

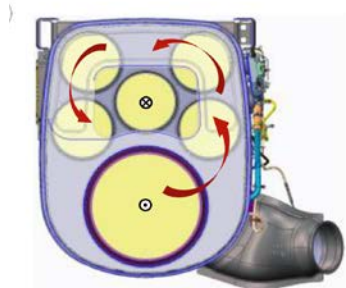
Towards Zero-impact Emissions for a Demonstrator Truck with Active Thermal Management, Dual-SCR, DPF and e-Diesel

Joachim Demuynck, Dirk Bosteels

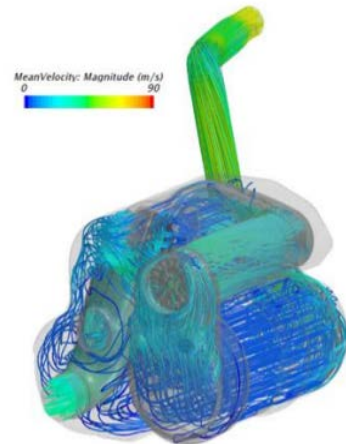
SAE HD Diesel Sustainable Transport Symposium • Gothenburg • 3 May 2023

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

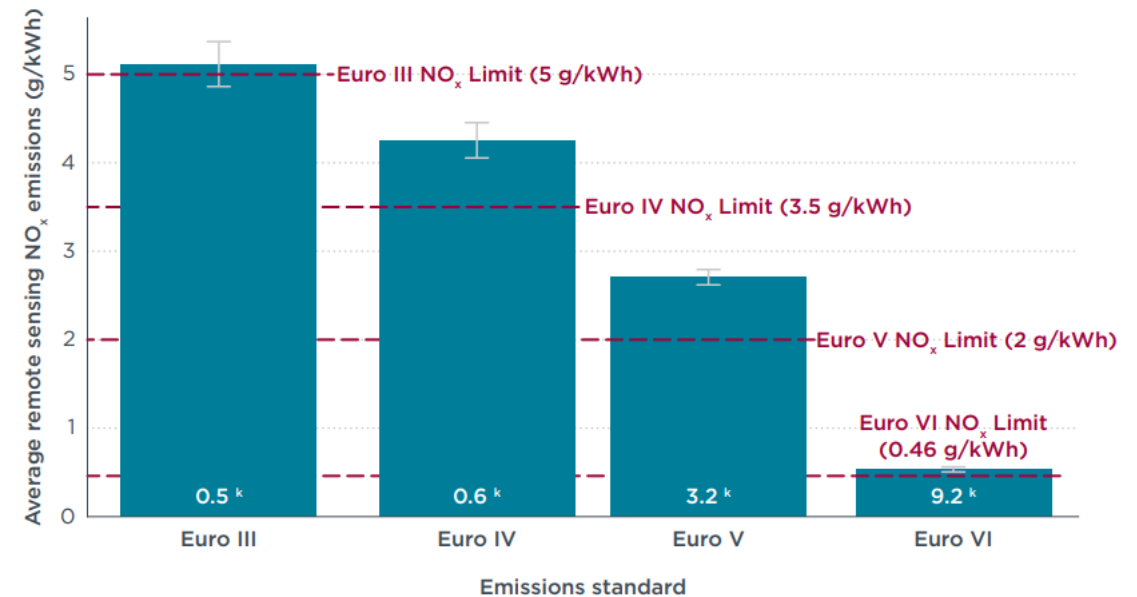
- Implementation of advanced emission control systems in a compact design
- Actual emissions reduction in the fleet confirmed by remote sensing data



Source: DAF



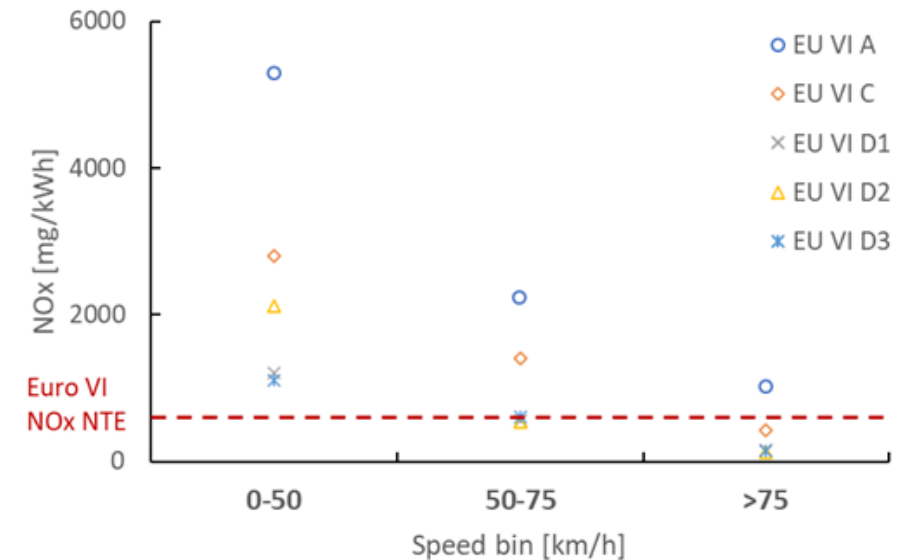
Source: Daimler



Source: Average NO_x emissions of heavy-duty trucks by European emission standards for Flanders remote sensing campaign, [ICCT, 2022](#)

Further evolution expected towards Euro 7

- Analysis of real-world emissions of Euro VI vehicles
 - Highest emissions mainly occur in 0-50 km/h speed bin
 - Initial cold-start peak
 - Low-load operation
 - Emissions reduced from Euro VI-A to VI-D
 - Euro VI-D/E post processing still excludes critical data



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

- Euro 7 proposal further focuses on on-road emissions performance with introduction of RDE test procedure for Heavy-duty vehicles

Content

- HD diesel demonstrator concept
- Reduction of initial cold-start emissions
- Euro VII data analysis
- HD diesel demonstrator with sustainable renewable fuels

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 + DOC + DPF + SCR

➤ Acknowledgement of project partners



➤ Scientific papers with full details

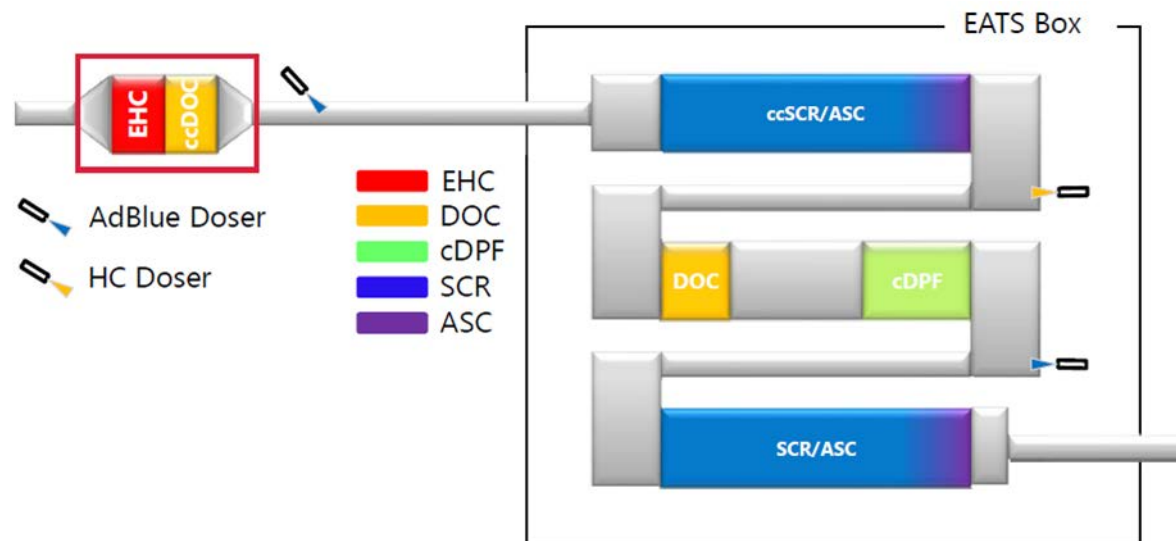
P. Mendoza Villafuerte, et al.; [“Demonstration of Extremely Low NOx Emissions with Partly Close-Coupled Emission Control”](#), 42nd Vienna Motor Symposium 2021

P. Mendoza Villafuerte, et al.; [“Future-proof heavy-duty truck achieving ultra-low pollutant emissions”](#), Transportation Engineering, Volume 9, September 2022, 100125, 2022

HD diesel demonstrator concept

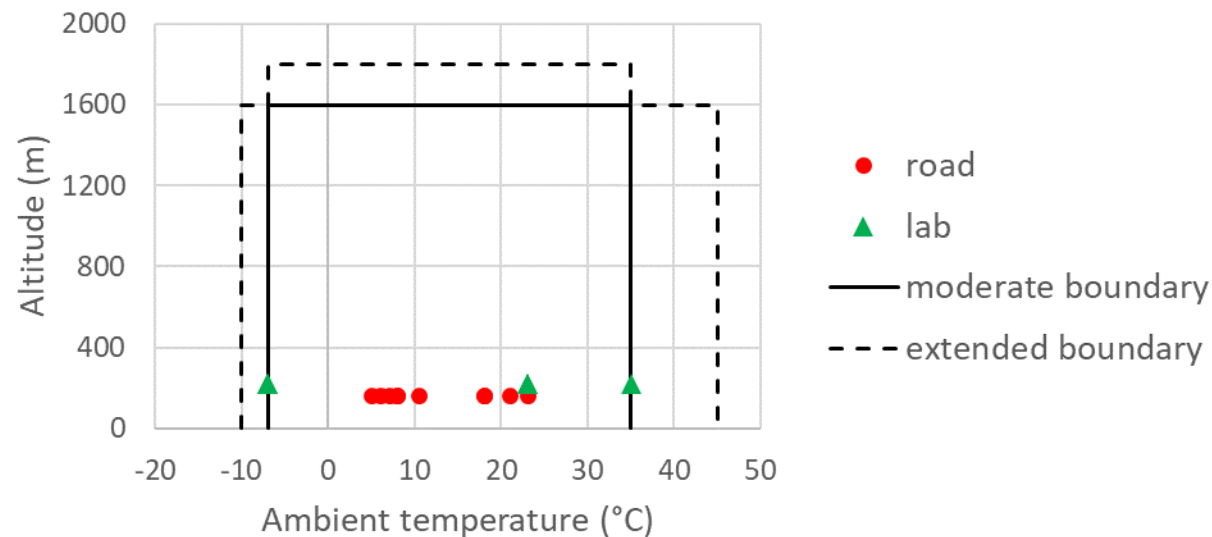
➤ AECC emissions control system

- 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



Focus is on low load and challenging cold-start

- Up to boundary of normal area covered of the Euro 7 proposal for
 - Ambient temperature
 - Payload: 10% (focus) – 50% – 100%
- Different tests conducted to vary trip composition
- Additional challenge by starting with empty SCR and partially regenerated filter

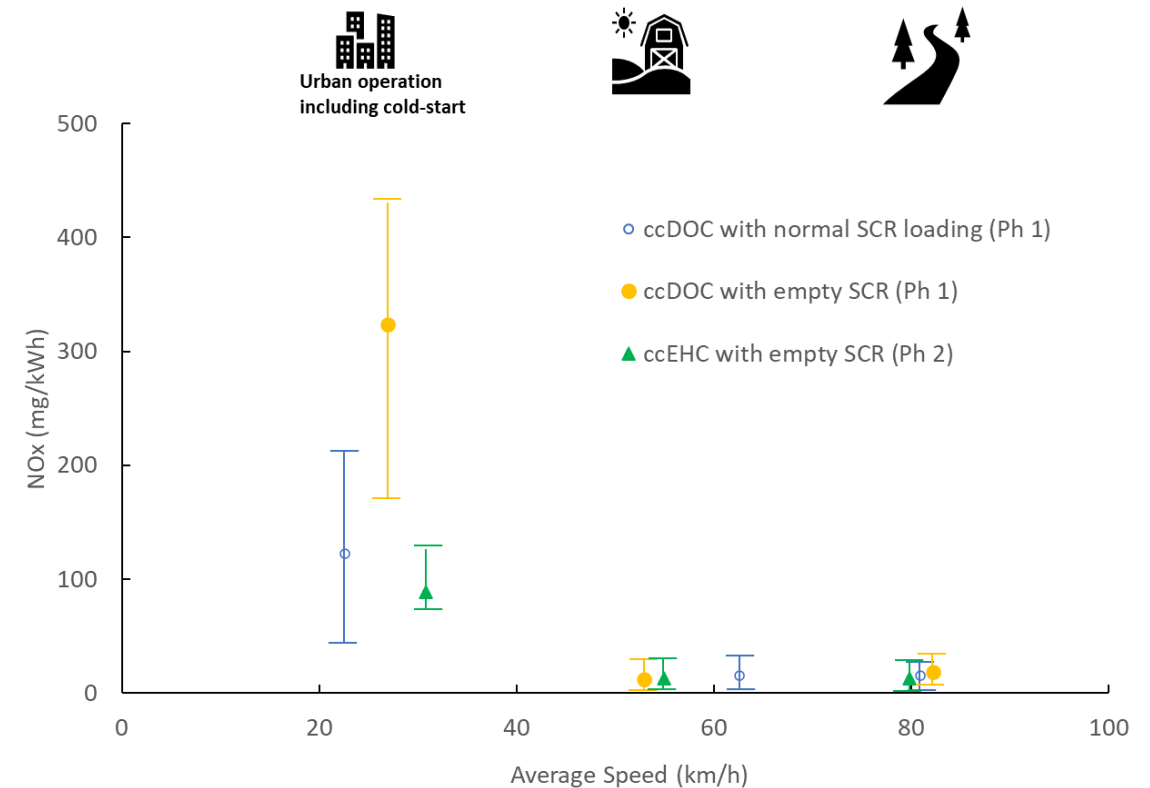


Test type	Test	Project phase
Road	In-Service Conformity (ISC)	ccDOC and ccEHC
	Urban Delivery (UD)	
	Alternative Route	
Lab	Real-World Test	ccDOC
	Urban Delivery	
	JRC RDE	
	TU Graz low-load	

Reduction of initial cold-start emissions

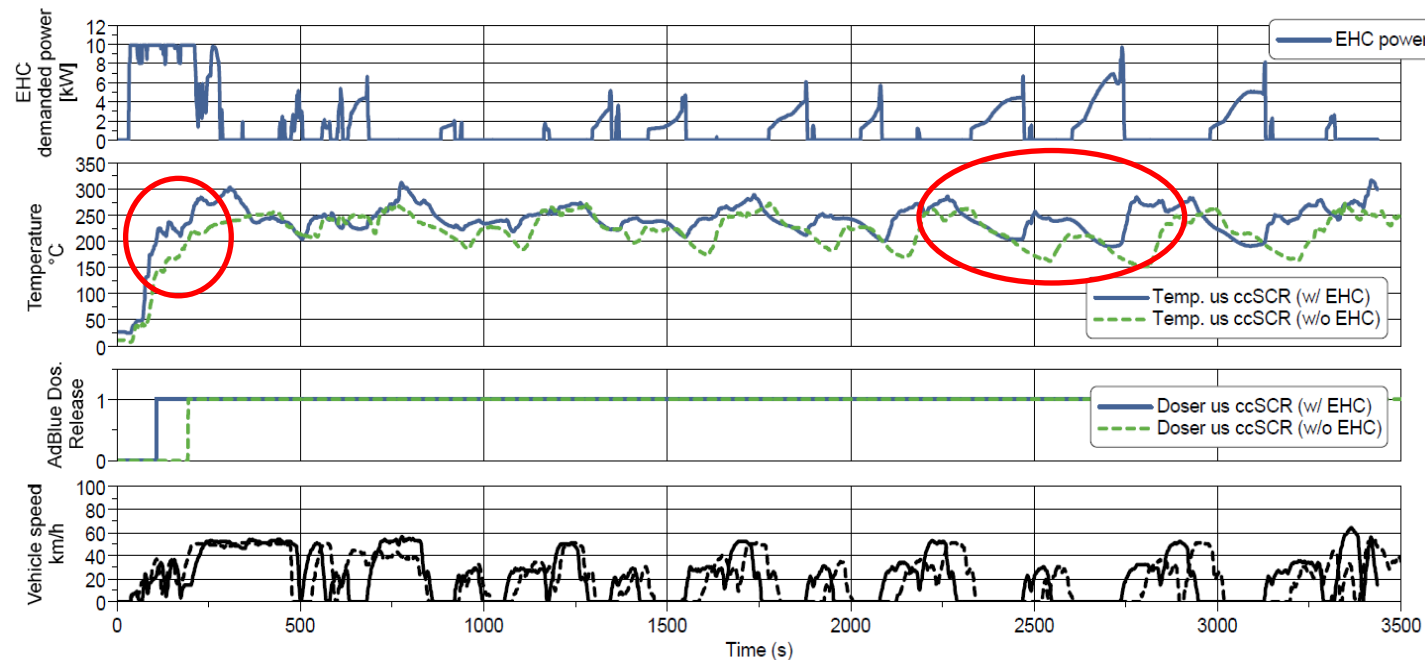
- Significant improvement of urban emissions including cold-start compared to Euro VI-D in phase 1 of the project with ccDOC
- Near-zero emissions under warm operation
- Impact of ammonia storage depletion procedure shows robust control is needed for AdBlue® dosing, ammonia storage and thermal management
- NOx emissions reduced by 60-77% with EHC in phase 2 of the project
 - Faster heat-up during initial cold-start
 - Maintaining temperature during low-load or start-stop driving

Overview of ISC and UD tests at 10% payload



Reduction of initial cold-start emissions

- Illustration of EHC control strategy and effect during Urban Delivery test
 - AdBlue dosing can start around 60 s earlier
 - System is kept at operating temp regardless of long stops
- As the vehicle is not a hybrid, the EHC power was generated by a genset installed in the trailer





More videos available on YouTube (AECC eu):

https://www.youtube.com/channel/UCbPS9op5ztLqrv6zIMH_IcQ





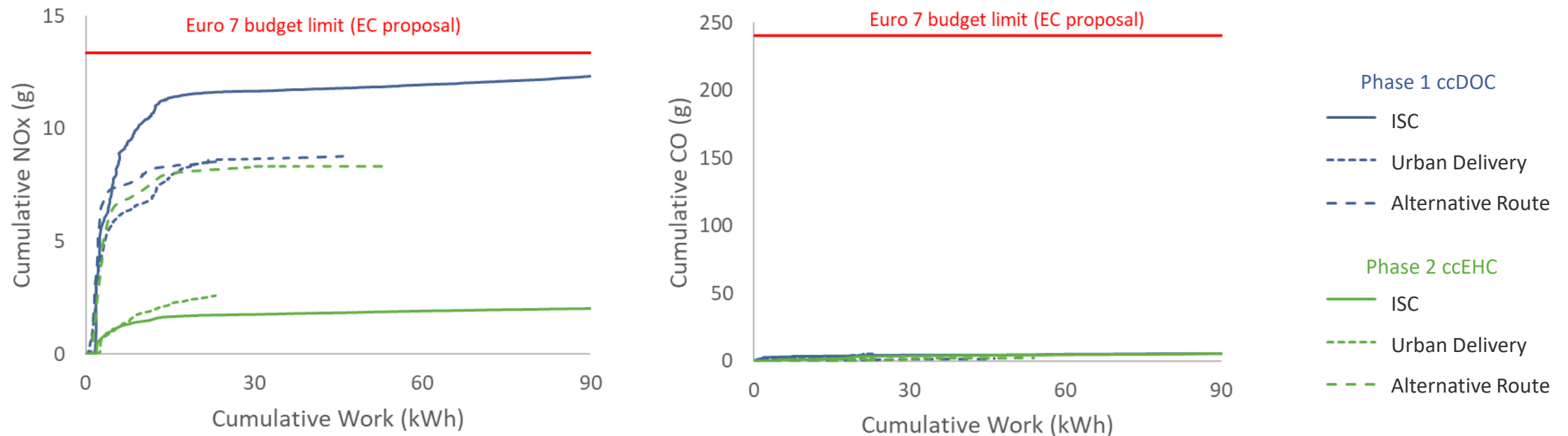
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https://www.youtube.com/channel/UCbPS9op5ztLqrv6zIMH_IcQ



All data is below the proposed emission budget limit

➤ Gaseous pollutants

- All data shown is with empty SCR at the start of the test
- NOx emissions are highest challenge
- All data is significantly below the limit for CO, NH₃ and N₂O

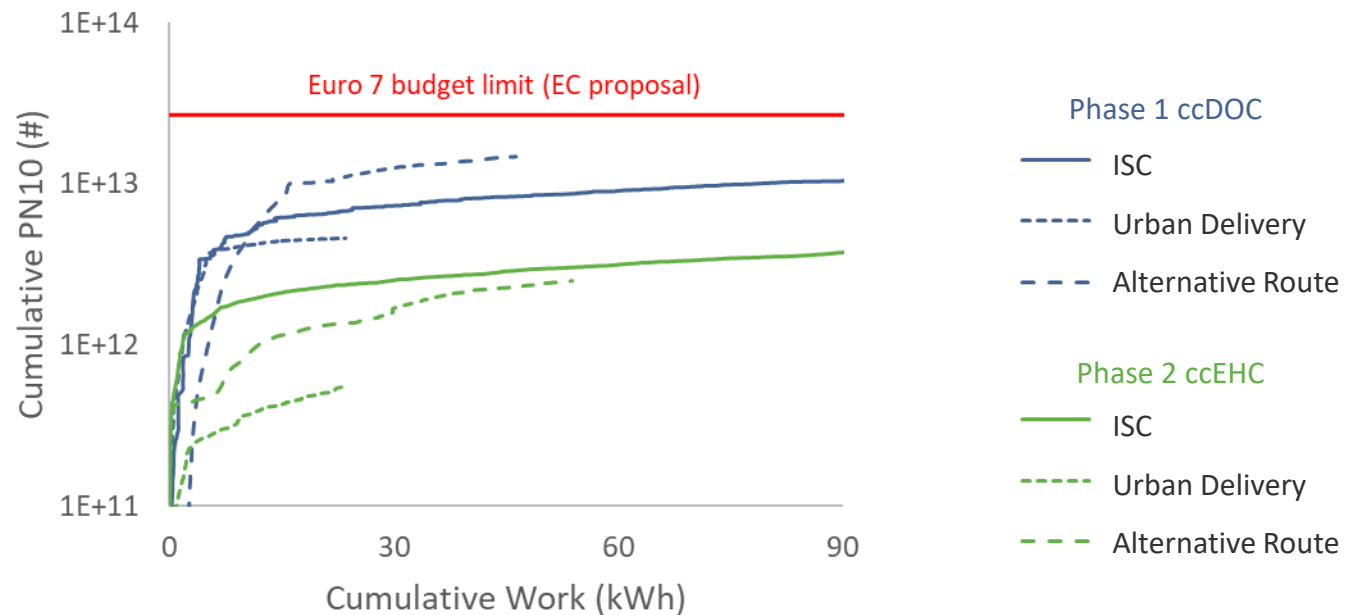


Note: Hot WHTC reference value used is 29.7 kWh

All data is below the proposed emission budget limit

➤ Particulates

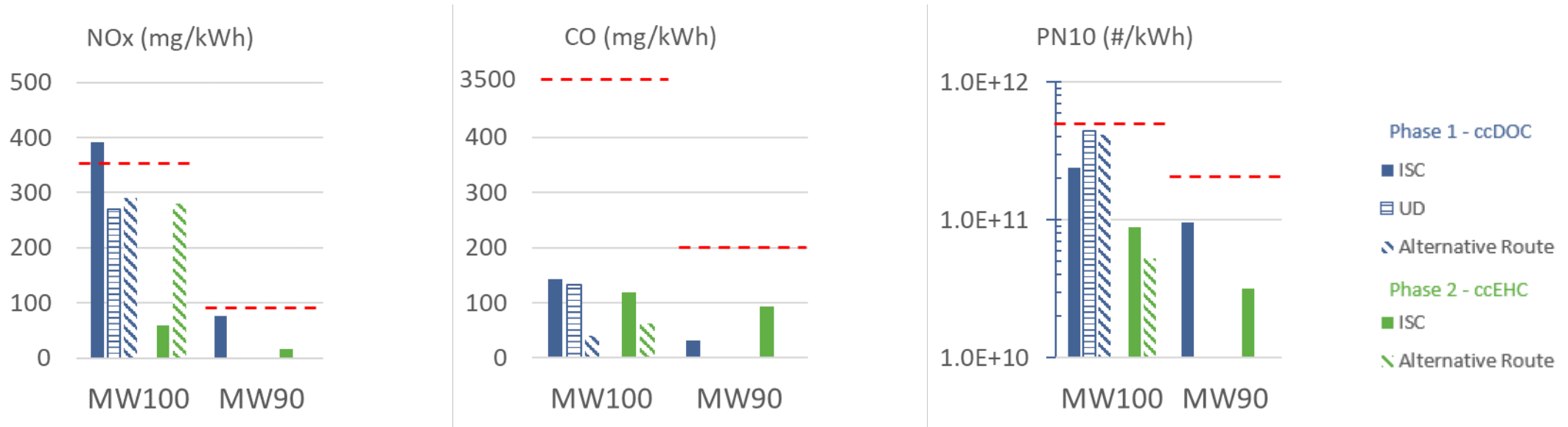
- All data shown is with partially regenerated filter at the start of the test
- All tests are below the limit
- Data indicates lower PN10 with ccEHC, but no repetitions available to further investigate



Note: Hot WHTC reference value used is 29.7 kWh

All phase 2 data is below the proposed MW90/100 limits

- All data shown is with empty SCR and partly regenerated filter at the start of the test
- All tests from phase 2 with ccEHC remain below the limits for NO_x
- All tests from both phases remain below the limits for CO, NH₃, N₂O and PN10



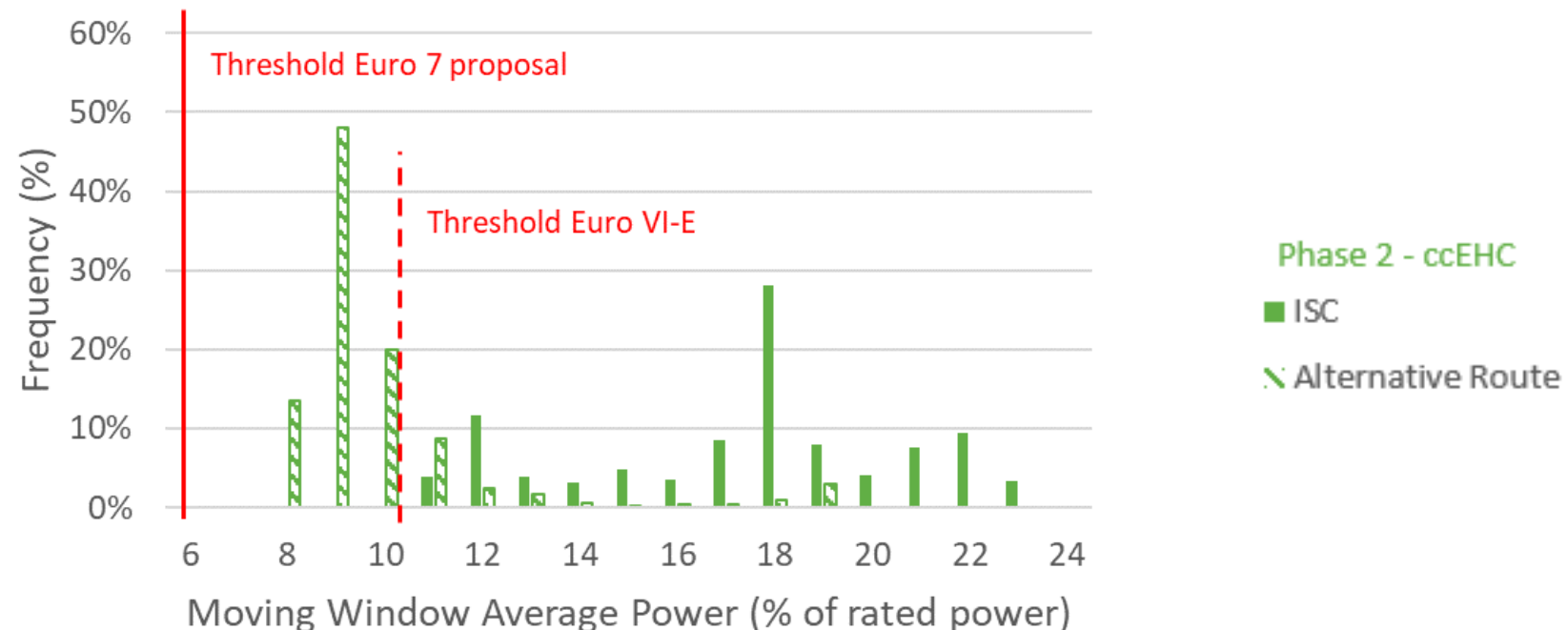
Note 1: only ISC reaches the 3xWHTC work threshold

100th percentile is calculated for tests where at least 1 window is available (as if it would be part of a longer test)

Note 2: Hot WHTC reference value used is 29.7 kWh, window specific emissions calculated based on actual cumulated work

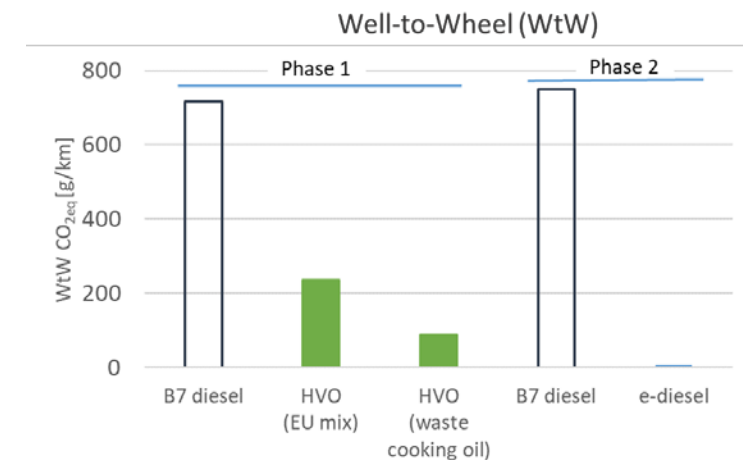
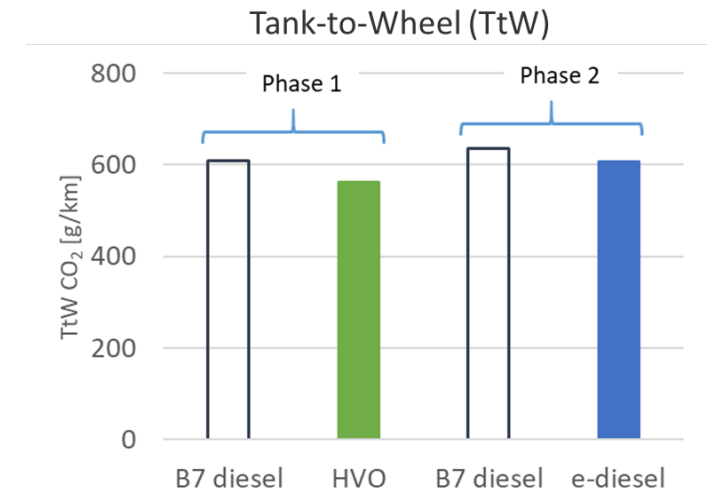
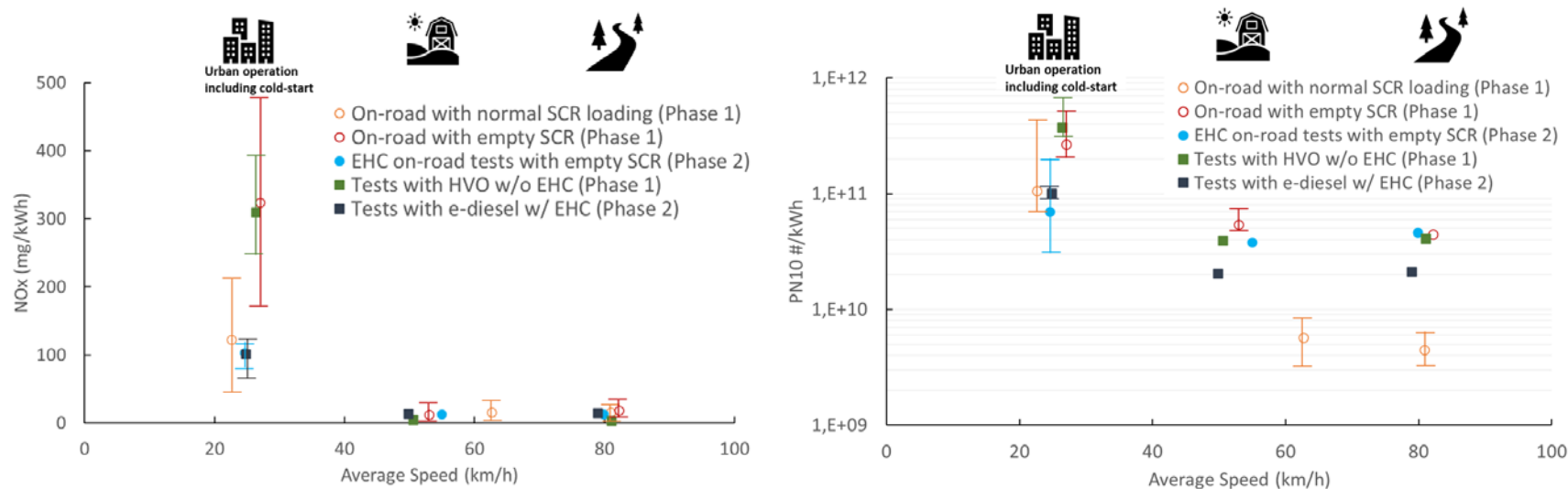
Moving Window method considers all data measured

- Average power for each Moving Window is higher than the proposed 6% threshold
- Low load tests cover significant amount of data below the Euro VI-E 10% threshold



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 CO₂ reduction
- E-diesel has the potential to nearly eliminate WtW CO₂ 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

- An advanced emission control system was implemented on a demonstrator diesel truck, including
 - A catalyst in close-coupled position in combination with an electrically heated catalyst
 - Dual-SCR with twin urea-dosing system
 - Catalysed particulate filter
- Ultra-low gaseous and particulate emissions were demonstrated over a broad range of driving conditions
 - Significant reduction of initial cold-start peak
 - Near-zero emissions after initial cold-start
- Ultra-low pollutant emissions were confirmed on HVO and e-diesel enabling significant reductions in WtW CO₂ emissions



THANK YOU !



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