Zero-impact emissions with advanced emission control systems and sustainable renewable fuels

J. Demuynck, P. Mendoza Villafuerte, D. Bosteels; AECC
A. Kuhrt, F. Bunar, M. Brauer; IAV

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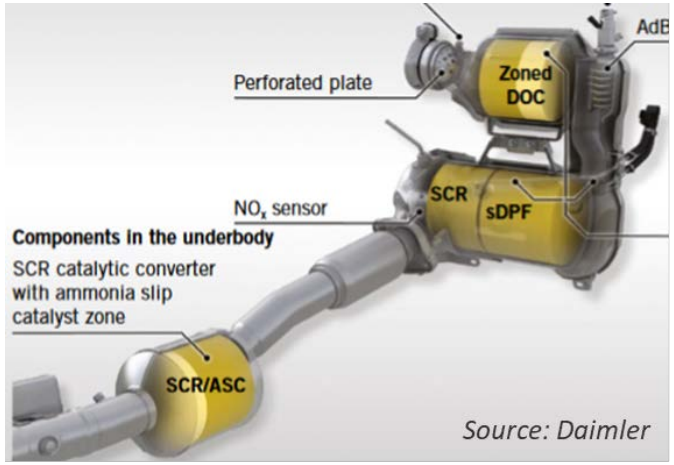
AECC
ASSOCIATION FOR EMISSIONS CONTROL BY CATALYST

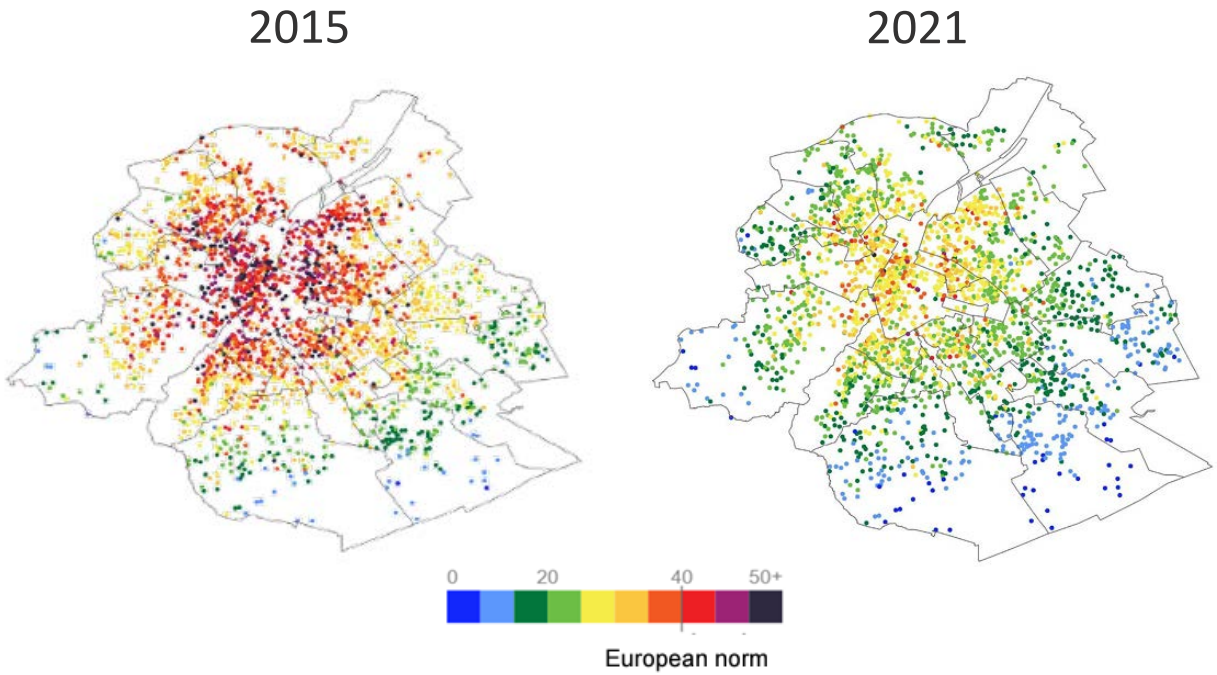
Euro 6d significantly reduced impact on air quality

- RDE procedure with PEMS for NOx and PN
- Evolution in emission control systems
  - LD diesel - combination of deNOx technologies
  - LD Gasoline - introduction of particulate filter



Source: PSA

- Several reports about improved air quality
- Example of NO_2 in Brussels



Source: CurieuzenAir report air quality in Brussels, 2022

Emission legislation evolution expected towards Euro 7

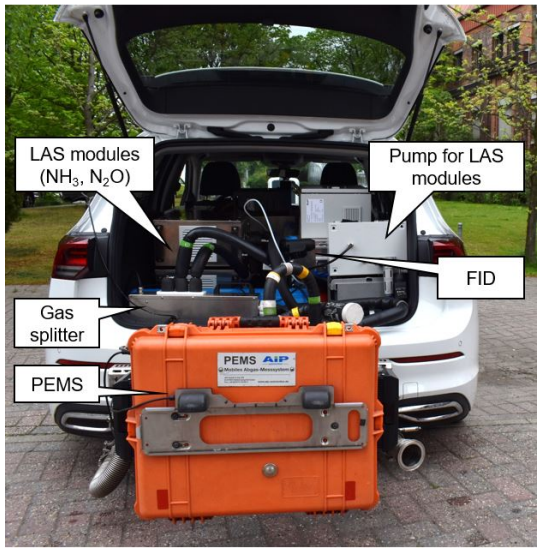
- Further contribute to air quality improvement with advanced emission control systems
  - New WHO guidelines, published in September 2021
  - Proposal to review the EU Ambient Air Quality Directive is expected on 26 October 2022
  - Targeting zero-impact emission level, see for example FVV research project 1407
- Assumptions for light-duty vehicles based on the Euro 7 impact assessment scenarios
  - Pollutant emission limit scenarios vary between low – medium – high ambition
    - Tightening for regulated pollutants
    - Introduction of limit for currently non-regulated pollutants
  - Definition of normal and extended area for testing conditions
    - Ambient conditions
    - Driving dynamics
    - Reduction of minimum trip length for averaging of initial cold-start emissions
  - Extension of durability requirements

LD gasoline demonstrator concept

- Project partners

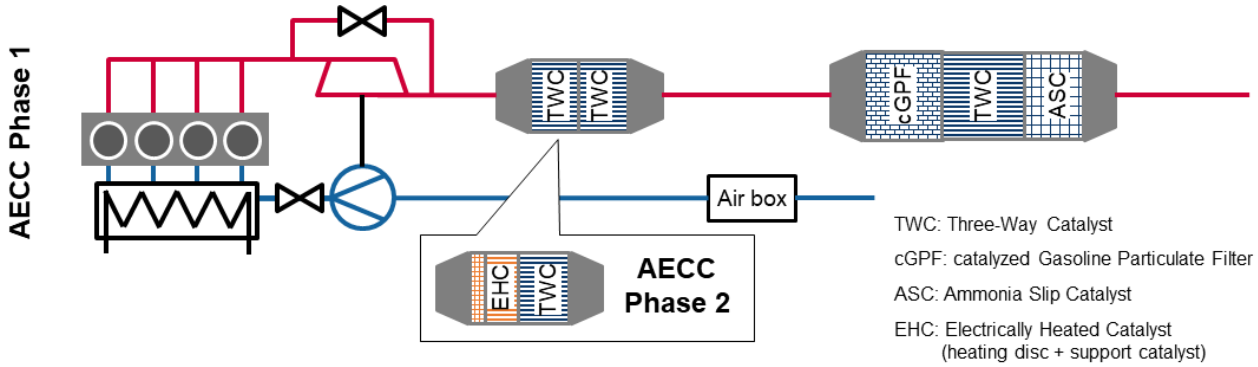
- Base vehicle
  - C-segment
  - 1.5l engine with 4 cylinders
  - Variable valve train and cylinder deactivation
  - 48V mild-hybrid (belt-driven, P0 configuration)

- Instrumentation
  - Chassis dyno: 3x standard sampling points, 2x FTIR and tailpipe PN10
  - Road: prototype PEMS to measure CO_2, NOx, CO, THC, PN10, NH_3 and N_2O



LD gasoline demonstrator concept

- Euro 6d baseline: cc cGPF + uf TWC
- AECC emission control system
  - Phase 1: cc TWC, uf cGPF+TWC+ASC
  - Phase 2: cc EHC|TWC, uf cGPF+TWC+ASC
  - Bench aged components targeting 160k km

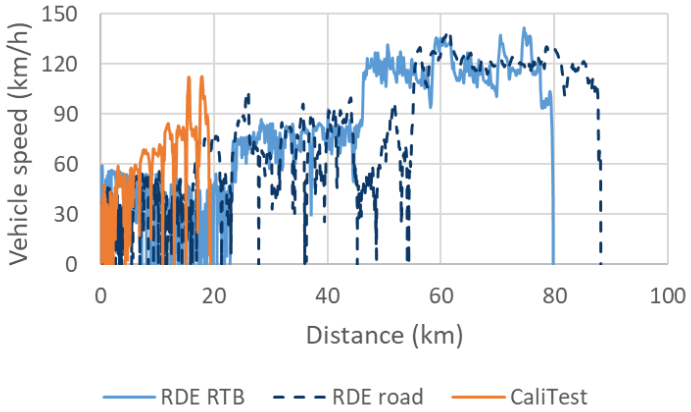


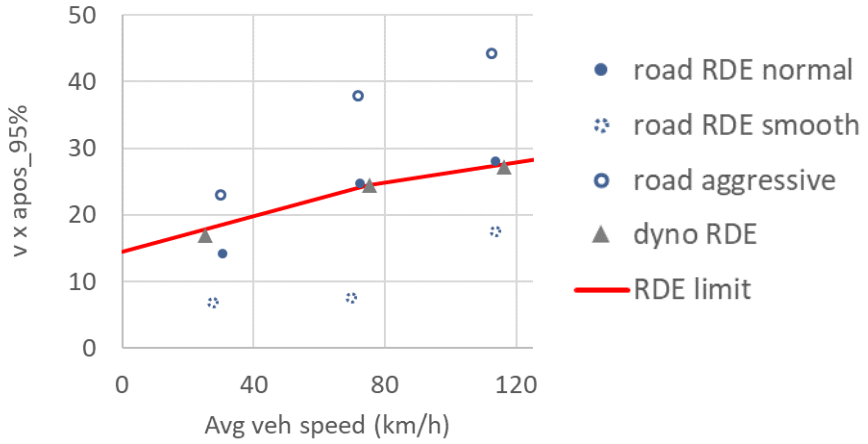
J. Demuynck, et al.; "Ultra-low Emissions of a 48V Mild-Hybrid Gasoline Vehicle with Advanced Emission Control Technologies", 15th International Conference on Engines and Vehicles, 2021

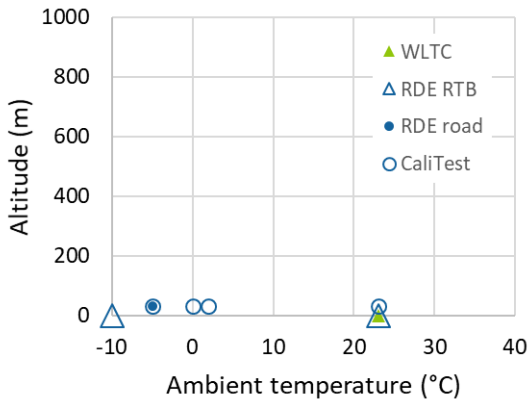
J. Demuynck, et al.; "Zero-Impact Emissions from a Gasoline Car with Advanced Emission Controls and E-Fuels" 43rd International Vienna Motor Symposium, 2022

LD gasoline demonstrator testing

- 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

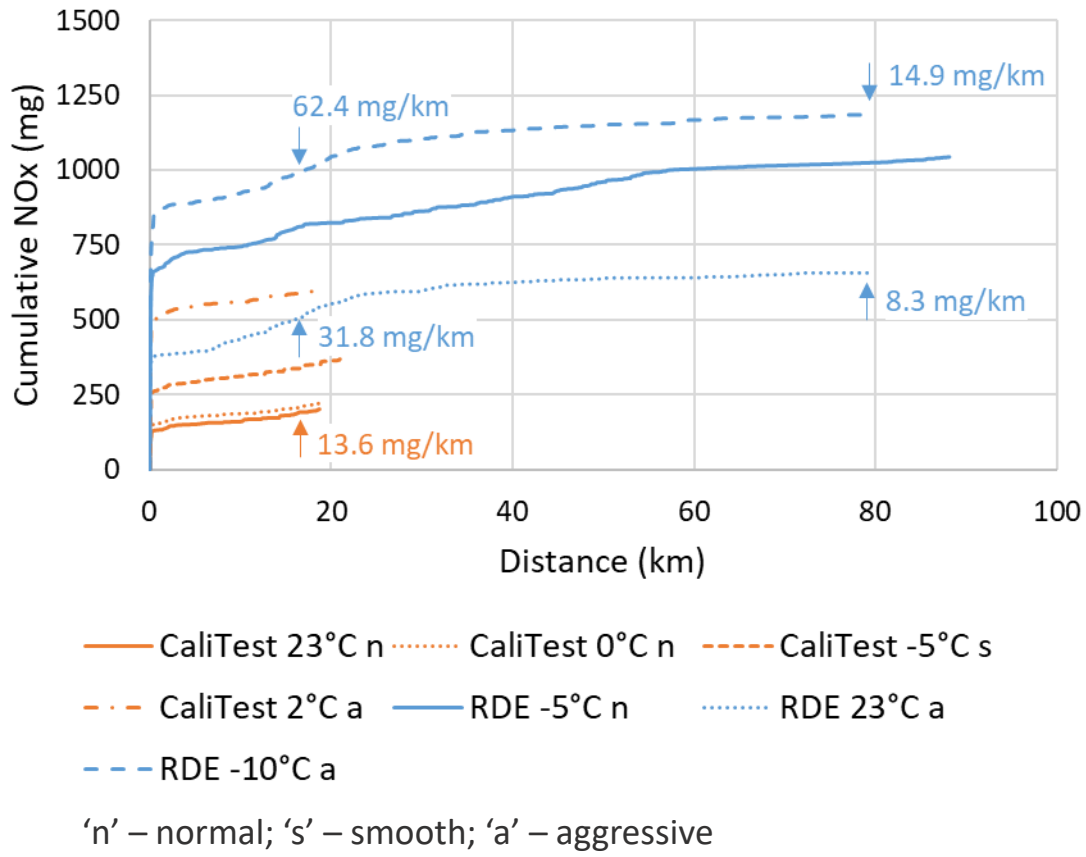






NOx emissions with ccTWC

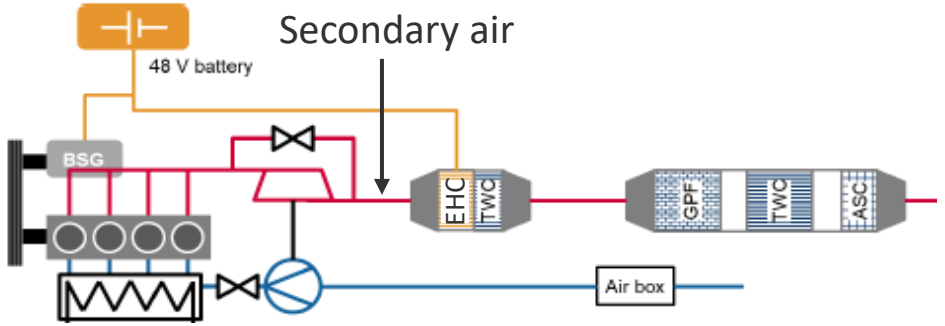
- Near-zero emissions under warm operation independent from test conditions
- Initial cold-start emissions impacted by
  - ambient temperature
  - driving dynamics
- Rest of investigations focused on challenging cold-start test ‘RDE aggressive’ on chassis dyno at 23 °C and -10 °C
  - 4s initial idle time
  - First acceleration to 60 km/h

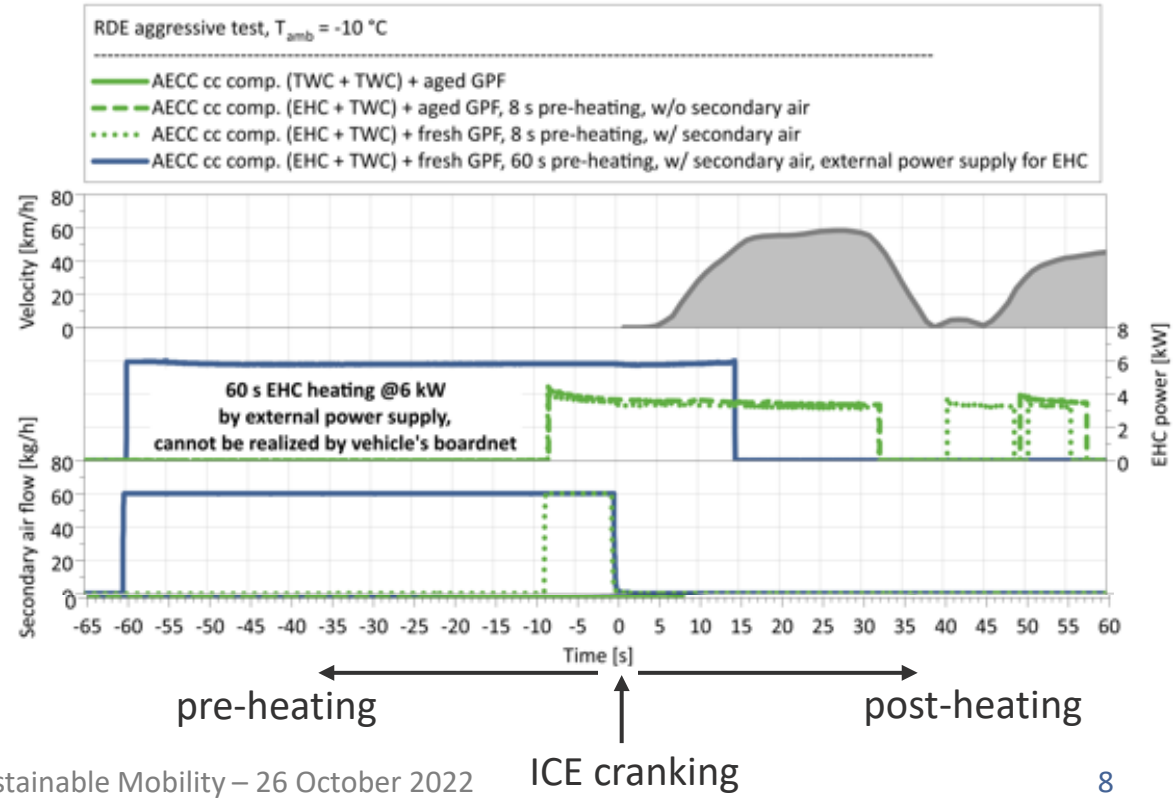


[1] The results are reported as measured by the PEMS under the specified test routes and conditions
[2] Urban values are evaluated at a trip length of 16 km

Implementation of electrically heated catalyst (EHC)

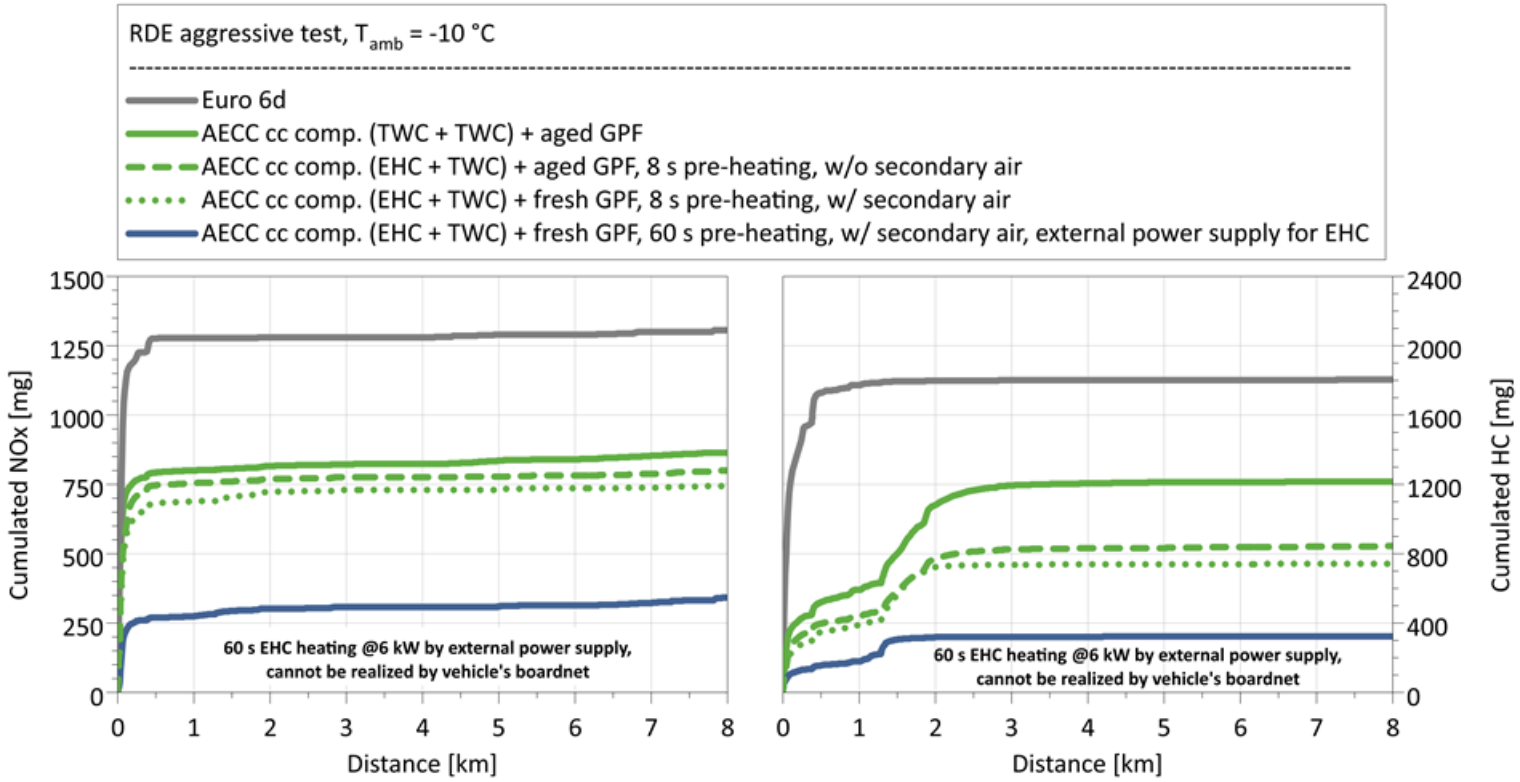
- Reduce the remaining initial cold-start emissions
- Operation strategy
  - Pre-heating in combination with post-heating
  - 60s pre-heating as outlook to advanced hybrids
  - Secondary air in exhaust manifold to enhance heat transfer within catalyst during pre-heating phase
- There is further potential due to certain constraints within this project, for example
  - Flow distribution not uniform, 90° bend at inlet
  - The part was not insulated





Reduction of cold-start emissions compared to Euro 6d

- EHC with 8s pre-heating similar to ccTWC for NOx, reduction for THC
- EHC with 60s pre-heating reduces cold-start at -10 °C to level measured at 23 °C



Ignition

Engine load: 0 %

Vehicle speed: 0 km/h

500

0

NOx

2 ppm

30 s or 150 m to near-zero emissions

500

0

NOx

0 ppm

More videos available on YouTube (AECC eu): https://www.youtube.com/channel/UCbPS9op5ztLqrv6zlMH_IcQ

EHC

TWC

GPF

TWC

ASC

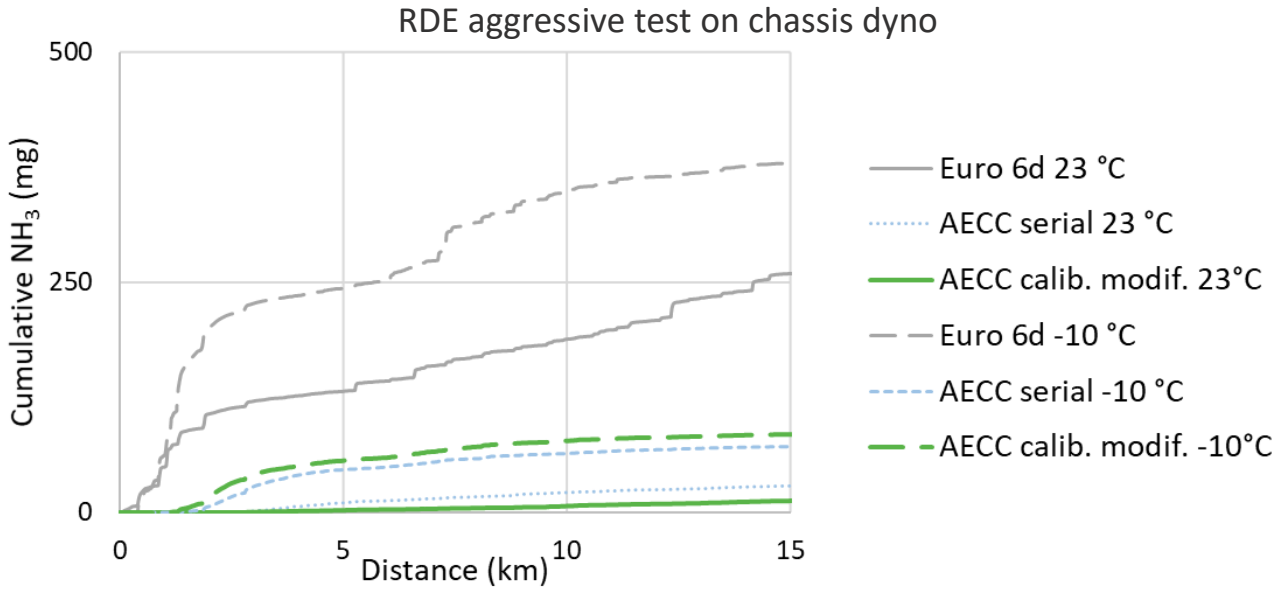
Engine catalyst heating

EHC heating

Closed-loop lambda control

NH_3 emissions

- Euro 6d level can increase to 10-40 mg/km towards aggressive driving, as reported by JRC[3-4]
- 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 significant reduction compared to Euro 6d level
  - 0.5-4.6 mg/km measured



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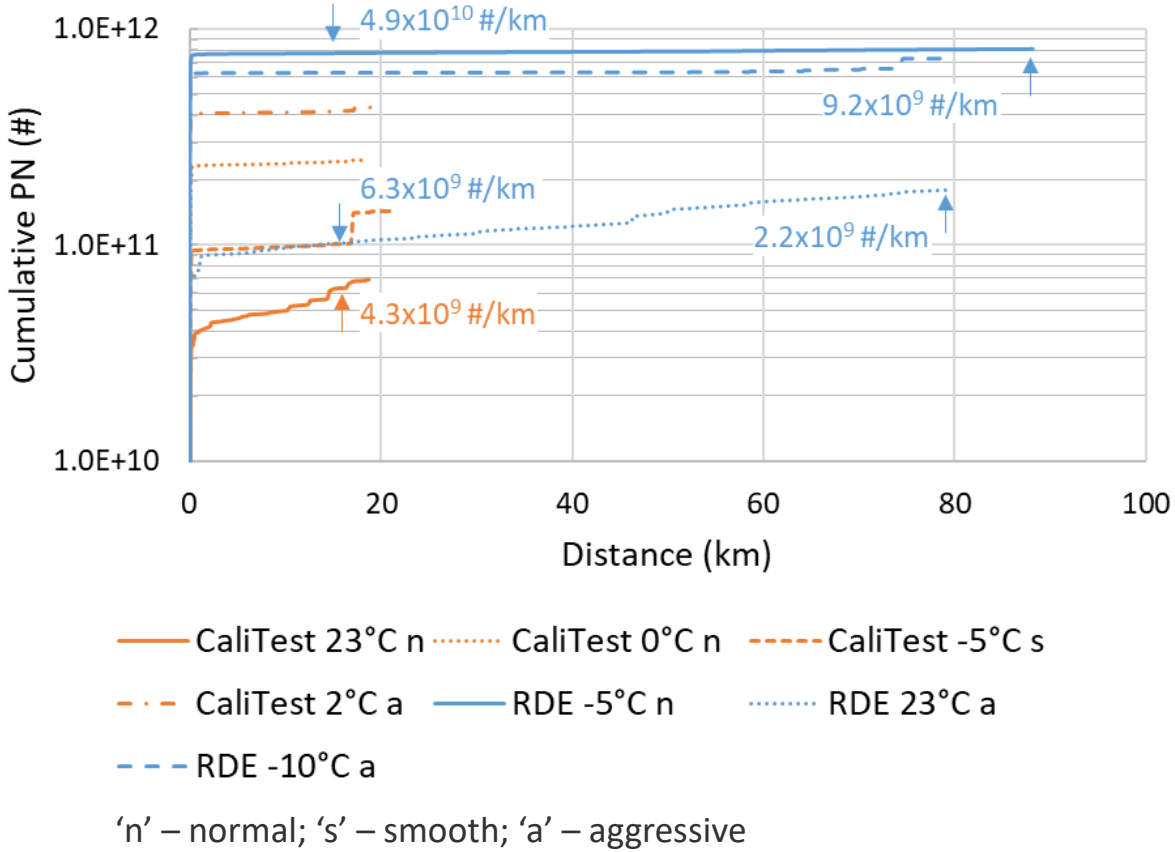
[3] R. Suarez-Bertoa, et al.; Transp. Res. Part D Transp. Environ. 49 (2016) 259-270
[4] R. Suarez-Bertoa, et al.; Atmospheric Environment 166 (2017) 488-497

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
- Significant variation impacted by
  - Ambient temperature
  - Driving conditions
  - Engine-out emissions
  - Initial filter status



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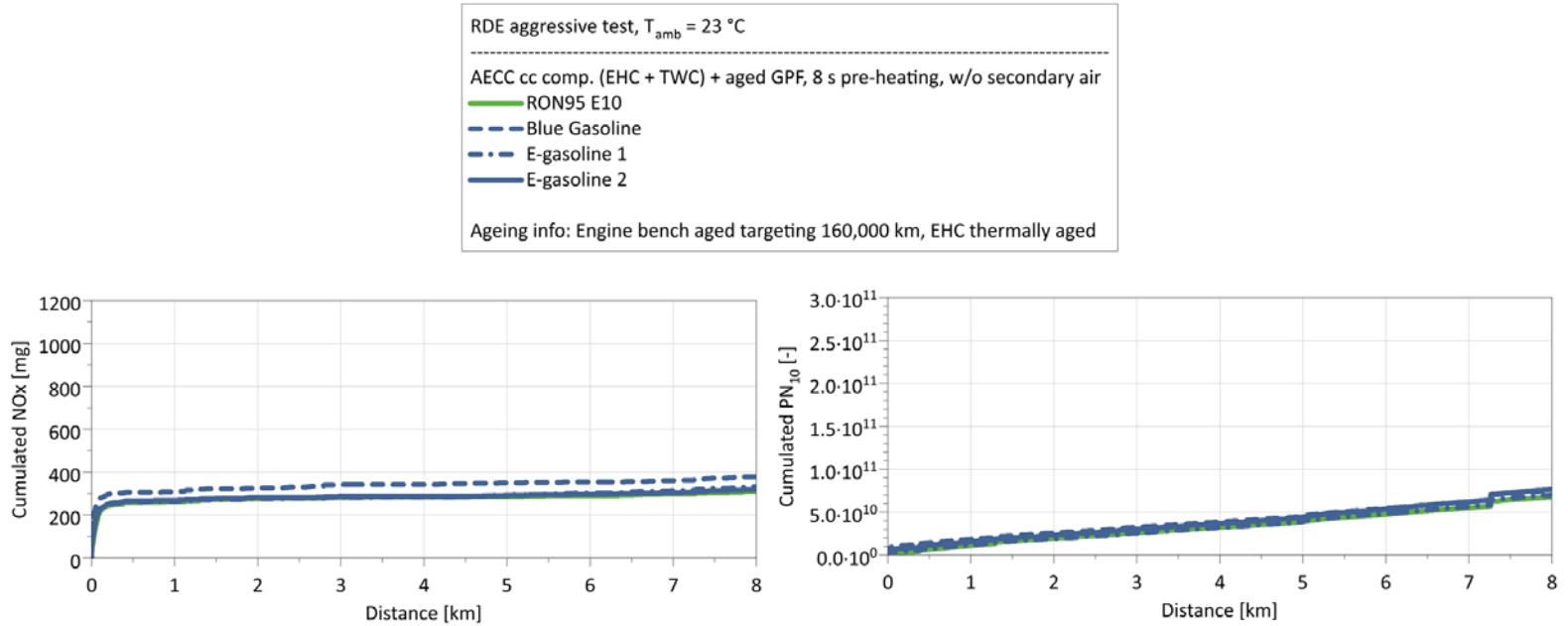
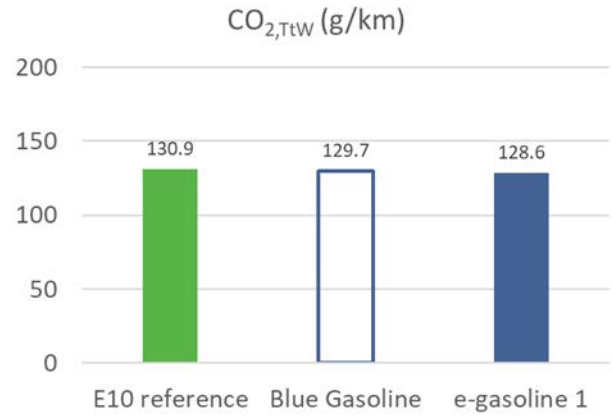
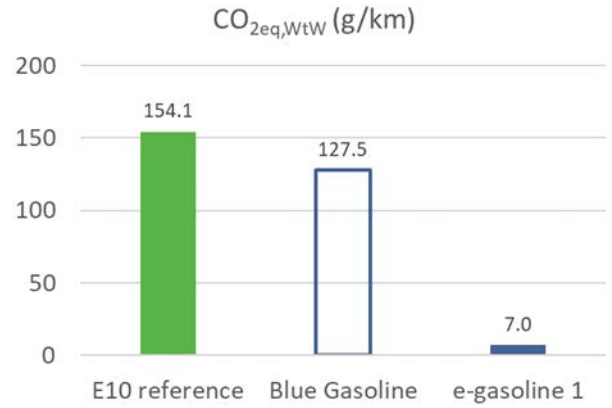
LD gasoline demonstrator with sustainable renewable fuels

- Ultra-low pollutant emissions confirmed on Blue Gasoline and 2 e-gasoline samples
- Well-to-Wheel CO_2 compared to E10 reference
  - Blue Gasoline example of significant reduction possible today
  - E-gasoline has the potential to nearly eliminate WtW CO_2 emissions







J. Demuynck, et al.; "Advanced Emission Controls and E-fuels on a Gasoline Car for Zero-Impact Emissions" SAE paper 2022-01-1014, SAE PFL conference, 2022

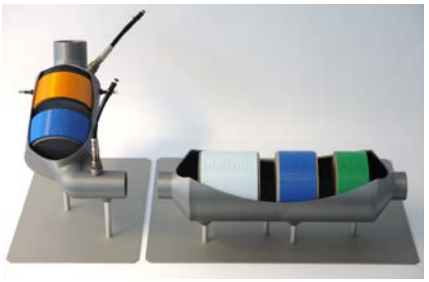
Summary

- Advanced emission control system was integrated in a 48 V mild-hybrid gasoline demonstrator vehicle
  - Close-coupled TWC substrate with high cell density
  - Active thermal management with EHC
  - Ammonia Slip Catalyst in addition to improved lambda control

- Towards zero-impact emission level
  - Significant reduction of initial cold-start peak compared to already low Euro 6d level
  - Near-zero emissions after initial cold-start peak

Additonal information about the AECC demonstrators

- Light-duty gasoline and diesel demonstrators at the MinNOx exhibition
  - Experience the emissions reduction live on an iPad while driving
  - Display model of the emission control systems
- Heavy-duty diesel demonstrator material on the AECC website
  - Project brochure
  - Publications



P. Mendoza Villafuerte, et al.; "Future-proof heavy-duty truck achieving ultra-low pollutant emissions with a close-coupled emission control system including active thermal management", Transportation Engineering, Volume 9, September 2022, 100125, 2022

D. Bosteels, et al.; "Combination of advanced emission control technologies and sustainable renewable fuels on a long-haul demonstrator truck", SIA Powertrain & Energy conference, 2022

THANK YOU !

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