Zero-impact emissions from a gasoline car with advanced emission controls and e-fuels

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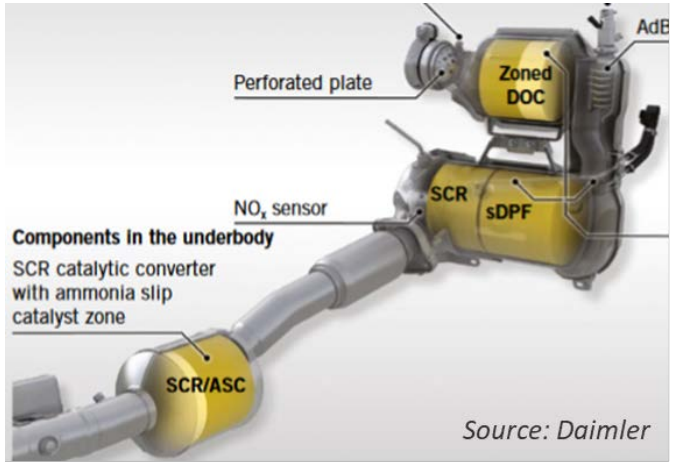
AECC
ASSOCIATION FOR EMISSIONS CONTROL BY CATALYST

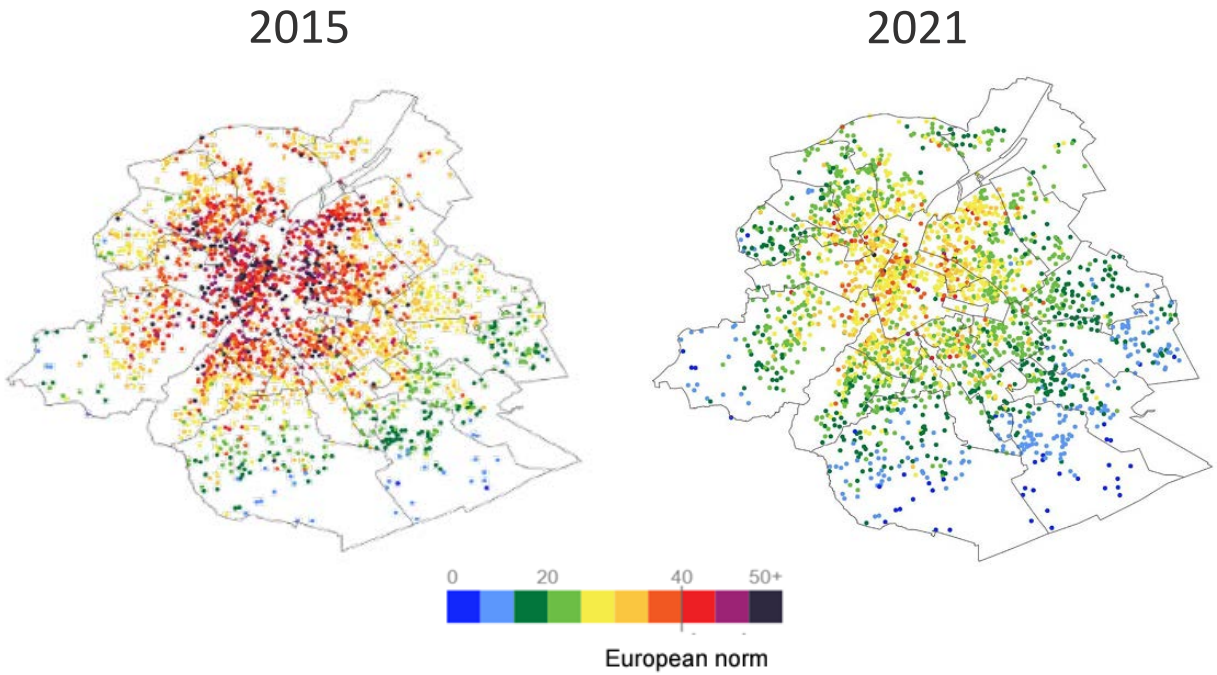
Euro 6d significantly reduced impact on air quality

- RDE procedure with PEMS for NOx and PN
- Evolution in emission control systems
  - LD diesel - combination of deNOx technologies
  - LD Gasoline - introduction of particulate filter



Source: PSA

- Several reports about improved air quality
- Example of NO_2 in Brussels



Source: CurieuzenAir report air quality in Brussels, 2022

Emission legislation evolution expected towards Euro 7

- Further contribute to air quality improvement with advanced emission control systems
  - New WHO guidelines, published in September 2021
  - The EU Ambient Air Quality Directive is being reviewed
- Key elements from the Euro 7 proposal for light-duty vehicles
  - Fuel-neutral pollutant emission limits at lowest Euro 6 level
  - Introduction of limit for NH_3
  - Cold-start budget for trips < 10 km
  - Extension of RDE test conditions
    - Any trip composition
    - New parameter for driving dynamics in first 2 kms after an initial cold-start
  - Extension of durability requirements
- Adoption of Euro 7 expected within Q1 of 2024


EUROPEAN COMMISSION

Brussels, 10.11.2022
COM(2022) 586 final

2022/0365 (COD)

Proposal for a

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7) and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009

(Text with EEA relevance)

{SEC(2022) 397 final} - {SWD(2022) 358 final} - {SWD(2022) 359 final} - {SWD(2022) 360 final}

EN EN

Reduction of ICE 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 emissions
  - Immediate reductions for the existing fleet in addition to new vehicles
  - Production is a reality, further investments depending on the policy framework
  - Proposal is expected from EU Commission for vehicles running exclusively on CO_2-neutral fuels

03.05.2021 | Image | #Powertrain systems

Source: Bosch (2021)

Blue Gasoline with 20 percent lower CO_2 emissions

BOSCH

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)

SIEMENS energy PORSCHE

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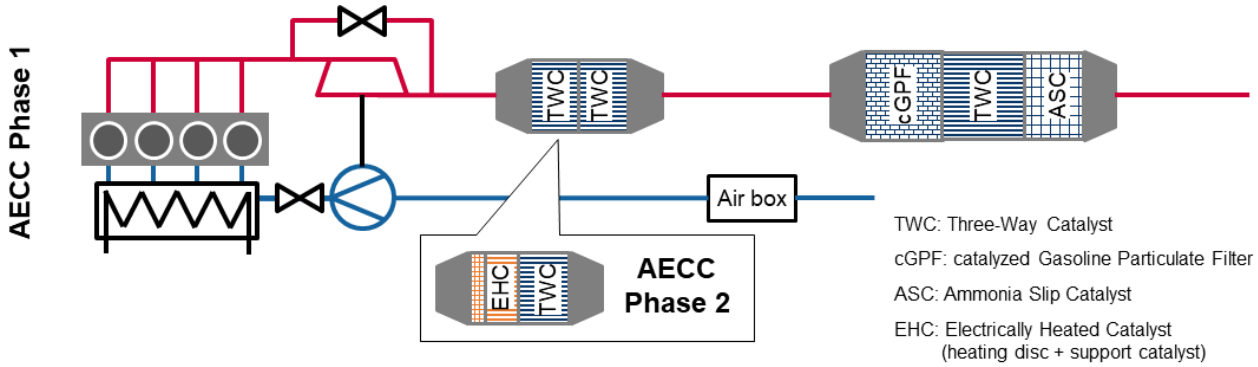
LD gasoline demonstrator concept

- Base vehicle
  - C-segment
  - 1.5l engine with 4 cylinders
  - Variable valve train and cylinder deactivation
  - 48V mild-hybrid (belt-driven, P0 configuration)
  - Euro 6d
- Instrumentation
  - Chassis dyno: 3x standard sampling points, 2x FTIR and tailpipe PN10
  - Road: prototype PEMS to measure CO_2, NOx, CO, THC, PN10, NH_3 and N_2O

LD gasoline demonstrator concept

- Euro 6d 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

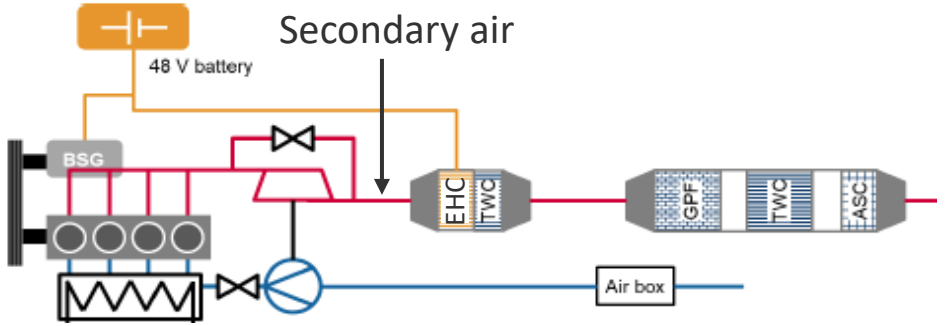


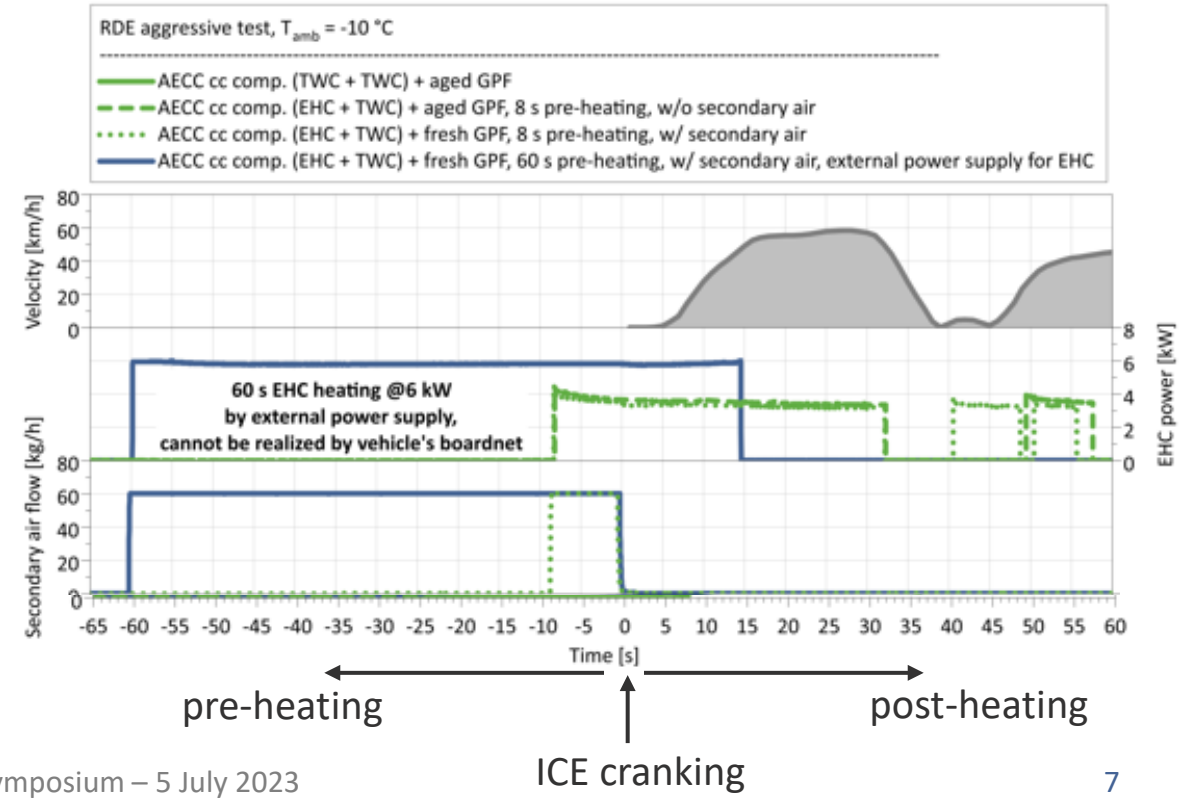
J. Demuynck, et al.; "Ultra-low Emissions of a 48V Mild-Hybrid Gasoline Vehicle with Advanced Emission Control Technologies", 15th International Conference on Engines and Vehicles, 2021

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

Implementation of electrically heated catalyst (EHC)

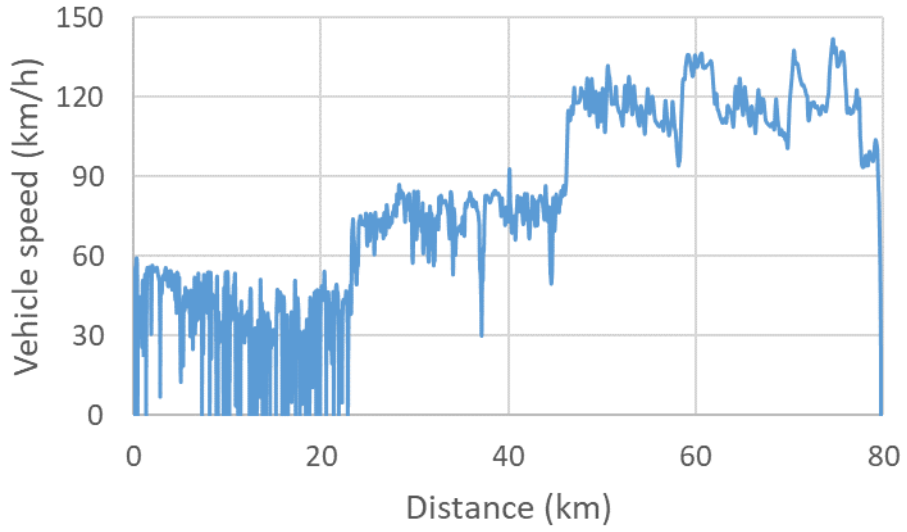
- Reduce the remaining initial cold-start emissions
- Operation strategy
  - Pre-heating in combination with post-heating
  - 60s pre-heating as outlook to advanced hybrids
  - Secondary air in exhaust manifold to enhance heat transfer within catalyst during pre-heating phase
- There is further potential due to certain constraints within this project, for example
  - Flow distribution not uniform, 90° bend at inlet
  - The part was not insulated

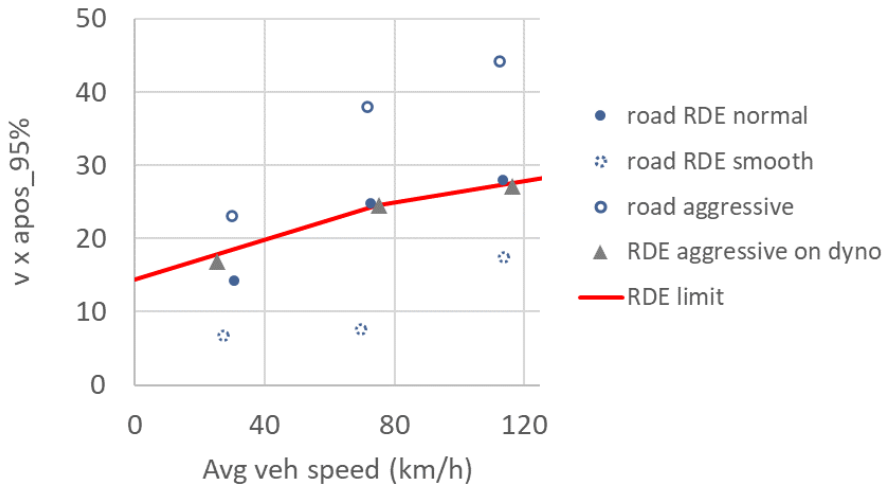




Testing focused on initial cold-start emissions

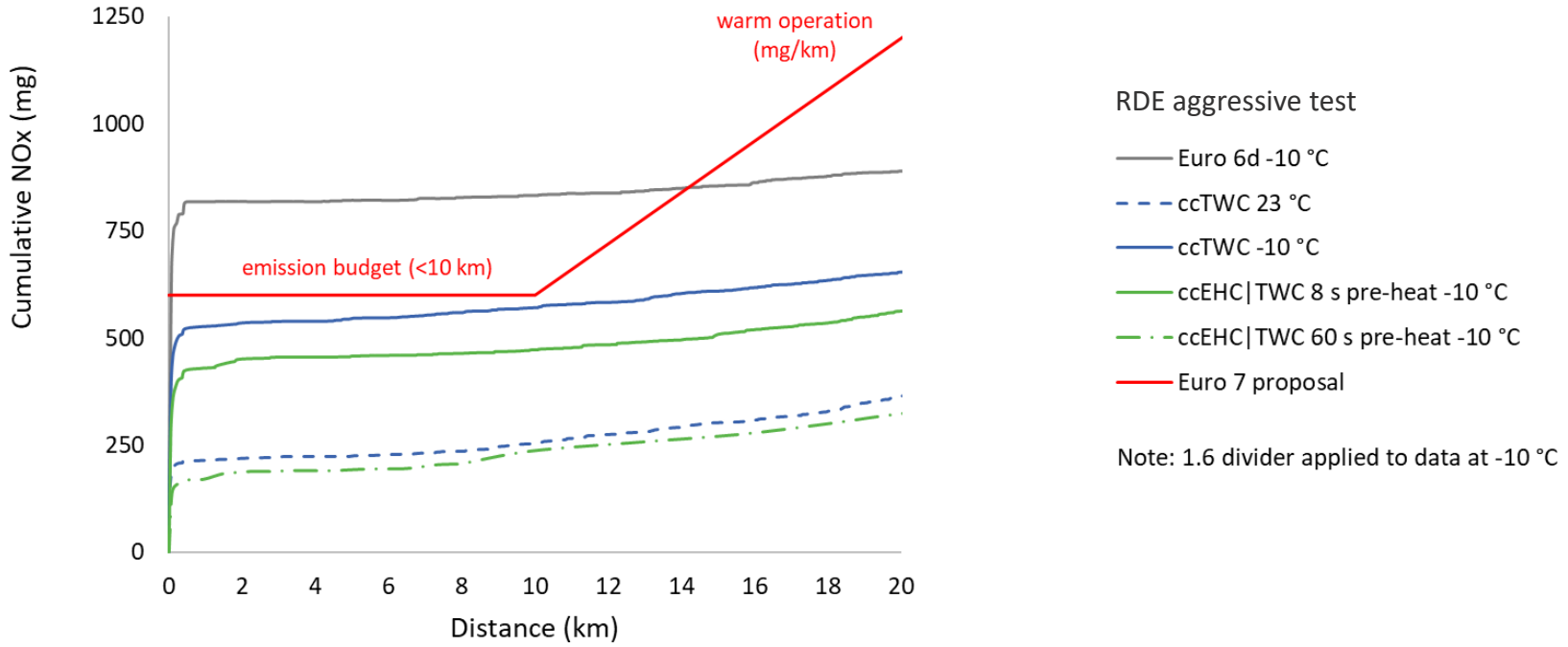
- RDE aggressive test is conducted on the chassis dyno
  - At Euro 6 RDE boundary for vxa_{pos}
  - 3s of idling between key-on and drive-off
  - First acceleration immediately to 60 km/h
  - At ambient temperature of 23 °C and -10 °C
  - Maximum average wheel power during first 2 kilometers after the initial cold-start is ~15%





Gaseous emissions are mainly from initial cold-start

- The highest cold-start NOx peak measured is below the proposed Euro 7 emission budget limit
- Near-zero emissions under warm operation



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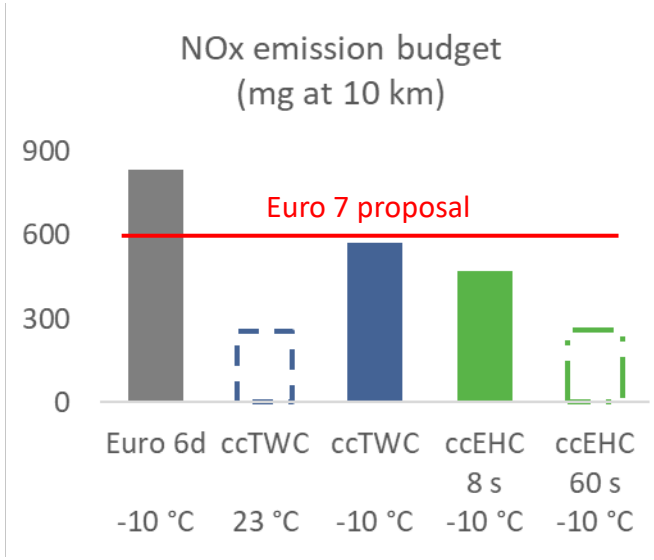
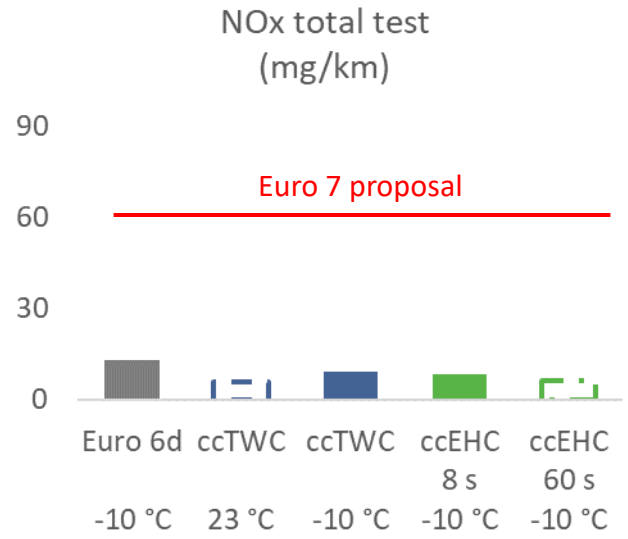
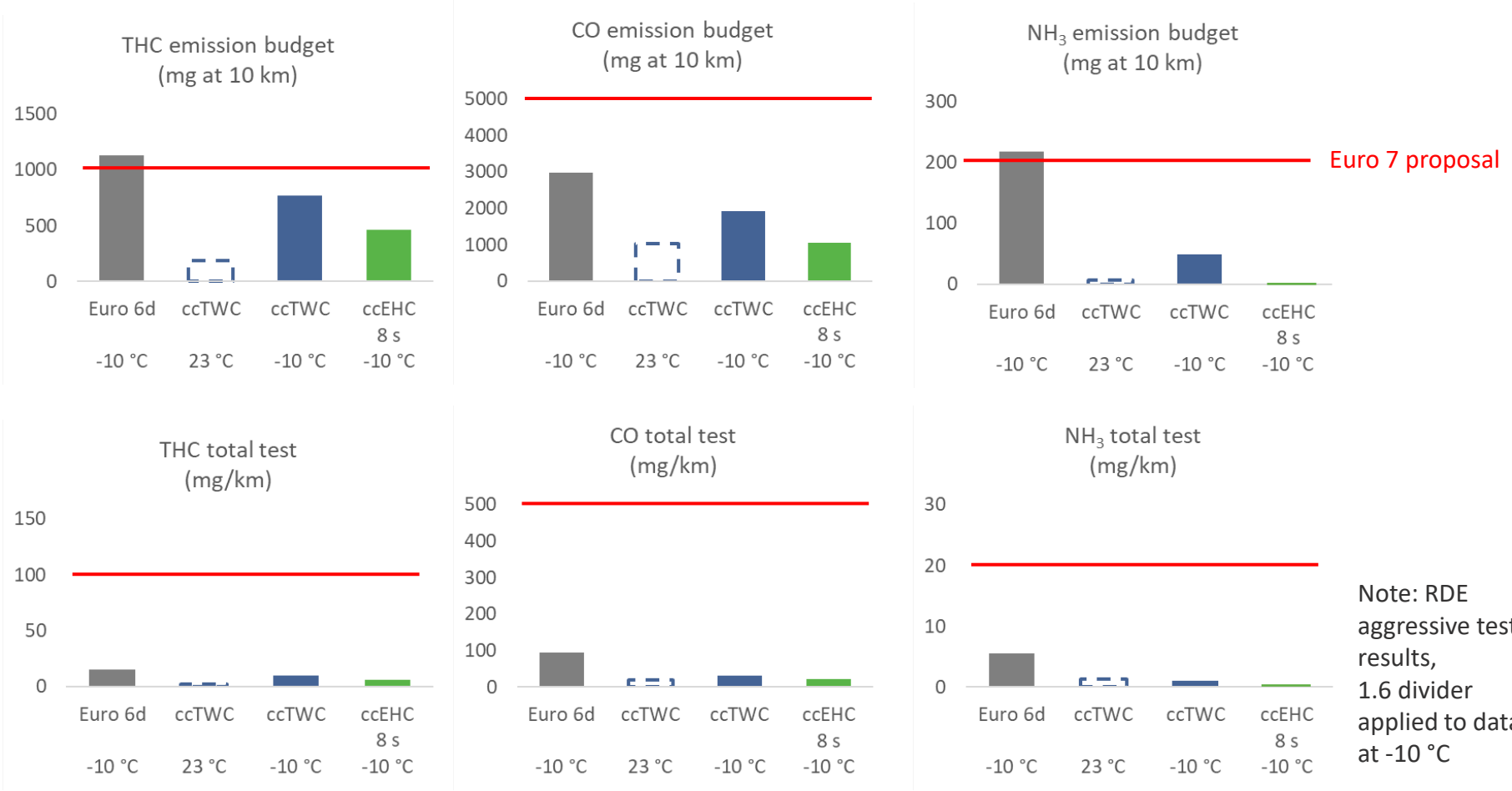




Note: RDE aggressive test results, 1.6 divider applied to data at -10 °C

Gaseous emissions are mainly from initial cold-start

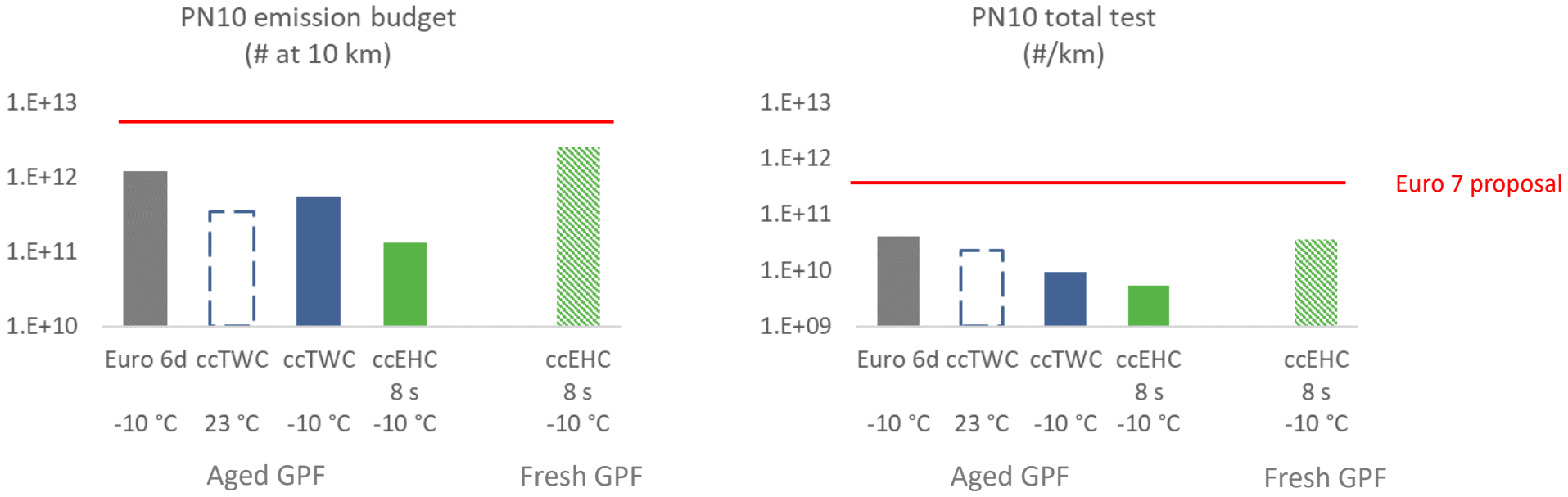
- Tests are significantly below the proposed Euro 7 limits for THC, CO and NH_3
  - Emission budget
  - Total test result



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

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 proposed Euro 7 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

Ignition

Engine load: 0 %

Vehicle speed: 0 km/h

500

0

NOx

2 ppm

30 s or 150 m to near-zero emissions

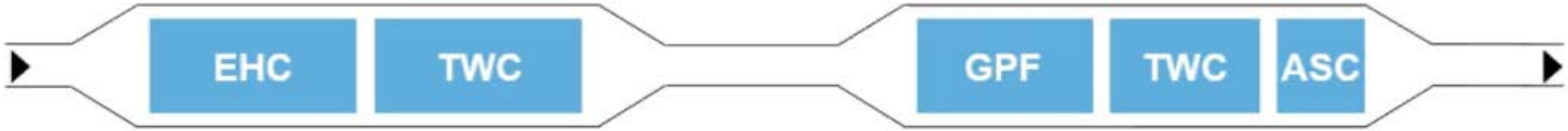
500

0

NOx

0 ppm

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



Engine catalyst heating

EHC heating

Closed-loop lambda control

LD gasoline demonstrator with sustainable renewable fuels

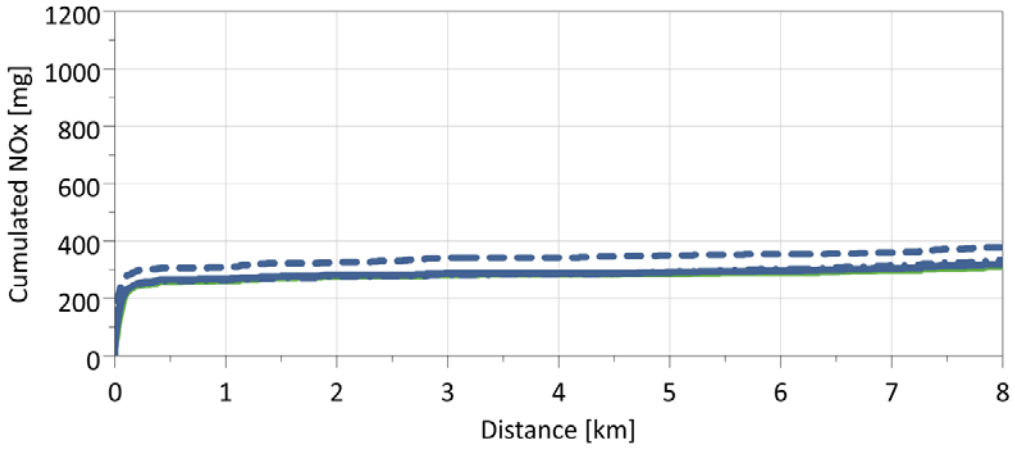
- Ultra-low pollutant emissions confirmed on Blue Gasoline and 2 e-gasoline samples

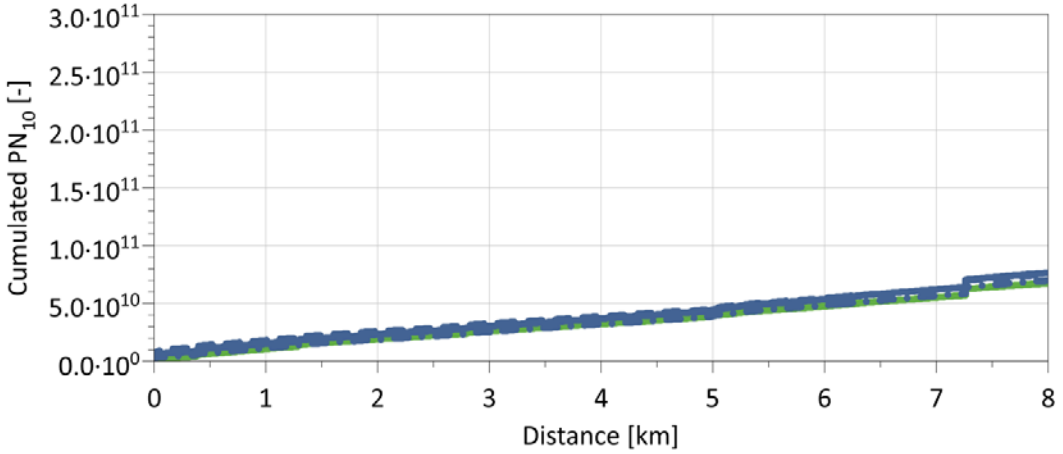
RDE aggressive test, T_{amb} = 23 °C

AECC cc comp. (EHC + TWC) + aged GPF, 8 s pre-heating, w/o secondary air

- RON95 E10
- Blue Gasoline
- E-gasoline 1
- E-gasoline 2

Ageing info: Engine bench aged targeting 160,000 km, EHC thermally aged





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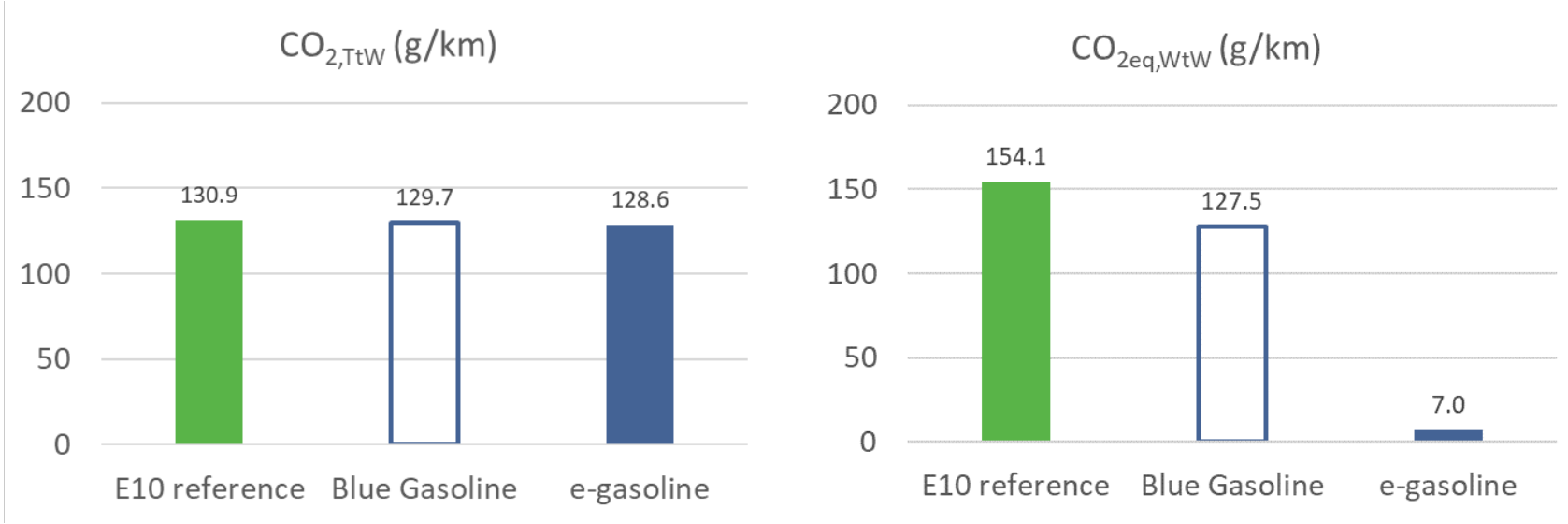
J. Demuynck, et al.; "Advanced Emission Controls and E-fuels on a Gasoline Car for Zero-Impact Emissions", SAE paper 2022-01-1014, 2022

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



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Summary

- Advanced emission control system was integrated in a 48 V mild-hybrid gasoline demonstrator vehicle
  - Close-coupled TWC substrate with high cell density
  - Active thermal management with EHC
  - Ammonia Slip Catalyst in addition to improved lambda control

- Towards zero-impact emission level
  - Significant reduction of initial cold-start peak compared to already low Euro 6d level
  - Near-zero emissions after initial cold-start peak
  - Sustainable renewable fuels to nearly eliminate WtW CO_2 emissions

Acknowledgements

- AECC members and the International Platinum Group Metals Association (IPA)

IPA INTERNATIONAL PLATINUM GROUP METALS ASSOCIATION · EMITEC TECHNOLOGIES · JM Johnson Matthey Inspiring science, enhancing life · SOLVAY Progress beyond · NGK · umicore Automotive Catalysts

- External project partners

IAV · Concawe

IAV · DENSO · CATALER · BOSCH · aramco · PORSCHE

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

AGU Sector Group

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THANK YOU !

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