Heavy-duty Euro 7 update and AECC demonstration programmes

Int. Symposium of Low Emissions and Fuel Efficient Technologies to Meet China 7 Requirements • 26 March 2024 • Chengdu

AECC represents European Emissions Control Companies

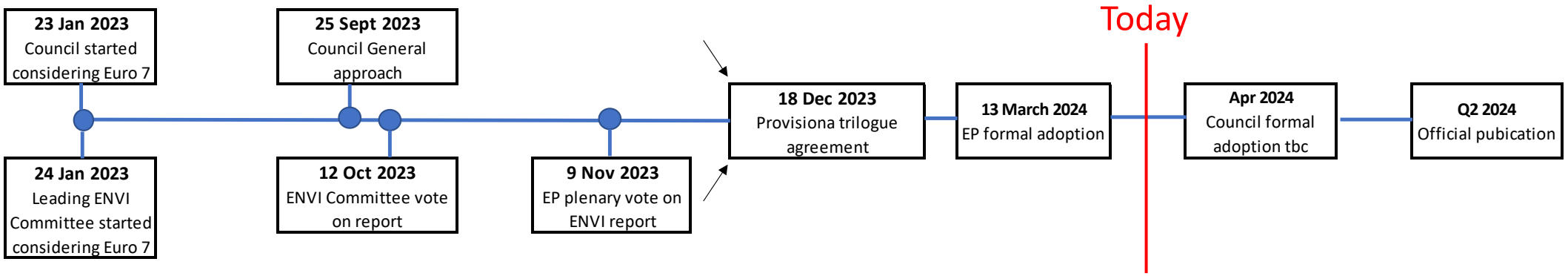
- Exhaust emissions control technologies for original equipment, retrofit and aftermarket for all new cars, commercial vehicles, motorcycles, and non-road mobile machinery
  - AECC is listed in EU Transparency Register (# 78711786419-61) and has consultative status with the UN Economic and Social Council (ECOSOC)

Agenda

- Heavy-duty Euro 7 update
- AECC heavy-duty diesel demonstration programme
  - Criteria pollutants with state-of-the-art emission control systems
  - GHG emissions with sustainable renewable fuels
  - Conclusions
- Outlook
  - HD CO_2 review and CO_2 neutral fuels
  - H_2 ICE (Internal Combustion Engine)
  - NRMM (Non-Road Mobile Machinery)

Overview of ongoing Euro 7 process

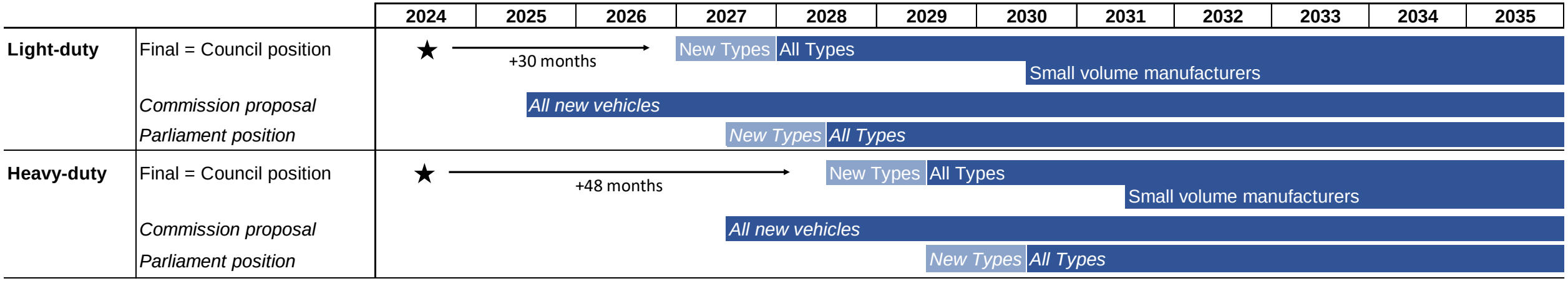
- Euro 7 proposal is in ordinary legislative procedure by EU Council and European Parliament
  - Provisional trilogue agreement reached on 18 December 2023 (Council and EP press release)
  - Final draft text is available on the Council website here
  - Formal adoption ongoing before EU elections (June 2024)



- Implementing legislation development by European Commission reconvened in Q1/2024
  - Drafting by European Commission DG GROW and DG JRC
  - Consulting stakeholders in AGVES (Advisory Group on Vehicle Emissions Standards) meetings
  - Little development needed for exhaust because Euro 6/VI test procedures are nearly kept

Euro 7 implementation timeline

- Reference to entry into force of main act
- Entry into force is 20 days following publication in Official Journal



* Assuming entry into force in July 2024

** Implementation timing for new systems, components or separate technical units is same as New Types

Euro 7 for heavy-duty vehicles

- Significant reduction of limit values
  - ~50% reduction for already regulated pollutants
  - New limits introduced for NH_3 and N_2O
- PN10 measurement procedure instead of PN23
- Test procedures nearly kept from Euro VI-E
  - MAW low power threshold is reduced from 10% to 6%

	WHSC/WHTC (/kWh)	RDE (/kWh)
NOx (mg)	200	260
PM (mg)	8	-
PN (10 nm, #)	$6x10^{11}$	$9x10^{11}$
CO (mg)	1500	1950
NMOG (mg)	80	105
NH_3 (mg)	60	85
CH_4 (mg)	500	650
N_2O (mg)	200	260

- Durability is extended
  - Main lifetime up to 300 000 km or 8 years (Cat. 1), 700 000 km or 12 years (Cat. 2)
  - Additional lifetime up to 375 000 km or 10 years (Cat. 1), 875 000 km or 15 years (Cat. 2)
    - Durability multiplier for gaseous pollutant emissions tbc by 31 December 2025

Cat. 1: N2, N3<16t, M3 <7.5t
Cat. 2: N3>16t and M3>7.5t

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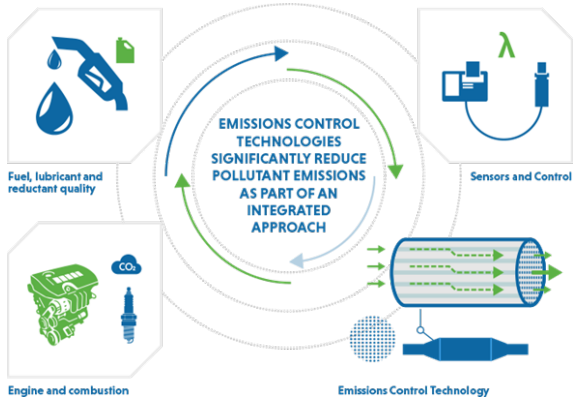
AECC demo data on criteria pollutants and GHG emissions

- Demonstrators show ultra-low pollutant emissions with emission control technologies in an integrated approach
- Tests show compatibility with drop-in sustainable renewable fuels, with substantial reduction in WtW CO_2 emissions
- Acknowledgement of external project partners



IPA IAV Concawe

IPA IAV DENSO CATALER BOSCH aramco PORSCHE

IPA FEV BASF We create chemistry CORNING cefic sector group NESTE aramco

AGU Sector Group

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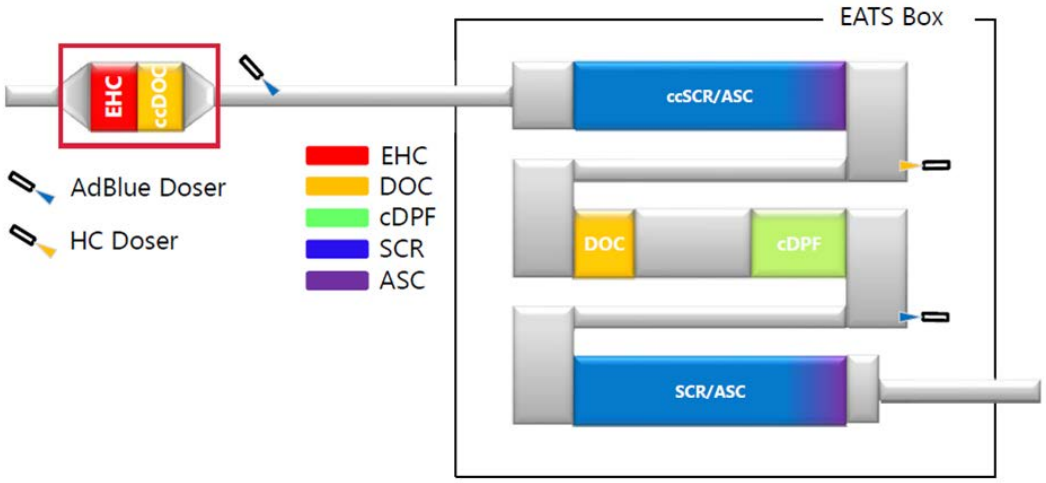
HD diesel demonstrator concept

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



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
P. Mendoza Villafuerte, et al.; "Future-proof heavy-duty truck achieving ultra-low pollutant emissions", Transportation Engineering, Volume 9, September 2022, 100125, 2022

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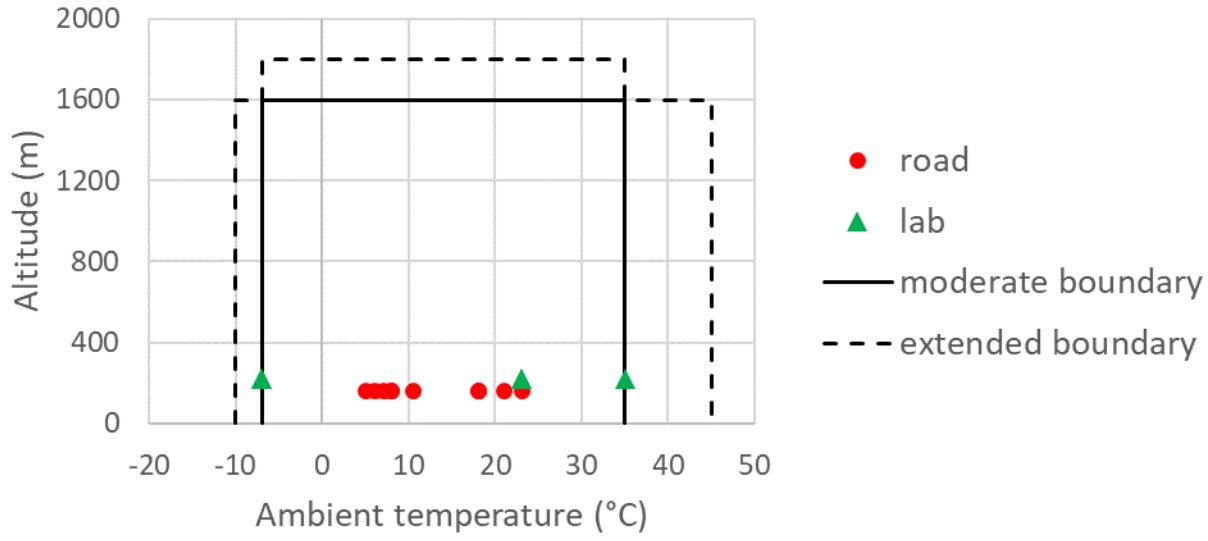
Focus was on low load and challenging cold-start

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

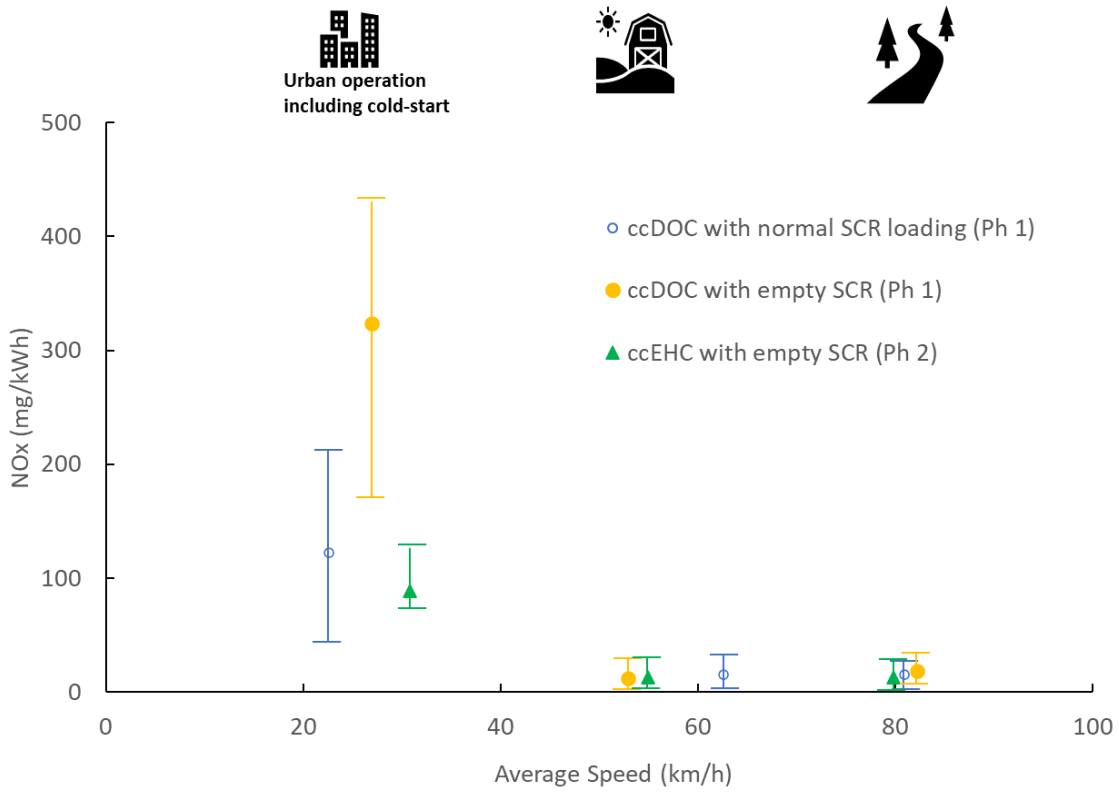


Test type	Test	Project phase
Road	In-Service Conformity (ISC)	ccDOC and ccEHC
	Urban Delivery (UD)	
	Alternative Route	
Lab	Real-World Test	ccDOC
	Urban Delivery	
	JRC RDE	
	TU Graz low-load	

Reduction of initial cold-start emissions with EHC

- Significant improvement of urban emissions including cold-start compared to Euro VI-D in phase 1 of the project
- 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 further 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



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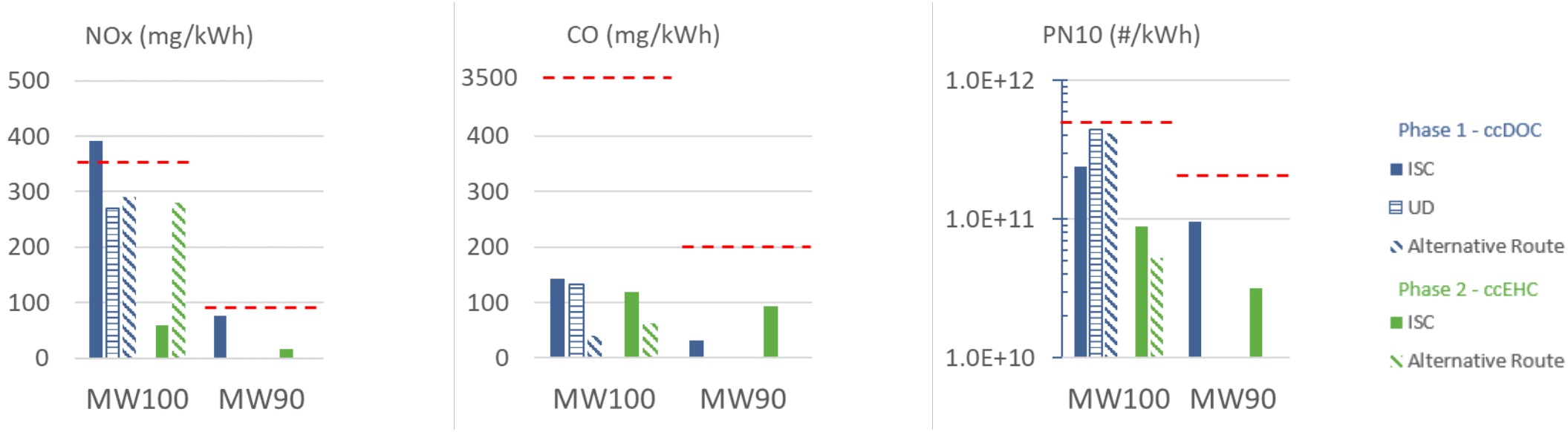
All phase 2 data is below the original Euro 7 proposal limits

- 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 NOx
- All tests from both phases remain below the limits for CO, NH_3, N_2O 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

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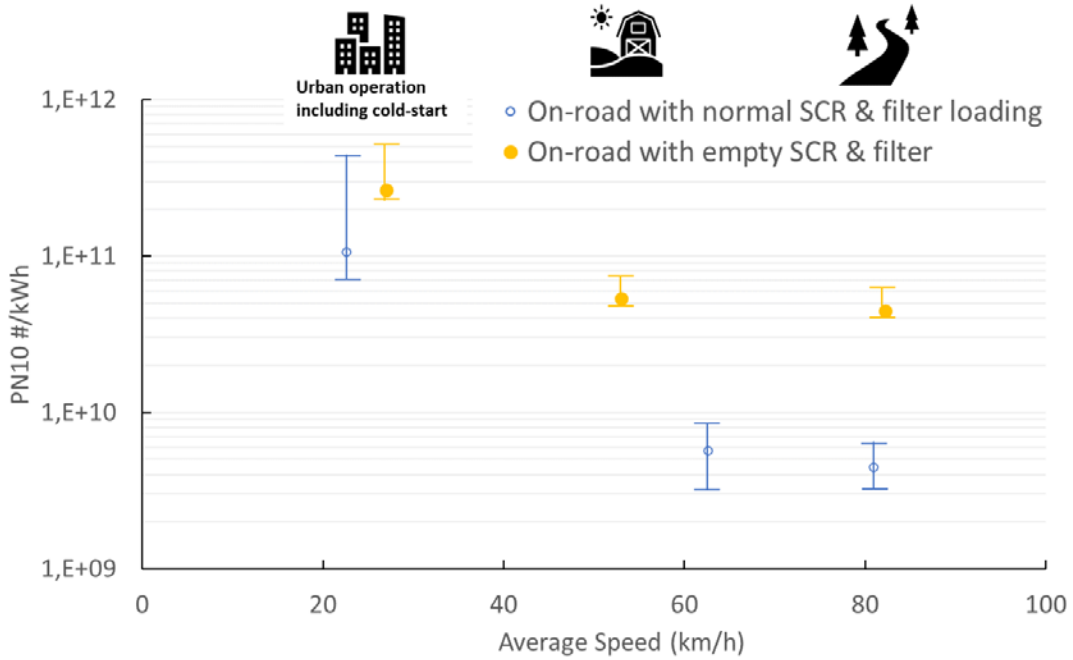
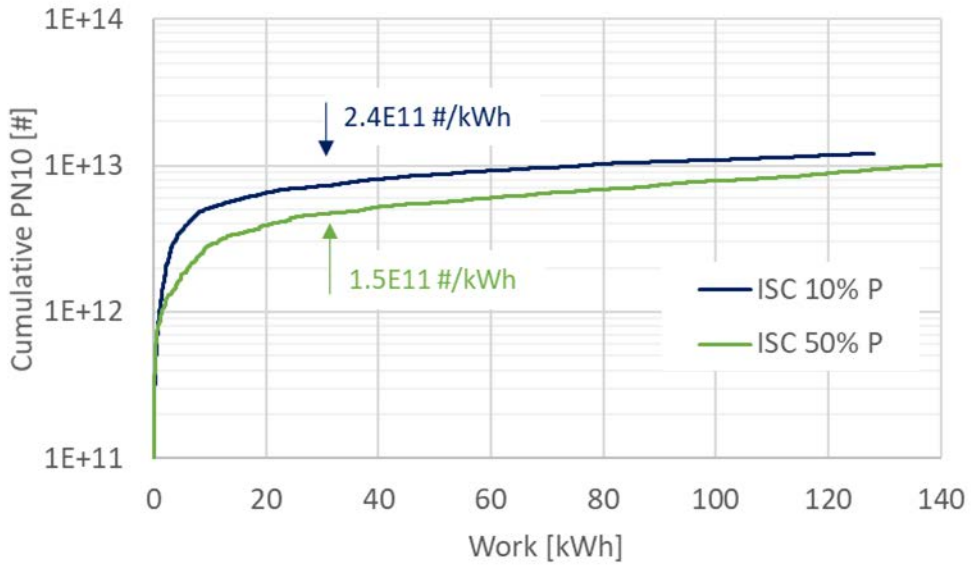
Good control of particulate emissions

- Low PN10[1,2] emissions are achieved at urban delivery and in service conformity trips[3]
- Temperature, payload and trip profile can impact these emissions





[1] The results are reported as measured
[2] Test conducted are not covering all possible critical conditions for PN
[3] Tests were conducted with empty SCRs' ammonia storage and passively regenerated DPF unless indicated otherwise. ISC 10% PL conducted at 21°C, ISC 50% PL conducted at 18°C

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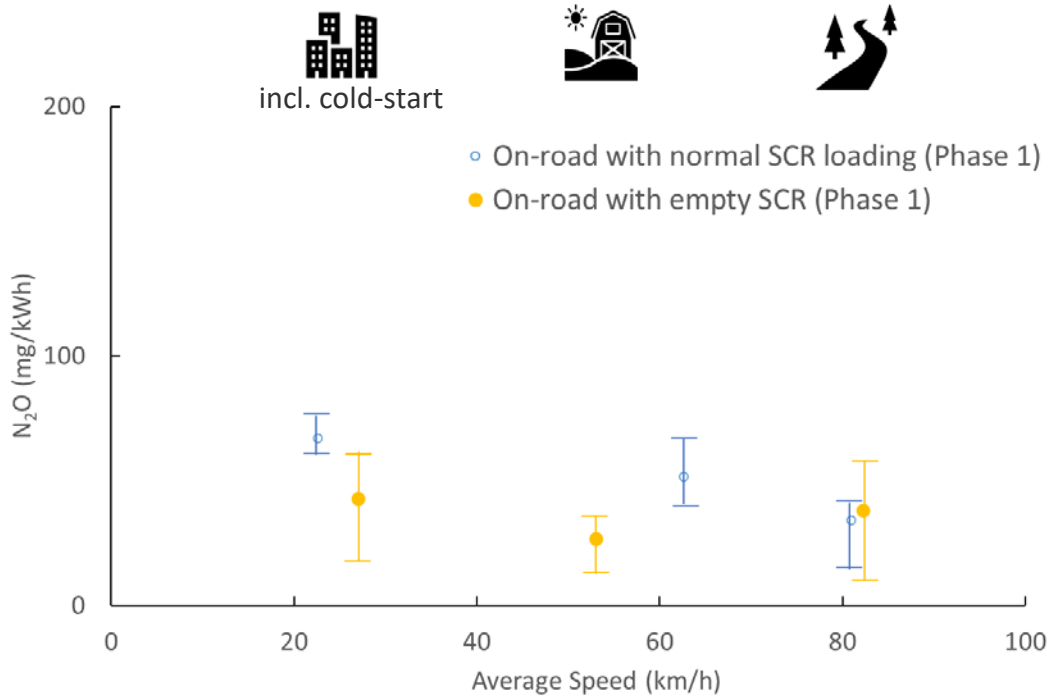
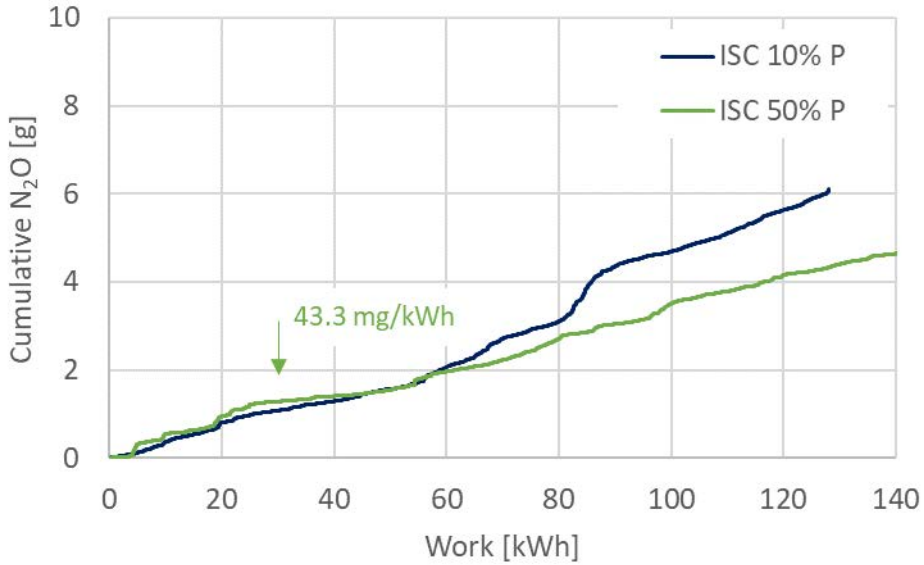
Good control of non-regulated emissions

- N_2O emissions are kept to low levels
- Near-zero NH_3 emissions have been achieved due to the AdBlue® dosing control in combination with the implementation of an ASC after each SCR





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Near-zero emissions within 2 km after motorway cold-start

See video at https://youtu.be/LAMV3RZCTB0

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

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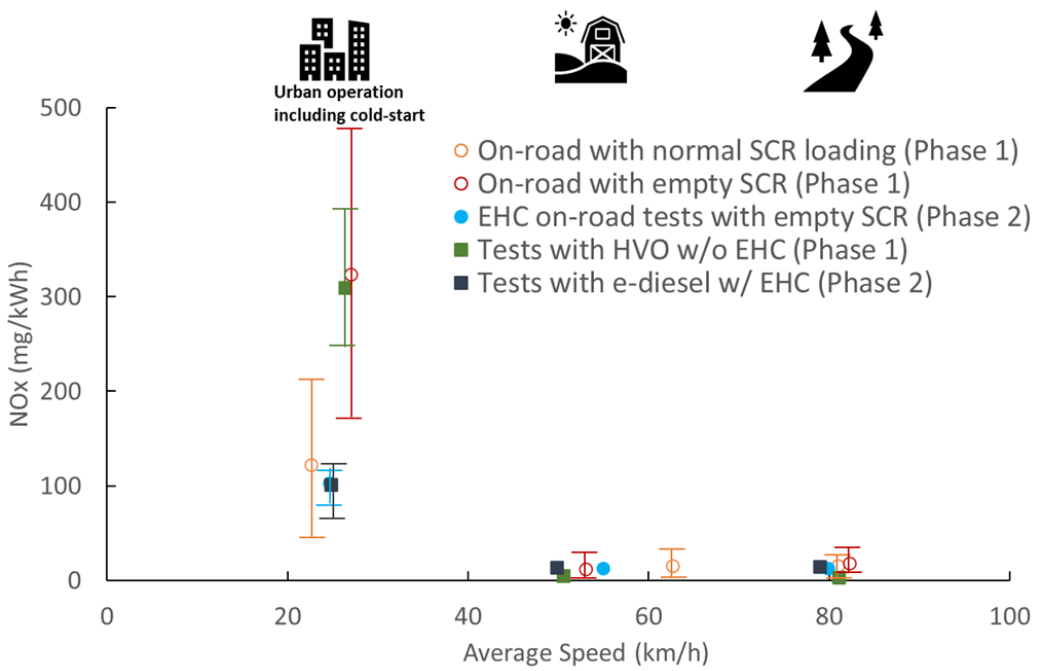
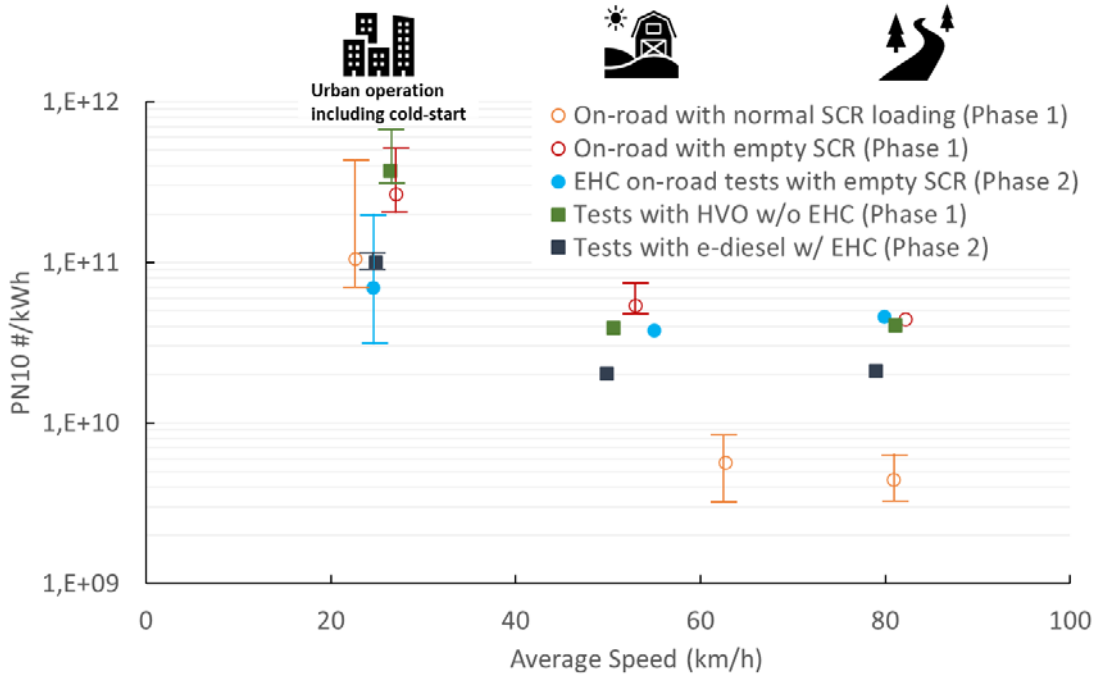
HD diesel demonstrator with sustainable renewable fuels

- Ultra low-pollutant emissions confirmed on HVO and e-diesel





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

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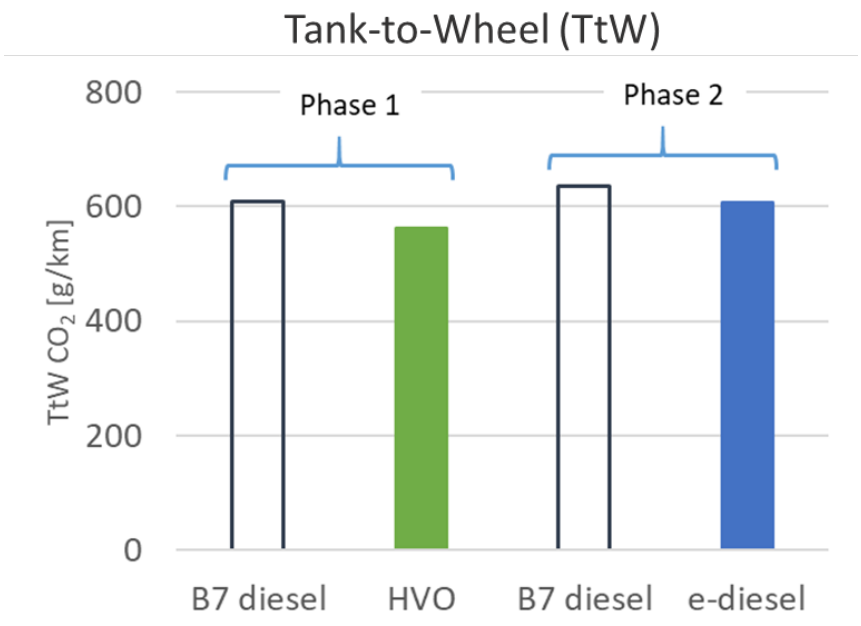
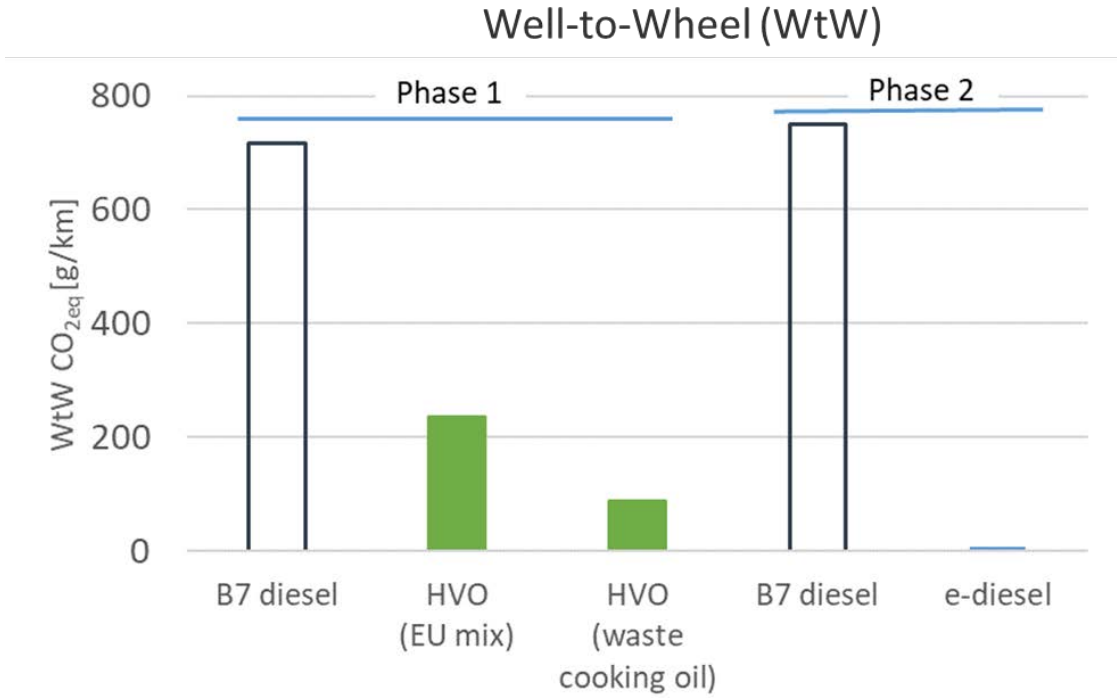
HD diesel demonstrator with sustainable renewable fuels

- HVO already offers today up to 90% WtW CO_2 emissions 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

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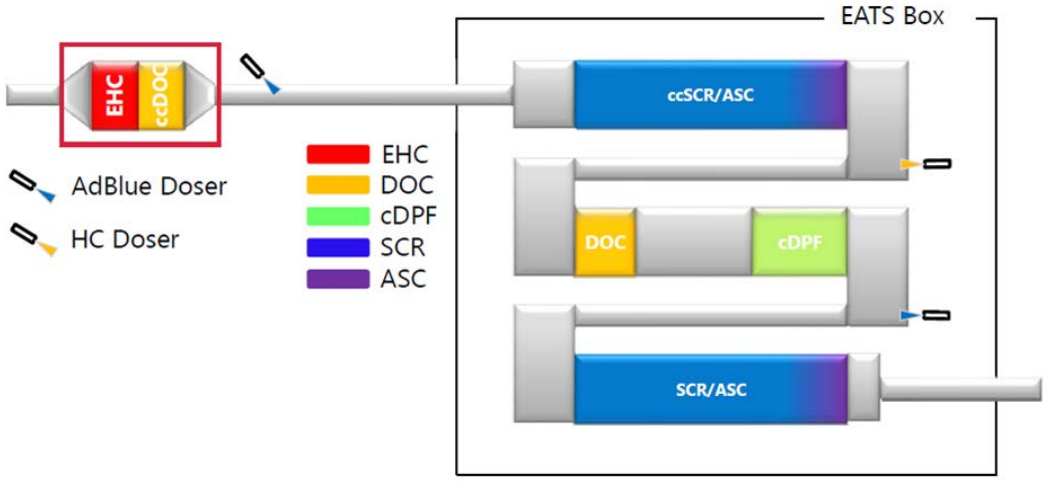
Conclusions

- Available emission control technologies used
  - Close-coupled layout
  - Active thermal management
  - Dual-dosing SCR with ASC
  - Catalysed DPF



- Ultra-low gaseous and particulate emissions are technically feasible under real-world driving conditions
  - Significant reduction of initial cold-start peak
  - Near-zero emissions after initial cold-start peak

- In combination with near-zero Well-to-Wheel CO_2 emissions using sustainable renewable fuels

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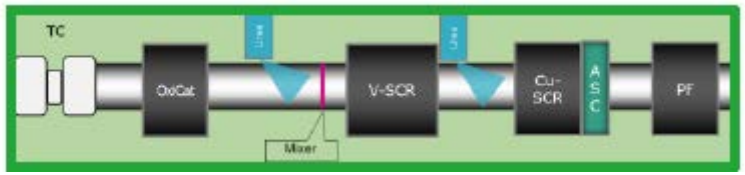
Heavy-duty CO_2 review and CO_2 neutral fuels

- European Parliament and Council reached provisional trilogue agreement on 18 January 2024
  - CO_2 reduction targets
    - -45% from 2030, -65% from 2035, -90% from 2040
    - Urban buses: -90% by 2030, -100% by 2035; inter-urban buses are exempted
    - -7.5% for trailers and -10% for semi-trailers, from 2030
  - Review of the regulation is requested in 2027
    - Expansion of the scope to small lorries
    - Role of a Carbon Correction Factor (CCF) in the transition towards zero-emission HDVs
- Formal adoption process is ongoing
  - Recital 13b added on CO_2 neutral fuels

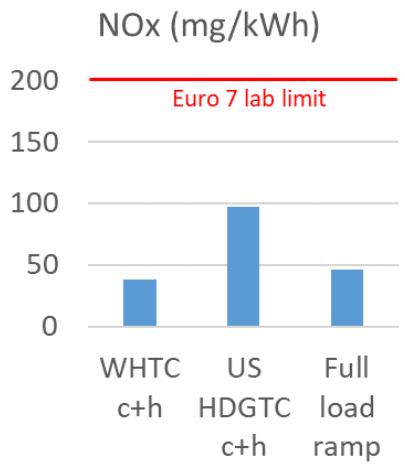
> *(13b) Following consultation with stakeholders, the Commission will, within a year from entry into force of this regulation, assess the role of a methodology for registering HDV exclusively running on CO_2 neutral fuels, in conformity with Union law and with Union climate neutrality objective;*

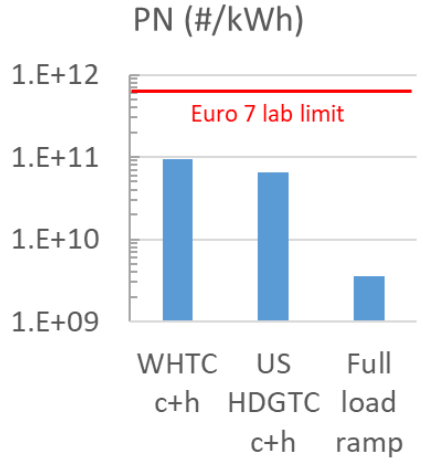
H_2 ICE (Internal Combustion Engine)

- Type approval procedures are being adopted at UNECE for HD and NRMM
- AECC is looking into emission control requirements
  - Publications will follow in 2024 from demo project of Aramco and ActBlue France at AVL
    - System investigated



    - All results are below Euro 7 limits

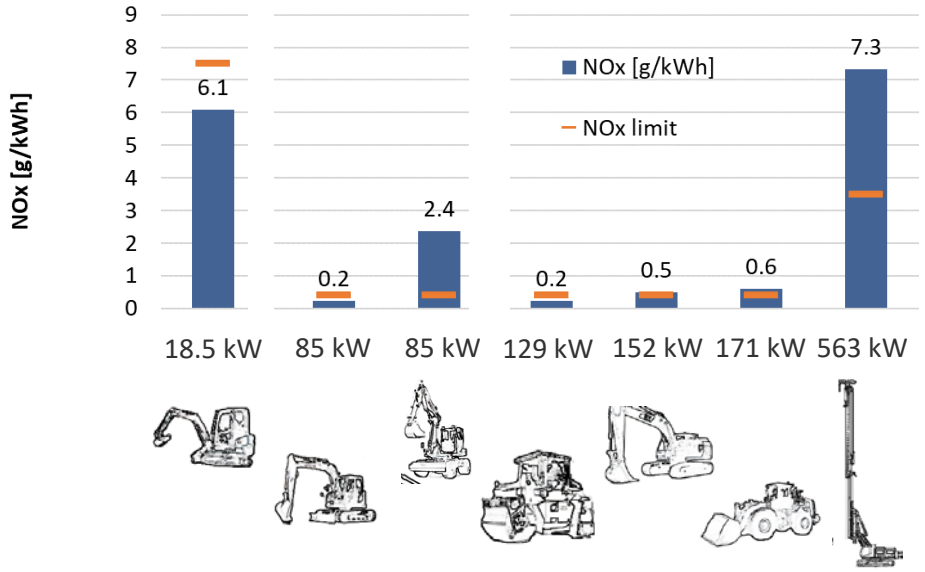


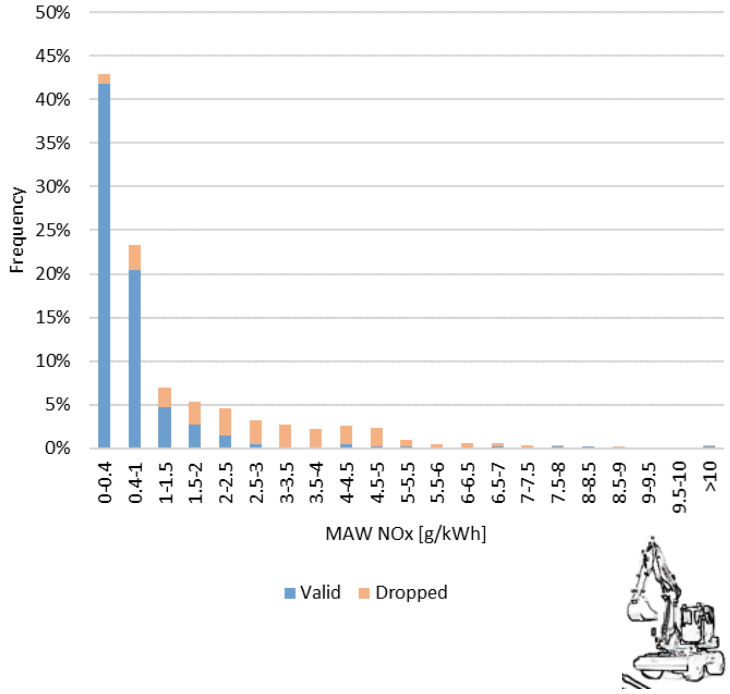


NRMM: Non-Road Mobile Machinery

NRMM (Non-Road Mobile Machinery)

- AECC is looking into demonstration activities
- AECC and TNO looked at real-world NOx emissions of Stage V machines in the field
  - Large variation in average real-world NOx emissions
  - NRMM regulation does not consider a substantial share of the real working conditions





R. Vermeulen, et al.; "Real-World NOx emissions of Stage V NRMM", Transport and Air Pollution Conference, 2023

THANK YOU

www.aecc.eu
@AECC_eu
AECC (Association for Emissions Control by Catalyst)
AECC eu

Additional references

- AECC fact sheet on myths and truths about Euro 7
- Implementation of available and affordable emission control systems
  - Cost assessment of engineering houses
    - LD demo vehicles
    - HD demo vehicle
  - Provided as input to European Commission impact assessment
- Emission control systems are designed for minimised impact on backpressure
  - See Q&A document of AECC-IPA Technical Seminar on Euro 7