Towards zero-impact emissions for LDV and HDV demonstrators with advanced emission controls and sustainable renewable fuels

Dirk Bosteels

ECMA 15th International Conference • 22-23 October 2024 • New Delhi

AECC is now the Association for Emissions Control and Climate

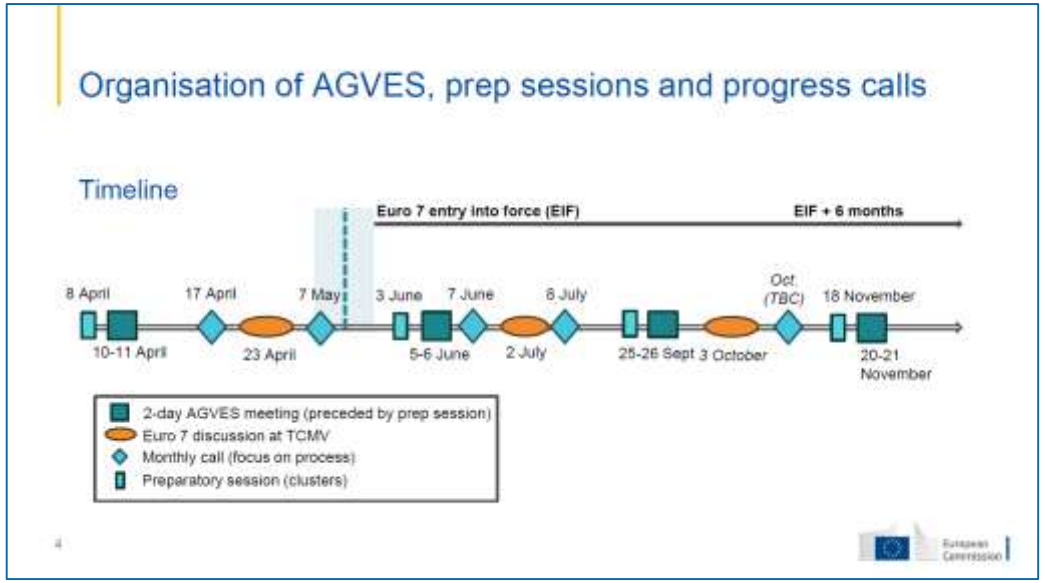
- AECC expands its scope
  - Air quality and **climate** requirements
  - Mobile and **stationary** emissions sources
  - Sustainable **components and systems**, including
    - Catalysts
    - Filters
    - Adsorbers
    - Fuel cells
    - Electrolysers
- AECC is listed in EU Transparency Register (# 78711786419-61) and has consultative status with the UN Economic and Social Council (ECOSOC)

Agenda

- Euro 7 update
- AECC demonstration programmes
  - Light-duty diesel and gasoline passenger car
  - Heavy-duty diesel truck
  - Conclusions
- Outlook
  - CO_2 reviews and CO_2 neutral fuels
  - Life Cycle Assessment

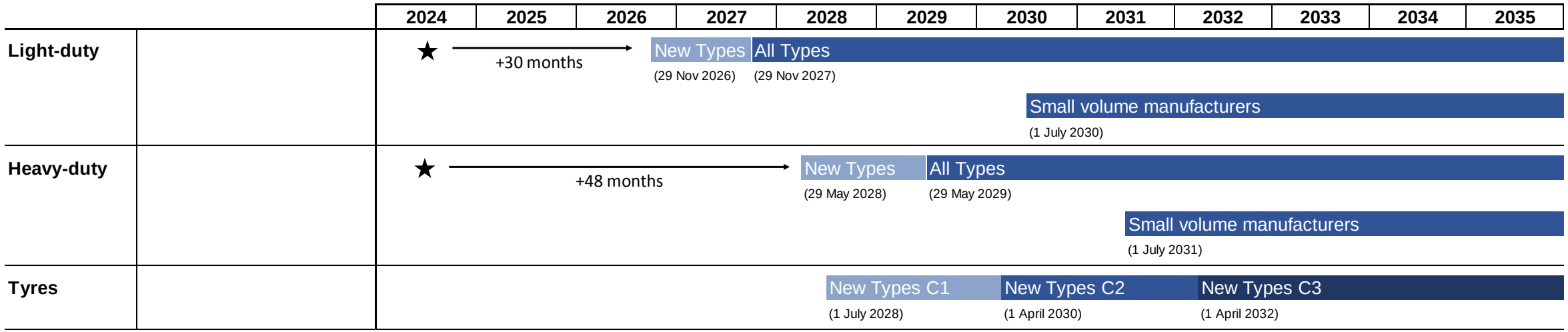
Overview of ongoing Euro 7 process

- Euro 7 regulation published in EU Official Journal on 8 May 2024
- Implementing legislation being developed by European Commission
  - Drafting by European Commission's DG GROW and DG JRC
  - Consulting stakeholders in Advisory Group on Vehicle Emissions Standards (AGVES) meetings
  - Little development needed for exhaust as Euro 6/VI test procedures are nearly kept
  - Content of several topics is developed at UNECE (e.g. battery durability, brakes, tyres, …)



Euro 7 implementation timeline

- Provisional trilogue agreement included relative reference to entry into force of main act
- Final implementation dates are known following publication in Official Journal



Reflection on Euro 7 discussion for light-duty vehicles

- Influenced by CO_2 emissions standards
  - Setting -100% tailpipe target by 2035
  - But even then, ICE will be on the road until 2050
  - All powertrains to fulfill future air quality requirements
- Too much focus on worst case conditions
  - Due to wording ‘any’ for test conditions in Euro 7 proposal
- AECC fact sheet on myths and truths

  https://www.aecc.eu/wp-content/uploads/2023/09/2023-08-31-AECC-Factsheet.pdf

Myths and truths about
Euro 7 pollutants limits for new vehicles in the EU

Every new vehicle sold in the next decades should play its part in reducing air pollution. The robust Euro 7 rules proposed by the European Commission put EU citizens' health first and will keep the automotive sector competitive globally.

Euro 7 is ~~un~~necessary

All EU citizens will benefit: an upgrade to Euro 7 reduces health risks caused by vehicle traffic. Each € invested in Euro 7 results in a reduction of 5€ on healthcare and environment costs.

Keeping Euro 6/VI is not sufficient.
20% of distance driven in Europe is outside current test boundaries. Wider Euro 7 test methods will better capture emissions resulting from driving in different conditions.

Euro 7 limits are ~~not~~ feasible

The necessary emission control technology is already available and has been tested successfully with vehicles on the road.

Fitting the latest emission control technology can reduce truck NOx emissions by 75-96% compared to Euro VI-C and NOx from a gasoline car by 40-64% from Euro 6d.
Vehicle manufacturers are already developing new vehicles with more stringent limits than Euro 6/VI in mind.

Euro 7 will ~~not~~ make Europe competitive

China and the United States are moving ahead with more stringent standards than Euro 6/VI. Europe cannot stay behind if it wants to remain competitive.

Investing in Euro 7 comes at incremental cost of 0.6-5.7 billion euro compared to the 59 billion euro each manufacturer is expected to invest in electrification, connectivity and automation by 2050.

Euro 7 is ~~not~~ affordable

Cars and trucks will remain affordable as equipping them with new emission control technologies comes at a very small proportion of the cost of a new vehicle.

Studies on the impact of Euro 7 estimate the additional cost of new cars to be between 104-251€ compared to Euro 6d.
Contrary to some claims, Euro 7 vehicles will not need to comply with all possible driving situations, hence automatic gearboxes and hybridisation technologies should not be counted among the cost to adapt to the new standards.

AECC IPA

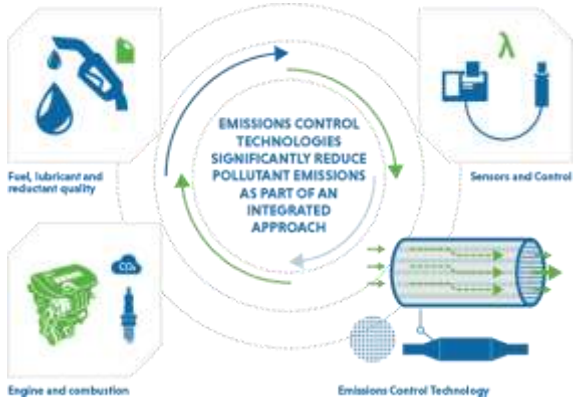
Discover the full Euro 7 fact list and what technology can deliver.

Agenda

- Euro 7 update
- AECC demonstration programmes
  - Light-duty diesel and gasoline passenger car
  - Heavy-duty diesel truck
  - Conclusions
- Outlook
  - CO_2 reviews and CO_2 neutral fuels
  - Life Cycle Assessment

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

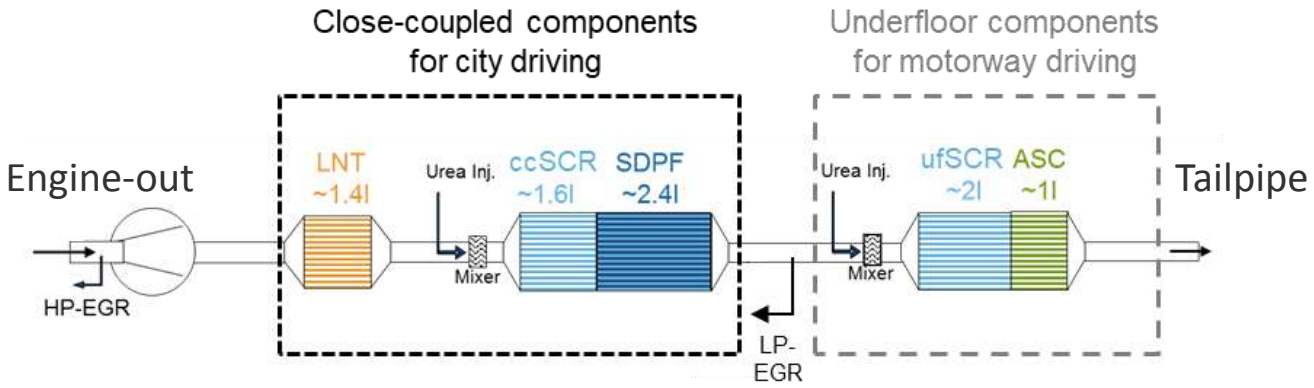
IPA FEV BASF cefic NESTE aramco

AGU Sector Group

LD diesel demonstrator concept

- Base vehicle
  - C-segment vehicle
  - 1.5l engine with 4 cylinders
  - 48V mild-hybrid system
  - Euro 6b type-approval

- Emission control system
  - LNT + dual-SCR + DPF
  - Hydrothermally aged components targeting 160k km

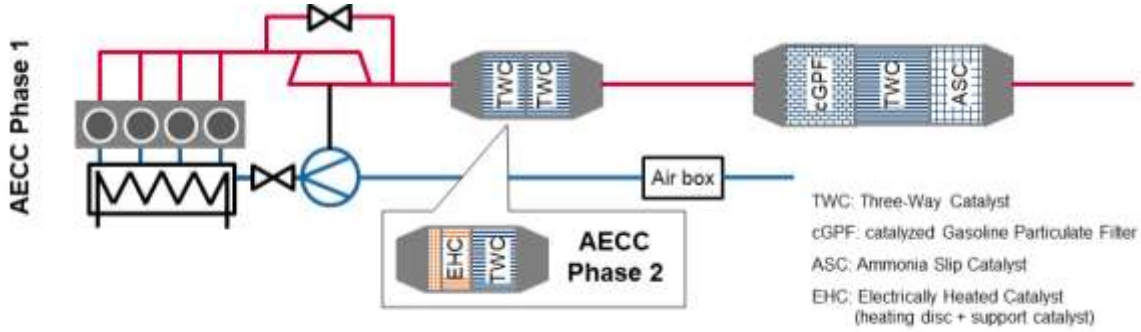


J. Demuynck, et al.; "Integrated Diesel System Achieving Ultra-Low Urban and Motorway NOx Emissions on the Road", 40th Vienna Motor Symposium, 2019
https://www.aecc.eu/wp-content/uploads/2020/07/190516-AECC-IAV-IPA-Integrated-Diesel-System-achieving-Ultra-Low-NOx-on-the-road-Vienna-Symposium.pdf
Joint MTZ publication with Bosch, Vitesco, FEV and IAV https://www.aecc.eu/wp-content/uploads/2020/09/200901-modern-diesel-MTZ.pdf
Videos of instantaneous conversion performance available at www.youtube.com/channel/UCbPS9op5ztLqrv6zlMH_IcQ

LD gasoline demonstrator concept

- Base vehicle
  - C-segment vehicle
  - 1.5l engine with 4 cylinders
  - Variable valve train and cylinder deactivation
  - 48V mild-hybrid
  - Euro 6d type-approval 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

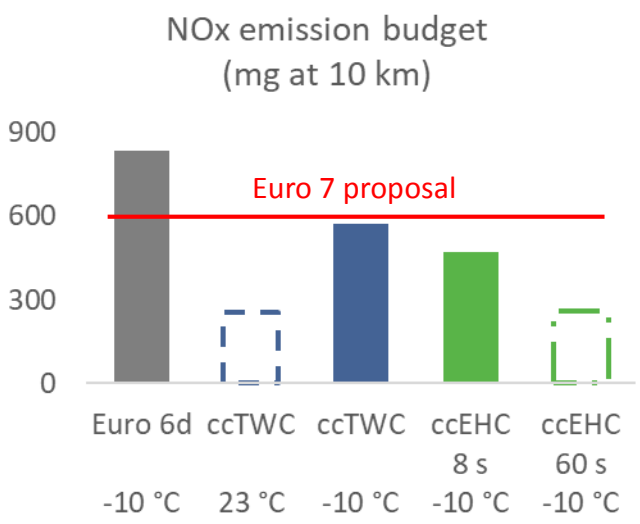


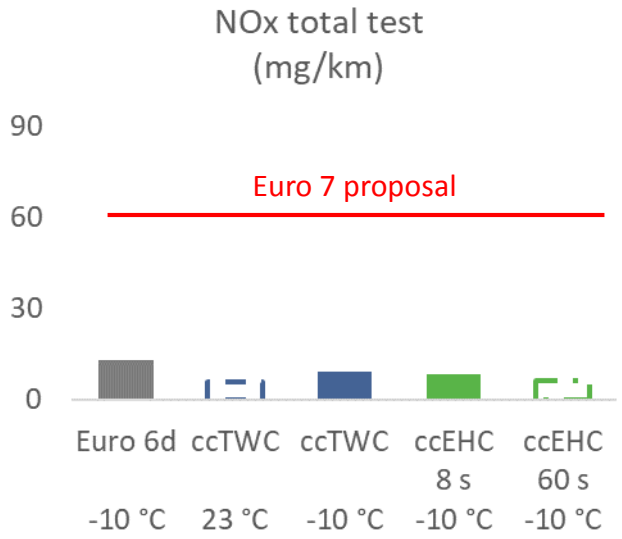
J. Demuynck, et al.; "Ultra-low Emissions of a 48V Mild-Hybrid Gasoline Vehicle with Advanced Emission Control Technologies", 15th International Conference on Engines and Vehicles, 2021
J. Demuynck, et al.; "Zero-Impact Emissions from a Gasoline Car with Advanced Emission Controls and E-Fuels" 43rd International Vienna Motor Symposium, 2022

gasoline

Gaseous emissions are mainly from initial cold-start

- Highest cold-start NOx peak remains below original Euro 7 proposal
- Near-zero emissions under warm operation on all tests
- Further potential is possible for initial cold-start NOx due to demonstrator constraints



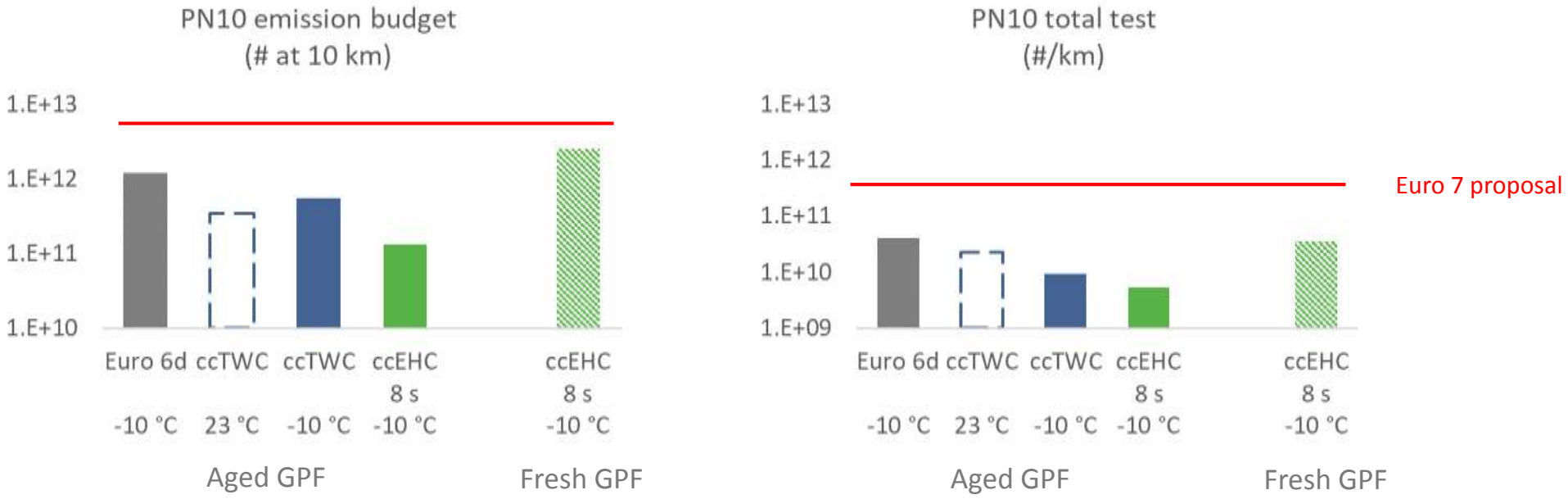


Note: RDE aggressive test results, 1.6 divider applied to data at -10 °C

gasoline

Particulate emissions are mainly from initial cold-start

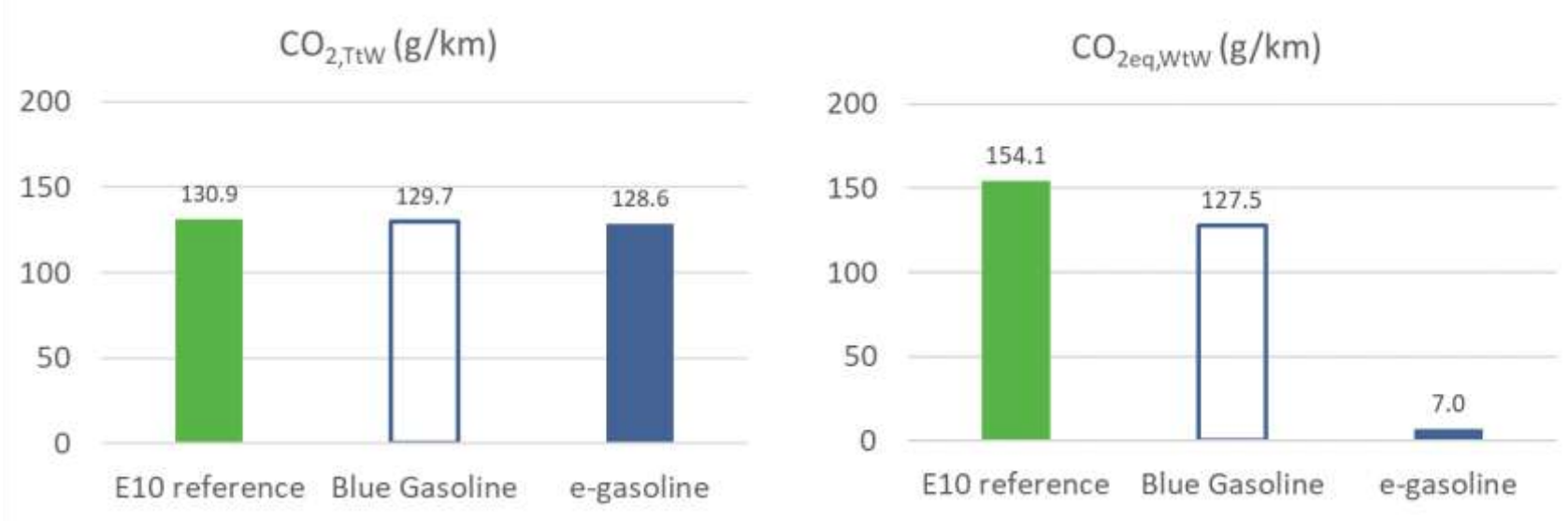
- Most data is measured with aged GPF
  - Ash and soot accumulation supports filtration efficiency
  - Test with ccEHC at -10 °C repeated with fresh GPF
- All PN10 data remains below the original Euro 7 proposal limit



Note: RDE aggressive test results, 1.6 divider applied to data at -10 °C; the fresh GPF test is not a valid test according to the Euro 7 proposal

LD gasoline demonstrator with sustainable renewable fuels

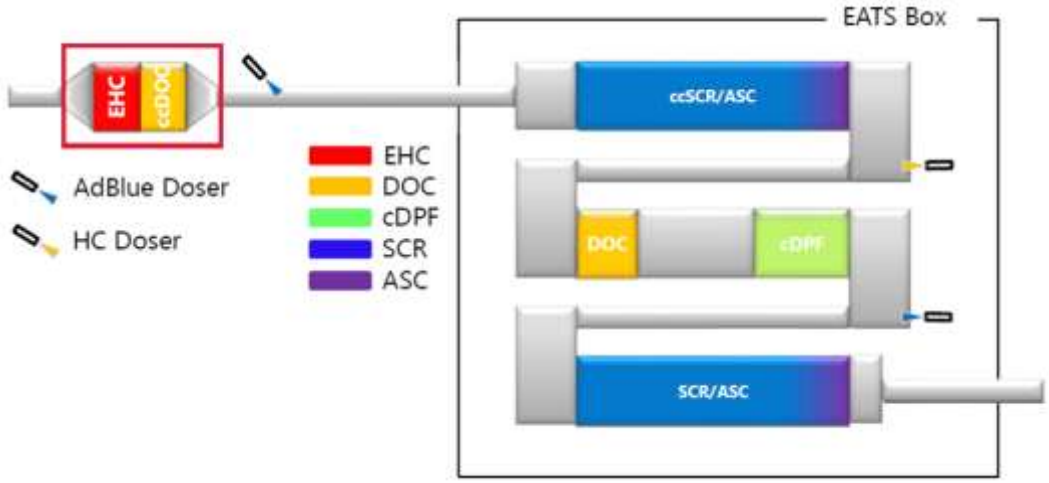
- Blue Gasoline already offers today significant reduction of -17% WtW CO_2 emissions
- E-gasoline has the potential to nearly eliminate WtW CO_2 emissions



J. Demuynck, et al.; "Zero-Impact Emissions from a Gasoline Car with Advanced Emission Controls and E-Fuels" 43rd International Vienna Motor Symposium, 2022
J. Demuynck, et al.; "Advanced Emission Controls and E-fuels on a Gasoline Car for Zero-Impact Emissions", SAE paper 2022-01-1014, 2022

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

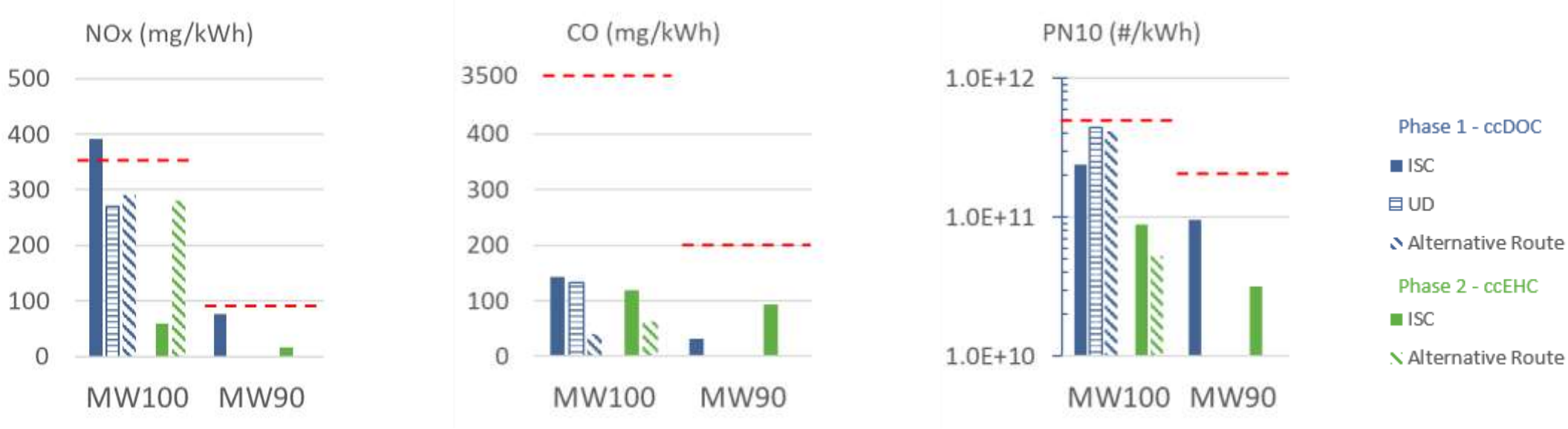


P. Mendoza Villafuerte, et al.; "Demonstration of Extremely Low NOx Emissions with Partly Close-Coupled Emission Control on a Heavy-duty Truck Application", 42nd Vienna Motor Symposium 2021
P. Mendoza Villafuerte, et al.; "Future-proof heavy-duty truck achieving ultra-low pollutant emissions", Transportation Engineering, Volume 9, September 2022, 100125, 2022

diesel

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

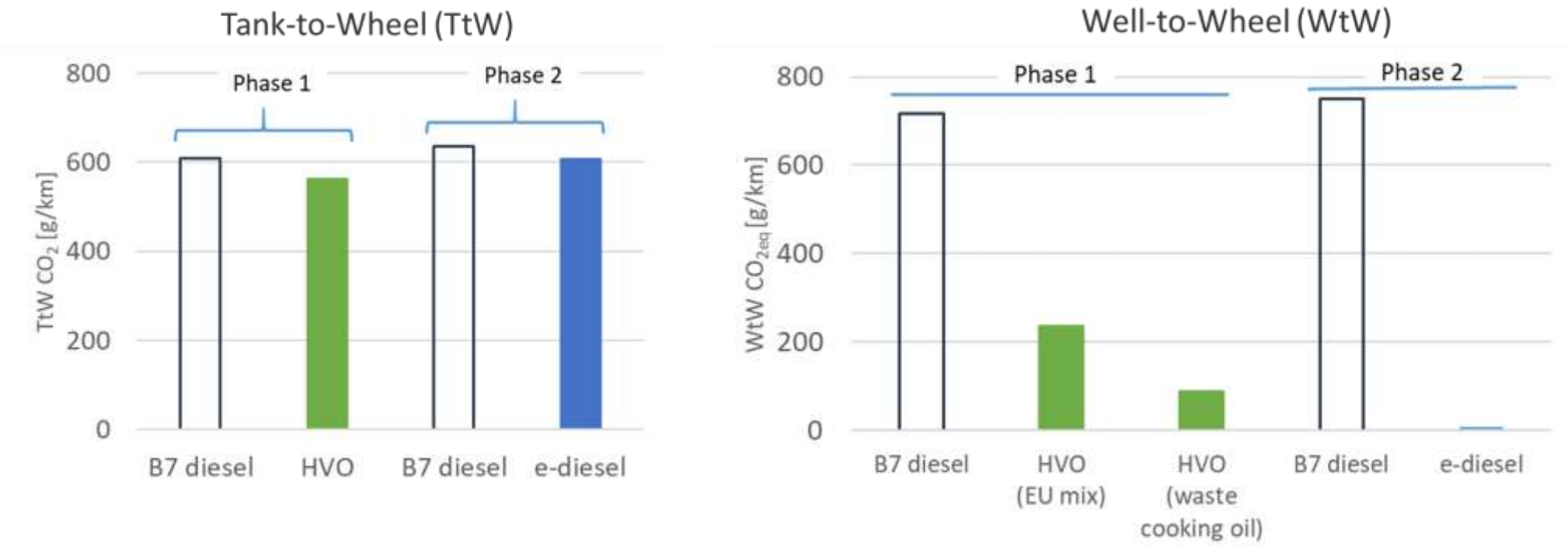
- All data shown is with empty SCR and partly regenerated filter at the start of the test
- All tests from phase 2 with ccEHC remain below the limits for NOx
- All tests from both phases remain below the limits for CO, NH_3, N_2O and PN10



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

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

Conclusions

- Available emission control technologies used
  - Active thermal management
  - Combination of close-coupled and underfloor components
  - Catalysed filters
  - Clean-up catalysts
- 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, also at low-load
- In combination with near-zero Well-to-Wheel CO_2 emissions using sustainable renewable fuels

Agenda

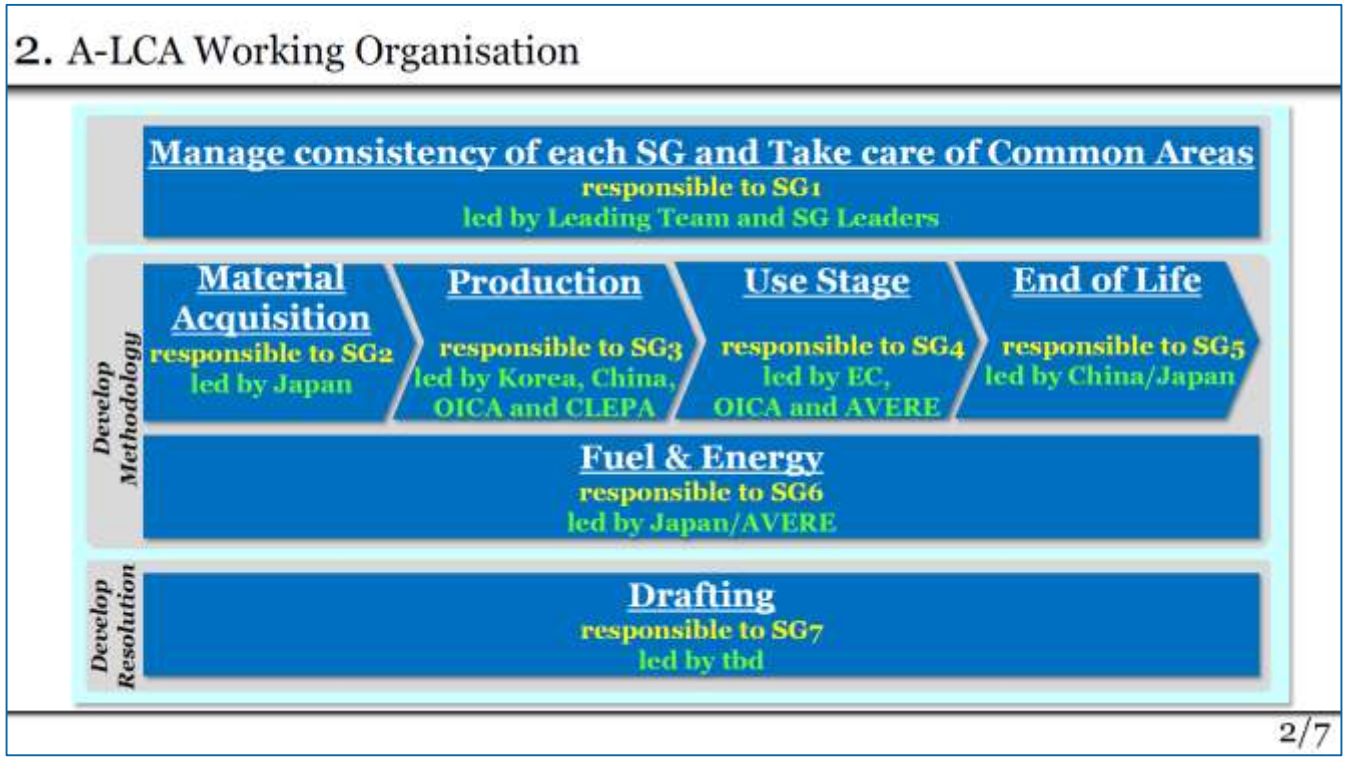
- Euro 7 update
- AECC demonstration programmes
  - Light-duty diesel and gasoline passenger car
  - Heavy-duty diesel truck
  - Conclusions
- Outlook
  - CO_2 reviews and CO_2 neutral fuels
  - Life Cycle Assessment

CO_2 reviews and CO_2 neutral fuels

- European Commission will review CO_2 legislation
  - Light-duty in 2026, starting with a progress report in 2025
  - Heavy-duty in 2027
- Development of procedures ongoing for vehicles running exclusively on CO_2 neutral fuels
  - Draft Commission proposal sent to Technical Committee on Motor Vehicles (TCMV) in Sept 2023
  - Definitions
    - Type of fuel: current draft only covers Renewable Fuels of Non-Biological Origin (RFNBO, i.e. e-fuel)
    - Minimum GHG reduction threshold: current draft requires -100% according to Renewable Energy Directive
  - Relying on OEM to ensure
    - Vehicles are equipped with a fueling monitoring and inducement system
    - Protection from tampering for the whole lifetime of the vehicle
  - Draft text also defines CO_2 emission of H_2 ICE is not to be measured
  - Discussion to follow for heavy-duty vehicles as well

Automotive Life-Cycle Assessment (A-LCA)

- AECC is part of the Informal Working Group on A-LCA at UNECE



- AECC extended its Well-to-Wheel studies to LCA (LDV and HDV)

THANK YOU

www.aecc.eu
@AECC_eu
AECC EU
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