COMBINATION OF ADVANCED EMISSION CONTROL TECHNOLOGIES AND SUSTAINABLE RENEWABLE FUELS ON A LONG-HAUL DEMONSTRATOR TRUCK

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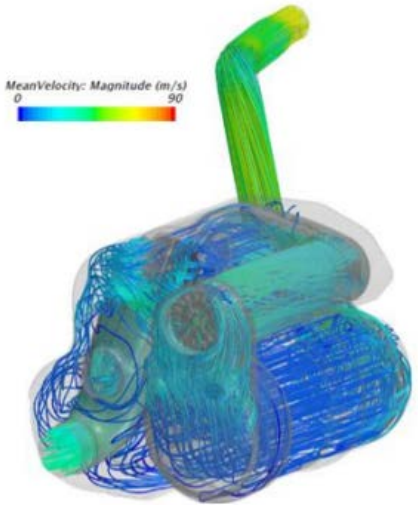
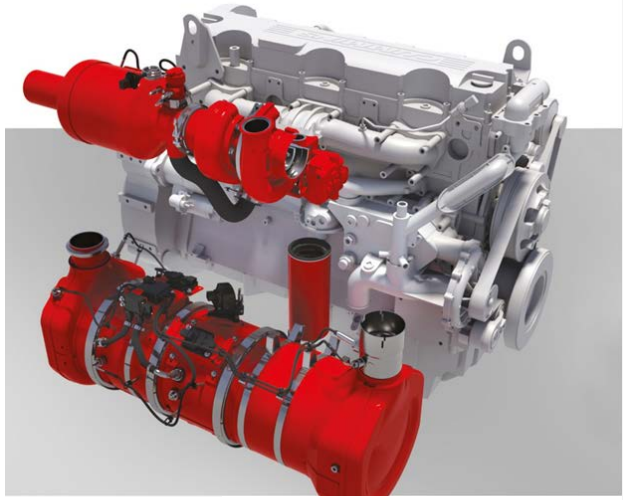
With the support of

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

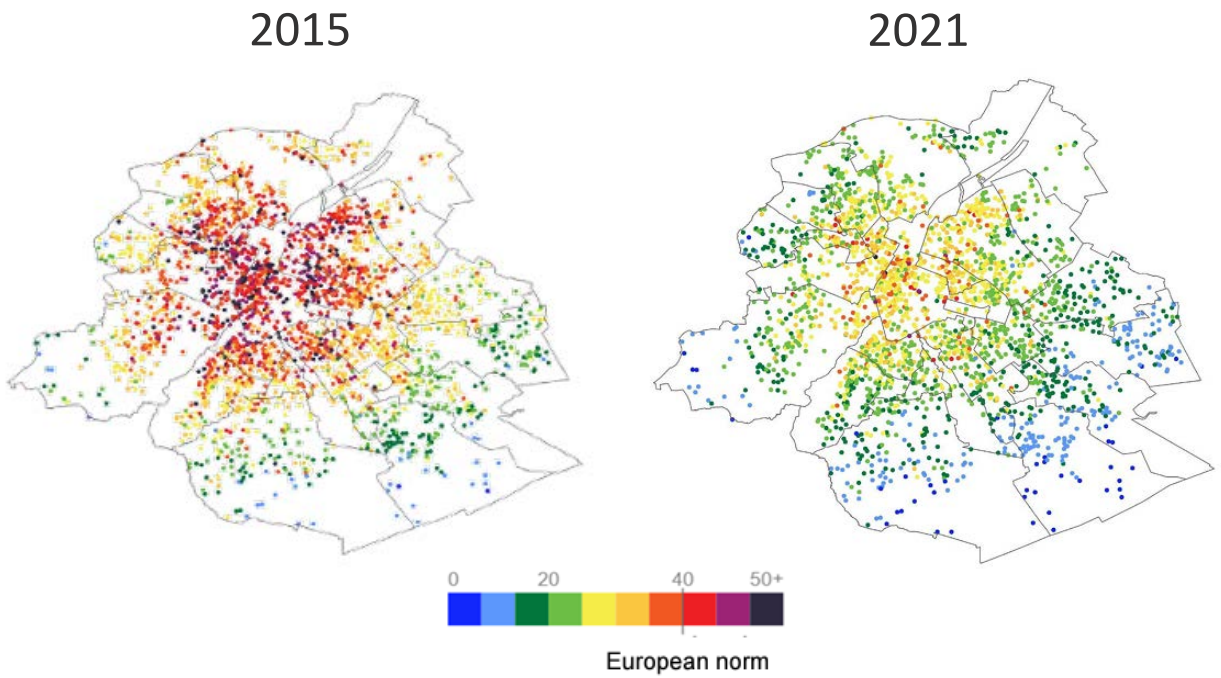
- Implementation of advanced emission control systems
- Several reports about improved air quality, for example NO_2 in Brussels
- Further emission control technology evolution expected towards Euro 7



Source: Daimler 2022



Source: Cummins, 2021



Source: CurieuzenAir report air quality in Brussels, 2022

Reduction of CO_2 emissions to mitigate climate change

- Increase in efficiency and level of electrification for new vehicles
- Wider usage of sustainable renewable fuels to reduce Well-to-Wheel and lifecycle CO_2 emissions
  - Immediate reductions for the existing fleet in addition to new vehicles
  - Production is a reality, further investments depending on the policy framework
  - Usage for road transport is not fully recognised in ‘Fit for 55’ proposal under discussion

Neste MY renewable diesel launched in Belgium

Source: Neste (2021)

Synthetic diesel and gasoline

Source: Aramco (2021)

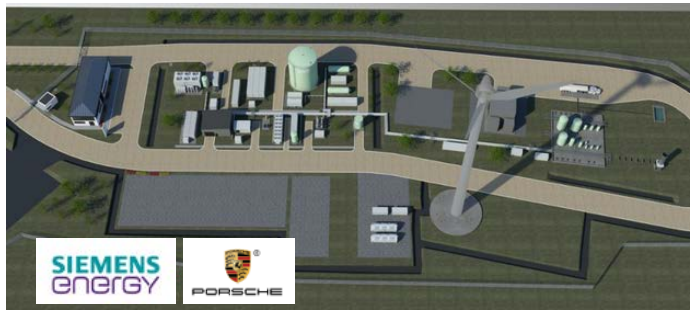
Two 50 BPD fuel pilot plants

80% CO_2 abatement compared to fossil

REPSOL NEOM aramco

Haru Oni pilot plant: wind power to e-fuel

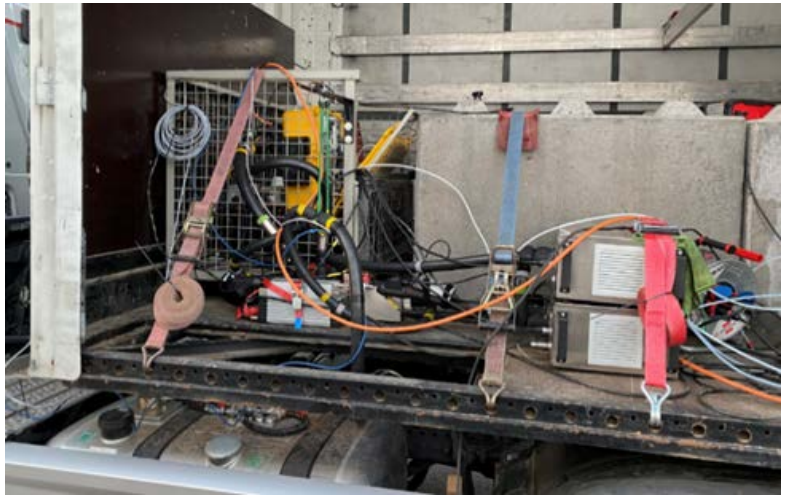
Source: Siemens Energy (2020)



HD Diesel demonstrator concept

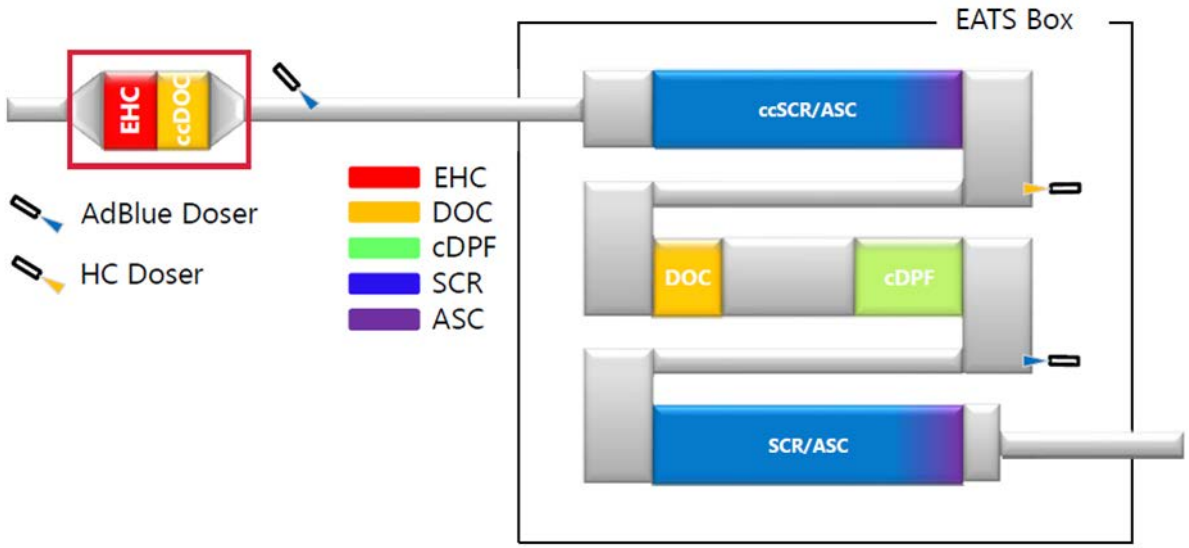
- Base vehicle description
  - MB Actros 1845 LS 4x2
  - Engine OM 471
    - Euro VI C certified
    - 12.8 litres, 6 cylinder in-line
    - High Pressure EGR

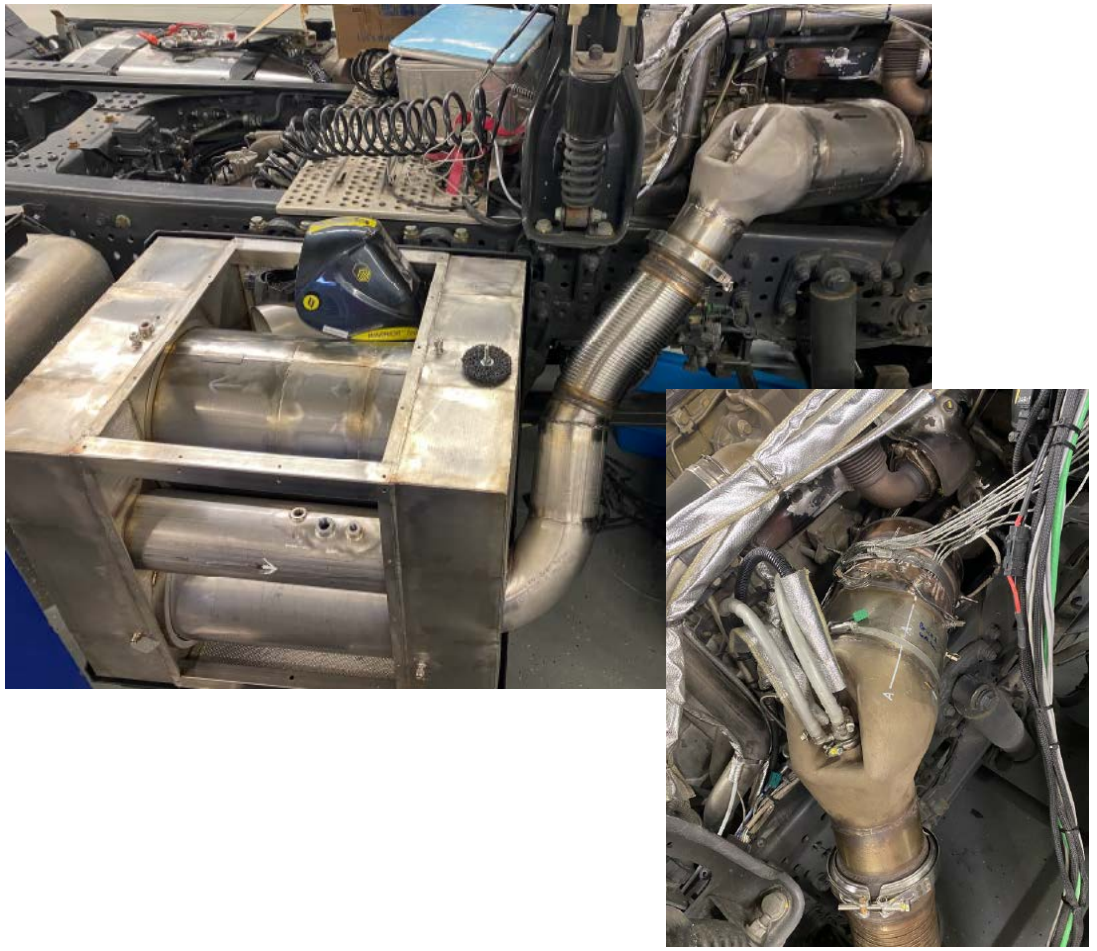
- Instrumented with prototype PEMS equipment to measure CO_2, NOx, CO, PN10, NH_3 and N_2O



HD Diesel demonstrator concept

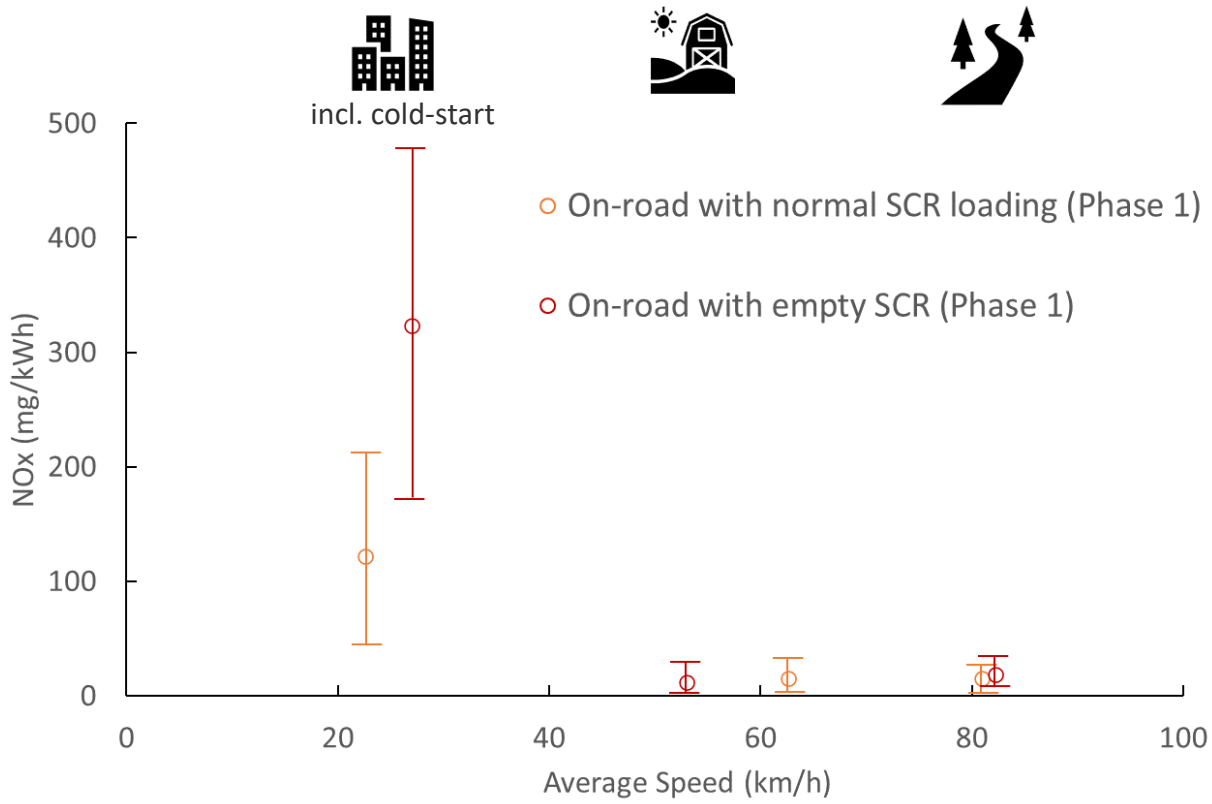
- AECC emissions control system
  - Phase 1: ccDOC, ccSCR/ASC+ ufDOC+cDPF+ SCR/ASC, twin AdBlue dosing and HC doser
  - Phase 2: additional EHC as part of the ccDOC
  - Components are hydrothermally aged targeting 500k km





HD Diesel demonstrator overall phase 1 NOx results

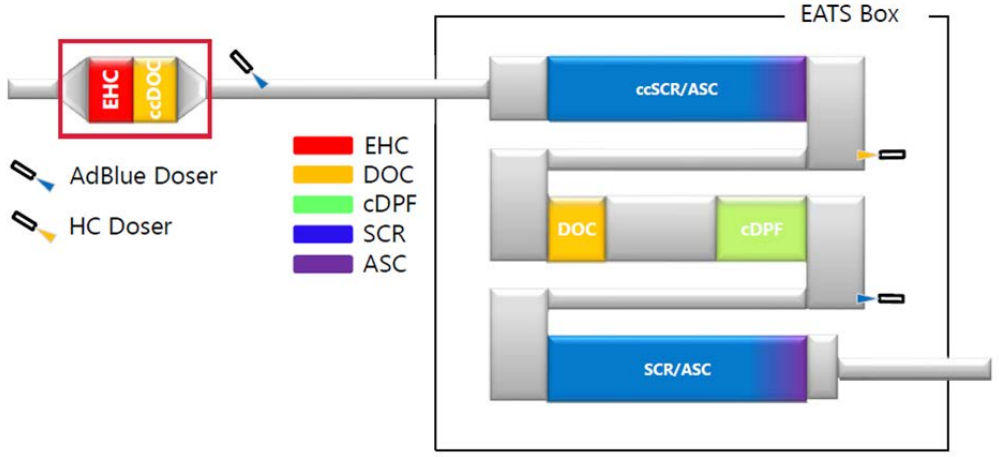
- On-road and chassis dyno test campaigns confirm significant improvement for urban emissions including cold-start compared to Euro VI-D
- Near-zero emissions under warm operation
- Impact of ammonia storage depletion procedure shows robust control is needed for AdBlue® dosing, ammonia storage and thermal management

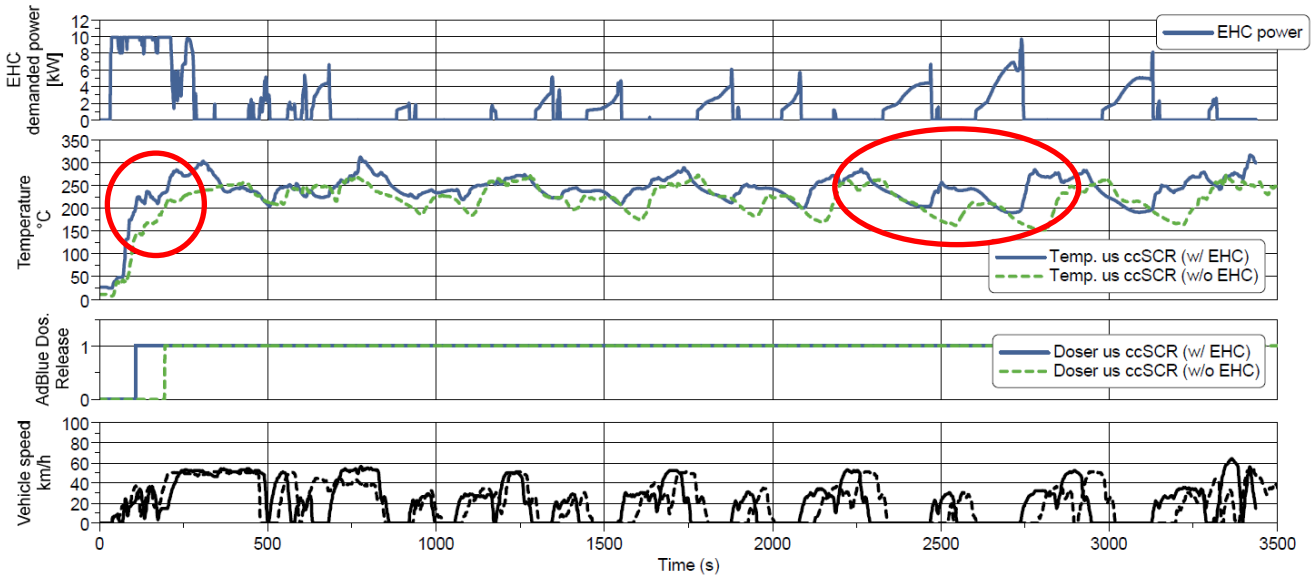


[1] P. Mendoza Villafuerte, et al.; "Real-World Emissions of Euro VI Heavy-Duty Vehicles", SAE Technical paper, 2021-01-5074, 2021
[2] P. Mendoza Villafuerte, et al.; "Demonstration of Extremely Low NOx Emissions with Partly Close-Coupled Emission Control on a Heavy-duty Truck Application", 42nd Vienna Motor Symposium 2021
[3] T. Selleri, et al.; "Measuring Emissions from a Demonstrator Heavy-Duty Diesel Vehicle under Real-World Conditions—Moving Forward to Euro VII", Catalysts 2022, 12(2), 184, 2022

Phase 2 of the HD Diesel demonstrator project

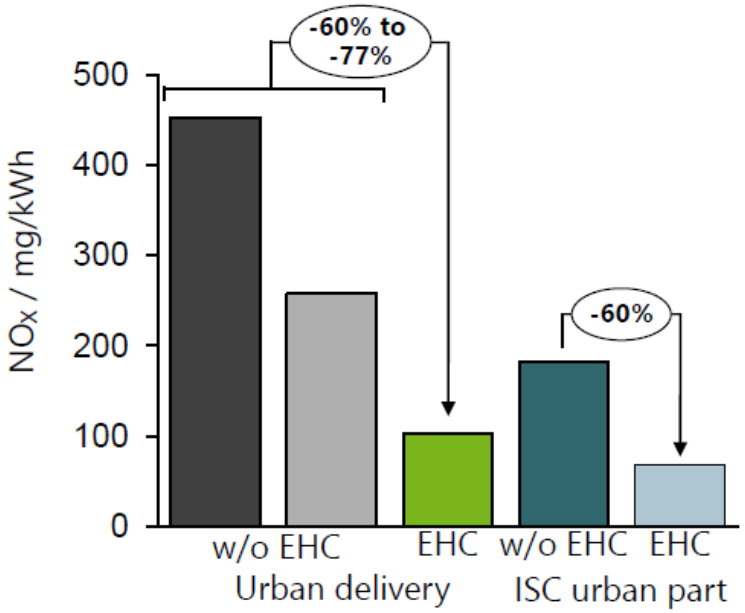
- Implementation of electrically heated catalyst as part of the ccDOC to reduce the remaining initial cold-start emissions
- Operation strategy
  - AdBlue dosing starts when ccSCR reaches 200°C, EHC helps reducing the heat up time
  - System is kept at operating temp regardless of long stops
- As the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

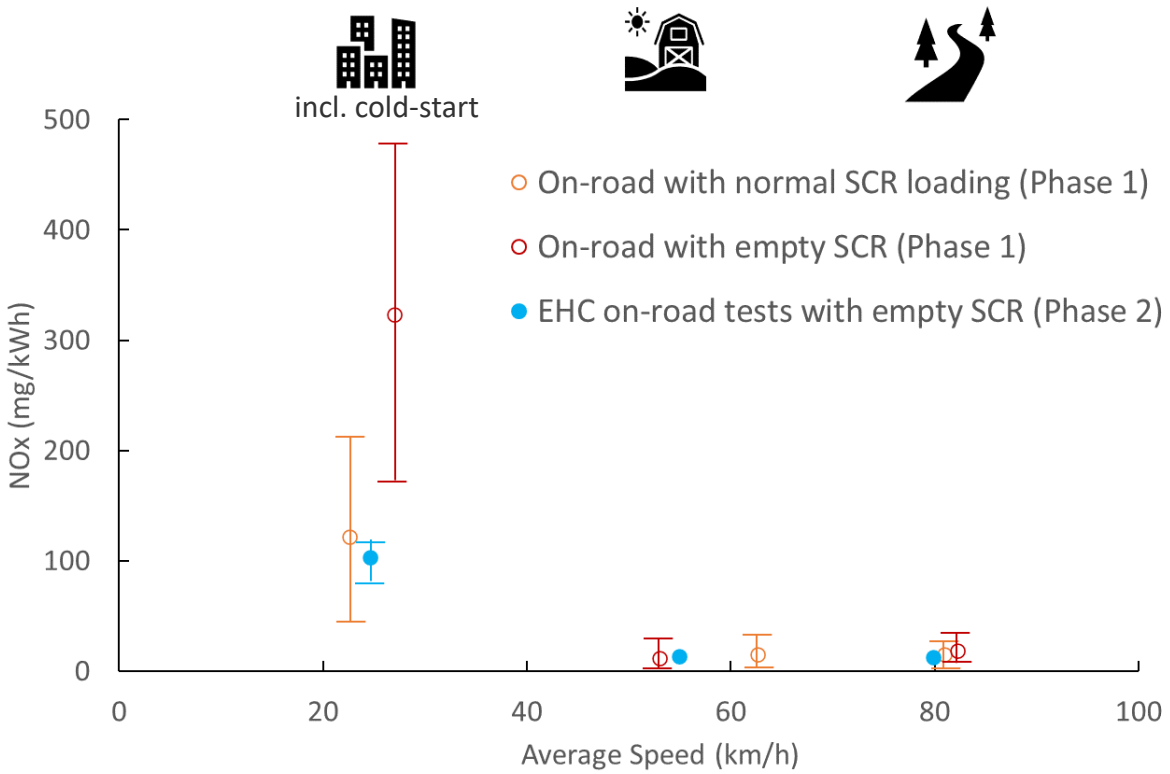




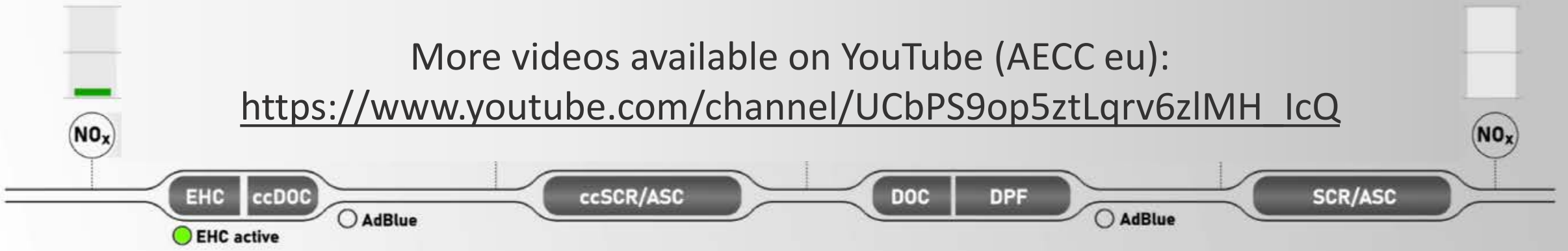
Reduction of initial cold-start emissions with EHC

- NOx emissions reduced by 60-77% with EHC compared to project phase 1
  - Faster heat-up during initial cold-start
  - Maintaining temperature during low-load or start-stop driving





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



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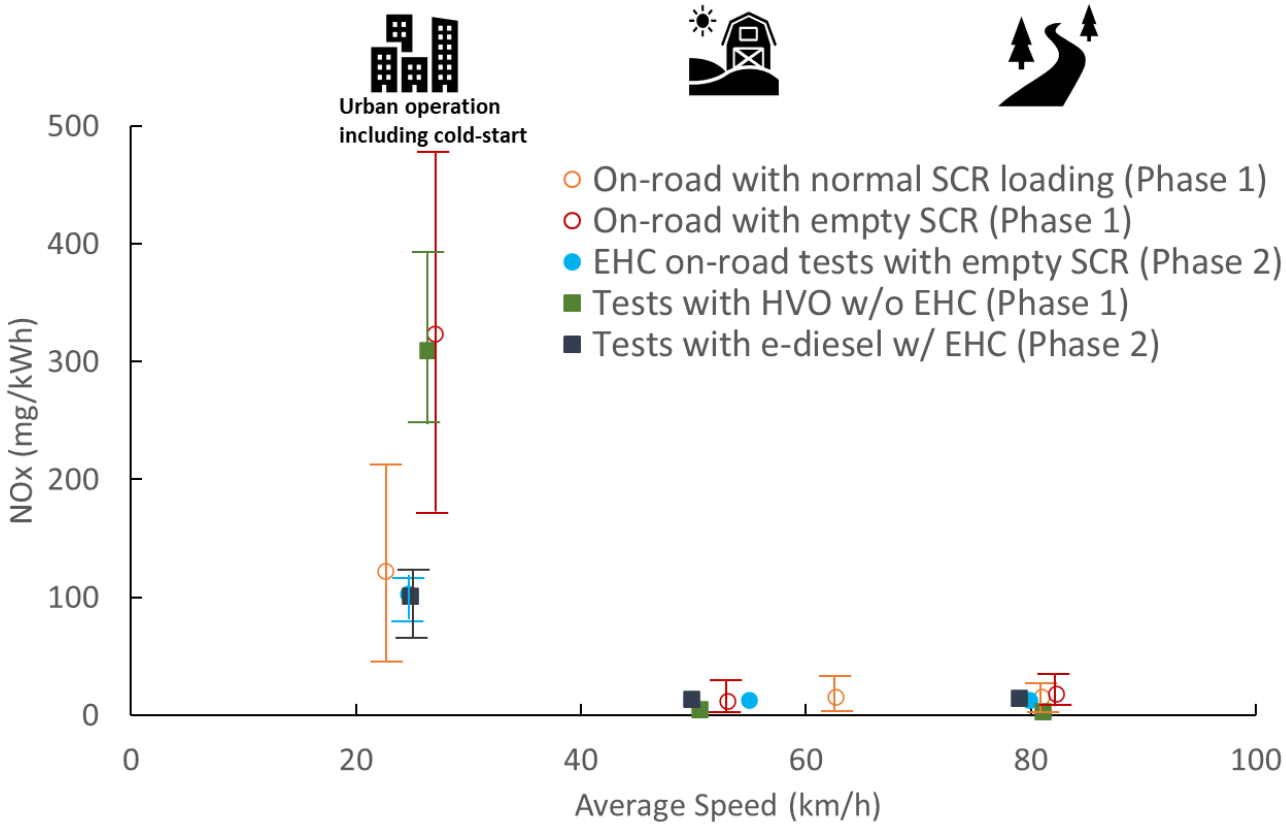
Ultra-low NOx emissions on sustainable renewable fuels

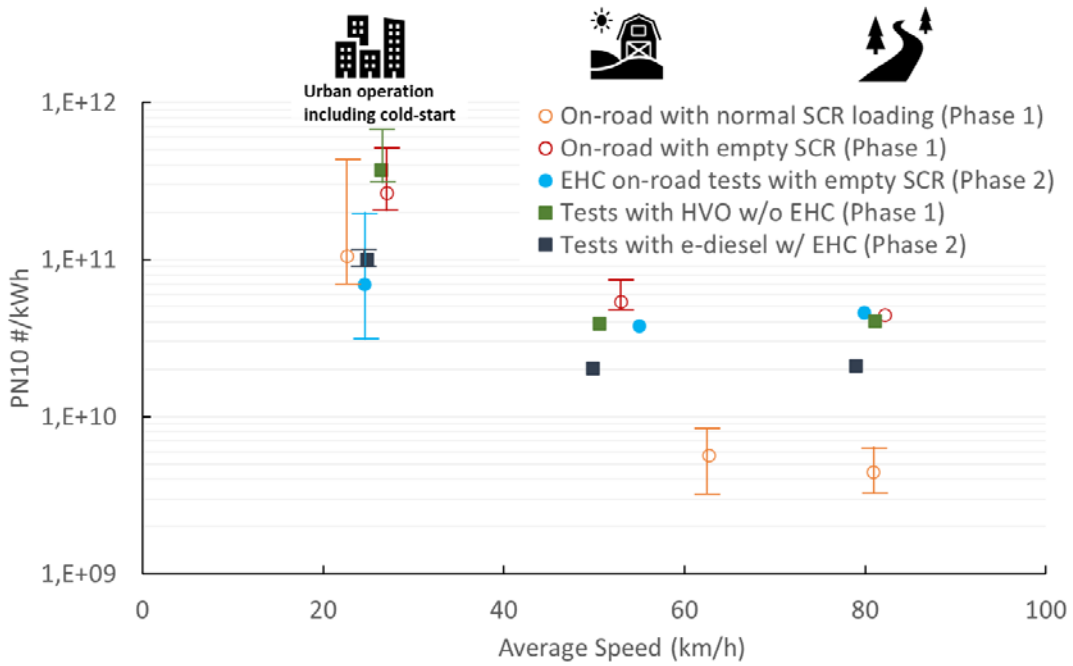
- The HD demonstrator vehicle was tested under the same routes for urban delivery and in-service conformity with sustainable renewable fuels
  - 100% HVO (within phase 1)
  - E-diesel (within phase 2)
- No negative impact was observed on the ultra-low pollutant emissions level

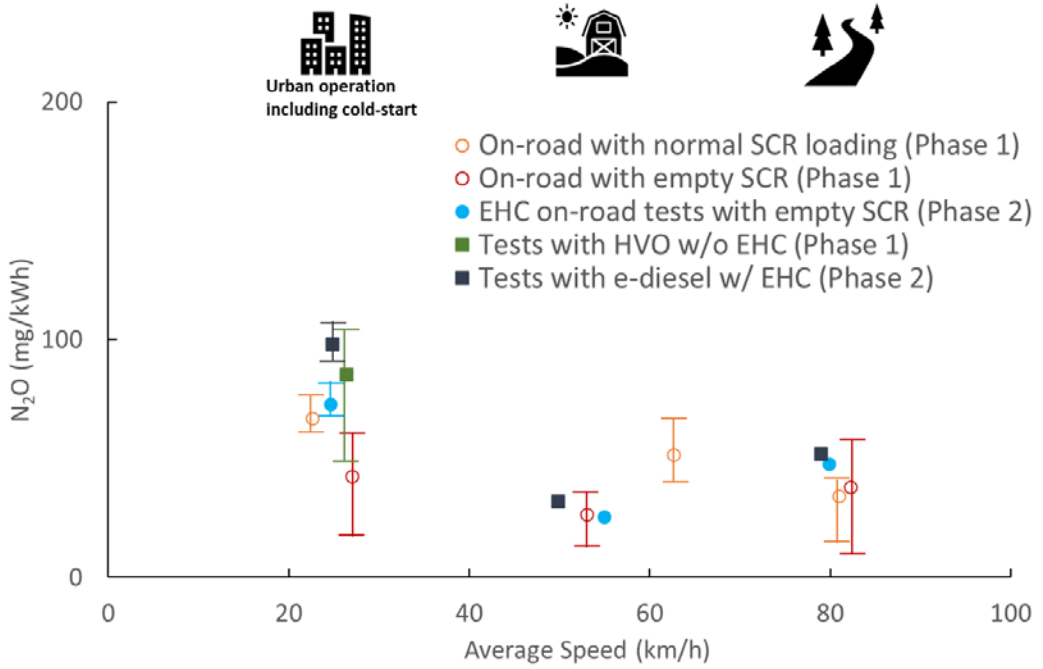


[1] Tests were conducted with empty SCRs' ammonia storage and passively regenerated DPF unless indicated otherwise

Non-regulated emissions with sustainable renewable fuels

- Low PN10 emissions confirmed on HVO and e-diesel
- N_2O emissions showed similar levels as with conventional fuel



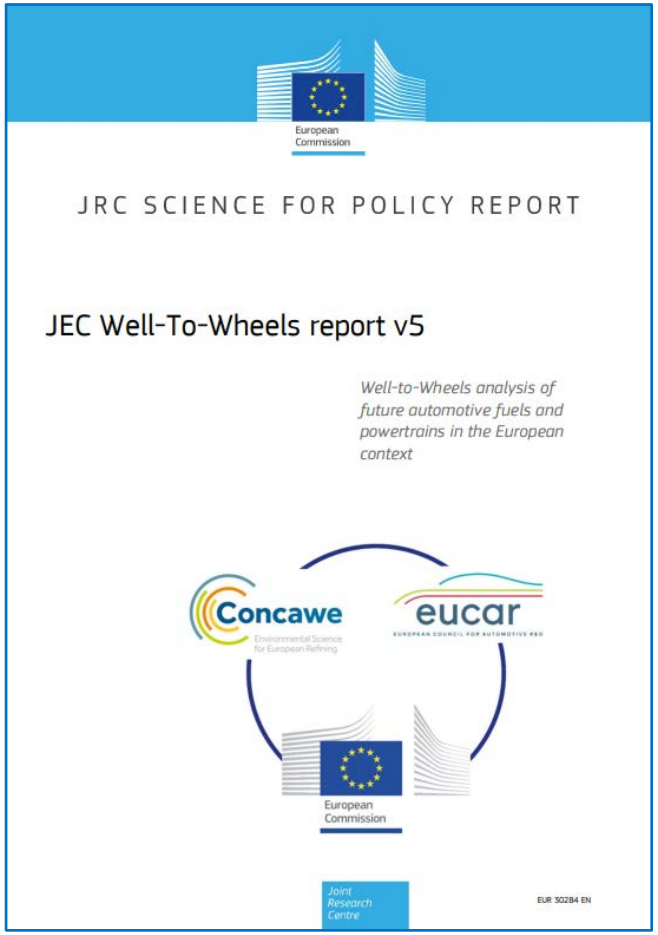


[1] The results are reported as measured by protype PN10 PEMS

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

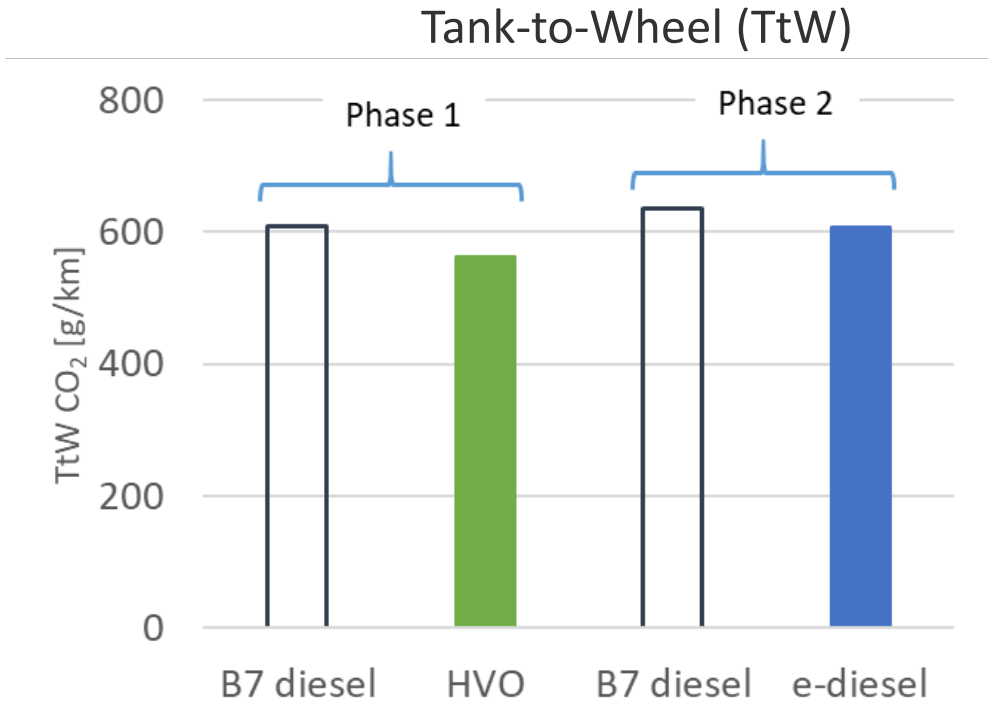
HD Diesel demonstrator Well-to-Wheel CO_2 emissions

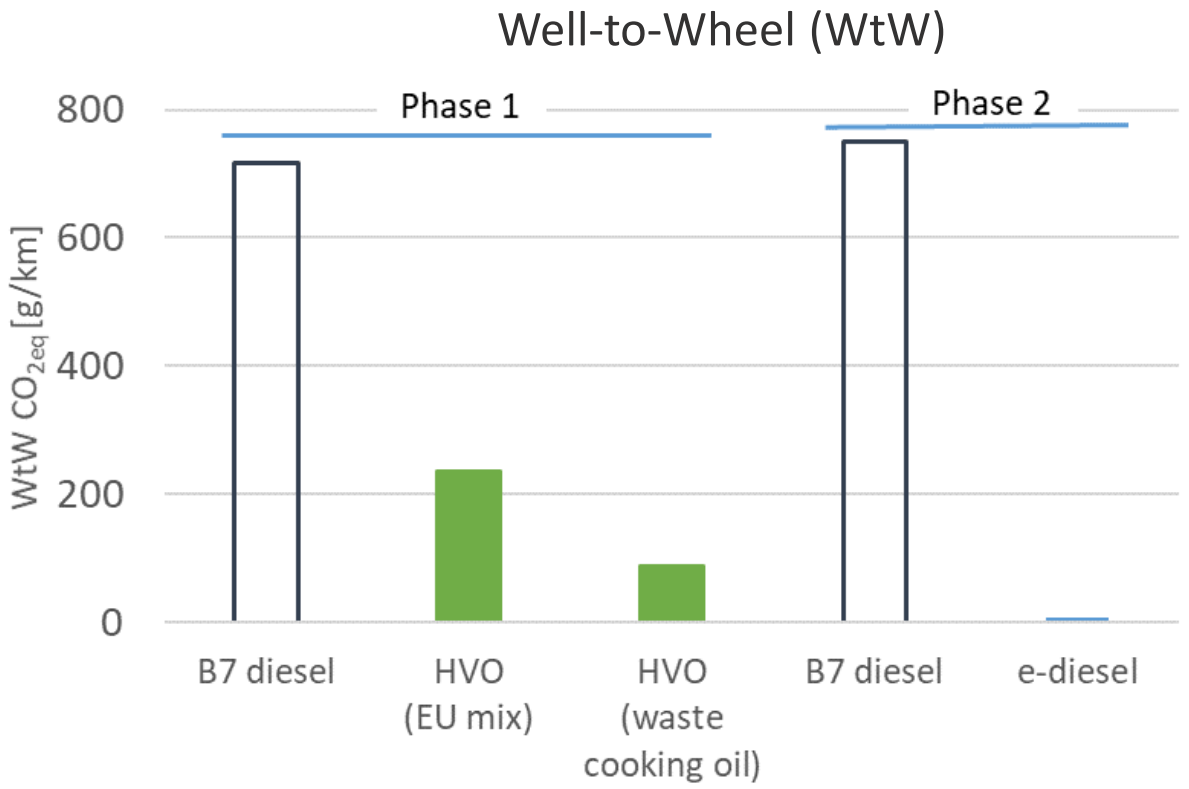
- JEC Well-To-Wheel report version 5 methodology has been used to calculate the WtW CO_2 emissions
  - Well-to-Tank (WtT) input data is coming from the JEC WtW report
  - Tank-to-Wheel input data is from the on-road testing performed and fuel properties provided by the fuel suppliers
- Following pathways are investigated
  - B7 market diesel
  - HVO
    - EU mix
    - Waste cooking oil
  - E-diesel



HD Diesel demonstrator Well-to-Wheel CO_2 emissions

- HVO already offers today significant reduction of up to 90% WtW CO_2 reduction straight from the pump depending on the feedstock
- E-diesel has the potential to nearly eliminate WtW CO_2 emissions





Summary and conclusions

- Advanced emission control system implemented on a heavy-duty demonstrator vehicle, including close-coupled catalyst and active thermal management
- Ultra-low pollutant emissions measured on market fuel
  - Significant reduction of initial cold-start peak and emissions under low-load operation
  - Near-zero emissions after initial cold-start peak
- Results validated on sustainable renewable fuels
  - Ultra-low pollutant emissions confirmed
  - Well-to-Wheel analysis shows significant CO_2 emissions reduction
- The internal combustion engine is part of the solution for meeting the EU Green Deal climate-neutral and zero-emission goals in 2050 along with electrification

THANK YOU FOR YOUR ATTENTION

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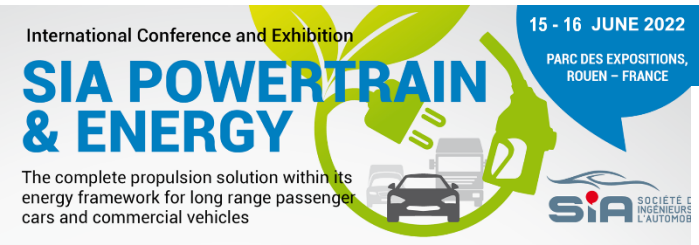

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