AECC-IPA Ultra-low Emissions Heavy-duty Demo Vehicle – Data Analysis in view of Euro 7

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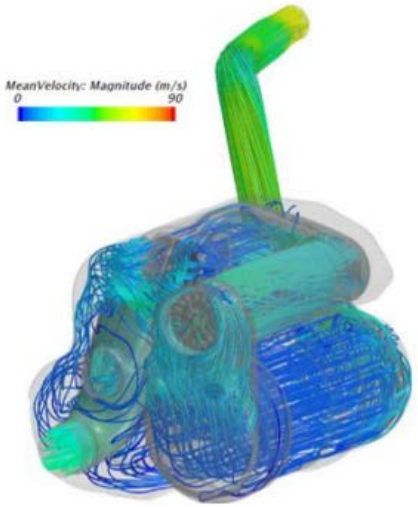
Real-world Zero-impact Pollutant Emissions for Euro 7 • Autoworld, Brussels • 27 September 2022

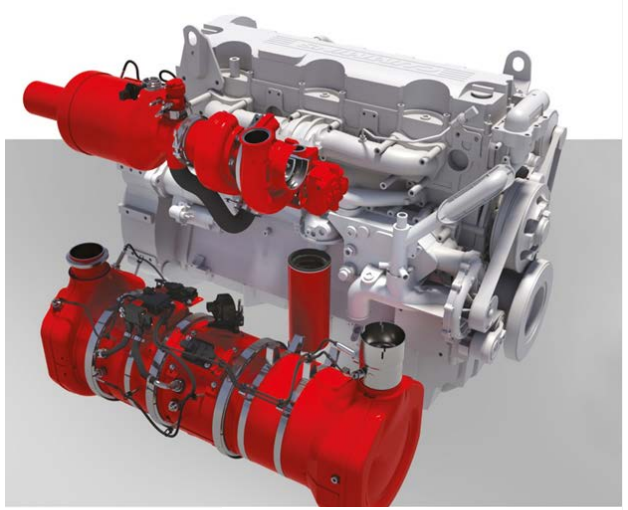
AECC
ASSOCIATION FOR EMISSIONS CONTROL BY CATALYST

Euro VI-D/E significantly reduced impact on air quality

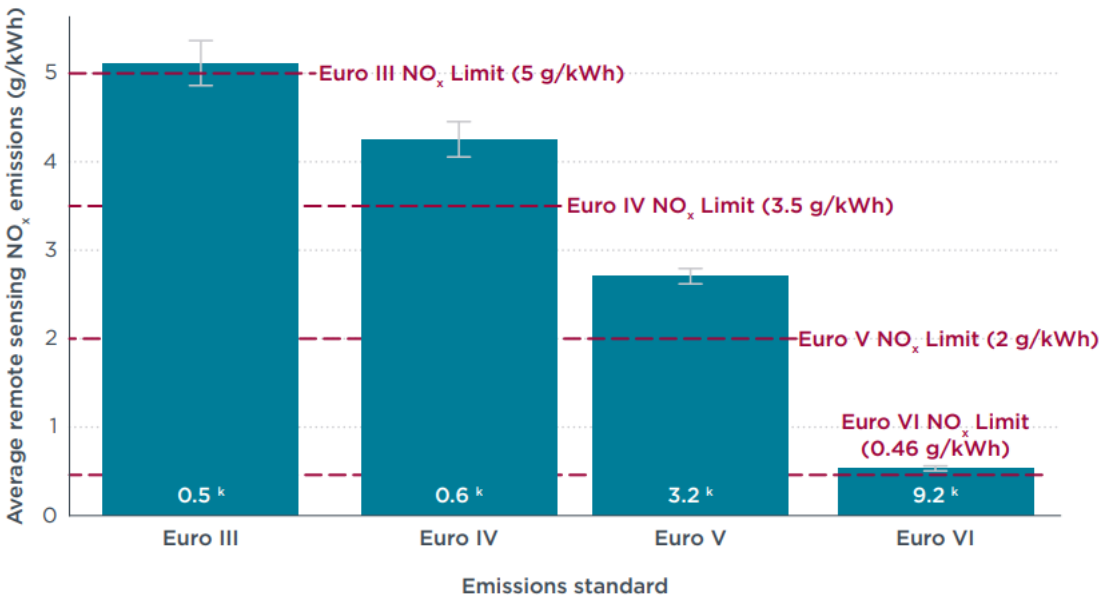
- Implementation of advanced emission control systems
- Remote sensing confirms Euro standards have improved the NO_x emissions from latest heavy-duty vehicles



Source: Daimler 2022



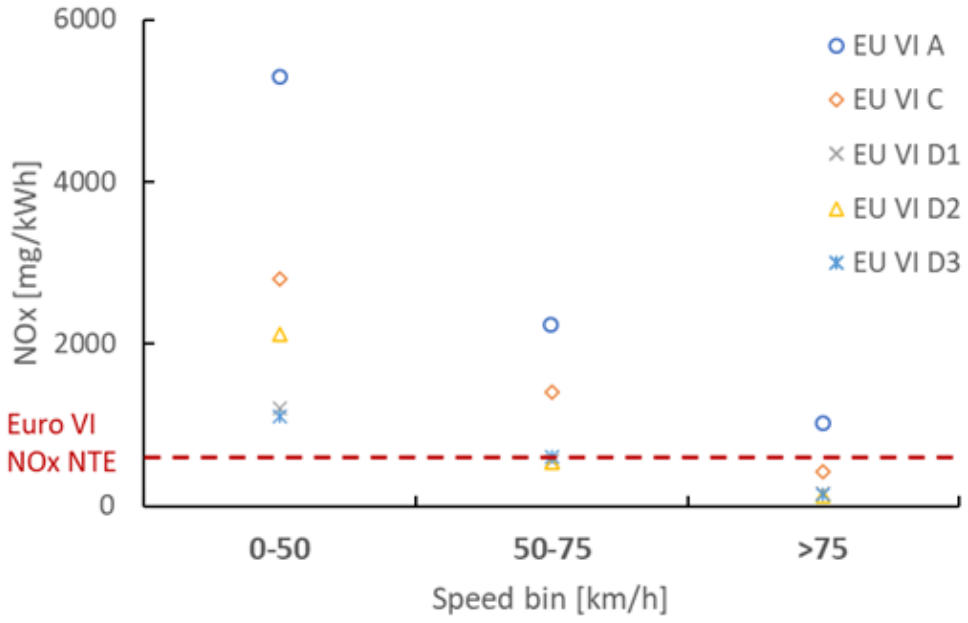
Source: Cummins, 2021



Source: Average NOx emissions of heavy-duty trucks by European emission standards for Flanders remote sensing campaign, ICCT, 2022

Euro VI on-road NOx emissions

- Real-world emissions of Euro VI vehicles for a broad range of HDV applications studied
  - Real-world operation data analysed[1]
  - The analysis covered
    - Impact of Euro VI-D/E data post processing vs. raw data
    - Actual real-world operation vs. Euro VI ISC
- Results show high emission events are still occurring
  - Highest emission events mainly occur in the 0-50 km/h speed bin
  - HD Euro VI-D and VI-E post processing still exclude critical data to get the final emissions calculation



[1] P. Mendoza Villafuerte, et al.; "Real-World Emissions of Euro VI Heavy-Duty Vehicles", SAE Technical paper, 2021-01-5074, 2021

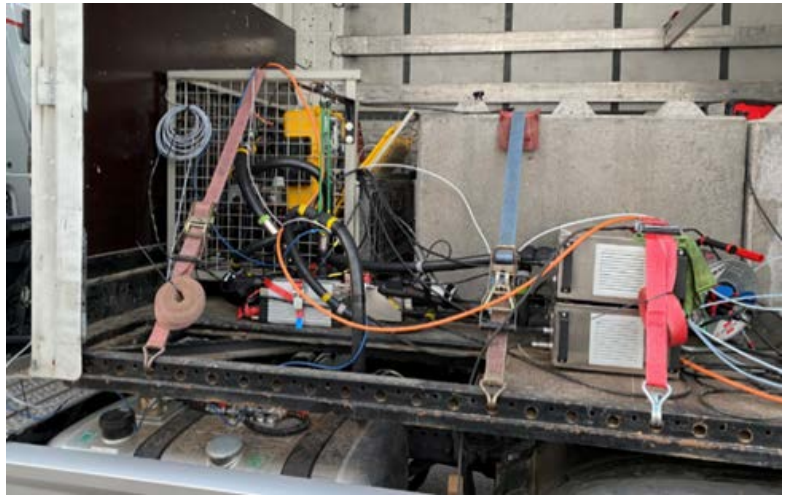
Further emission control technology evolution expected for Euro 7

- Assumptions for heavy-duty vehicles based on April 2021 scenarios from the CLOVE consortium
  - Pollutant emission limits
    - Tightening for regulated pollutants
    - Introduction of limit for currently non-regulated pollutants
  - Emission limits for normal and extended operating conditions
    - Any trip will be considered
    - Combination of cold-start budget with Moving Average Window (MAW) values for 90th and 100th percentile
    - For 700k km, further deterioration factors for 1200k km are being evaluated by CLOVE

HD diesel demonstrator concept

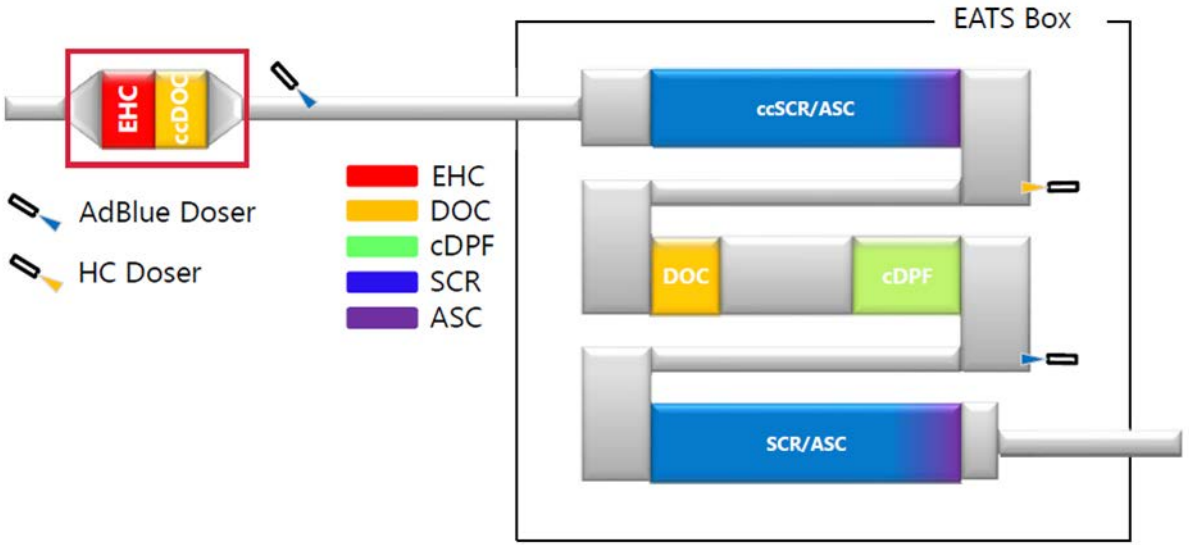
- Base vehicle description
  - MB Actros 1845 LS 4x2
  - Engine OM 471
    - Euro VI C certified
    - 12.8 litres, 6 cylinder in-line
    - High Pressure EGR

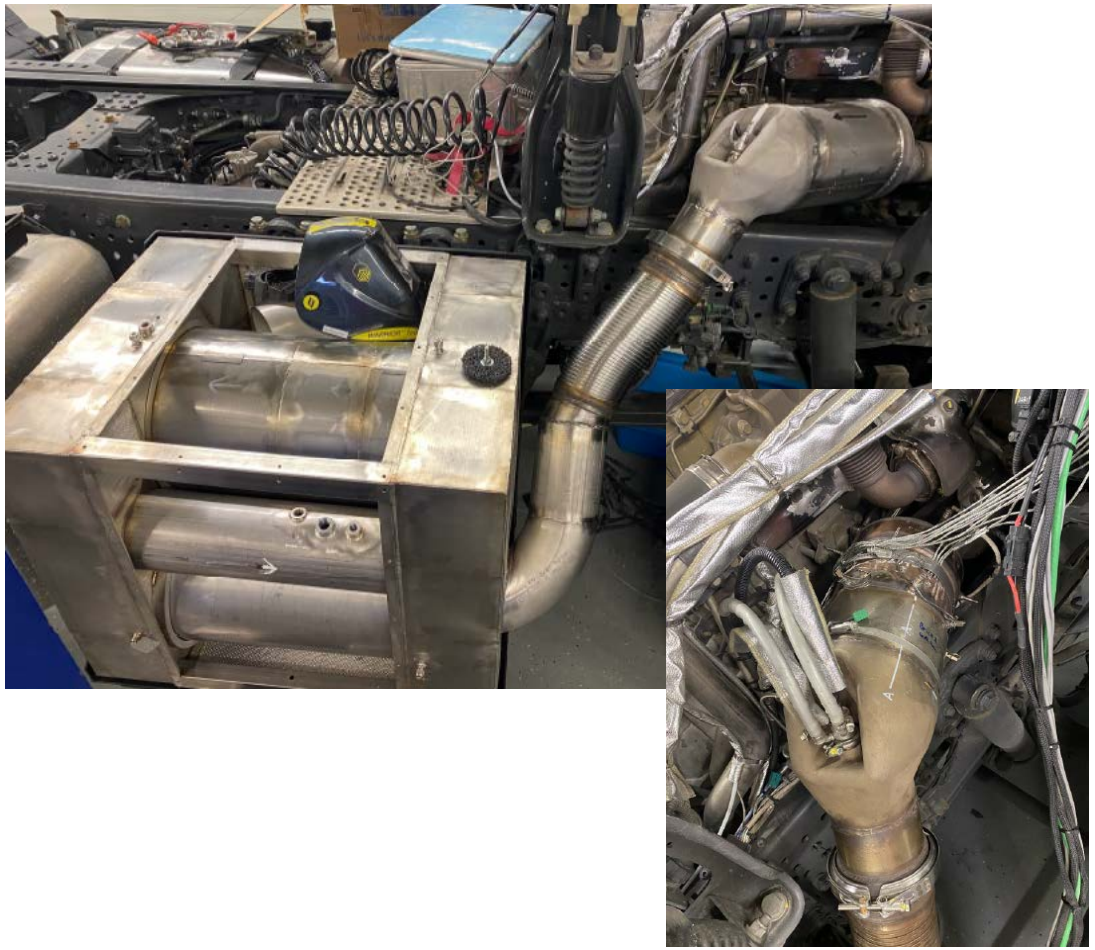
- Instrumented with prototype PEMS to measure CO_2, NOx, CO, PN10, NH_3 and N_2O



HD diesel demonstrator concept

- AECC emissions control system
  - Phase 1: ccDOC, ccSCR/ASC+ ufDOC+cDPF+ SCR/ASC, twin AdBlue dosing and HC doser
  - Phase 2: additional EHC as part of the ccDOC
  - Components are hydrothermally aged targeting 500k km





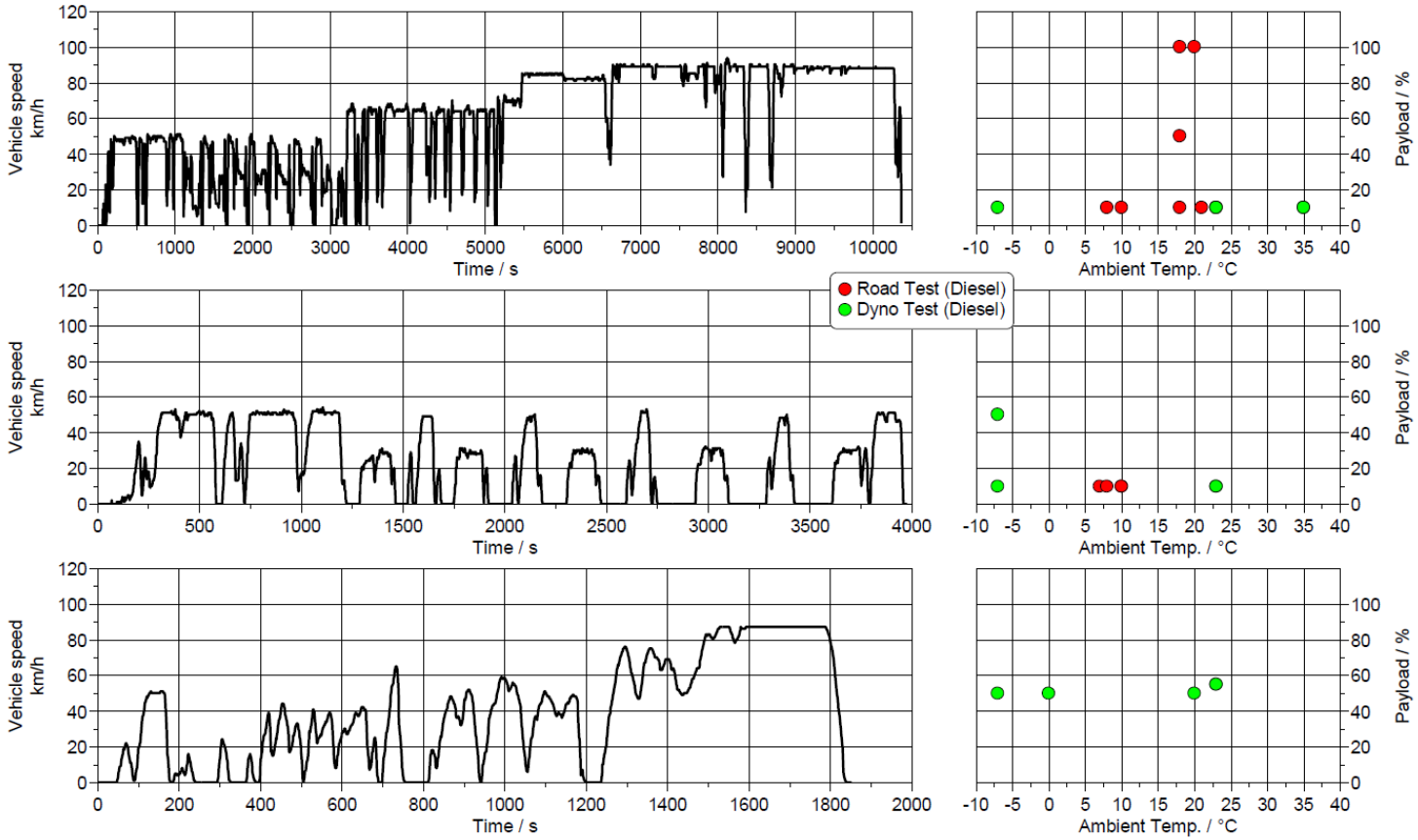
HD diesel demonstrator testing

- Combination of on-road (phase 1 and 2) and chassis dyno (phase 1, at the JRC) tests

- On-road ISC
  Chassis dyno RWT
  (Real World Test)

- Urban delivery

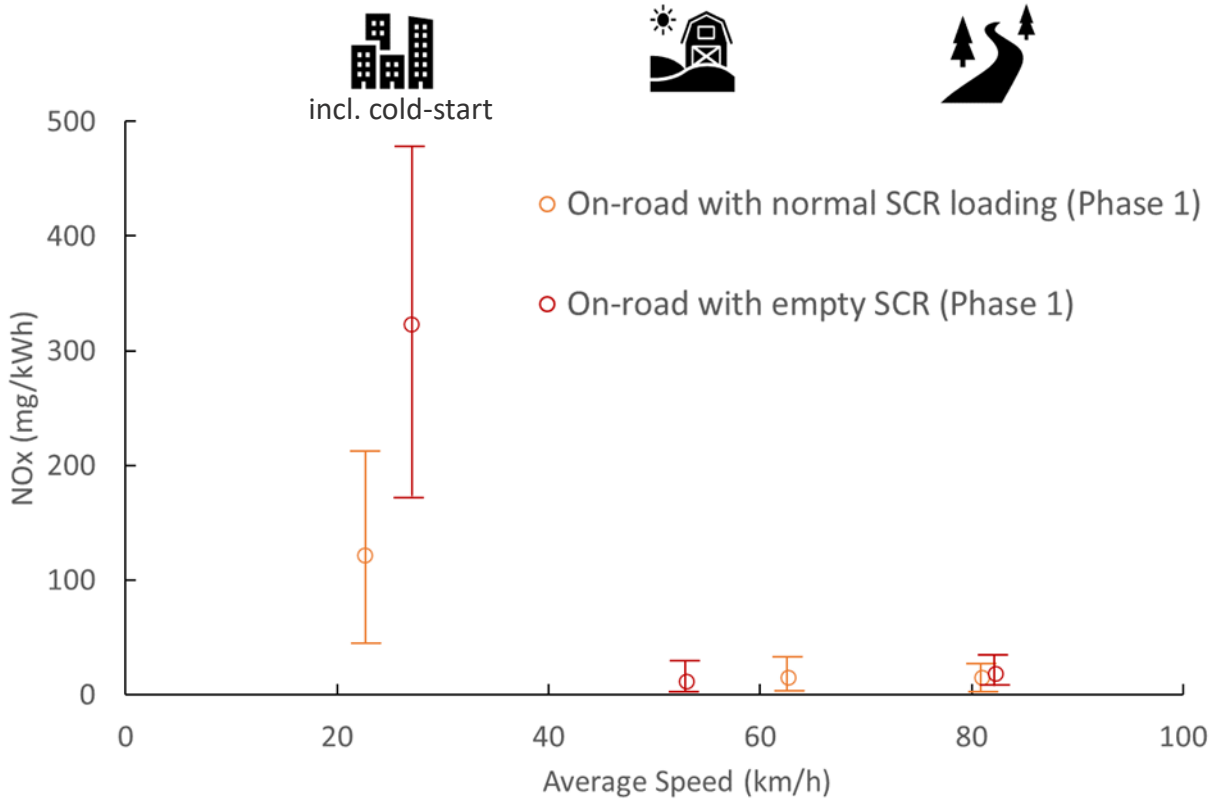
- WHVC[1]



[1] The chassis dyno WHVC emission test results are available but not included in this presentation

HD diesel demonstrator overall phase 1 NOx results

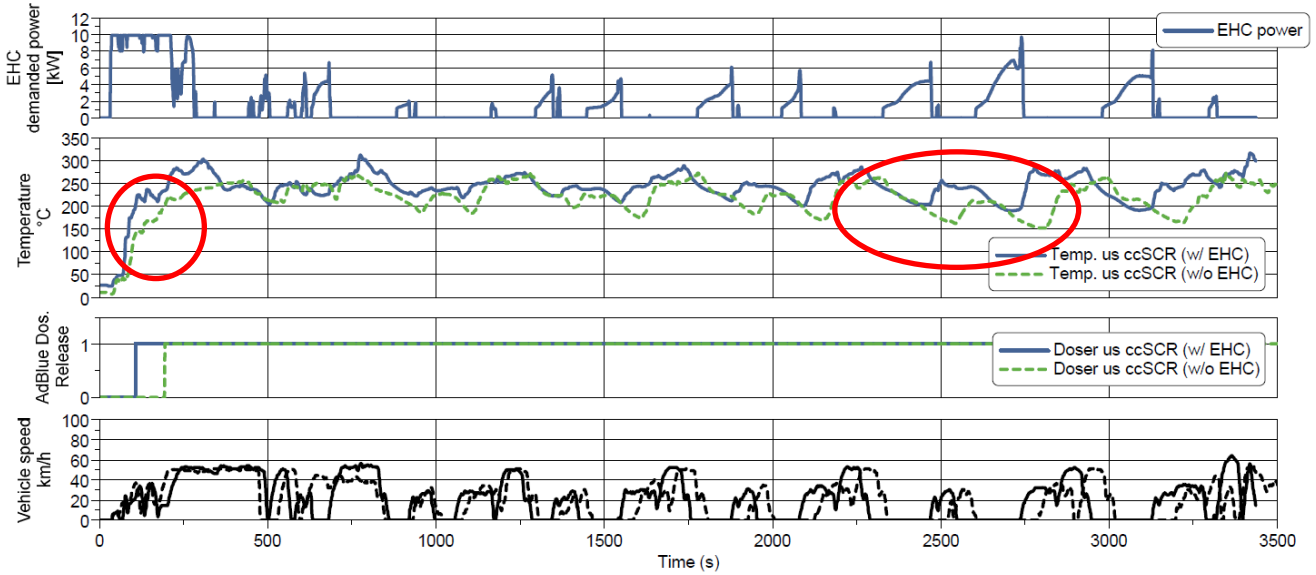
- Significant improvement for urban emissions including cold-start compared to up to 2000 mg/kWh measured for Euro VI-D[1, 2]
- Near-zero emissions under warm operation
- Impact of ammonia storage depletion procedure shows robust control is needed for AdBlue® dosing, ammonia storage and thermal management



[1] P. Mendoza Villafuerte, et al.; "Real-World Emissions of Euro VI Heavy-Duty Vehicles", SAE Technical paper, 2021-01-5074, 2021
[2] P. Mendoza Villafuerte, et al.; "Demonstration of Extremely Low NOx Emissions with Partly Close-Coupled Emission Control on a Heavy-duty Truck Application", 42nd Vienna Motor Symposium 2021

Phase 2 of the HD diesel demonstrator project

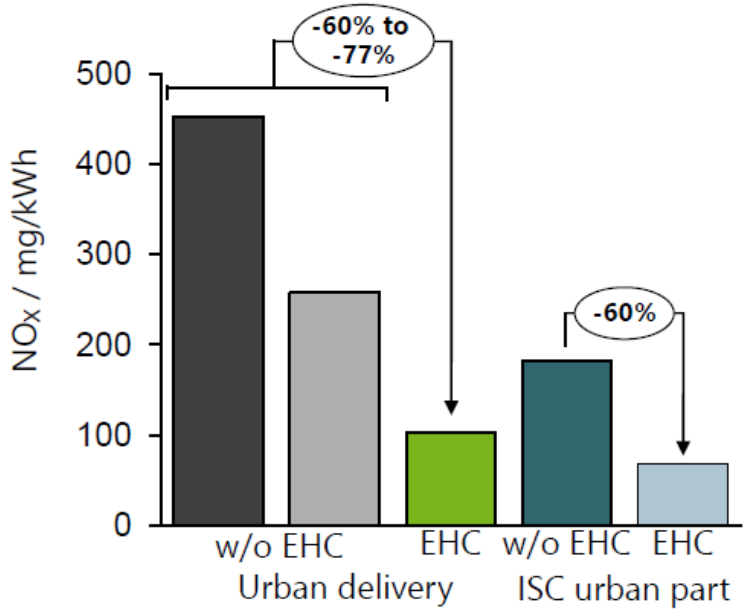
- Implementation of electrically heated catalyst as part of the ccDOC to reduce the remaining initial cold-start emissions[1]
- Operation strategy
  - AdBlue dosing starts when ccSCR reaches 200°C, EHC helps reducing the heat up time
  - System is kept at operating temp regardless of long stops
- As the vehicles is not a hybrid, the required power needed for the EHC was generated by a genset installed in the trailer

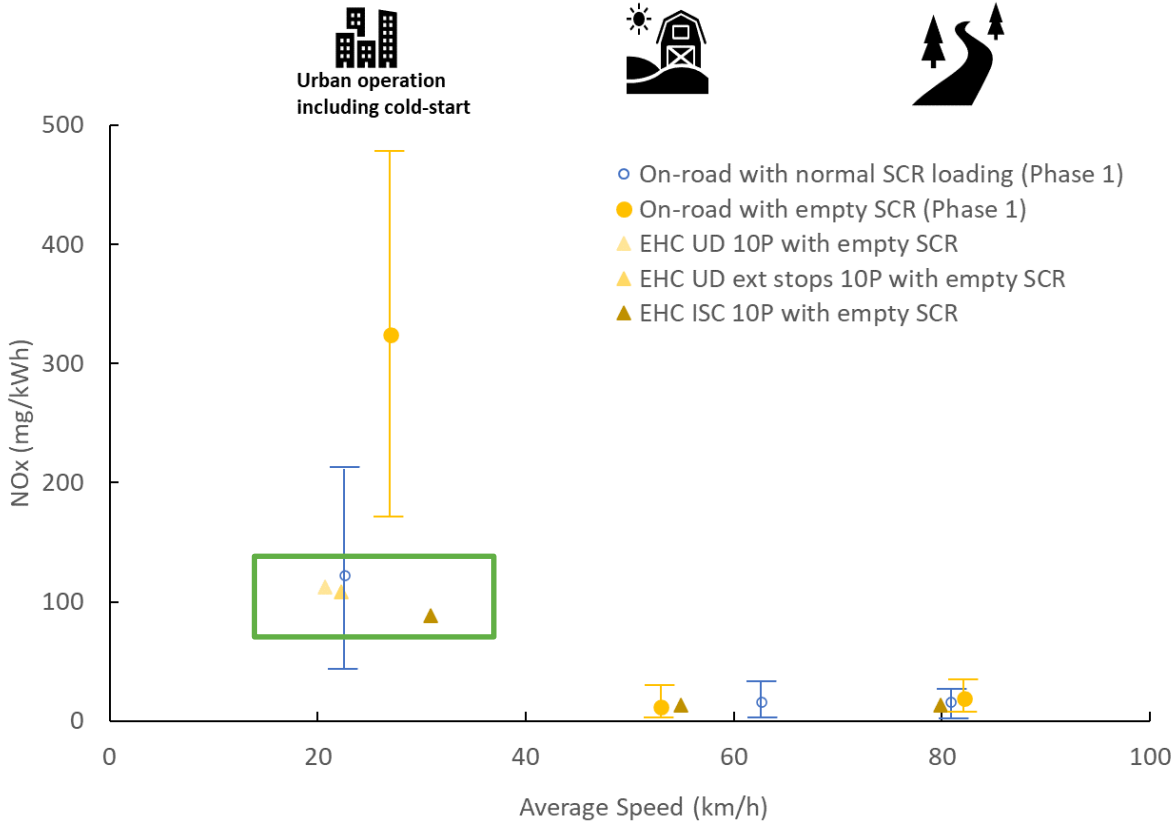


[1] P. Mendoza Villafuerte, et al.; "Future-proof heavy-duty truck achieving ultra-low pollutant emissions with a close-coupled emission control system including active thermal management", Transportation Engineering, Volume 9, September 2022, 100125, 2022

Reduction of initial cold-start emissions with EHC

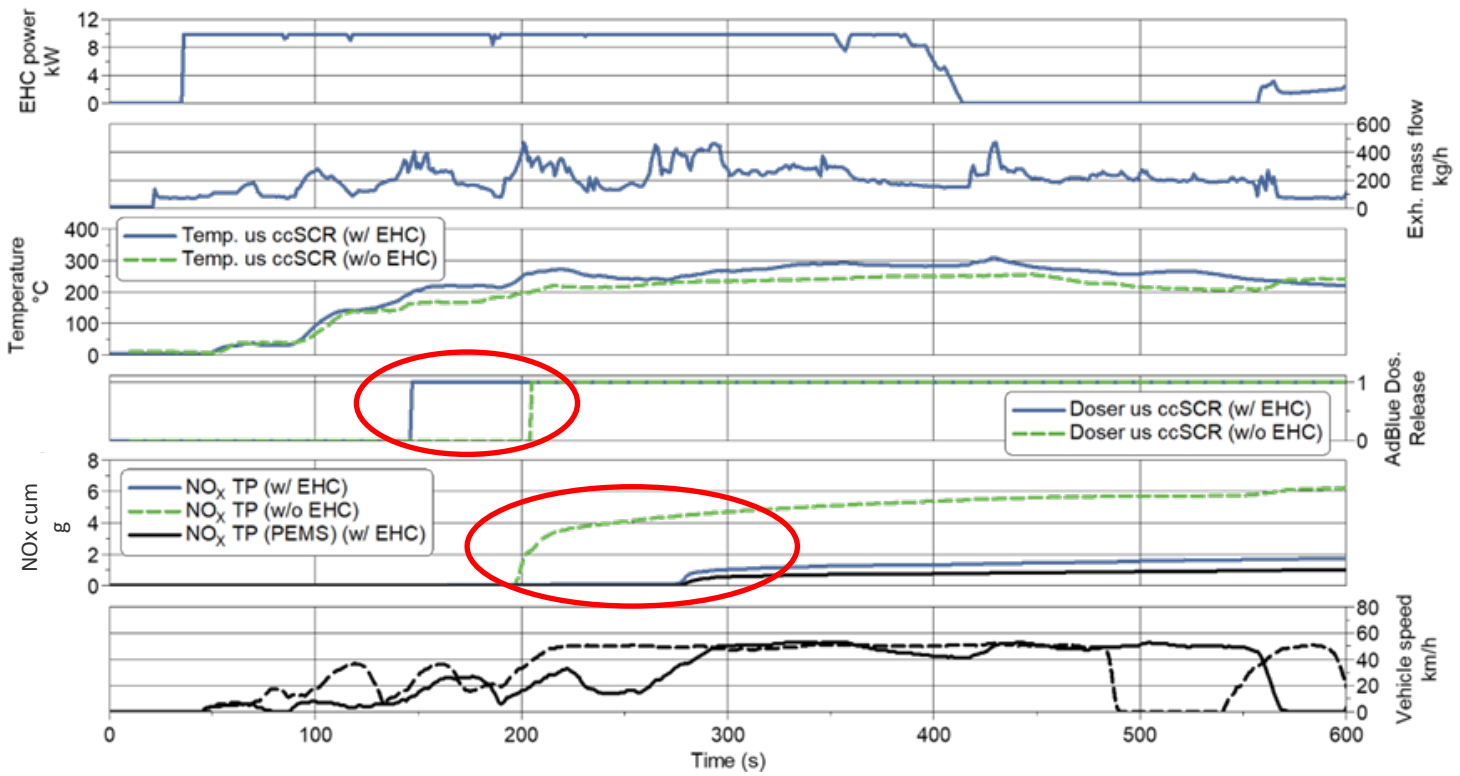
- NOx emissions reduced by 60-77% with EHC compared to first project phase
  - Faster heat-up during initial cold-start
  - Maintaining temperature during low-load or start-stop driving



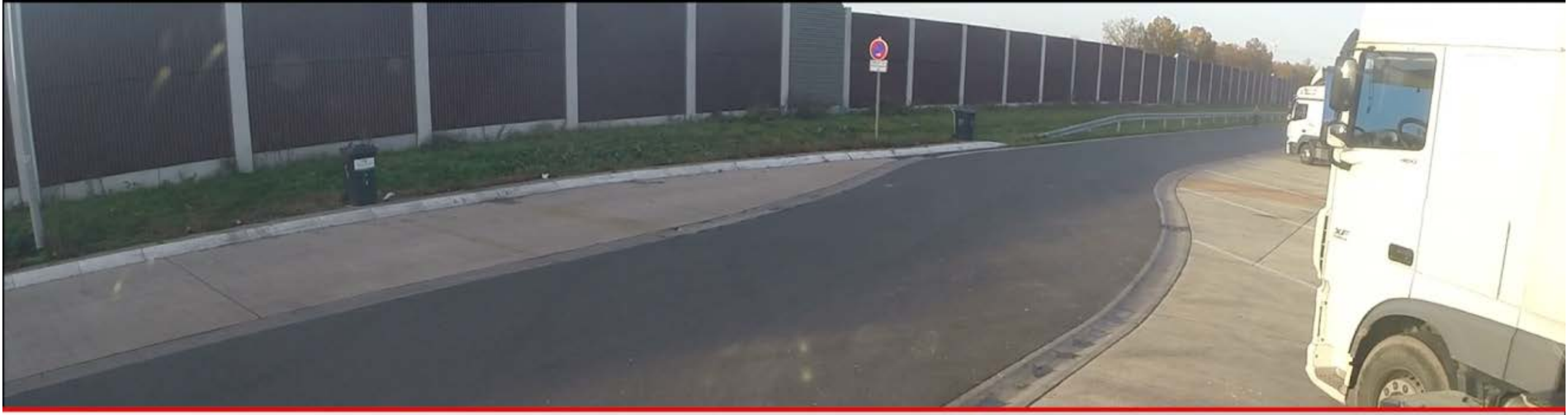


Reduction of initial cold-start emissions with EHC

- Urban delivery trip[1,2] initial 600 s
- EHC control strategy and effect
  - AdBlue dosing release of ccSCR is advanced 60 s
  - Around 67% NOx emissions reductions in complete cycle
- CO_2 impact depends on EHC control strategy



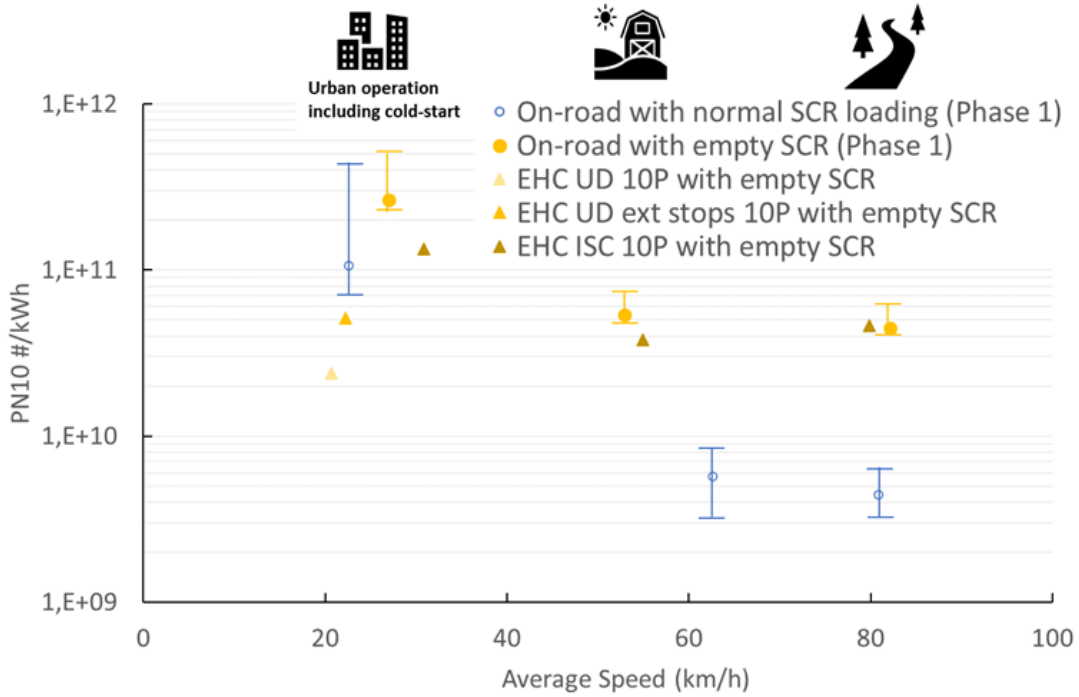
[1] The results are reported as measured by NOx and temperature sensors instrumented in the exhaust system
[2] Tests were conducted with depleted SCRs' ammonia storage and passively regenerated DPF unless indicated otherwise, test conducted at 16°C, 10% power threshold

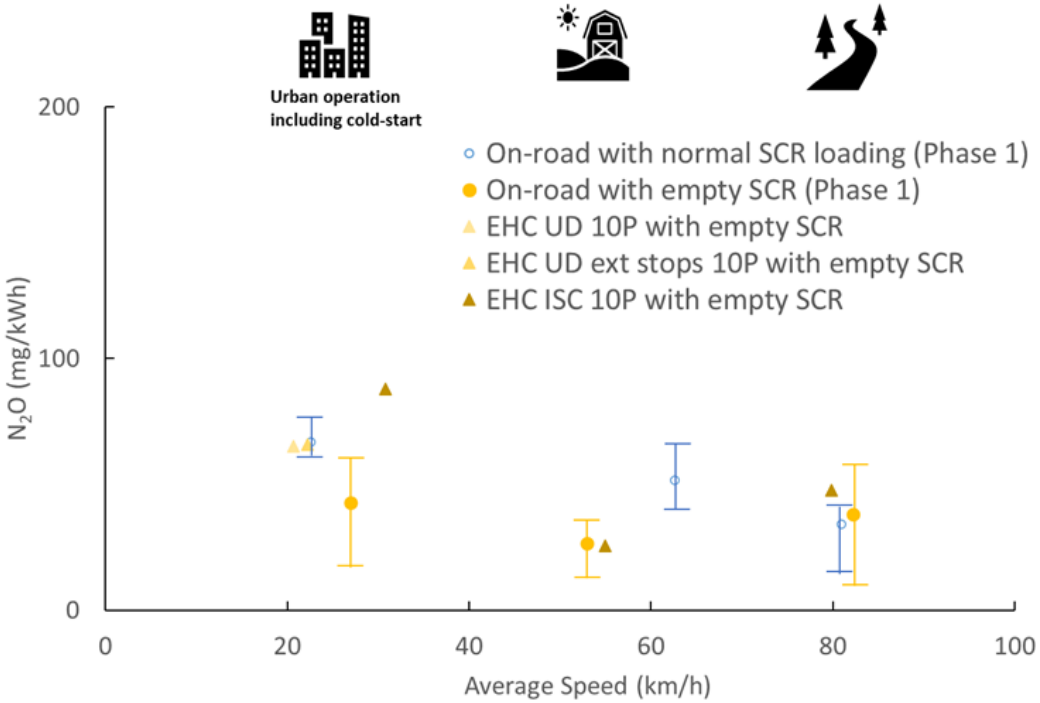


More videos available on YouTube (AECC eu):
https://www.youtube.com/channel/UCbPS9op5ztLqrv6zlMH_IcQ

Good control of non-regulated emissions

- Low PN10[1,2] emissions are achieved overall, cold start particulates remain main emission event
- N_2O emissions are kept at low levels



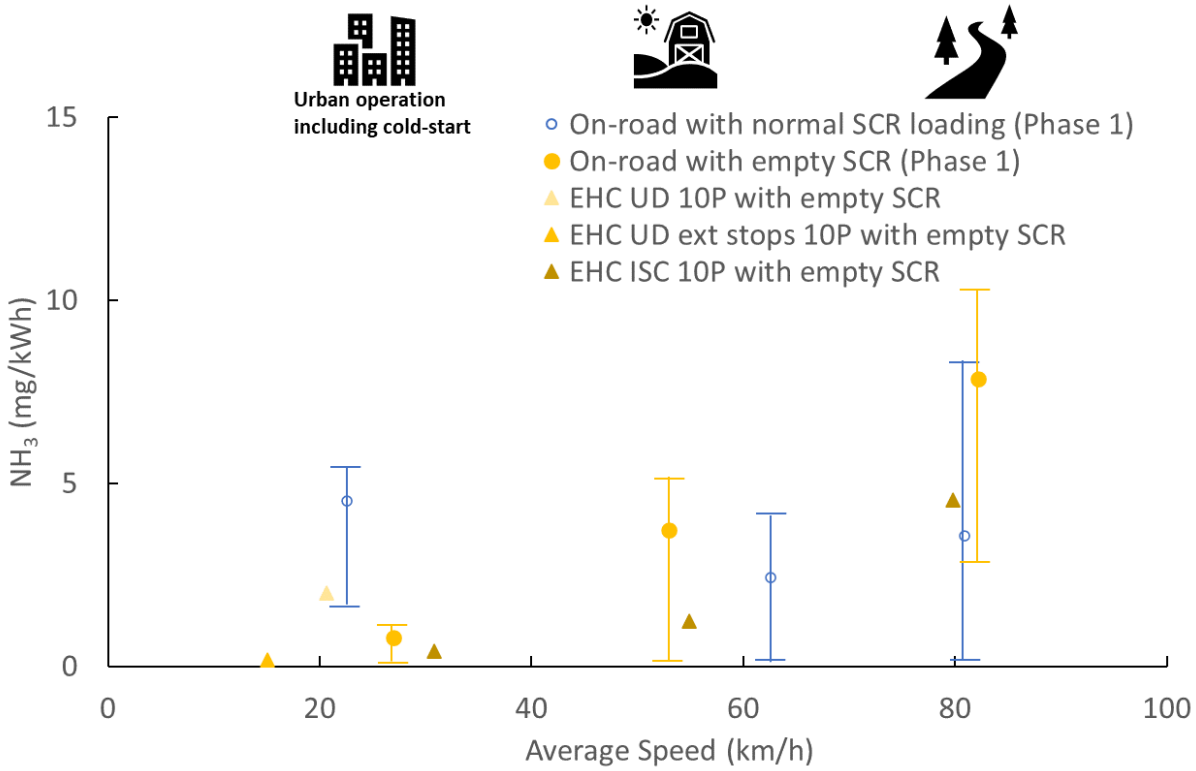


[1] The results are reported as measured by protype PN10 PEMS
[2] Tests were conducted with depleted SCRs' ammonia storage and passively regenerated DPF unless indicated otherwise

Near-zero NH_3 emissions in a broad range of operations

- Ammonia slip catalysts downstream each SCR keep good control of the NH_3 emissions

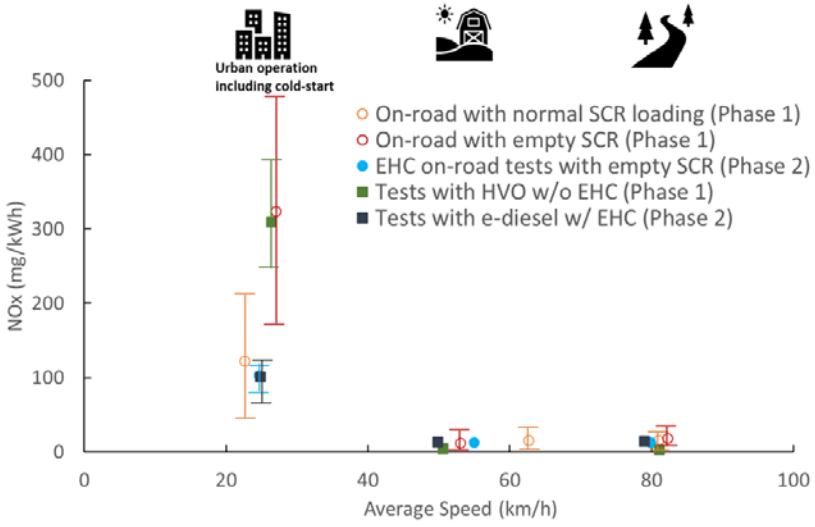
- The measured range of values for the NH_3 vary from 0.01 to 6,65 mg/kWh under urban operation, 0,04 to 5,64 mg/kWh and 0,26 to 11,75 mg/kWh for rural and motorway operation respectively

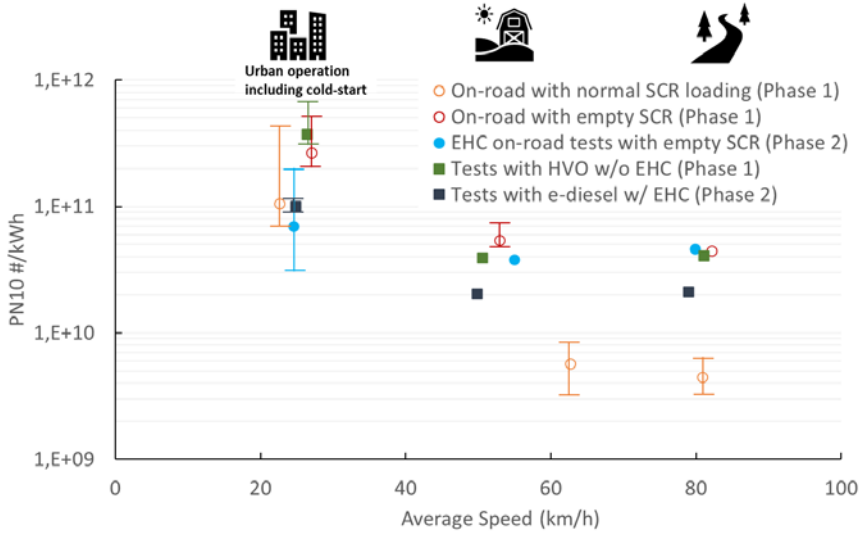


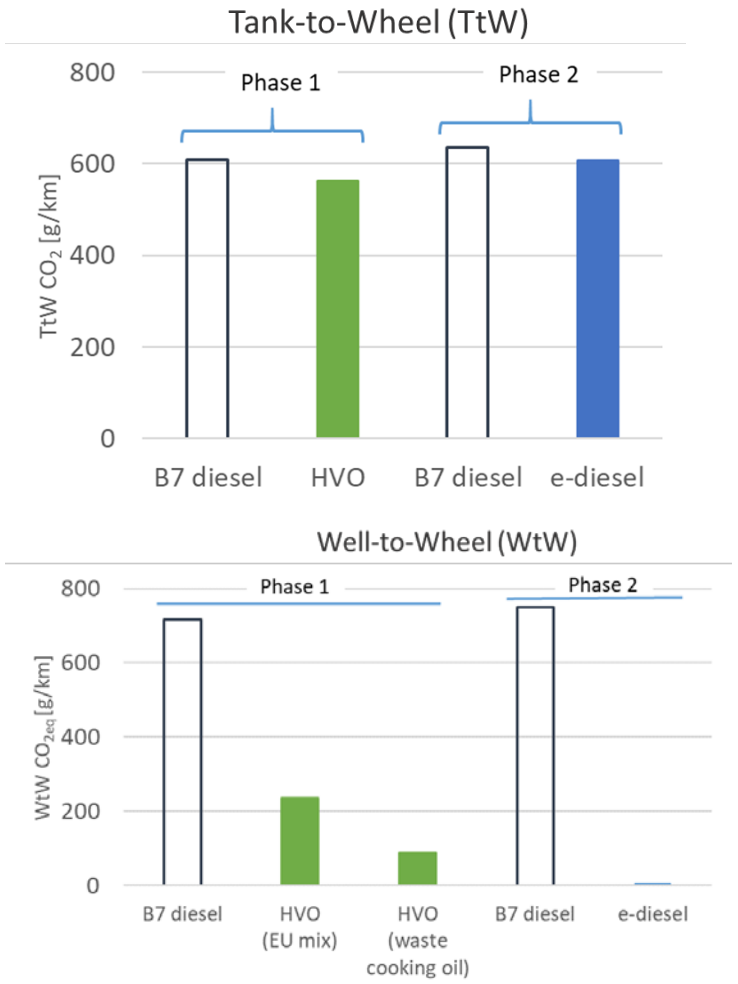
[1] Tests were conducted with depleted SCRs' ammonia storage and passively regenerated DPF unless indicated otherwise

HD diesel demonstrator with sustainable renewable fuels

- Ultra-low pollutant emissions confirmed on HVO and e-diesel
- HVO already offers today up to 90% WtW CO_2 reduction
- E-diesel has the potential to nearly eliminate WtW CO_2 emissions







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

Summary

- Ultra-low gaseous and particulate emissions are technically feasible in a broad range of driving conditions due to advanced catalysts in a close-coupled layout including a twin dosing system as well as a catalysed filter in combination with active thermal management
  - Significant reduction of initial cold-start peak
  - Near-zero emissions after initial cold-start peak
- Further information available today
  - Visit the exhibition to see a display model of the emission control system and look at the results in more detail
  - Heavy-duty diesel demonstrator vehicle

THANK YOU !