

# Integrated Diesel System Achieving Ultra-Low Urban and Motorway NOx Emissions on the Road

J. Demuynck, C. Favre, D. Bosteels, AECC

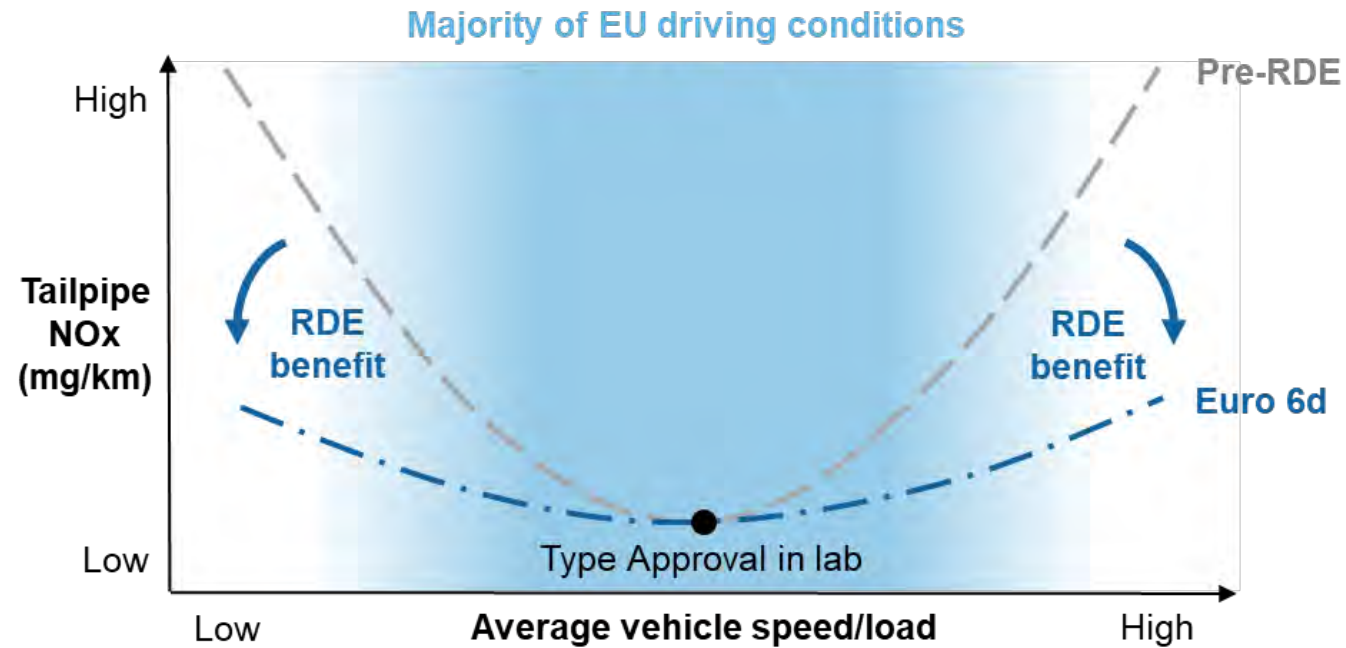
G. Randlshofer, IPA

F. Bunar, J. Spitta, O. Friedrichs, A. Kuhrt, M. Brauer, IAV GmbH

40<sup>th</sup> International Vienna Motor Symposium • 16 May 2019

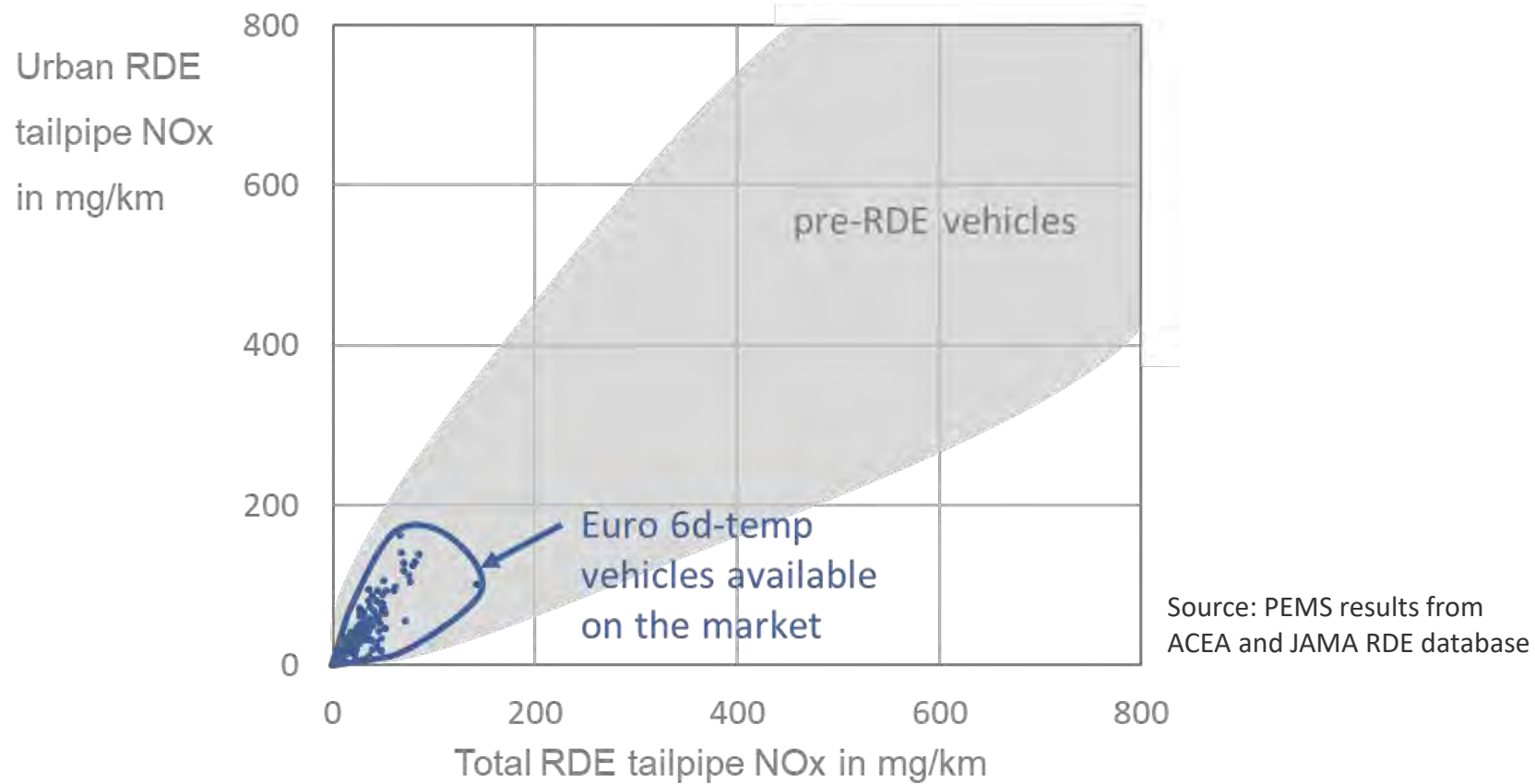
# RDE legislation has improved real-world NOx emissions

- RDE requirements ensure that emissions are controlled over wider range of conditions



# RDE legislation has improved real-world NOx emissions

- On-road emissions of Euro 6d-Temp cars are well within standards



# Objective: demonstrate consistent low NOx emissions

## ➤ Challenging driving conditions

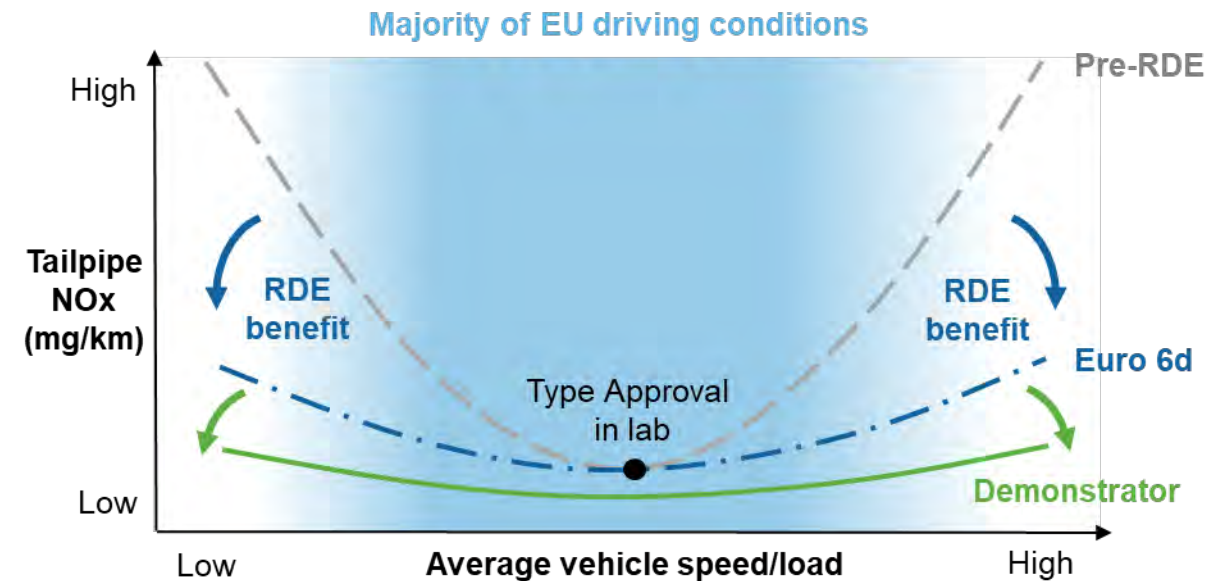
- Low speed/load  
e.g. city driving



- High speed/load  
e.g. motorway driving



- Transients  
e.g. overtaking



# Content

- Demonstrator concept: emission control technologies combined in integrated approach
- Tailpipe NOx and deNOx efficiency
  - RDE
  - City
  - Motorway
- Conclusions

# Vehicle and powertrain characteristics

## ➤ Vehicle

- C-segment
- 1700 kg

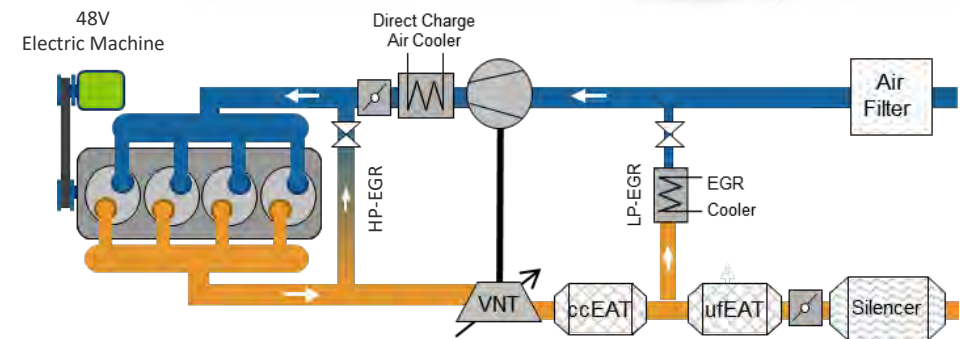
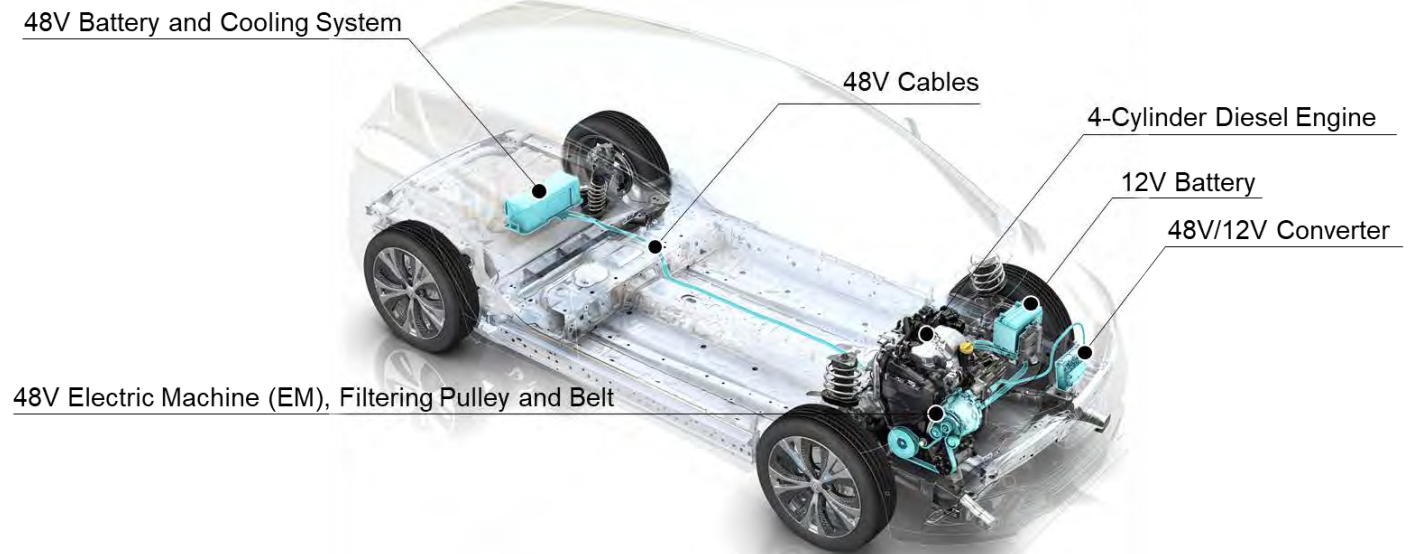
## ➤ Drivetrain

- Manual gearbox, 6-speed
- 48 Volt mild-hybrid (belt-driven, P0)

## ➤ Engine

- 1.5l, 4-cylinder, 2-valve
- EGR: uncooled HP and cooled LP

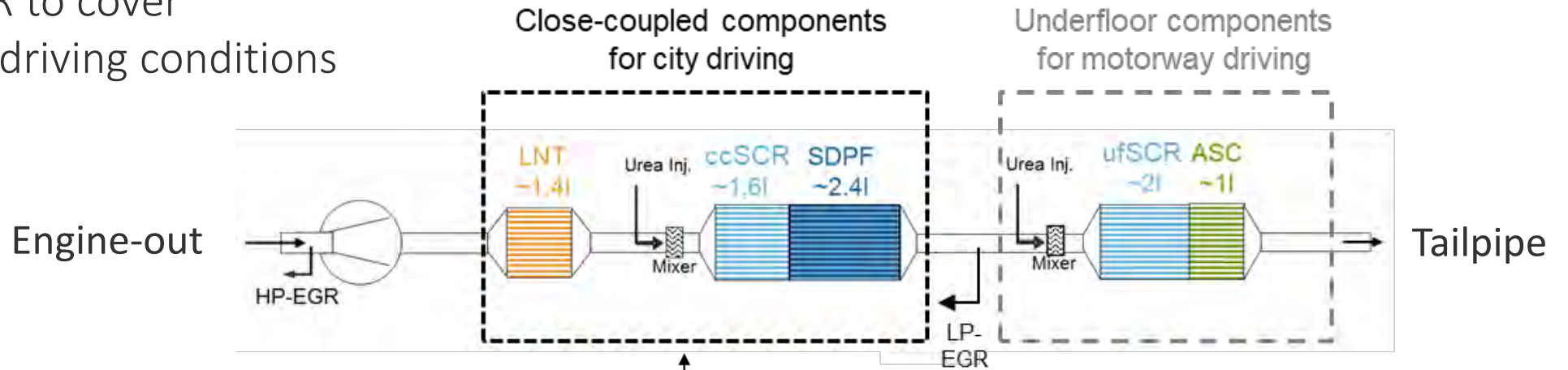
## ➤ Euro 6b type approval (LNT + DPF)



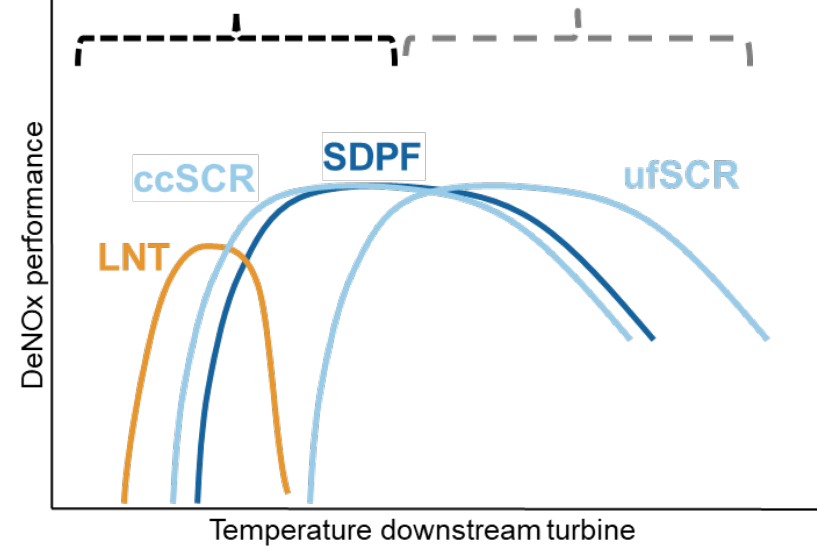


# Demonstrator concept: emissions control technologies

- LNT + dual-SCR to cover wide range of driving conditions



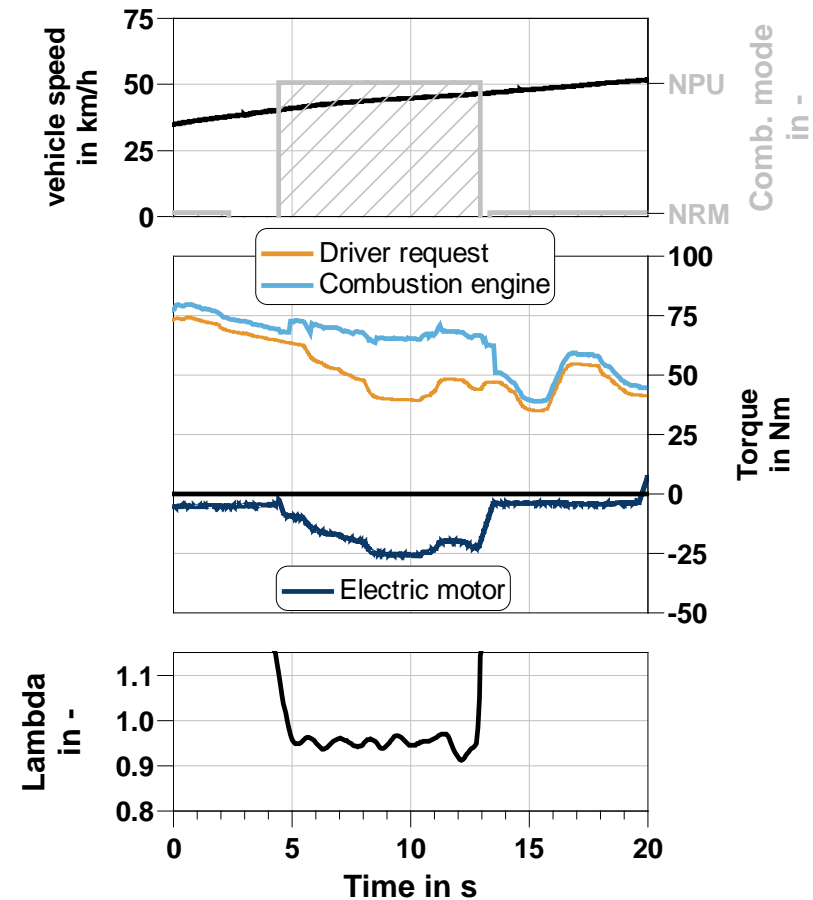
EGR: Exhaust Gas Recirculation  
 HP/LP: High/Low pressure  
 cc: close-coupled  
 LNT: Lean NO<sub>x</sub> trap  
 SCR: Selective Catalytic Reduction  
 DPF: Diesel Particulate Filter  
 SDPF: SCR on DPF  
 uf: underfloor  
 ASC: Ammonia Slip Catalyst



# Demonstrator concept: hybrid support to emissions control

- Stabilisation of LNT regeneration during city driving
  - e.g. transient load compensation in case of unstable driver request

- Others
  - Reduction of engine-out NO<sub>x</sub> peaks during transients
  - Support to thermal management





# Demonstrator concept: rapid prototype system control

➤ Stepwise active thermal management depending on LNT & ccSCR temperature

➤ When LNT < 170°C & ccSCR < 150°C

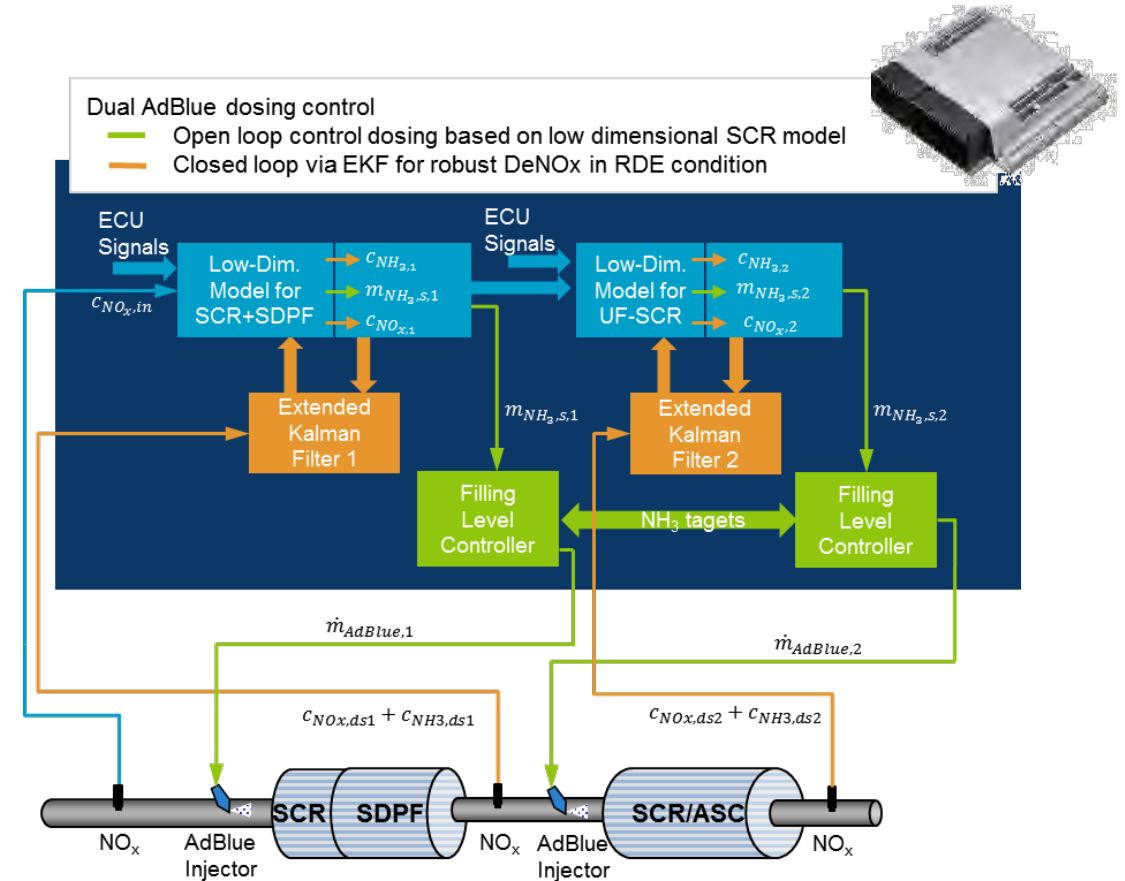
- throttle valve (used for EGR control):  
reduce exhaust mass flow rate

➤ When LNT > 170°C & ccSCR < 220°C

- late post-injection:  
create exothermic reaction on LNT
- 48V mild-hybrid system:  
increase load on ICE

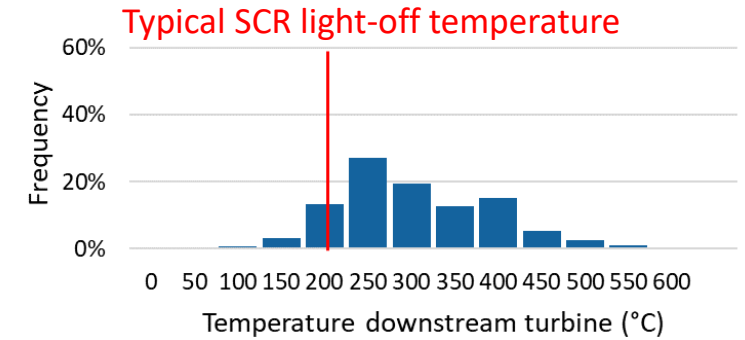
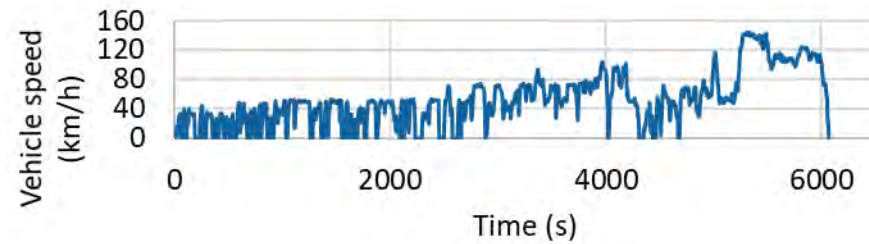
➤ Model-based control of SCR

- For optimum NH<sub>3</sub> dosing control without slip
- Separate dosing control for two urea injectors
- 3 NO<sub>x</sub> sensors used

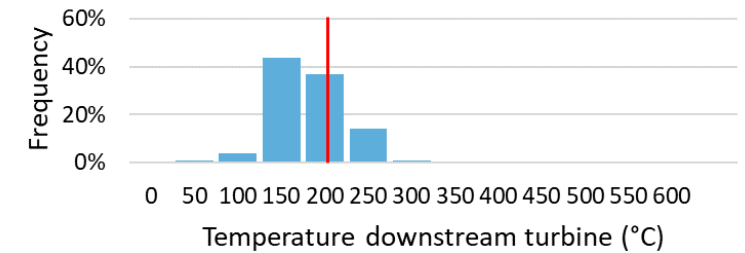
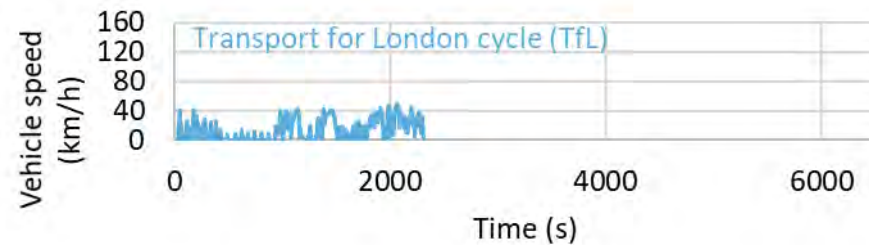


# Combination of emissions tests on the road and in the lab

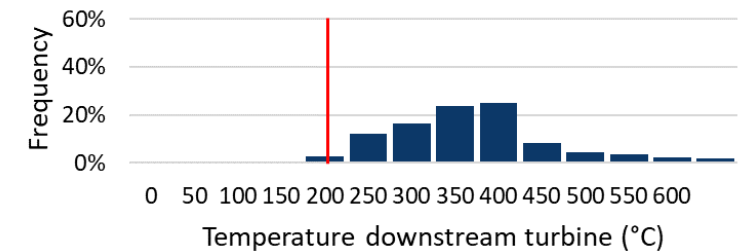
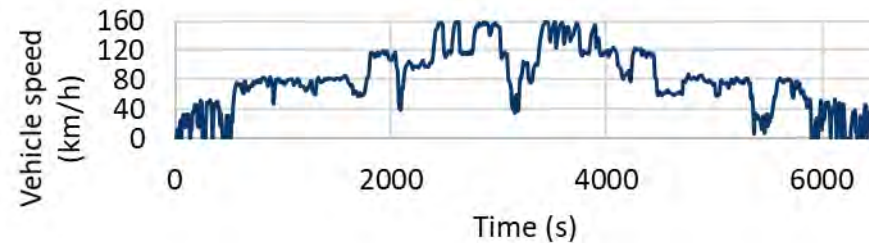
➤ RDE



➤ City



➤ Motorway

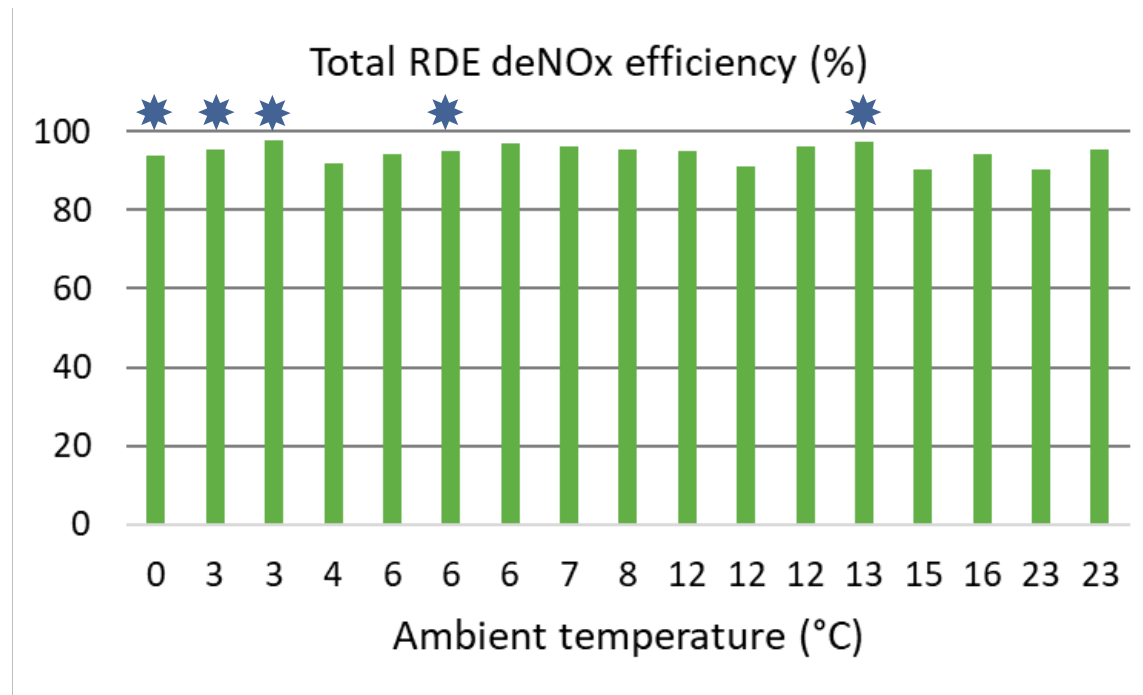
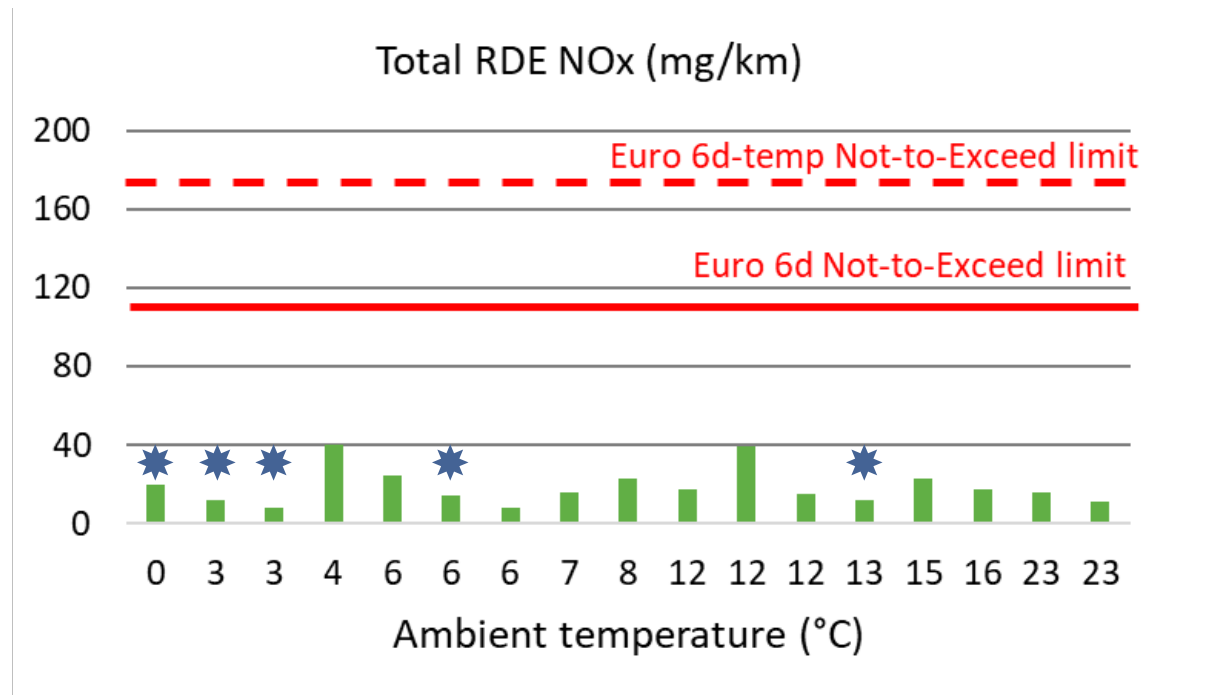


# Content

- Demonstrator concept: emission control technologies combined in integrated approach
- Tailpipe NOx and deNOx efficiency
  - RDE
  - City
  - Motorway
- Conclusions

# 8-40 mg/km achieved on RDE

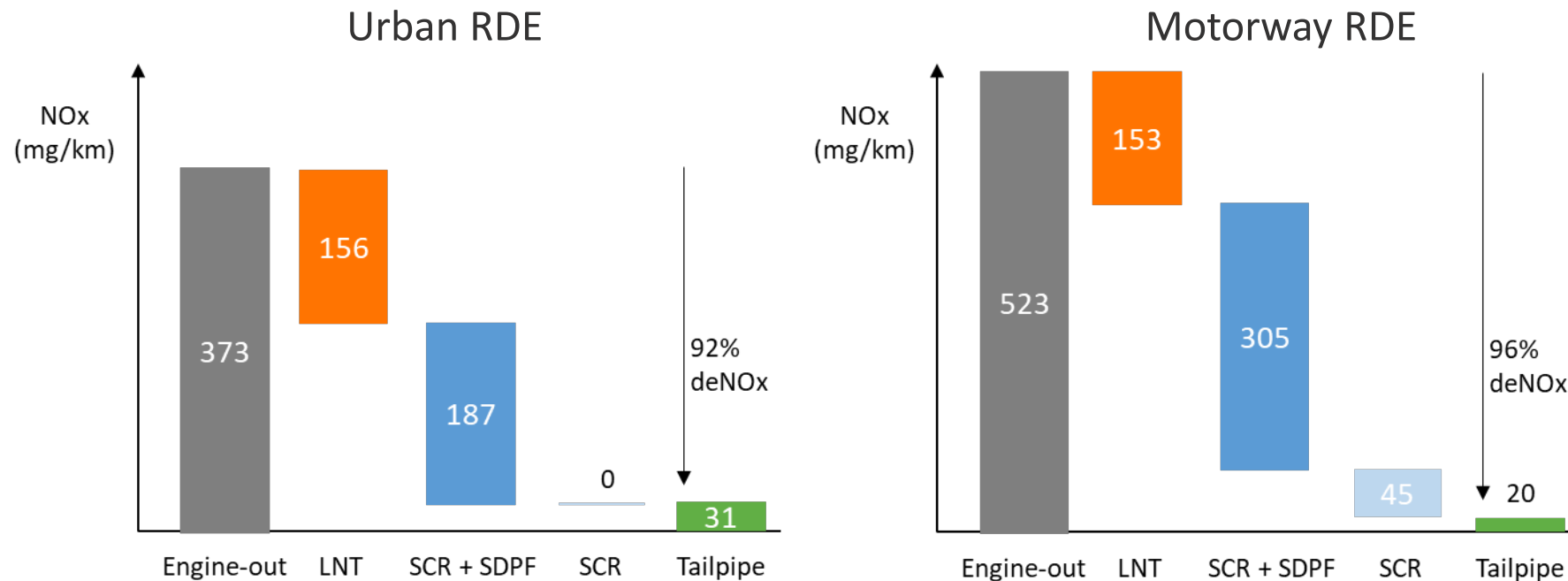
- 90-96% deNO<sub>x</sub> efficiency
- No impact of ambient temperature



\* Results at end of programme with refined calibration

# All aftertreatment components contribute to NOx control

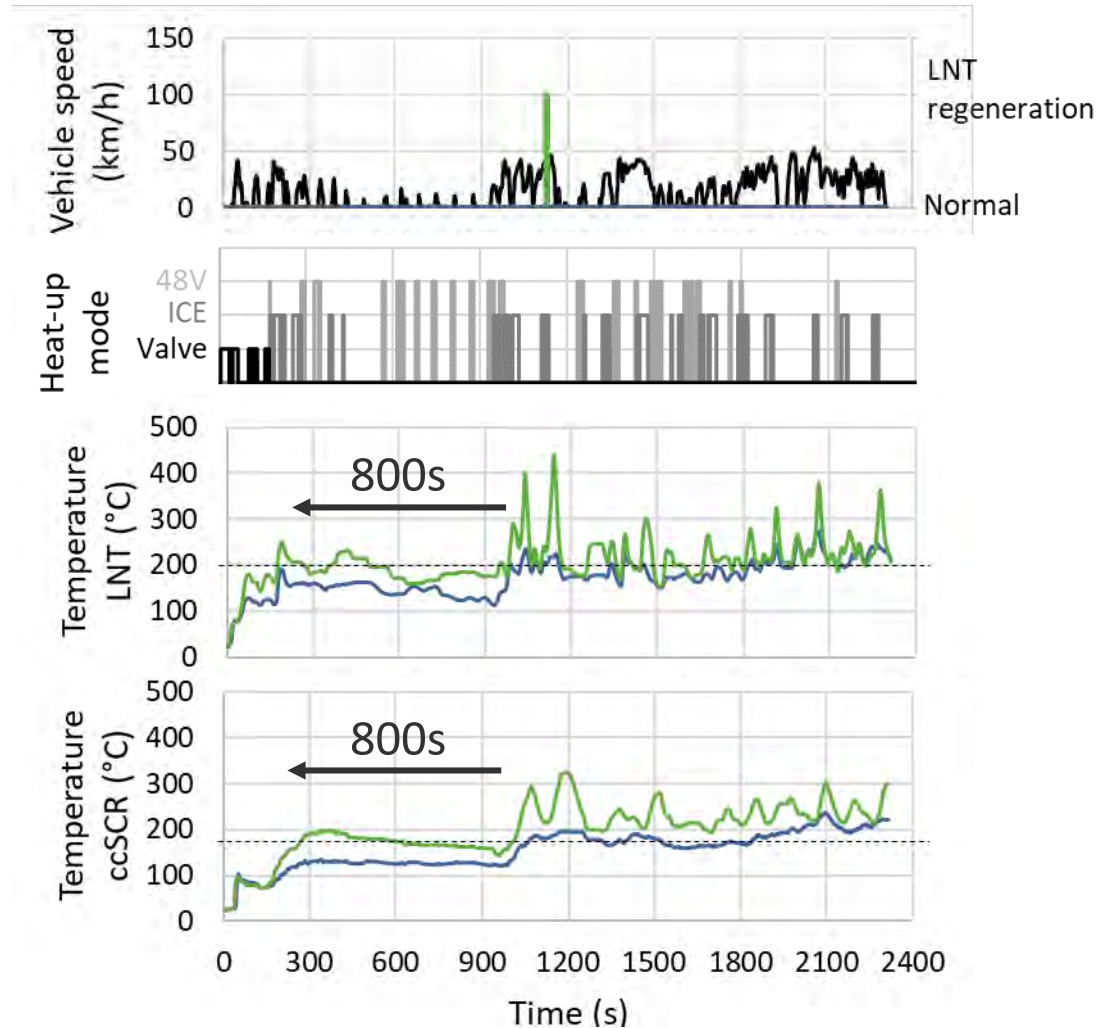
- City driving: LNT and close coupled SCR+SDPF
- Motorway driving: underfloor SCR required to secure robust emissions control



# Robust NOx control in the city, including cold-start

- LNT regeneration enabled at low load
- Active thermal management to ensure early heat-up
  - Active throughout entire TfL test
  - Typical light-off temperature reached within 300s after cold-start (800s gained)

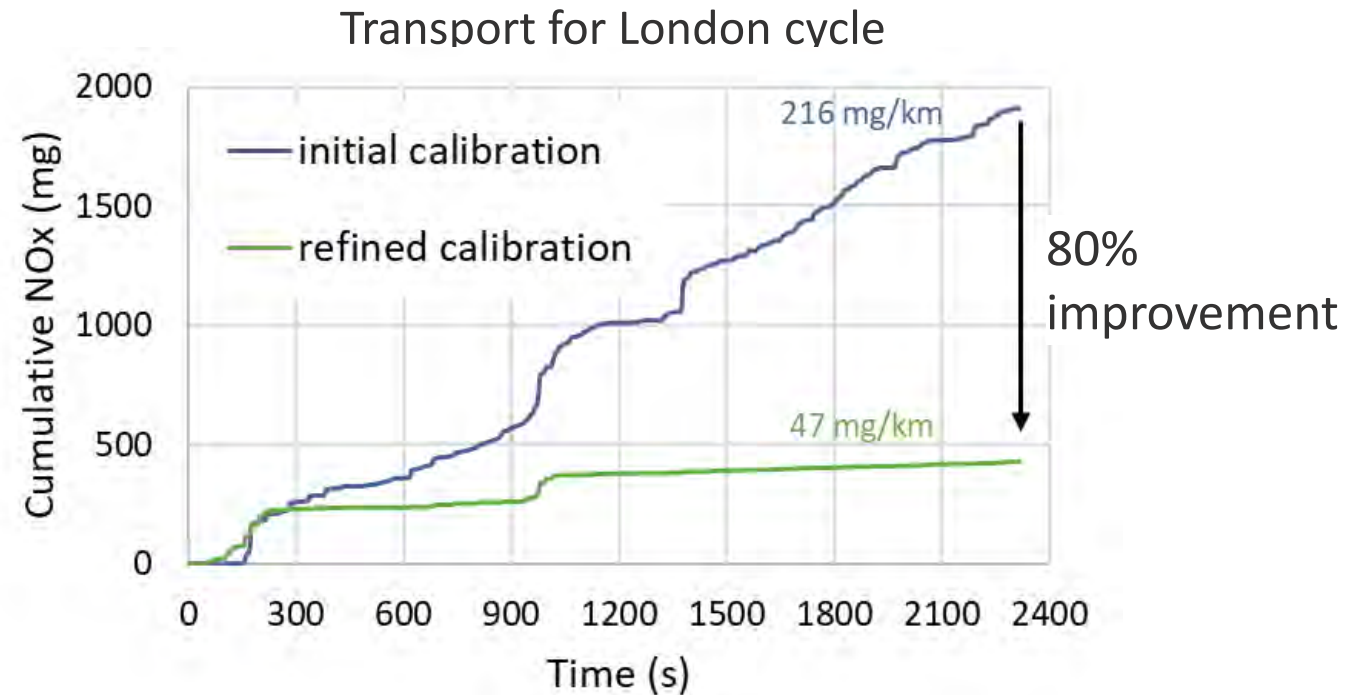
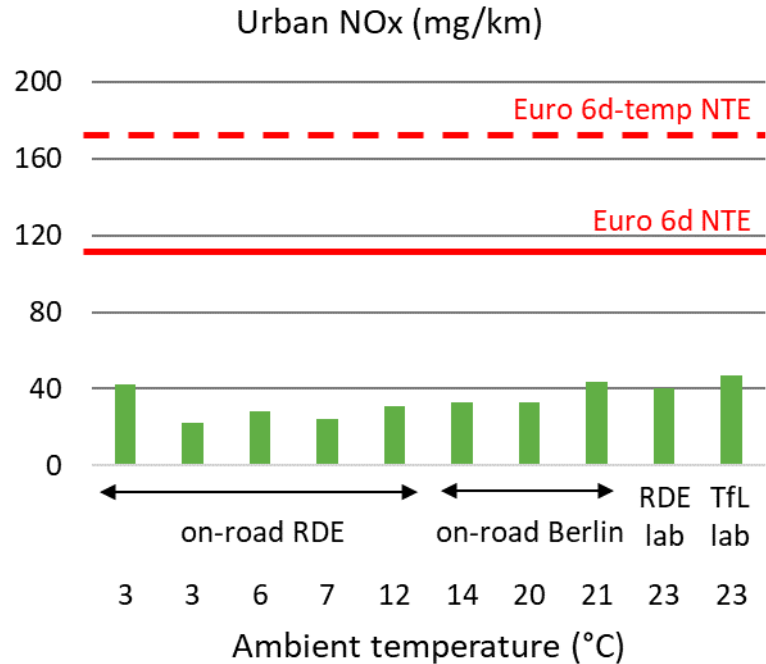
Thermal management:  
Initial calibration: not active  
Refined calibration: active





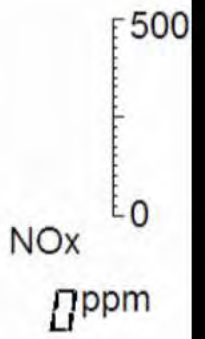
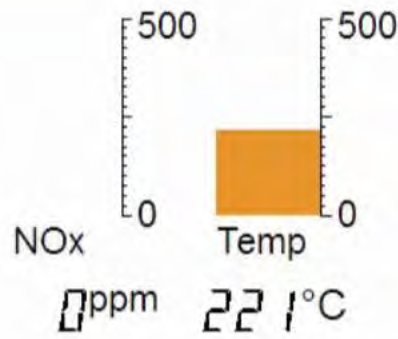
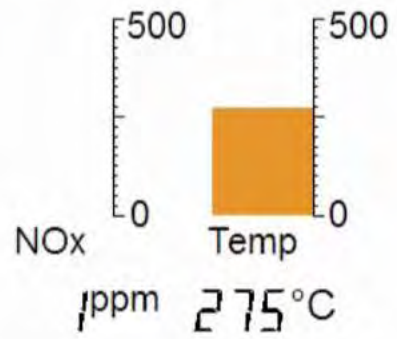
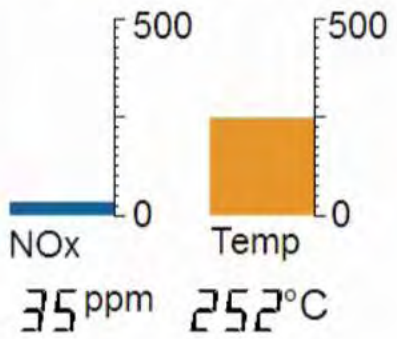
# 24-47 mg/km NOx in the city

- Including challenging Berlin and Transport for London (TfL) tests
- TfL NOx: 80% improvement due to LNT regeneration stabilisation and active thermal management
- Impact of calibration measures on CO<sub>2</sub> was below 3% on WLTC and RDE





Engine load: 11%    Vehicle speed: 0 km/h



Engine heat-up

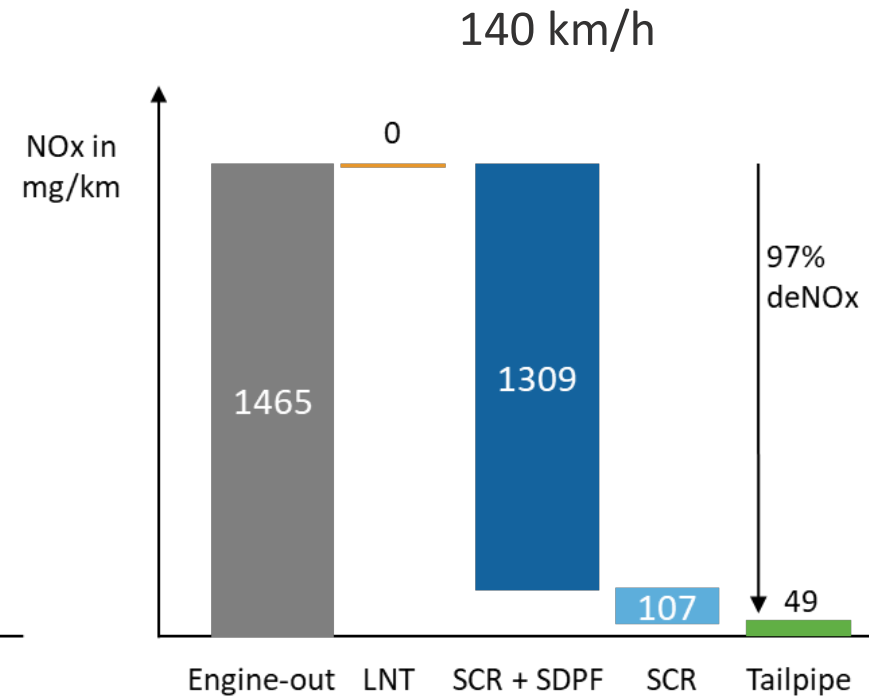
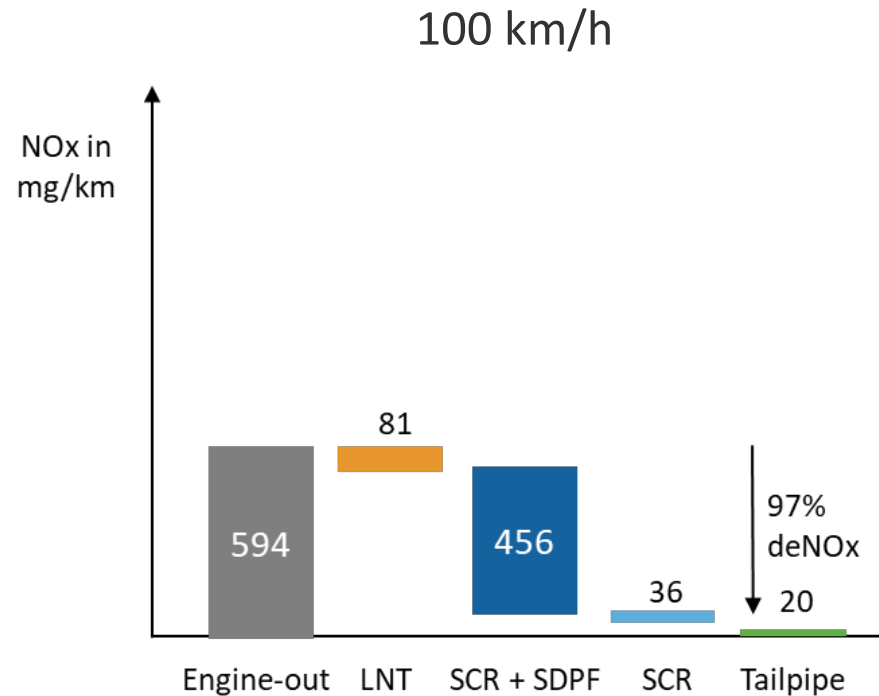
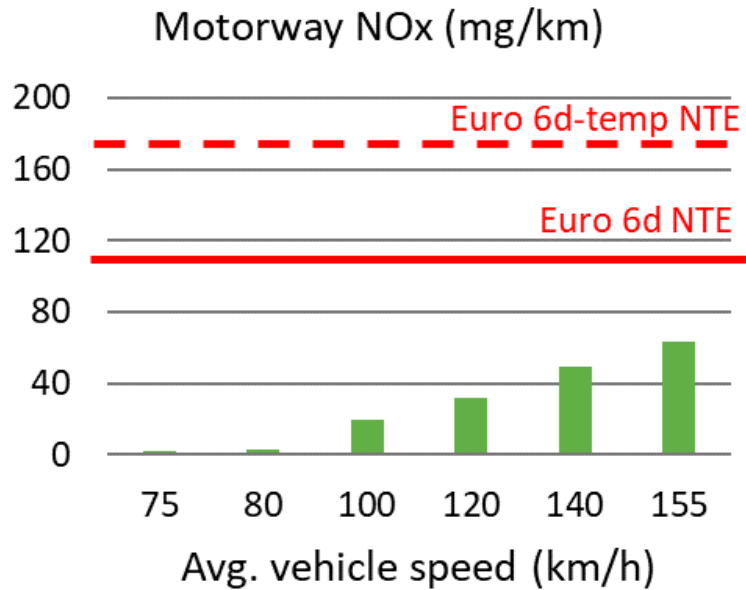
LNT regeneration

Urea doser 1

Urea doser 2

# 3-63 mg/km on the motorway

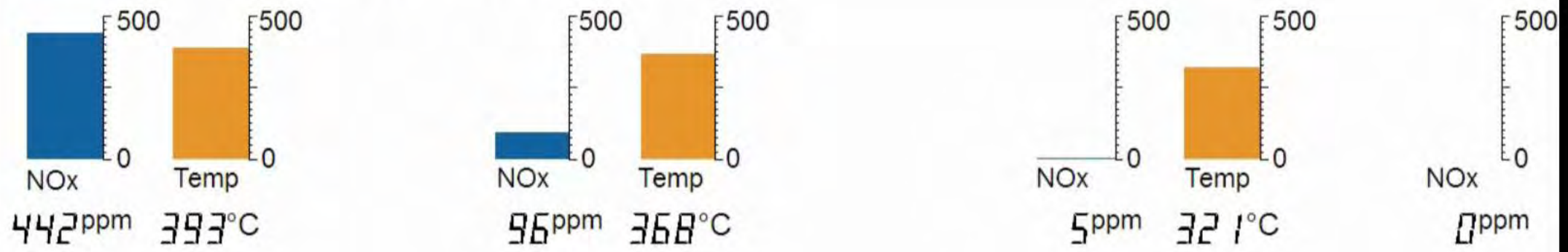
- 95-99% deNOx efficiency
- Main deNOx by dual-SCR
- Challenge is increase in engine-out emissions





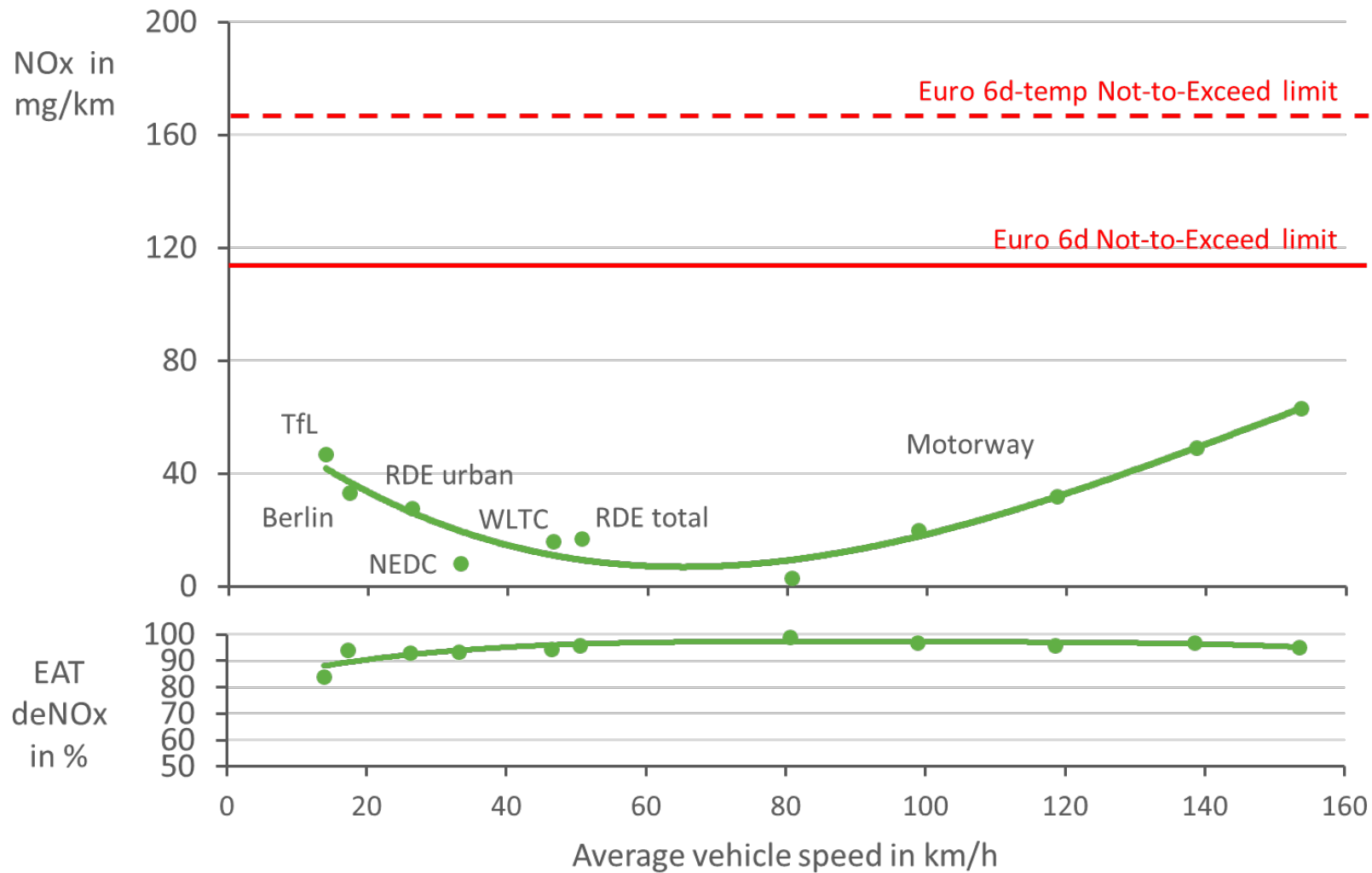


Engine load: 67%    Vehicle speed: 118 km/h



- Engine heat-up
- LNT regeneration
- Urea doser 1
- Urea doser 2

# Tailpipe NOx and deNOx efficiency summary



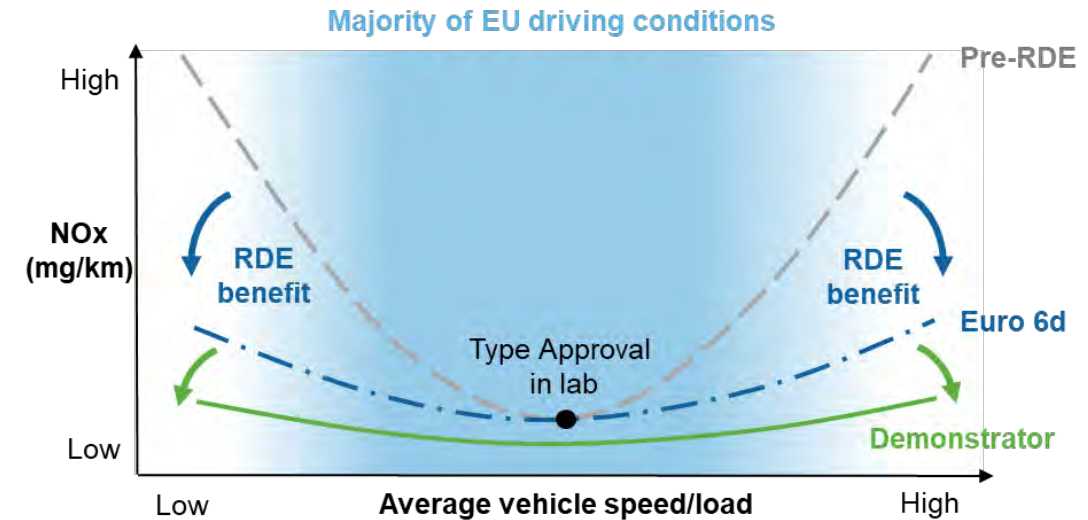
# Content

- Demonstrator concept: emission control technologies combined in integrated approach
- Tailpipe NOx and deNOx efficiency
  - RDE
  - City
  - Motorway
- Conclusions



# Conclusions

- RDE requirements have ensured better control of NOx emissions under most EU driving conditions – these Euro 6d-temp cars are on the road today.
- This demo car shows that diesel NOx emissions can be kept at a very low level in a consistent way, over a wide range of driving conditions.
- Tailpipe NOx measured are 24-47 mg/km in the city and 3-63 mg/km on the motorway.
- This is achieved by combining existing catalyst technologies with improved emissions control functions supported by hybrid technology.





# THANK YOU !

[www.aecc.eu](http://www.aecc.eu)

[dieselinformation.aecc.eu](http://dieselinformation.aecc.eu)

 @AECC\_eu

 AECC (Association for Emissions Control by Catalyst)

 @aeccbrussels

