Advanced emission controls and renewable fuels for future-proof engines with low pollutants and lifecycle CO_2 emissions

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AECC
ASSOCIATION FOR EMISSIONS CONTROL BY CATALYST

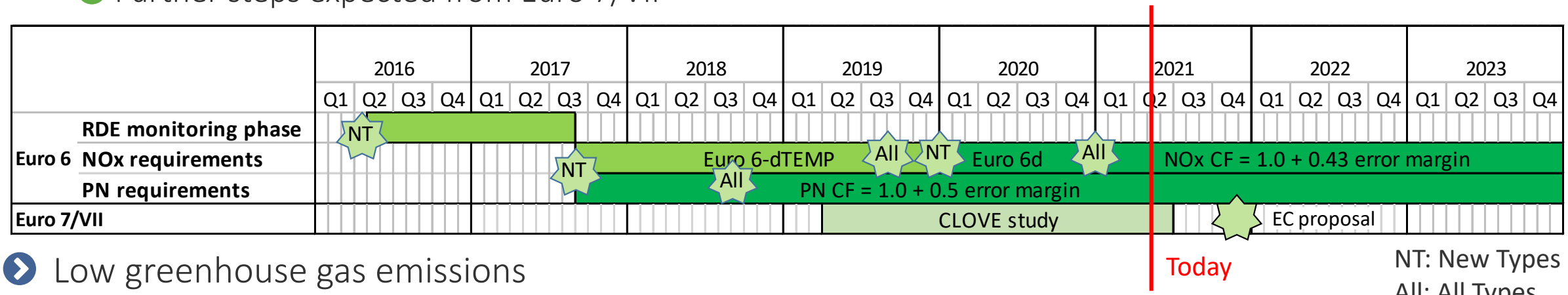
Association for Emissions Control by Catalyst (AECC AISBL)

AECC members : 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 as # 78711786419-61 in EU Transparency Register and has consultative status with the UN Economic and Social Council (ECOSOC)

ICE powertrains contribution to sustainability goals

- Low pollutant emissions
  - Significant steps taken with introduction of RDE towards Euro 6d
  - Further steps expected from Euro 7/VII



- Low greenhouse gas emissions
  - Increase in efficiency and level of electrification for new vehicles
  - Wider usage of renewable fuels to reduce Well-to-Wheel and lifecycle emissions
    - Immediate reductions for the existing fleet
    - New vehicles

GHG is a global issue, legacy fleet has to be part of solution

- GHG emissions contribute to global climate warming independently from location of origin
- GHG emissions are stored 300-1000 years in the atmosphere, accumulation of GHG emissions is to be minimised to stay within the limited available GHG budget for the 1.5°C target
- Electrifying the fleet is not enough as fleet renewal and renewable electricity ramp-up takes time
- The legacy vehicle fleet with ICEs needs to be part of the solution

Figure 5: Global annual passenger vehicle sales by drivetrain

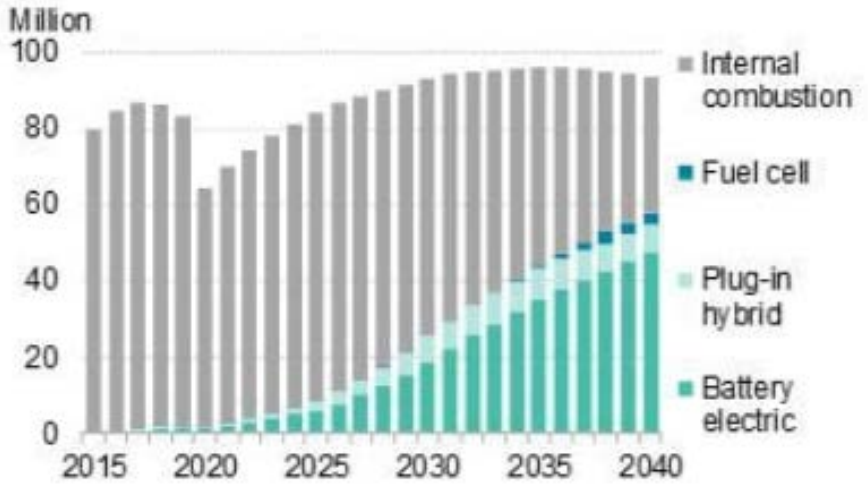
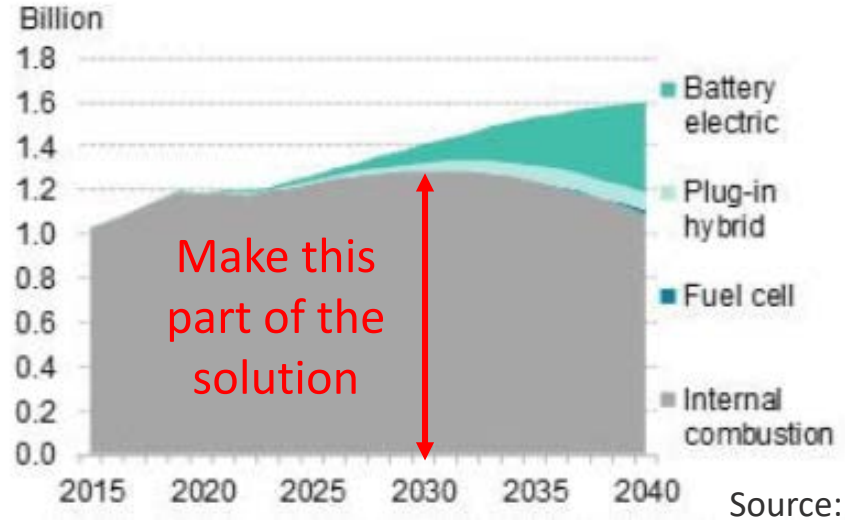


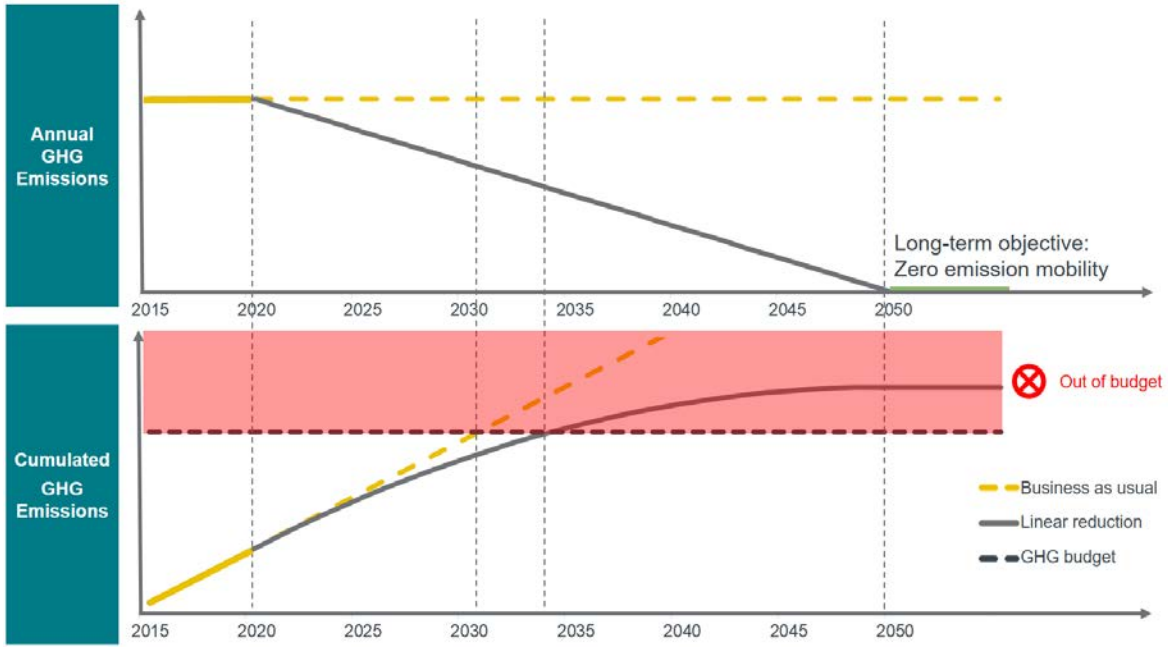
Figure 7: Global passenger vehicle fleet by drivetrain



Source: BloombergNEF (2020)

Transition to 2050 is essential due to available GHG budget

- Accumulation of emissions towards 2050 is to be minimized
- Existing scenarios expected to significantly exceed the budget
- Extra ‘carbon investment’ emissions will be emitted to build new infrastructures, filling up the GHG budget
- Renewable fuels are essential to achieve additional short-term CO_2 emission reductions
  - Drop-in capability allows using existing infrastructure
  - Only solution to reduce emissions from the legacy fleet in addition to new vehicles



Source: Frontier Economics (2021)

AECC validates renewable fuels in test programmes

- Ultra-low emissions are compatible with overall low WtW/LCA CO_2 emissions
- AECC demonstrates this for LD and HD vehicles
- Focus of this presentation is on LD diesel and gasoline

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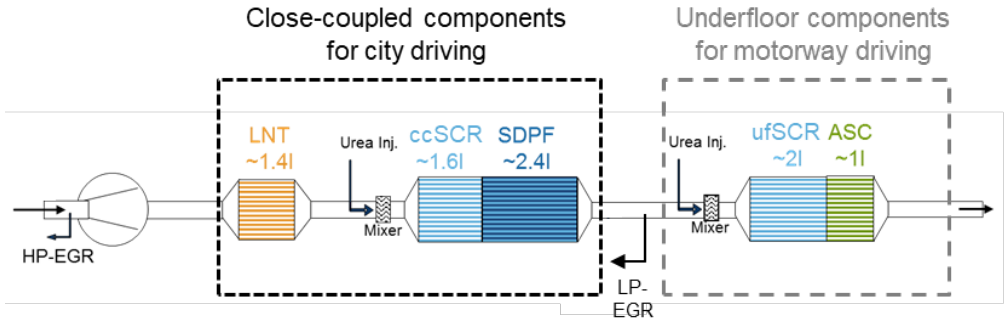
Acknowledgements of project partners

- LD diesel demonstrator
  - Project realisation
  - Follow-up work on renewable fuels and Well-to-Wheel analysis
- LD gasoline demonstrator
- HD diesel demonstrator

Automotive Grade Urea Sector Group

Ultra-low emissions diesel demonstrator

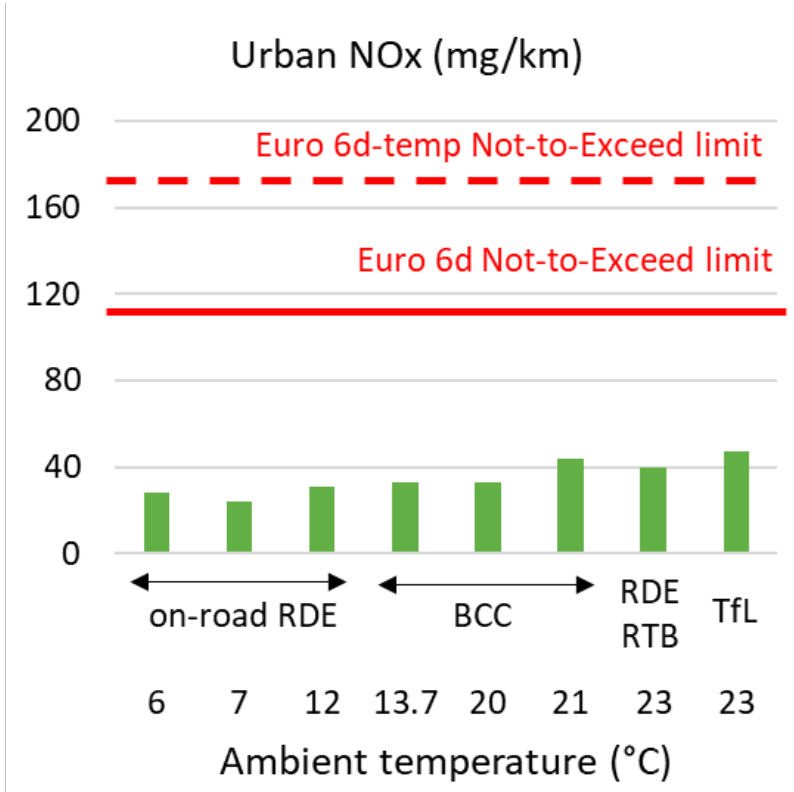
- Objective
  - Demonstrate ultra-low NOx emissions over wide range of driving conditions
  - Tests on renewable fuels
    - Investigate low Well-to-Wheel CO_2 emissions
      - Paraffinic fuels (HVO, BTL, e-diesel)
      - FAME based (B30)
    - Validate pollutant emissions achieved on market fuel
- Demonstrator concept
  - Emission control system with combination of Lean NOx Trap and dual-Selective Catalytic Reduction
  - 48V mild-hybrid system

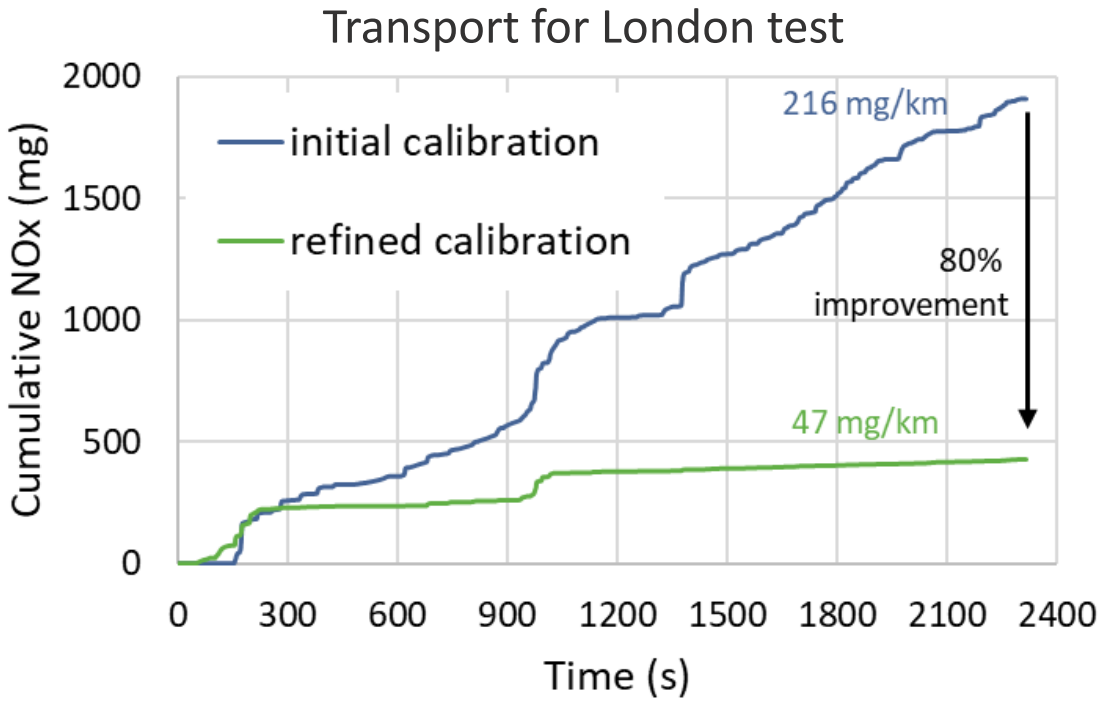


1) *J. Demuynck, et al.; "Integrated Diesel System Achieving Ultra-Low Urban and Motorway NOx Emissions on the Road", 40th Vienna Motor Symposium, 2019*
https://www.aecc.eu/wp-content/uploads/2019/04/190516-AECC-IAV-IPA-Integrated-Diesel-System-achieving-Ultra-Low-NOx-on-the-road-Vienna-Symposium.pdf
2) Joint MTZ publication with Bosch, Vitesco, FEV and IAV https://www.aecc.eu/wp-content/uploads/2020/09/200901-modern-diesel-MTZ.pdf
3) Videos of instantaneous conversion performance available at www.youtube.com/channel/UCbPS9op5ztLqrv6zlMH_IcQ

Ultra-low emissions diesel demonstrator

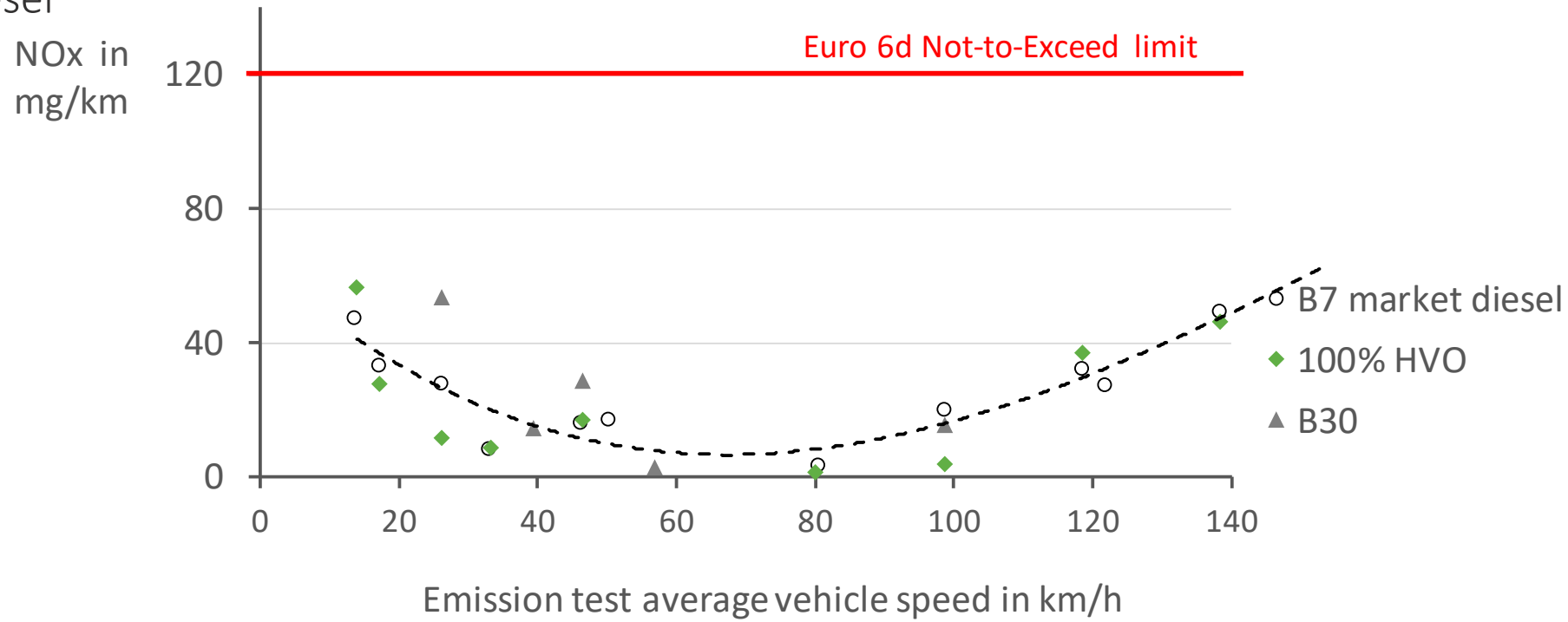
- Low urban NOx emissions for different tests over range of ambient temperature
- Significant improvement achieved due to LNT regeneration stabilisation and thermal management





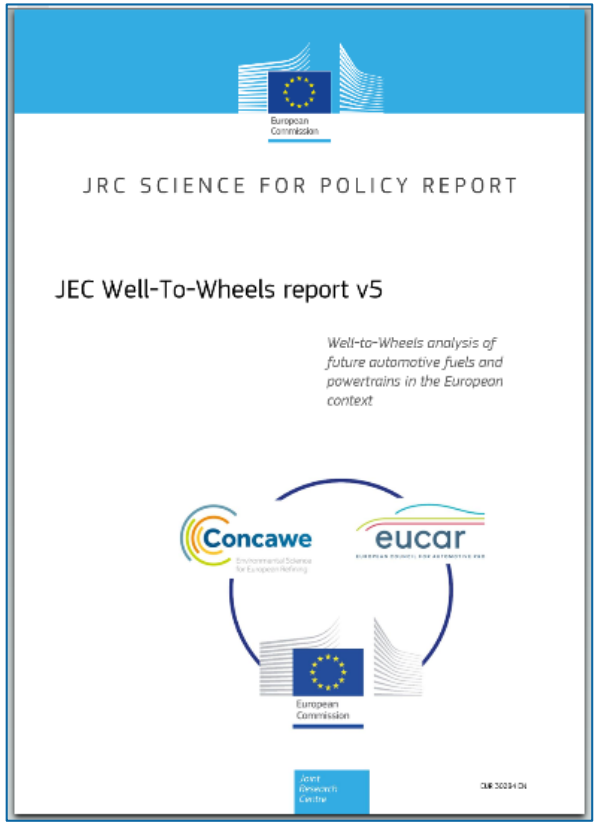
Low pollutant emissions confirmed for low carbon fuels

- Reference tests on B7 market diesel (7% fatty-acid-methyl-ester content)
- Tests on renewable fuels without modification to vehicle hardware or software
  - 100% HVO (Hydrotreated Vegetable Oil)
  - B30 diesel



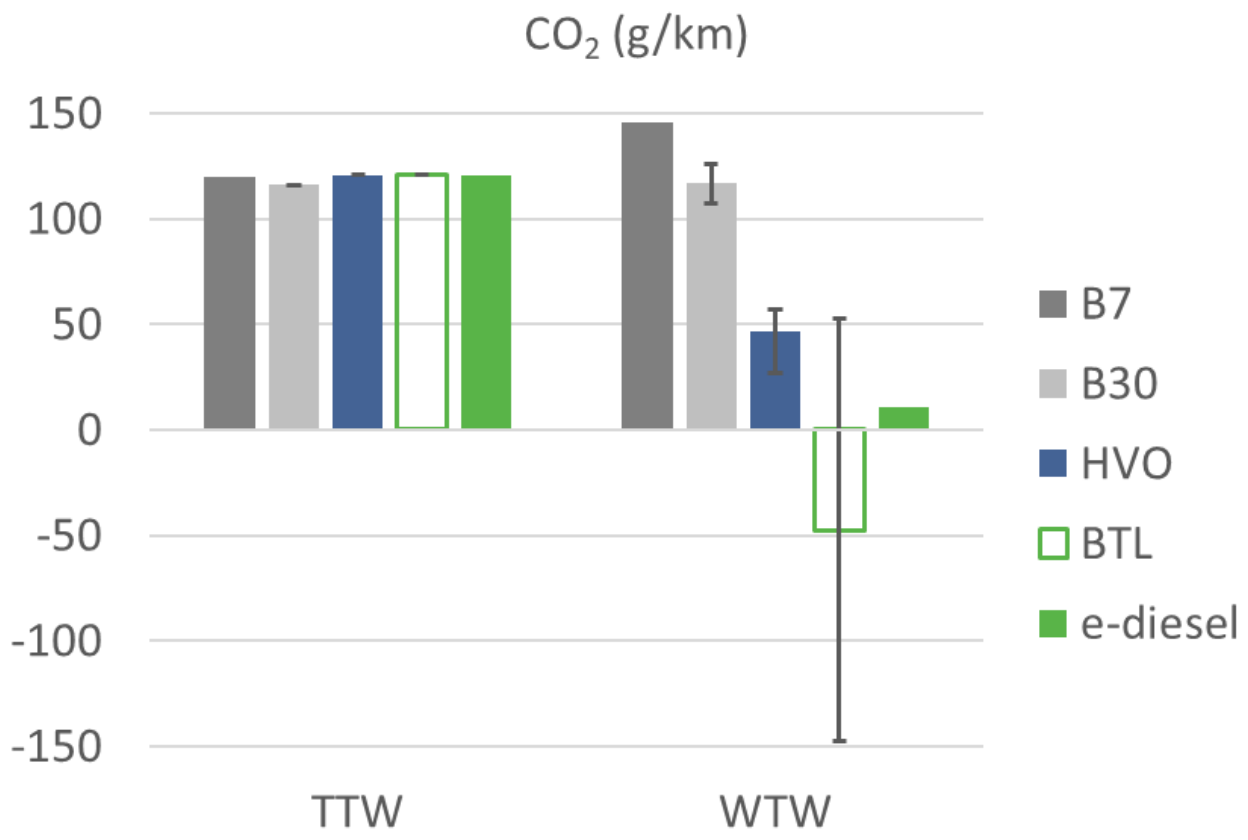
Well-to-Wheel calculations to investigate CO_2 impact

- Methodology of JEC WtW report v5 used http://dx.doi.org/10.2760/100379
- Several representative production pathways studied
  - Paraffinic fuels (associated with 100% HVO tests)
    - HVO: palm oil, waste cooking oil, EU mix
    - BTL (biomass-to-liquid): waste wood
      - Hydrothermal liquefaction
      - Fischer-Tropsch route with CCS (carbon capture and storage)
    - e-diesel: Fischer-Tropsch route with SOEC (solid oxide) electrolyser
  - FAME (associated with B7 and B30 tests)
    - Rapeseed oil
    - Palm oil
    - Waste cooking oil



Well-to-Wheel calculations to investigate CO_2 impact

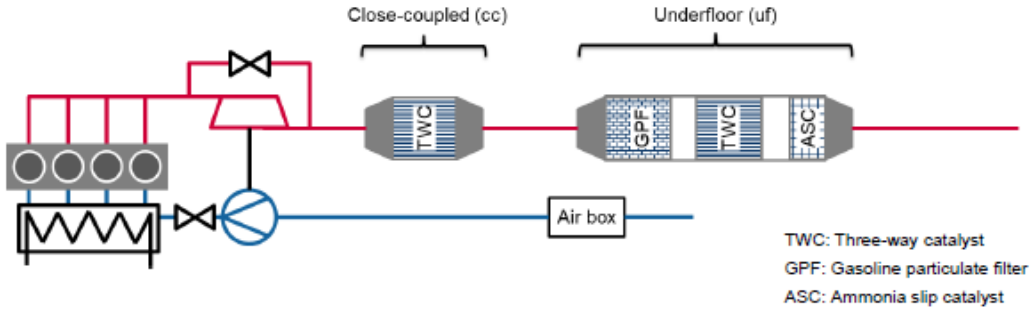
- Tank-to-Wheel (tailpipe) measurements show similar results for the different fuels
- Well-to-Wheel evaluation versus B7 reference depending on production pathway
  - B30: -14 to -26%
  - HVO: -60 to -82%
  - BTL: -64% to -200%
  - E-fuel: -93%



LD gasoline demonstrator concept

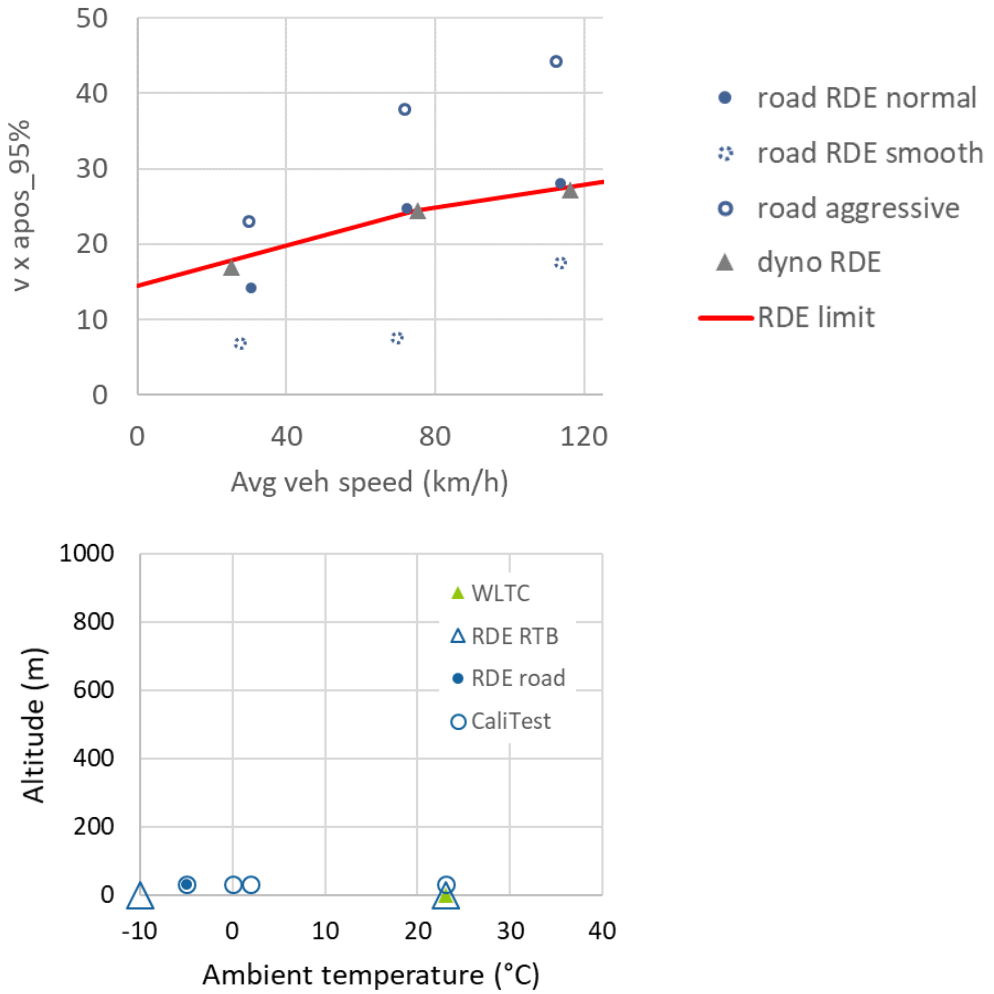
- Base vehicle
  - C-segment vehicle
  - Engine
    - 1.5l with 4 cylinders
    - Variable valve train with cylinder deactivation
  - 48V mild-hybrid (belt-driven, P0 configuration)
  - Euro 6d type-approval baseline with GPF + TWC
- Emission control system
  - ccTWC, ufGPF+TWC+ASC[1]

    [1] ASC operation strategy for gasoline under investigation in addition to improved lambda control
  - Bench aged components targeting 160k km



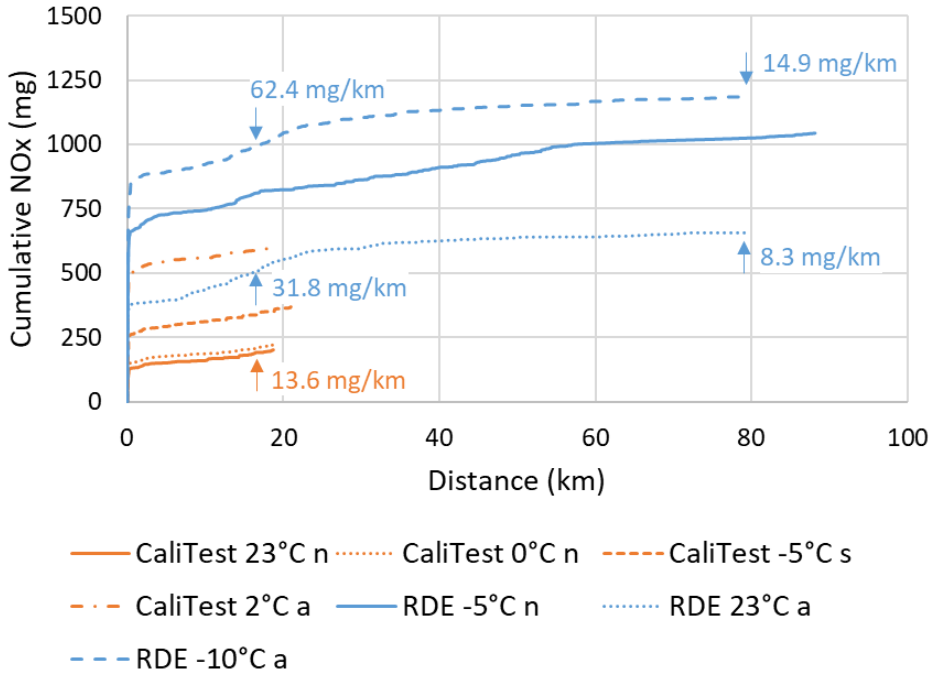
LD gasoline demonstrator preliminary data

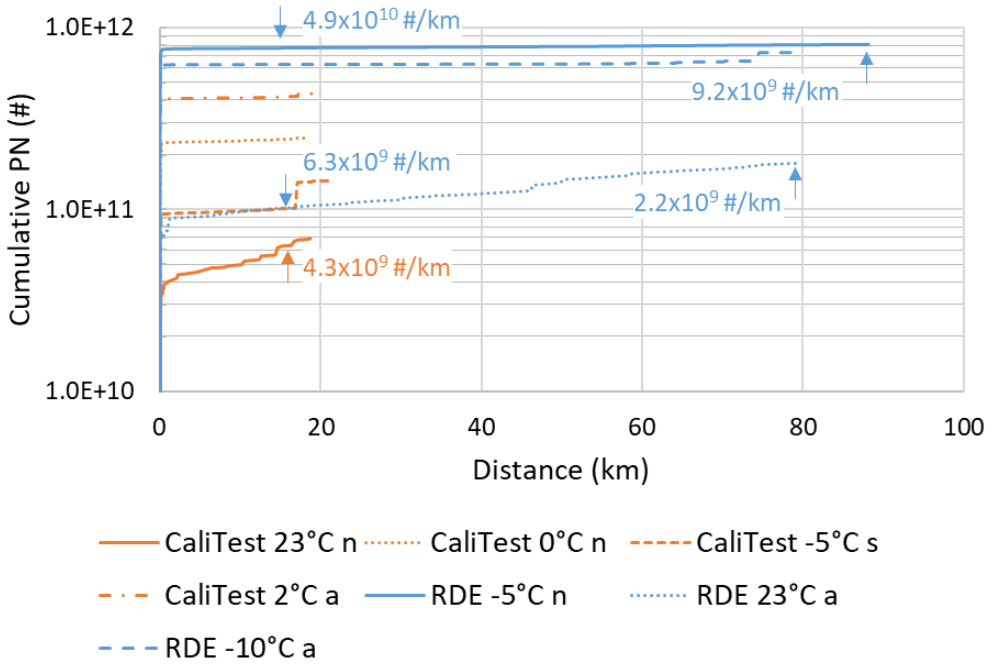
- Exploring beyond Euro 6 RDE boundary conditions
- On the chassis dyno
  - WLTC at 23°C
  - RDE aggressive at 23°C and -10°C
- On the road
  - RDE normal driving at -5°C
  - Short calibration test
    - Normal driving at 0°C and 23°C
    - Smooth driving at -5°C
    - Aggressive driving at 2°C



Ultra-low emissions over range of driving conditions

- Initial cold-start effect is observed for NOx and PN
- Near-zero emissions during the rest of the tests





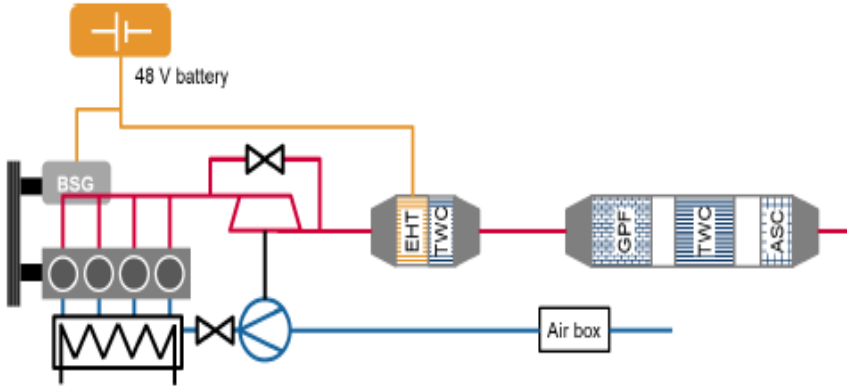
[1] The results are reported as measured by the PEMS under the specified test routes and conditions
[2] Urban values are evaluated at a trip length of 16 km

Conclusion

- Low pollutant emissions shown over wide range of driving conditions with advanced emission control systems integrated in modern vehicles
  - Light-duty diesel demonstrator
  - Light-duty gasoline demonstrator
- Significant WtW CO_2 reductions possible with the use of sustainable renewable fuels illustrated for a light-duty diesel demonstrator vehicle
- Part of this reduction is already possible for the existing fleet as most paraffinic compounds are drop-in for market diesel fuel, i.e. compatible with existing vehicles and infrastructure
- Internal Combustion Engine is part of the sustainable mobility solutions to contribute to EU Green Deal climate-neutral and zero-emission goals along with electrification

Outlook

- Further investigations for LD gasoline and HD diesel are ongoing
  - Implementation of electrically heated catalyst to further reduce initial cold-start emissions, e.g. on the LD gasoline demonstrator vehicle



  - Candidate sustainable renewable fuels for validation of ultra-low pollutant emissions are investigated
    - LD gasoline demonstrator: e-gasoline
    - HD diesel demonstrator: e-diesel, HVO, R33

THANK YOU !

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