Ultra-low Emissions of a 48V Mild-Hybrid Gasoline Vehicle with Advanced Emission Control Technologies and System Control

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AECC
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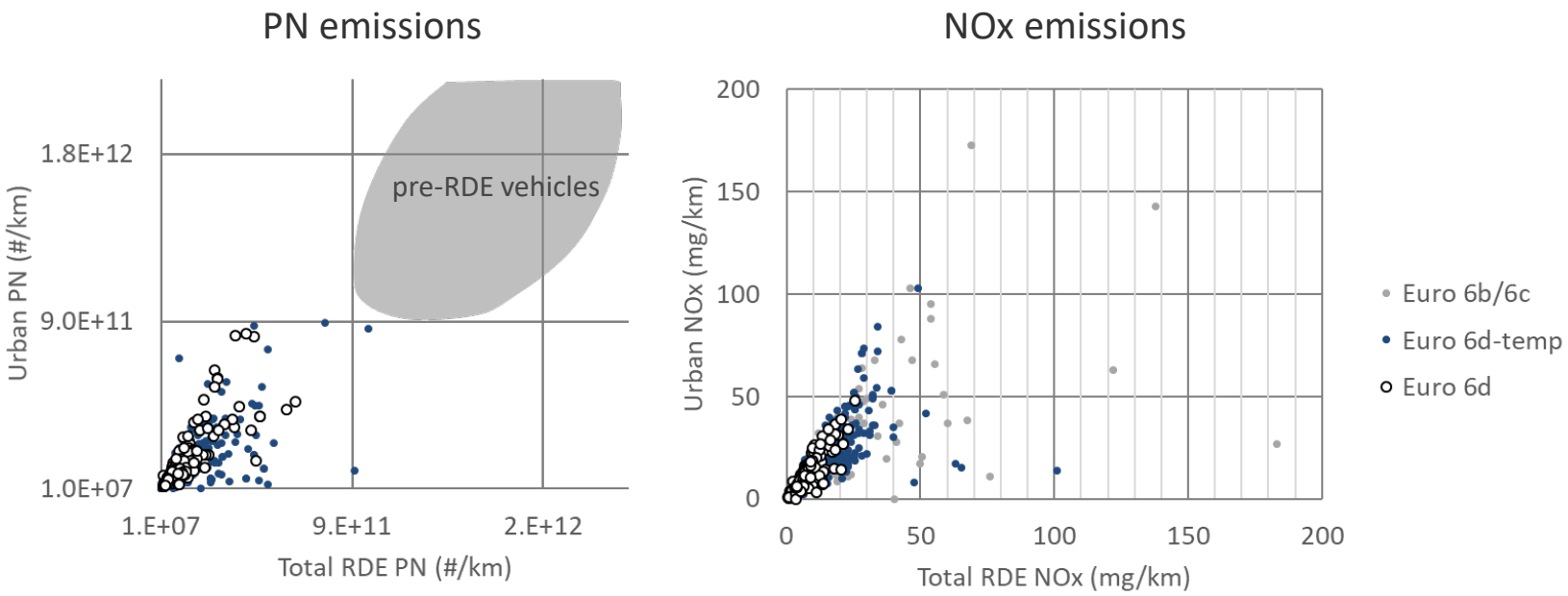
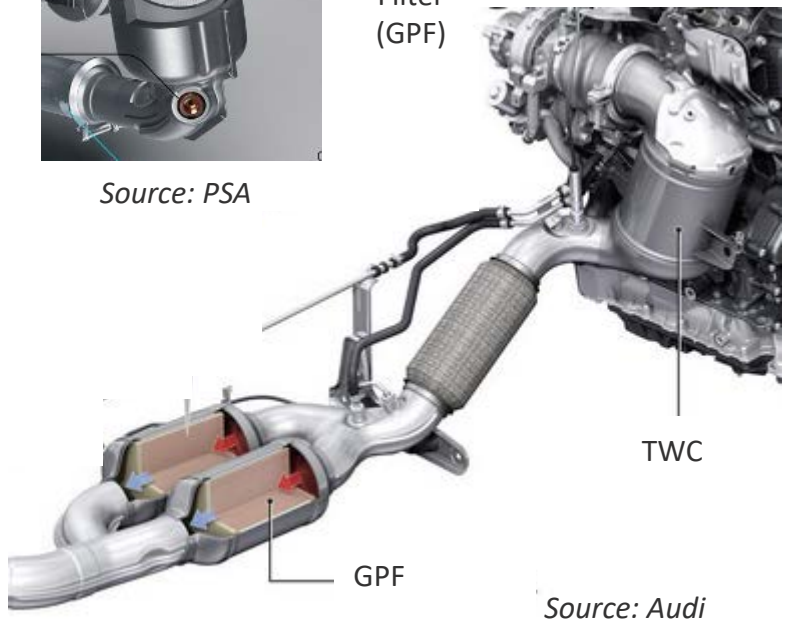
Gasoline emissions significantly reduced towards Euro 6d with advanced emission control systems



TWC

Gasoline Particulate Filter (GPF)

Source: PSA

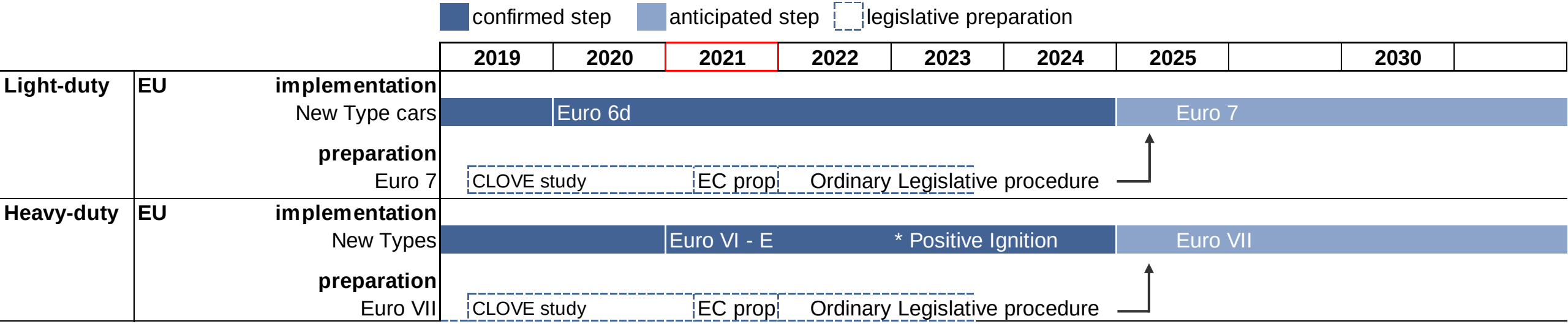


Source: Audi

Sources: - *ACEA/JAMA Euro 6d(-TEMP) PEMS data consulted 17 July 2020*
- *pre-RDE PN emissions factors from B. Giechaskiel, Int. J. Environ. Res. Public Health, 2018*

Emission legislation evolution expected towards Euro 7

- The AGVES expert working group met until end of April 2021
- CLOVE consortium
  - Presented scenarios for light- and heavy-duty vehicles
  - Will provide further input for the European Commission impact assessment
- The actual European Commission proposal is expected within 2021 followed by the ordinary legislative procedure with European Parliament and Council



LD gasoline demonstrator concept

- Base vehicle
  - C-segment vehicle
  - Engine
    - 1.5l with 4 cylinders
    - Variable valve train with cylinder deactivation
  - 48V mild-hybrid (belt-driven, P0 configuration)
  - Euro 6d type-approval baseline with GPF + TWC
- Project partners

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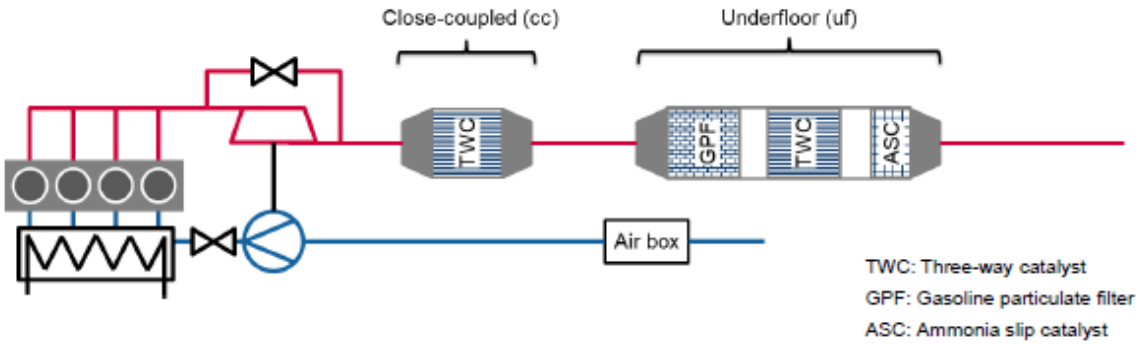
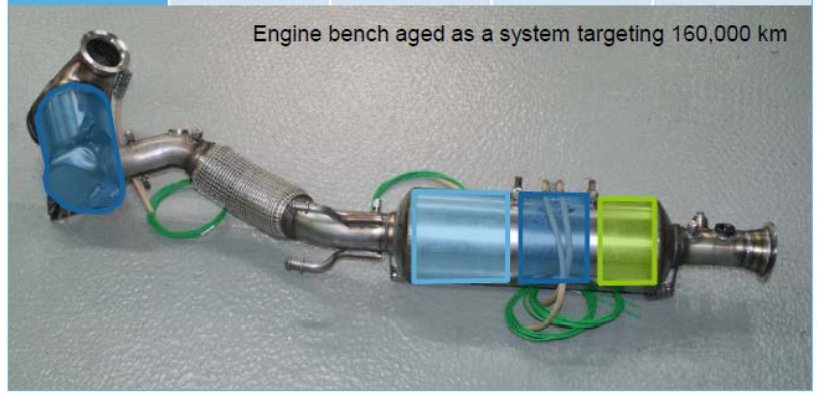
DENSO

LD gasoline demonstrator concept

- Emission control system
  - ccTW and ufGPF + TWC + ASC
  - ccTWC substrate with maximised surface area for enhanced cold-start performance
  - ASC operation strategy for gasoline investigated in addition to improved lambda control
  - Bench aged components targeting 160k km
- Two sets of calibration tested
  - Serial vehicle lambda control of ccTWC
    - Wideband lambda probe upstream
    - 2-step lambda probe downstream
  - Modification
    - Early closed-loop lambda control
    - Retarded spark timing



	cc TWC	uf cGPF	uf TWC	uf ASC
Diameter	4.66”	5.2”	5.2”	5.2”
Length	6”	4.72”	3.15”	2.36”
Cell density & wall thickness	900 cpsi x 2 mil	200 cpsi x 8 mil	600 cpsi x 2.5 mil	600 cpsi x 2.5 mil



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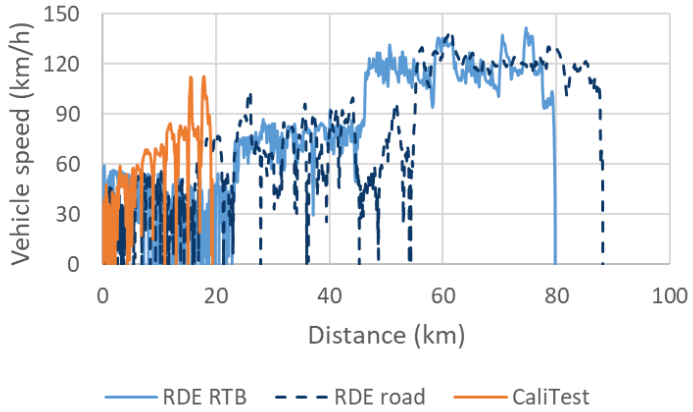
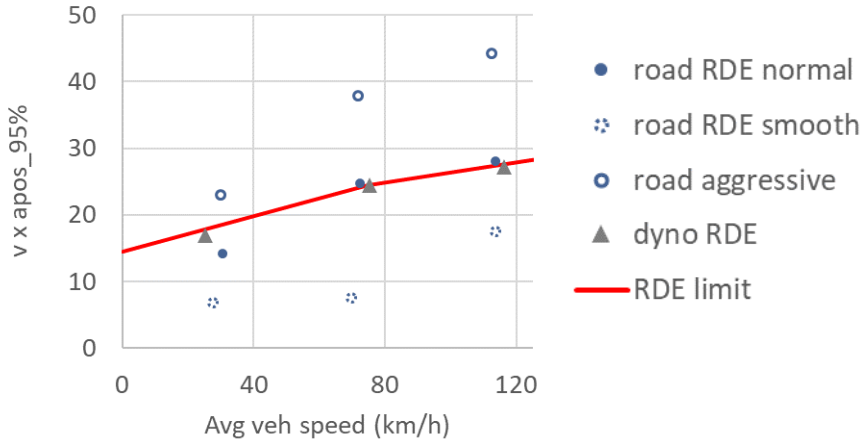
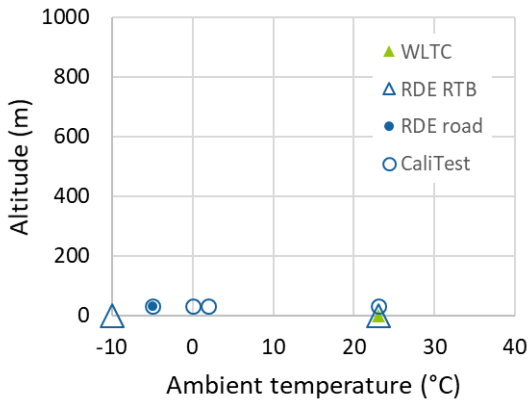
LD gasoline demonstrator data

- Tests conducted to characterise the emission performance
  - Road
    - RDE ~90 km
    - Calibration test (CaliTest) ~20 km
  - Chassis dyno
    - WLTC
    - RDE aggressive
- Exploring beyond Euro 6 RDE boundary conditions for
  - Ambient temperature
  - Driving style

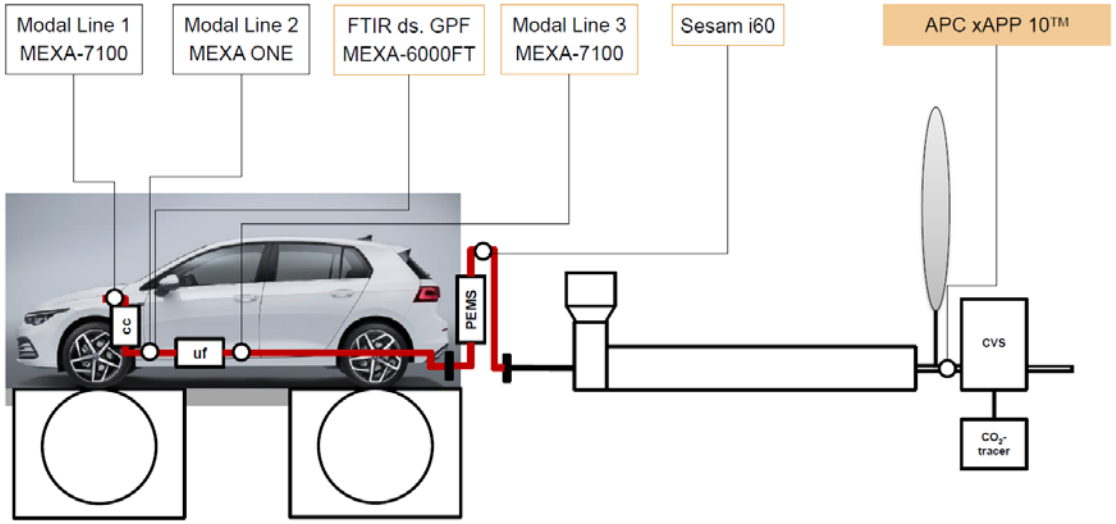






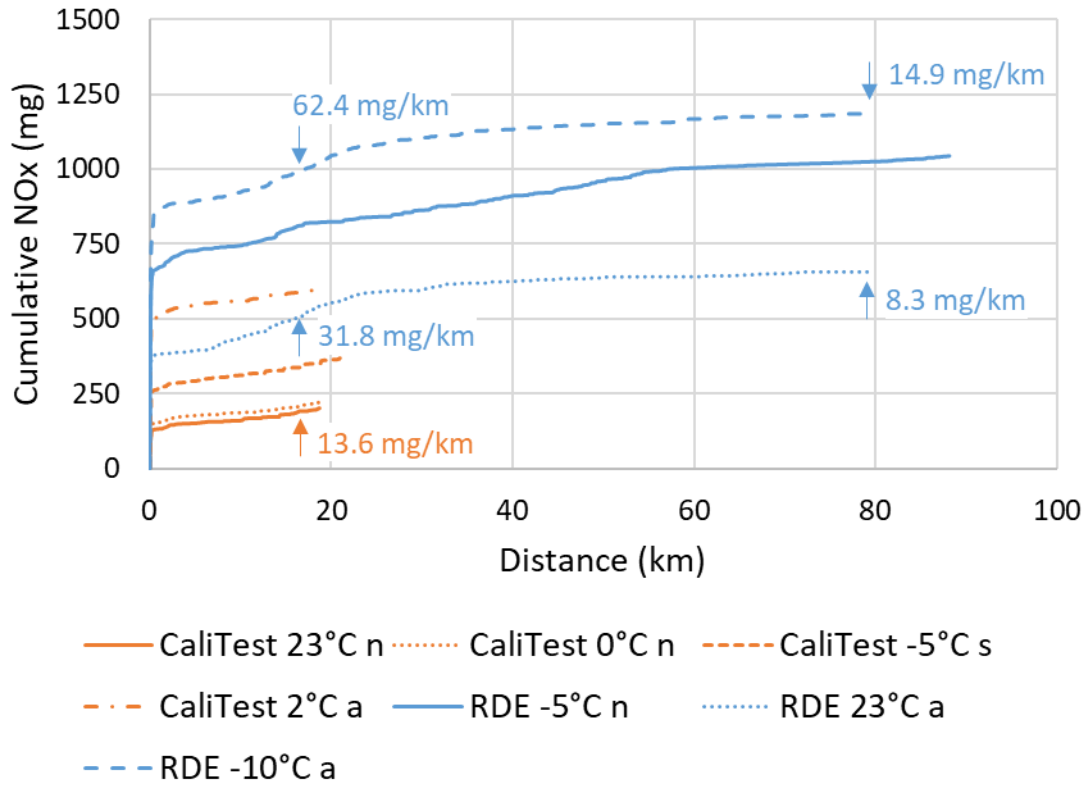
LD gasoline demonstrator data

- Instrumentation
  - Chassis dyno
    - 3x sample points
    - includes 2x FTIR and PN10
  - Road
    - PEMS
    - Prototype for NH_3, N_2O and PN10



NOx emissions

- Near-zero emissions under warm operation independent from test conditions
- Initial cold-start emissions impacted by
  - ambient temperature
  - driving dynamics



[1] The results are reported as measured by the PEMS under the specified test routes and conditions
[2] Urban values are evaluated at a trip length of 16 km

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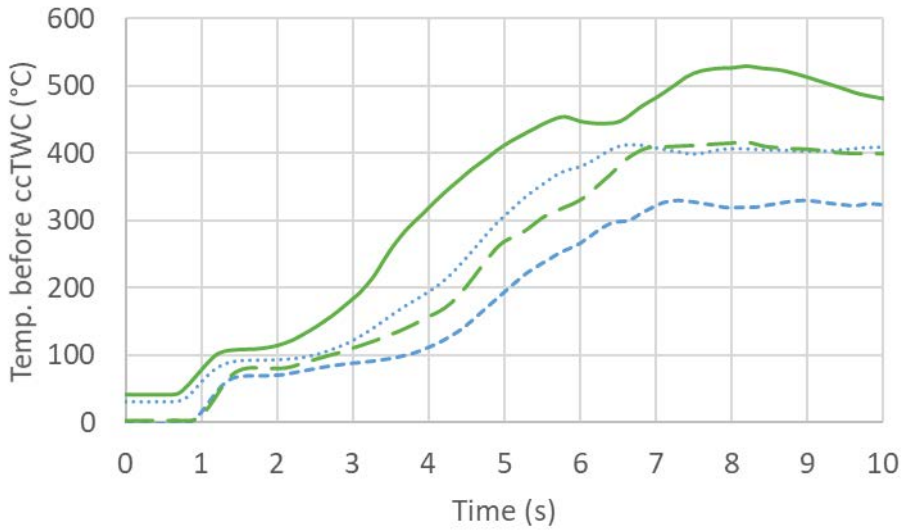
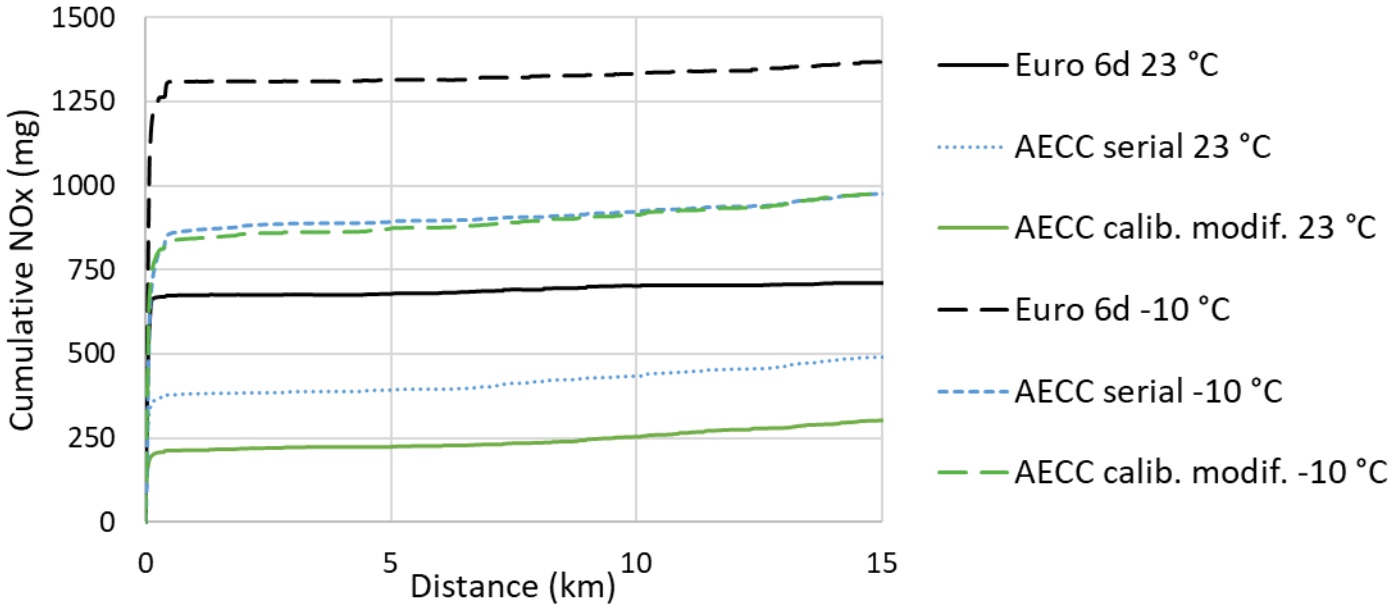
NOx emissions

- Effect of calibration modification
  - TWC light-off achieved ~1 second earlier
  - Reduction in initial cold-start peak at 23 °C, but limited effect at -10 °C





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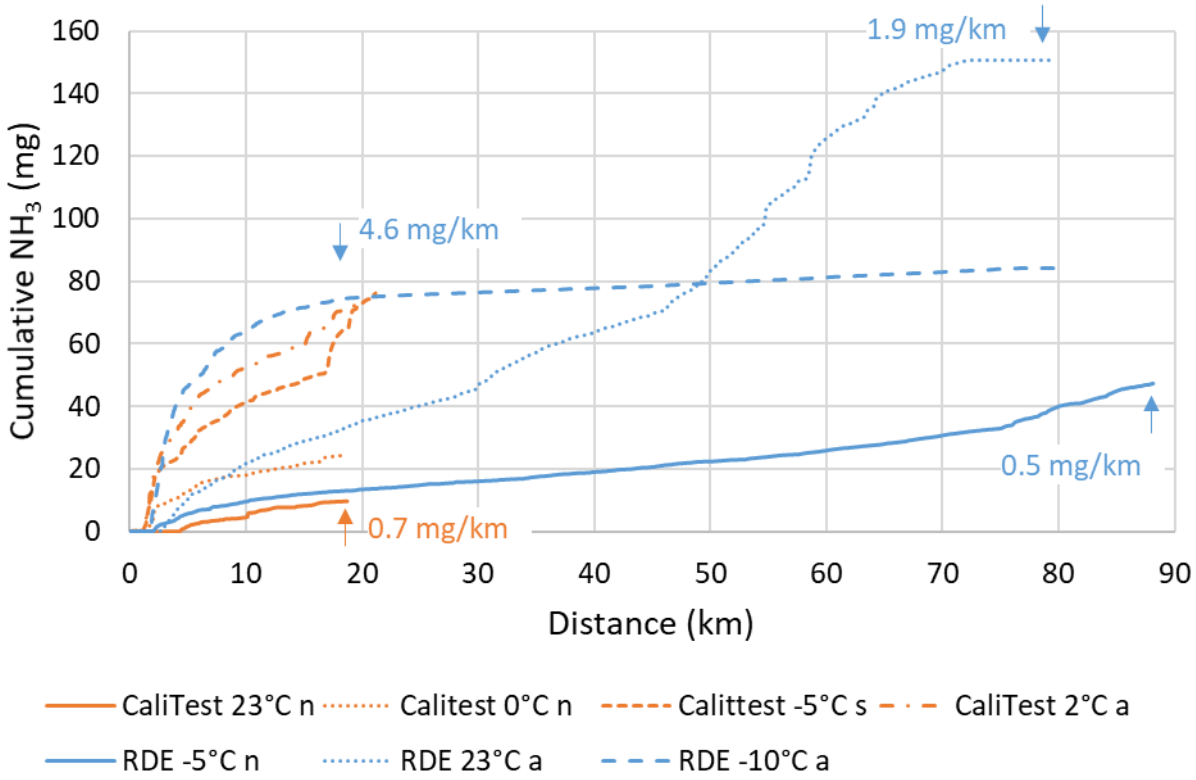
NH_3 emissions

- ASC operation strategy for gasoline investigated in addition to improved lambda control
  - Storage functionality captures emissions during first 1-3 km
  - Emissions increase under aggressive driving style but remain significantly below 10-40 mg/km reported for Euro 6 vehicles[3-4]



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[3] R. Suarez-Bertoa, et al.; Transp. Res. Part D Transp. Environ. 49 (2016) 259-270
[4] R. Suarez-Bertoa, et al.; Atmospheric Environment 166 (2017) 488-497

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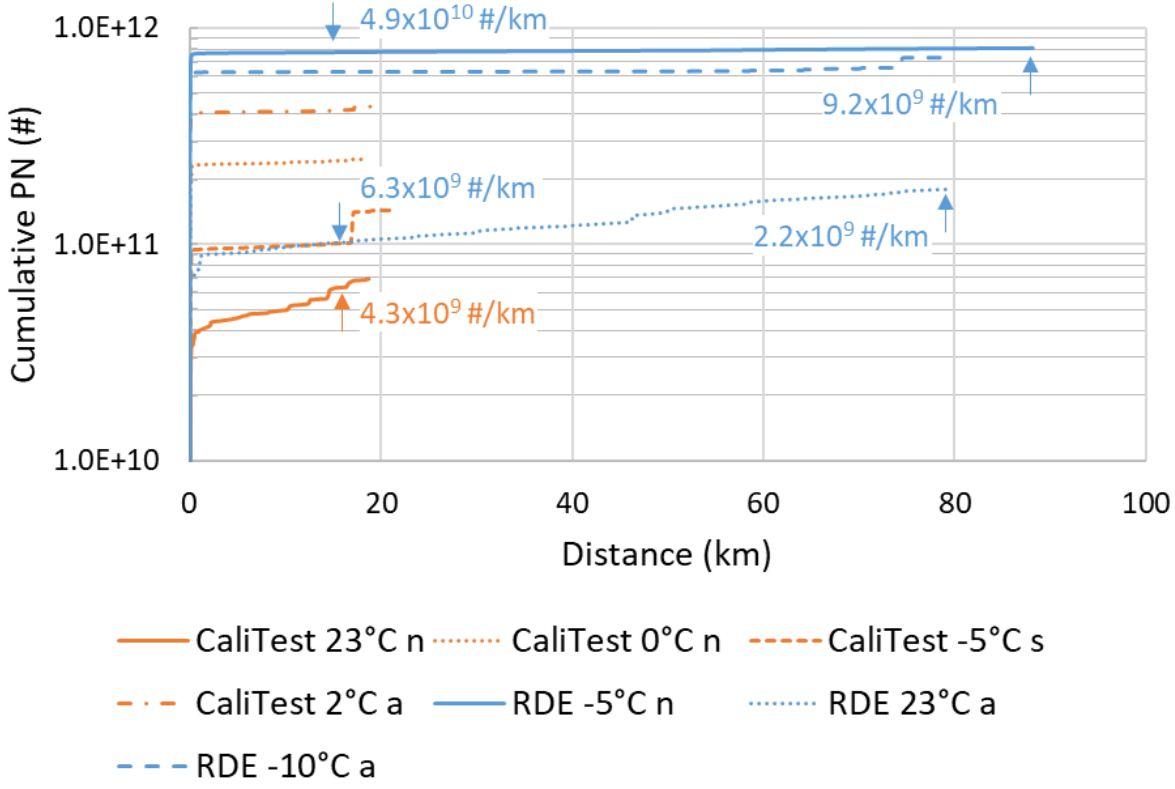
PN10 emissions

- Soot and ash accumulation during ageing of parts supports filtration efficiency
- Initial cold-start effect is observed
- Near-zero emissions during the rest of the tests



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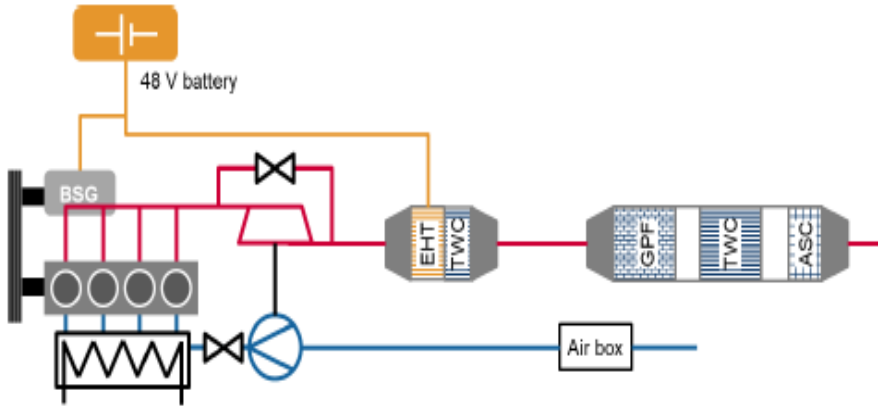
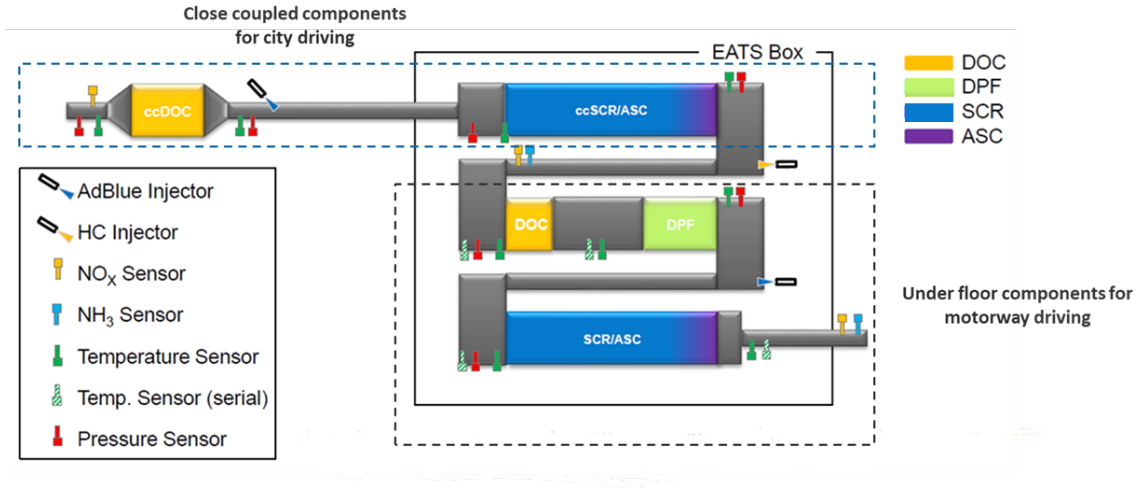
Summary

- Combination of close-coupled and underfloor components is implemented on a LD gasoline demonstrator vehicle to investigate
  - Early light-off for urban emission control
  - Consistent emissions reduction over the range of driving conditions
- Combination of tests conducted to characterise the emission performance
- Ultra-low emissions measured for range of driving conditions
  - Initial cold-start effect impacted by ambient temperature and driving dynamics
  - Near-zero emissions throughout rest of the test

Outlook

- 2021 follow-up activities for LD gasoline
  - Implementation of electrically heated catalyst to reduce the remaining initial cold-start emissions
  - Evaluation of a fresh GPF
  - Testing of renewable fuels with drop-in capabilities to investigate Well-to-Wheel CO_2 reductions
- Similar investigations ongoing for HD diesel





THANK YOU !

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