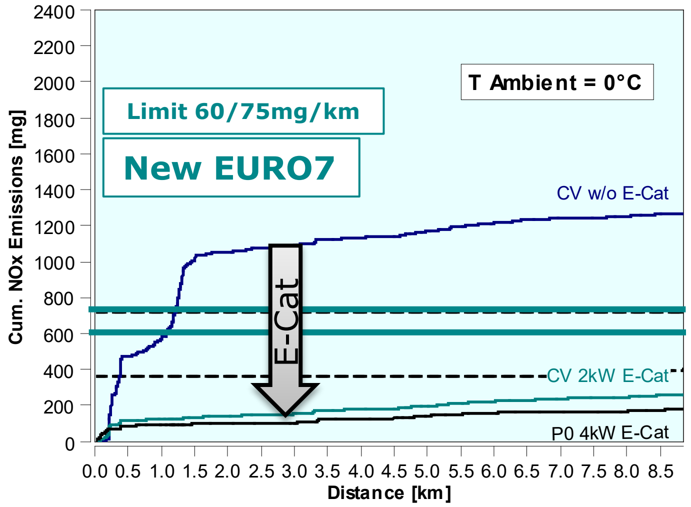
RDE Highway



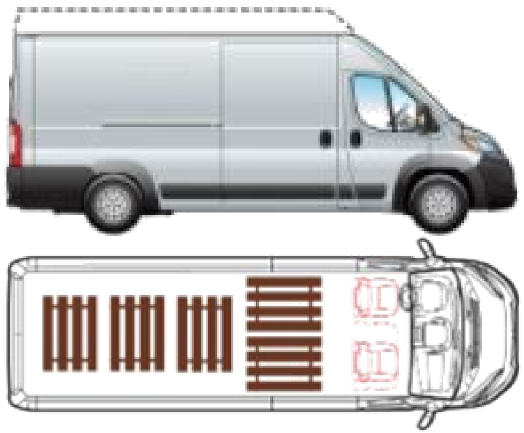
Initial System Evaluation Standard Conditions **0°C**

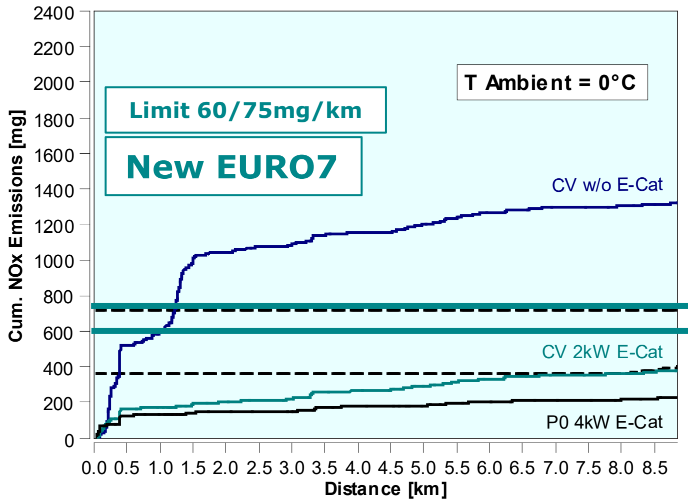
2900 kg





3400 kg





LCV Application, 2L Diesel

Operation Profile

- Low load cycle (TfL)
- 0°C @ Standard conditions

Evaluation Matrix:

- E-Cat – Voltage and Power
- Hybridisation
- Inner-Engine heat-up
- VVT – cost to benefit

➔ **Heat-up support necessary**

Emission Scenario Assumptions
EURO 7/VII OBM - Challenges

AVL Interpretation - Main upcoming EU7 OBM challenges

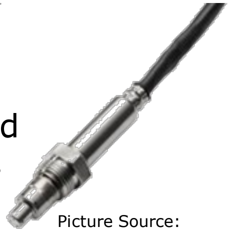
Gas Sensors

NO_x/NH_3:

- NOx Sensors existing. No new sensors will be developed.
- NO_x/NH_3 Cross-Sensitivity (NOx Sensor)
- NH3/HC Cross-Sensitivity (NH3 Sensor)
- Due to Sensor dewpoint, no measurement of cold start emissions
- Sensor Diagnosis
- Sensor Accuracy for low EU7 emissions.
- Aging?

$CO/HC/CH_4$:

- Model based
- No Sensors existing
- Feasibility?



Picture Source: Vitesco Technologies

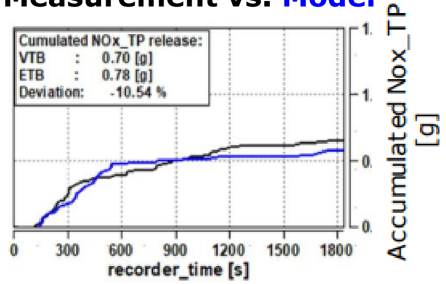
PN/PM Sensors

- No suitable sensor existing.
- OBM Feasibility unclear
- PN/PM monitoring by models very challenging
- "Advanced filter diagnostics" (GPF) with current P or T Sensors not accurate enough to fulfill the Vision of OBM.

Emission models

- Realtime capable ECU models for all emissions required.
- Emission results must be a combination of sensor values and emission models (e.g. when sensor not ready/plausible)
- Sensor plausibility / drift check with models

Measurement vs. Model



Legislative Definition open

- Limit definition incl. measurement / model tolerances.
- Averaging, driving distances, # of cycles?
- Data Reporting, Data transfer, Data Analysis
- Responsibilities (EC, OEM, Others?)
- OBM with PEMS tests in type approval
- Consequences for high emitters?
- TA with random malfunction

Calibration and Vehicle usage

- Model Calibration, Testing and Validation effort increases significantly (Vehicle, Virtual testbeds)
- High xCU Software development effort (models, sensor deviation, aging, poisoning)
- Learning functions for countermeasures if vehicle is close to OBM limits
- Alignment of: OBD <> OBM
- Mil on / Healing calibration
- Which part to replace in workshop / Repair Costs

Virtual sensors as part of the solution, but no Info on OBM exists

OBM Model Approach / Virtual Sensors
AVL Status @ Step2 on protype level

Step 1:

Model Quality Evaluation for OBM Requirements

- Model- Evaluation of technical feasibility with Real Time Models (MIL/SIL)
- Stationary & transient Evaluation of prediction quality incl. Cold and hot conditions

→ **Model Evaluation**

Step 2:

Model Simplification & Evaluation of ECU load on EVAL board

- Adaptation of Model Interfaces (Input / Output)
- Integration of ECU-internal sensor-, actuator- and model-data
- Evaluation of computing load on processor (e.g. EVAL board with TC38X)

→ **Model evaluation under ECU boundaries**
→ **Basic ECU requirements**

Step 3:

Model preparation for Integration via E-Hooks

- Clarification of Interfaces
- Validation in real time
- Model adadaptation to evaluate required computing power in real operation (EHOOK)

→ **Model ready for EHOOKS Integration**

Ready for Vehicle integration

Relevance & Readiness of Virtual sensors approach to be validated once targets are known

Summary 1st Review for PC/LD

Open points

- Minimum RDE distance
- Mis-use definition & consequences
- No info on OBD limits
- No details on OBM published (species, limits, tolerances,…)
  → Virtual sensor approach to be prepared, but no concept proof possible (missing targets)

We stand ready for focused exchange on your specific applications

Main Challenges

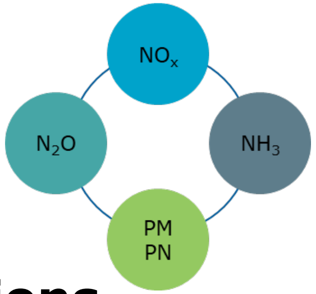
- Temperature management for low-load driving in cold conditions
  → E-cat or inner engine measures (VVT) or Hybridisation // or combination
- PN_{10} limit vs. urea dosing (focus Diesel)
- PN_{10}, CO and NH_3 (focus gasoline)
- Durability up to 200.000km or 10 years
- Brake Emissions
- Timeline (considering final EU7 publication incl. Implementing Regulations

Content

EU VII Legislation HD
AVL Interpretation

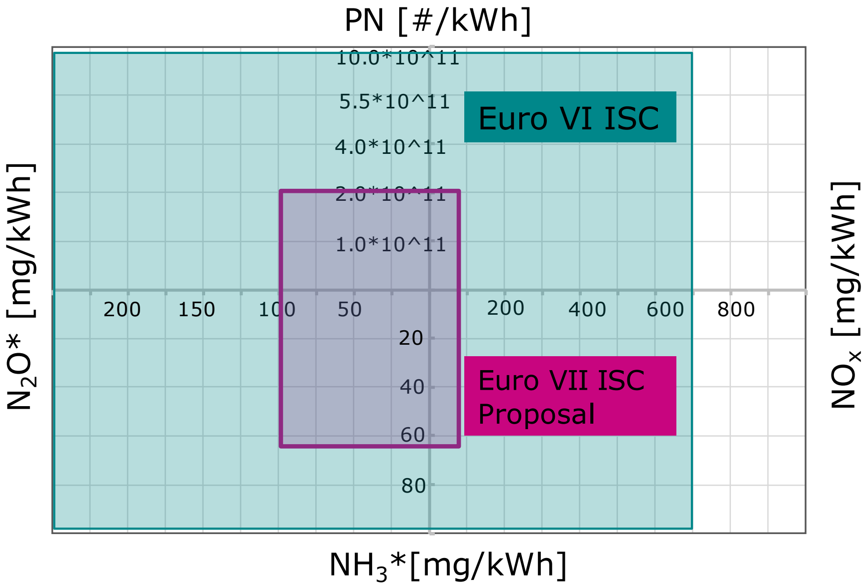
- **Transition** from **Lab Testing** to **Road Testing**
- **Emission** reduction down to
    - **350 mg/kWh NO_x** for **cold start**
    - **90 mg/kWh NO_x** in **hot condition**
- **Limits for HCHO, N_2O, CH_4, PN_{10}** and **NH_3** in **RDE**

→ **Balancing** of **conflicting targets**



- **Emission compliance** under **all RDE conditions**
    - Almost **no boundaries** on **test conditions** (ambient temperature, altitude, vehicle mileage, engine load, …)
    - **No** dedicated **preconditioning**
    - **No separate weighting** of **cold start**

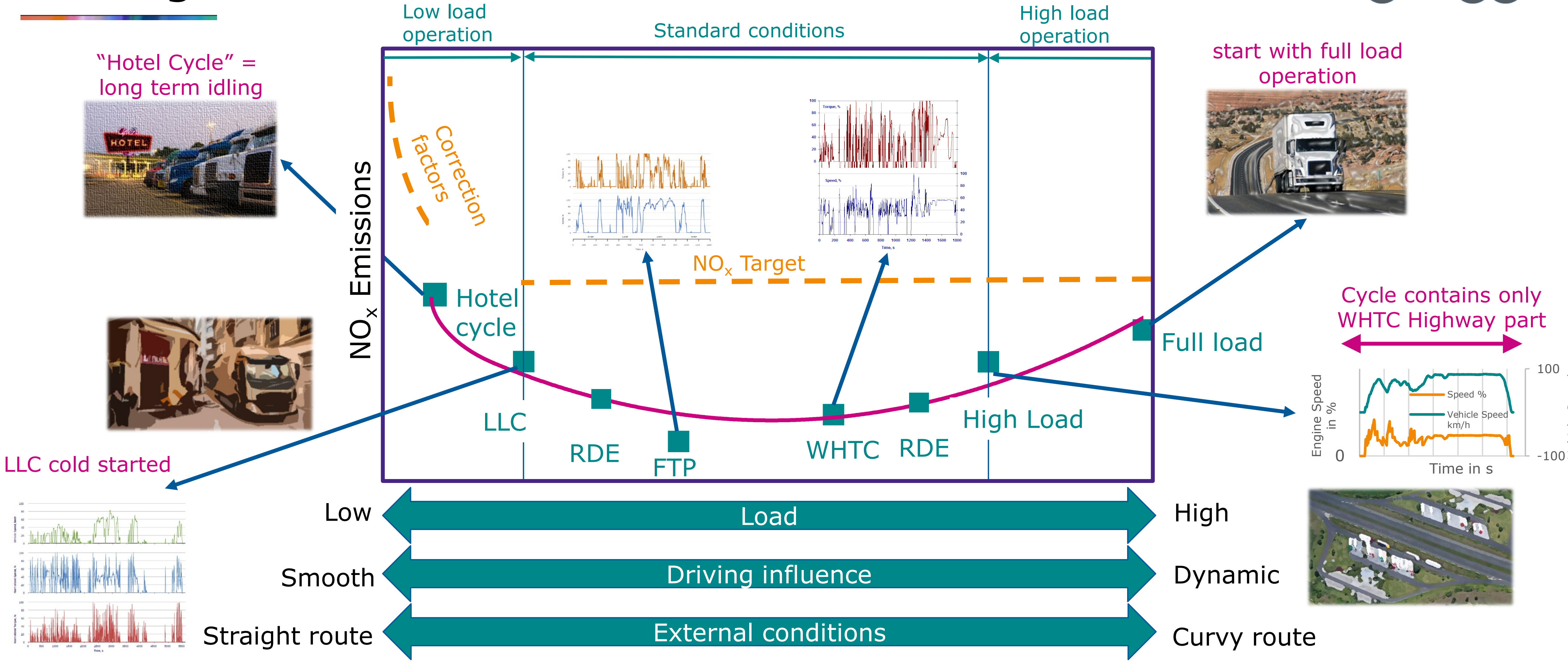
Proposed Limits for ISC



*: Euro VI no NH_3 and N_2O limit in ISC

EURO VII proposal: Significant emission reduction of all interacting emissions

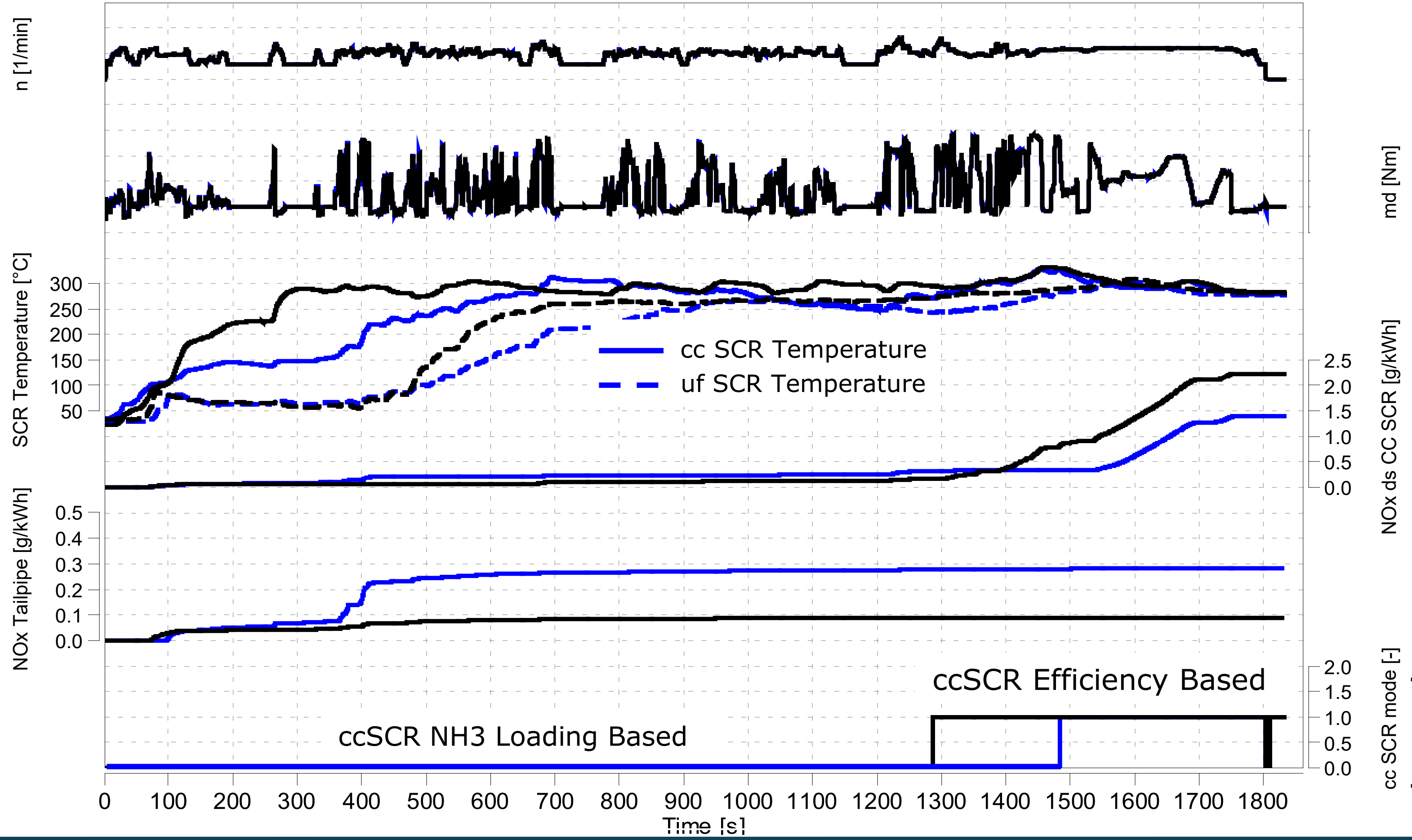
AVL EU VII Demonstrator
Driving Conditions

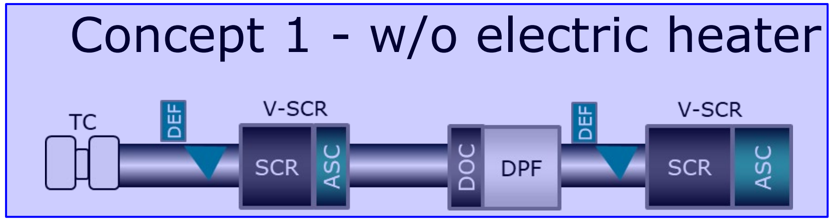


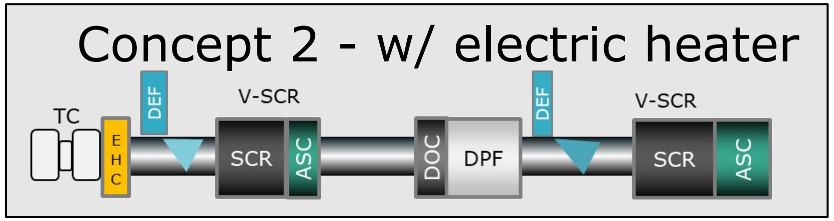
EURO VII: emission compliance under all driving conditions required.

AVL EU VII Demonstrator
Example WHTC Results

Example: WHTC cold







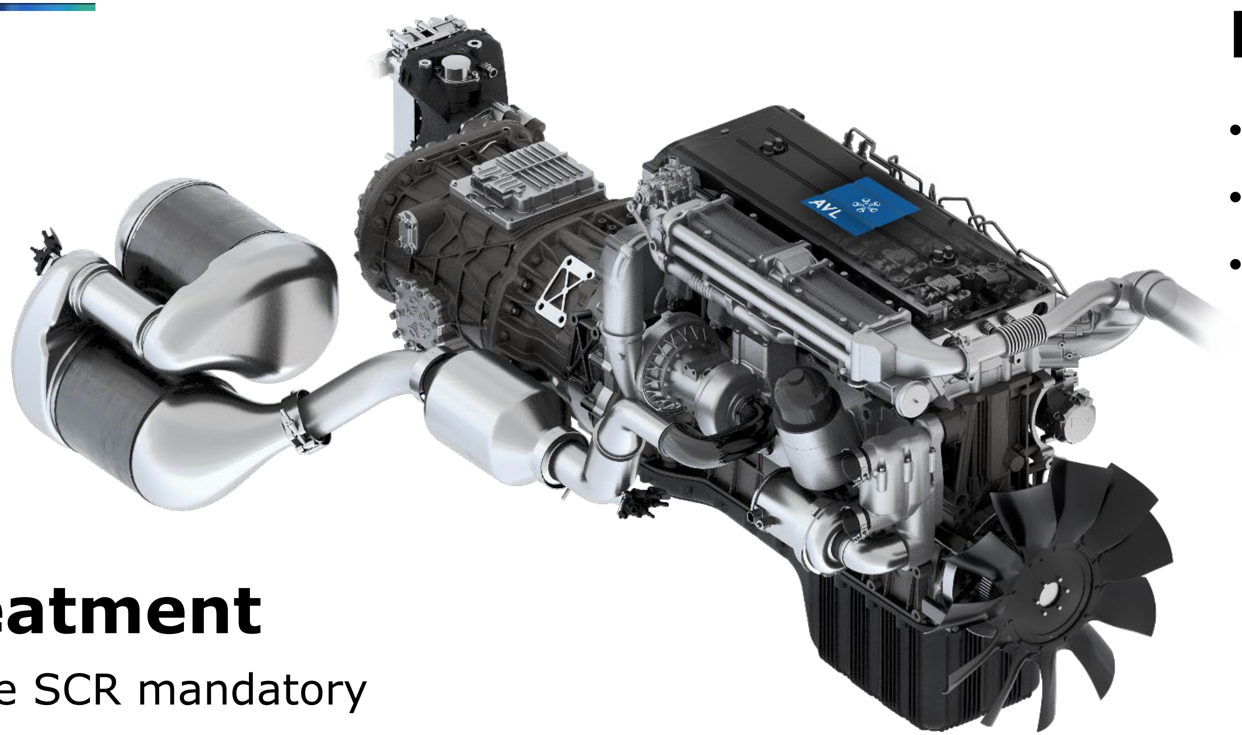
Concept	**NO_x Emissions in WHTC cold**	**EU VII NO_x Limit**
	g/kWh	
Concept 1	278	350
Concept 2	88	

→ Example Results in cold WHTC under lab condition w/ and w/o electric heater

→ Both solutions seem possible

Technology decision after evaluation in worst case boundary and aging conditions

Euro VII Legislation HD
Summary & Main Technology Elements Diesel



Engine

- High efficiency engine (CO2 reduction)
- Adaptive NO_X engine out strategy
- Advanced exhaust gas temp. management
  - Multiple injection strategy
  - Uncooled & cooled EGR
  - Intake & exhaust path
    - Intake throttle
    - Exhaust back pressure valve
    - Charge air cooler bypass
    - Switchable Miller
    - Cylinder deactivation

Aftertreatment

- Dual Stage SCR mandatory
- Vanadium SCR as main technology route due to N_2O limit
- Tailpipe filter due to urea borne particulates expected
- Electrically heated catalyst for highest emission robustness
- Model Based EAS Control
- Active DPF Soot Management

➢ Holistic approach necessary to choose the right technology bricks for engine & EAS considering OBD/OBM

AVL Technical Legislation Service – Stay Tuned

emrep@avl.com

UN ECE / WP 29 / GRPE / GRVA / GRx / IWG

AVL Experience Cloud
AVL EmRep – Emission Reports
AVL VeLPo – Vehicle Legislation Portal

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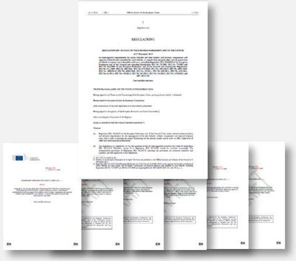

Customers
(external & internal)

Content

Thank you

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