

Post Euro 6/VI Norms: How well are we prepared for the next emission level towards Near Zero Impact

Dirk Bosteels

FEV Diesel Powertrain 3.0 conference •
8-9 July 2020



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

Content

- Introduction
 - Euro 7 process
 - Technologies available to handle real-world operation emissions
- Light-duty Diesel - Ultra-low emissions diesel demonstrator
- Heavy-duty Diesel - Real-world operation data of Euro VI vehicles
- Summary and outlook



Euro 7 confirmed in EU Green Deal communication

For cars, vans, buses and trucks

- European Commission working group:
Advisory Group on Vehicle Emission Standards (AGVES)
- Studies by CLOVE consortium until Mid of 2021
- European Commission proposal expected in 2021 followed by
ordinary legislative procedure with European Parliament and Council



➤ Schedule

➤ CLOVE



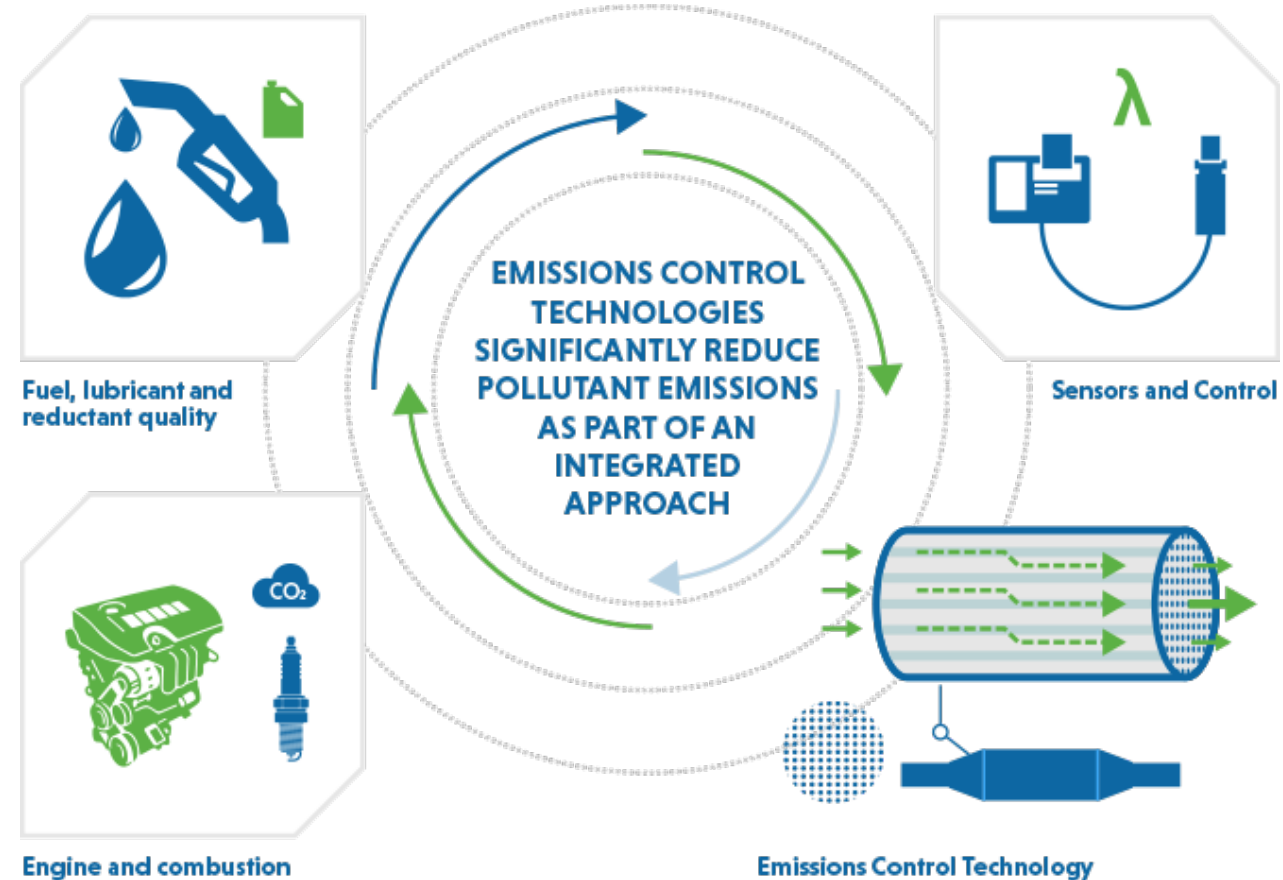
➤ EC/AGVES



Technologies available to handle real-world operation emissions

For light- and heavy-duty applications

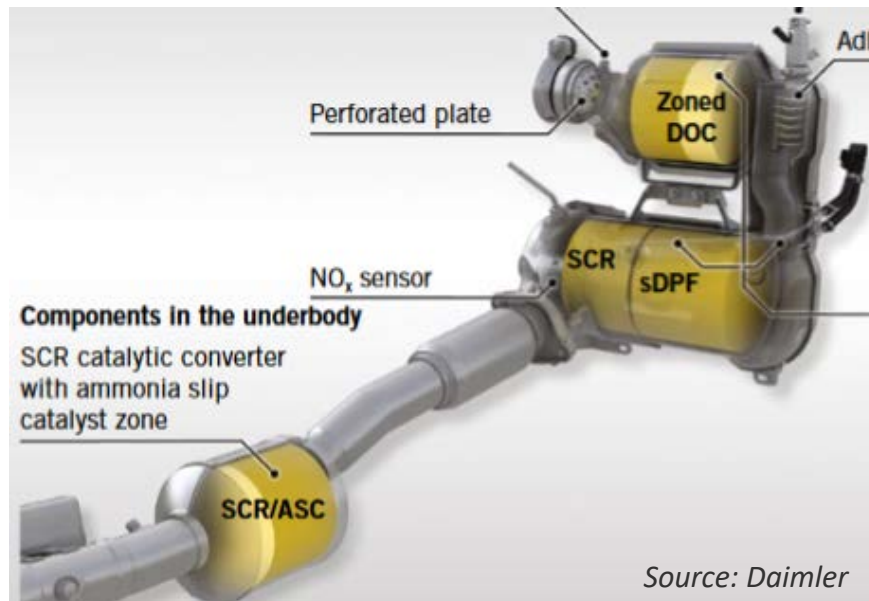
- Emissions control technologies significantly reduce pollutant emissions as part of an integrated approach
- Euro 7/VII will drive further innovation in
 - Catalyst and filter technology design
 - Emissions control system layout
 - System control



Technologies available to handle real-world operation emissions

For light- and heavy-duty applications

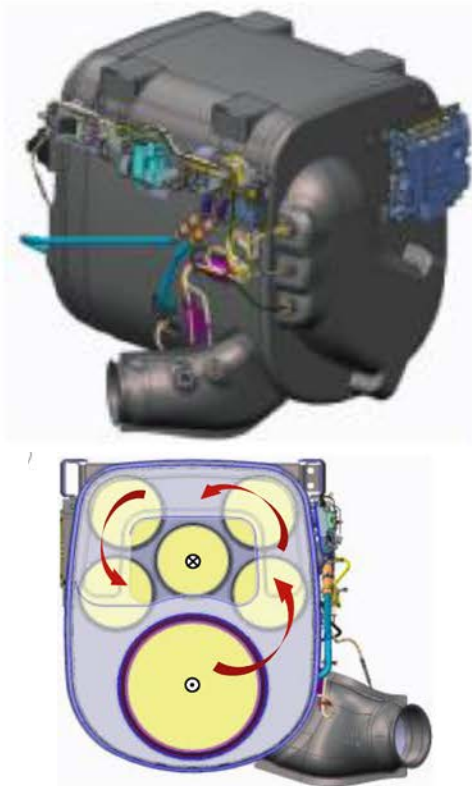
- Common system layout characteristics to handle real-world operation emissions
 - Close-coupled catalysts for cold-start and low speed/load driving in the city
 - Underfloor catalysts for high speed/load area on the motorway
 - Total catalyst and filter volume to cope with peak engine pollutant flow
- Examples of available systems for light-duty diesel



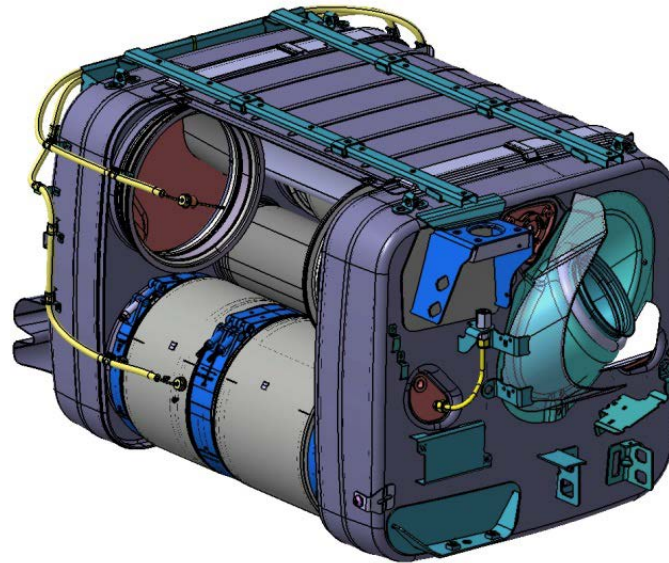
Technologies available to handle real-world operation emissions

For light- and heavy-duty applications

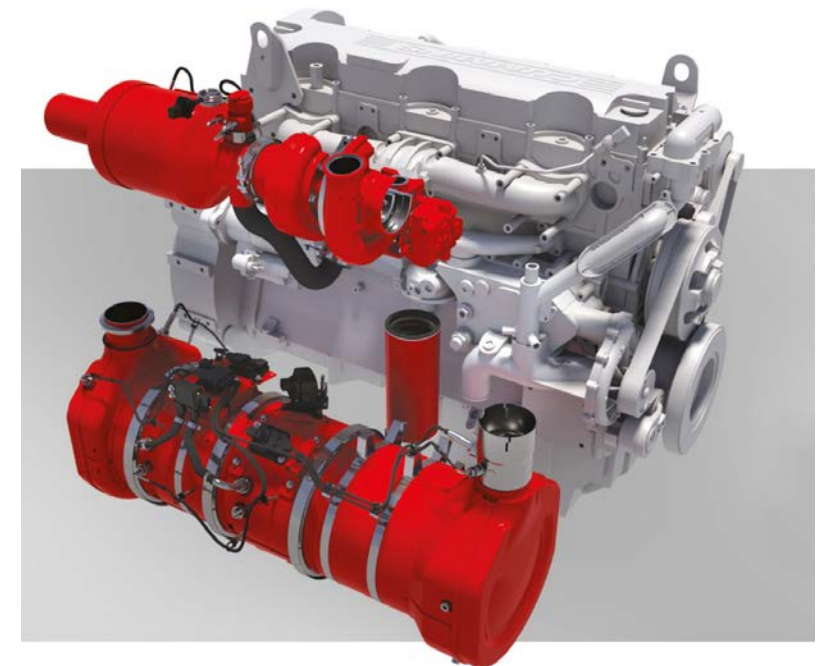
- Examples of available systems for heavy-duty diesel
- Example of announced system with close-coupled components for heavy-duty diesel



Source: DAF

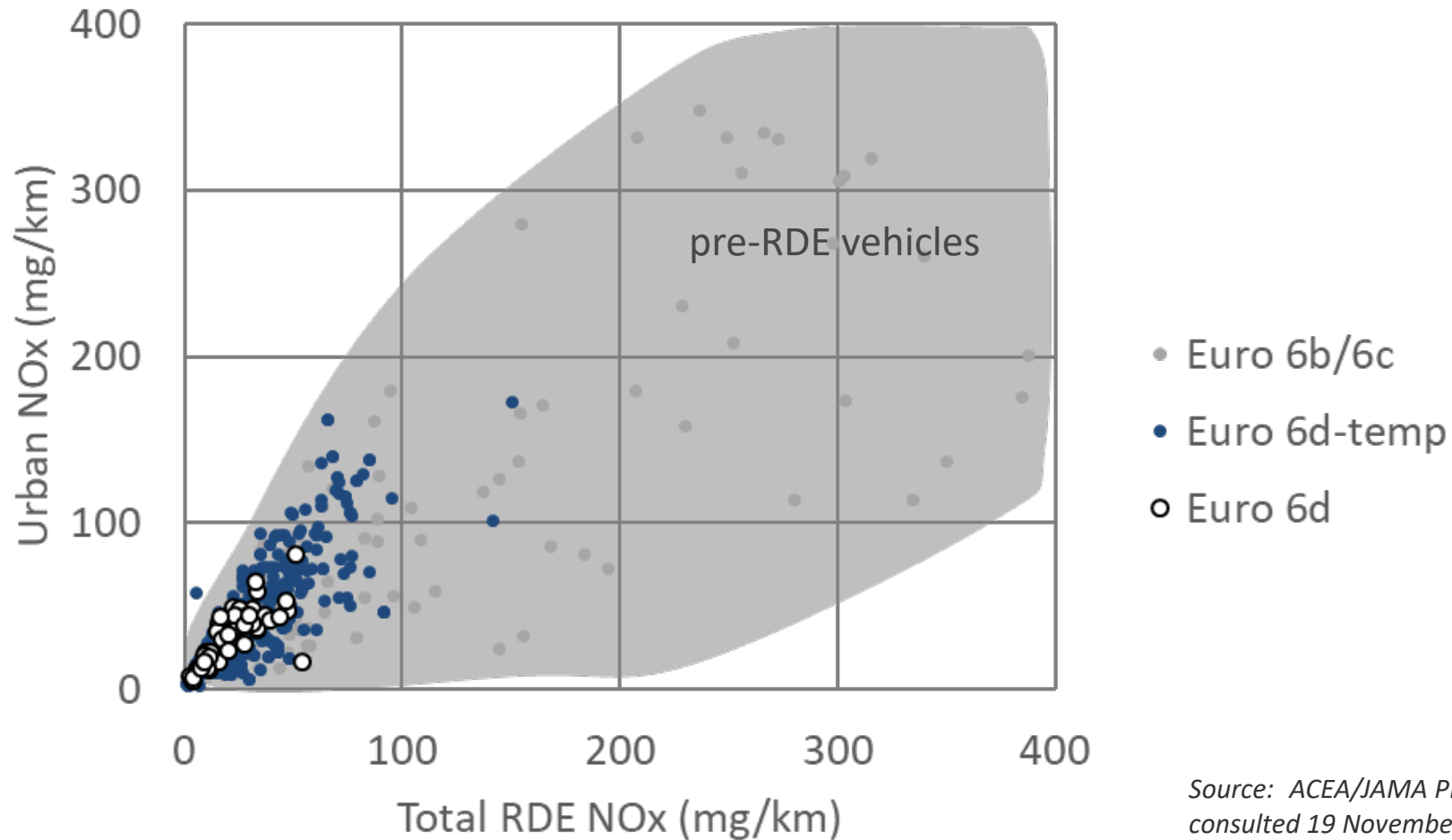


Source: Daimler



Source: Cummins

Significant reduction of diesel NOx emissions to Euro 6d



Source: ACEA/JAMA PEMS data
consulted 19 November 2019

Ultra-low emissions diesel demonstrator

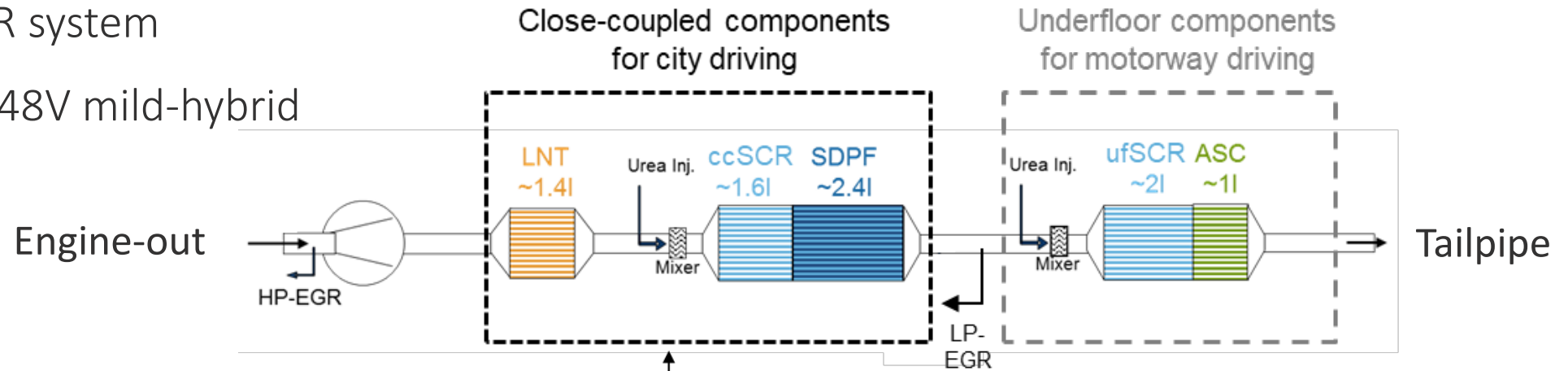
- C-segment Vehicle
 - 1700 kg
- Drivetrain
 - Manual gearbox, 6-speed
 - 48 Volt mild-hybrid (belt-driven, P0)
- Engine
 - 1.5l, 4-cylinder, 2-valve
 - EGR: uncooled HP and cooled LP
- Euro 6b type-approval (LNT + DPF)
- Reference paper

<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>

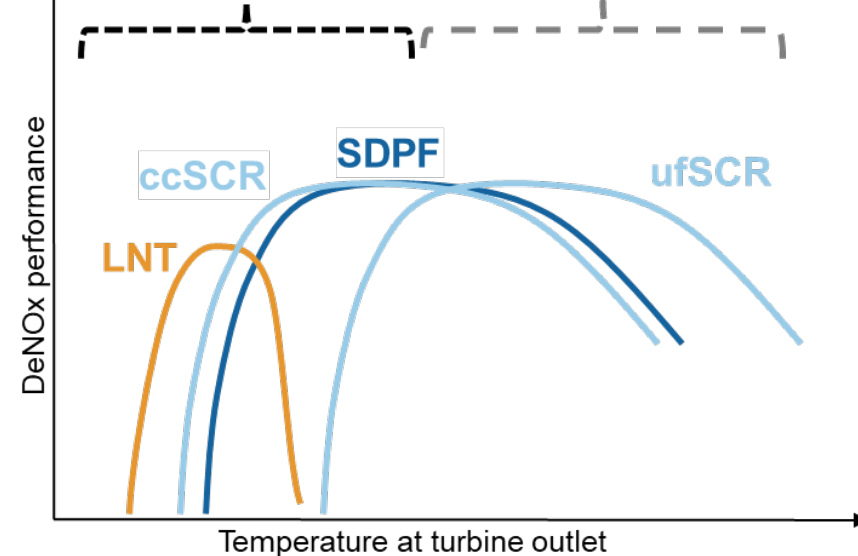


Emissions controls to cover wide range of driving conditions

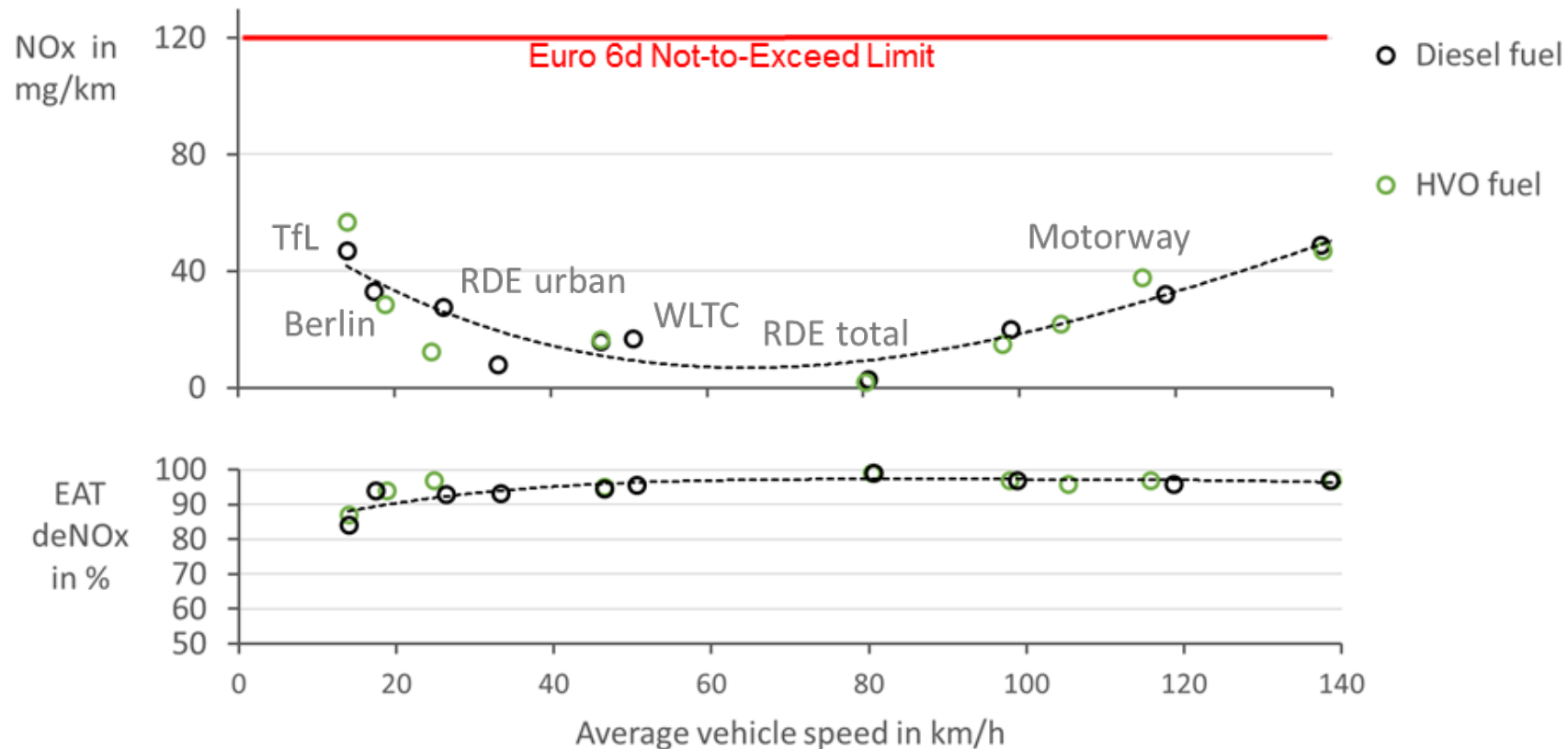
- LNT + dual-SCR system
- Supported by 48V mild-hybrid



EGR: Exhaust Gas Recirculation
 HP/LP: High/Low pressure
 cc: close-coupled
 LNT: Lean NOx trap
 SCR: Selective Catalytic Reduction
 DPF: Diesel Particulate Filter
 SDPF: SCR on DPF
 uf: underfloor
 ASC: Ammonia Slip Catalyst

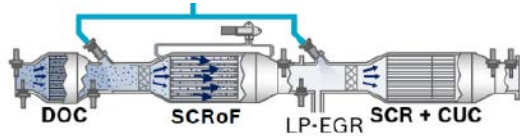


Robust NOx control over wide range of driving conditions

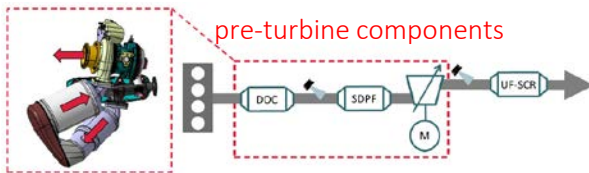


Other approaches exist to achieve low NOx

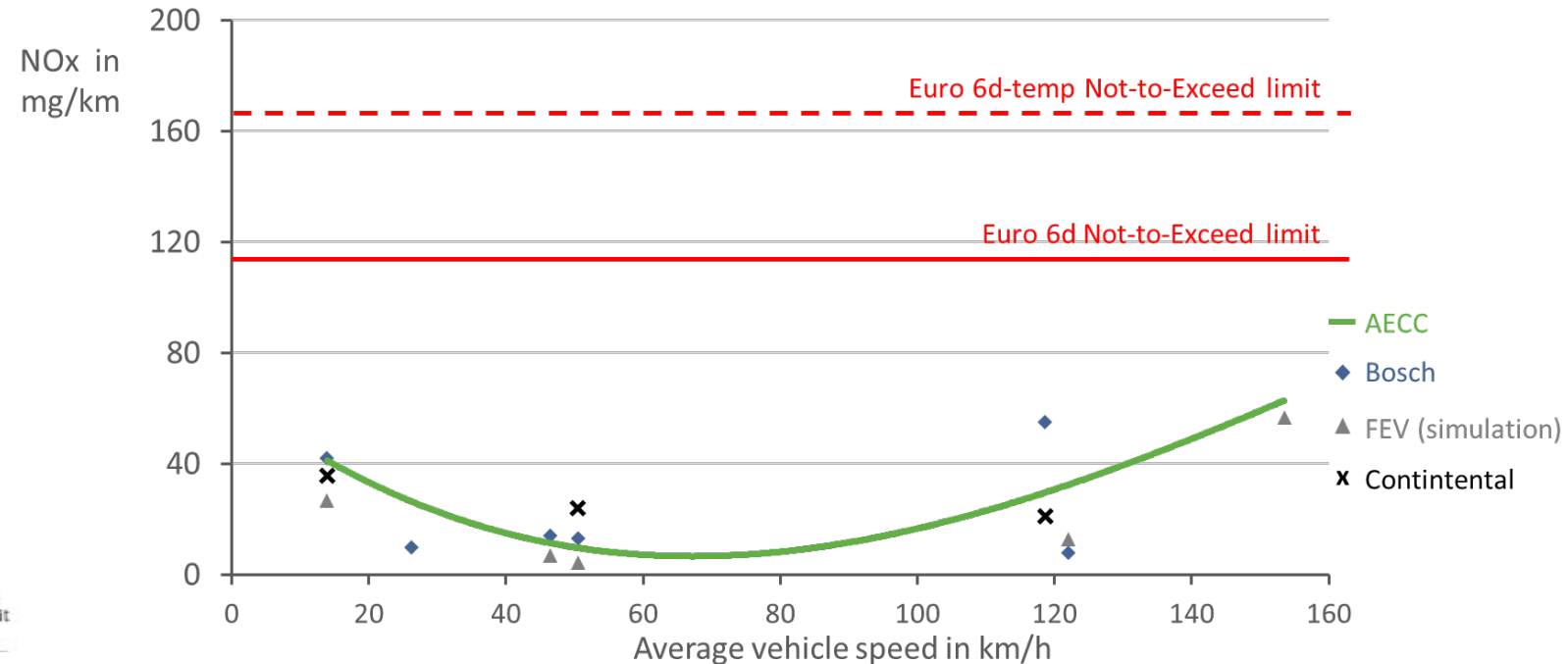
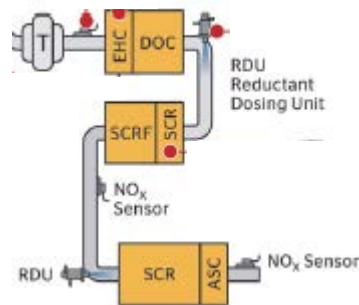
➤ Bosch [1]: DOC + dual-SCR



➤ FEV [2]: DOC + dual-SCR



➤ Continental [3]: eDOC + dual-SCR



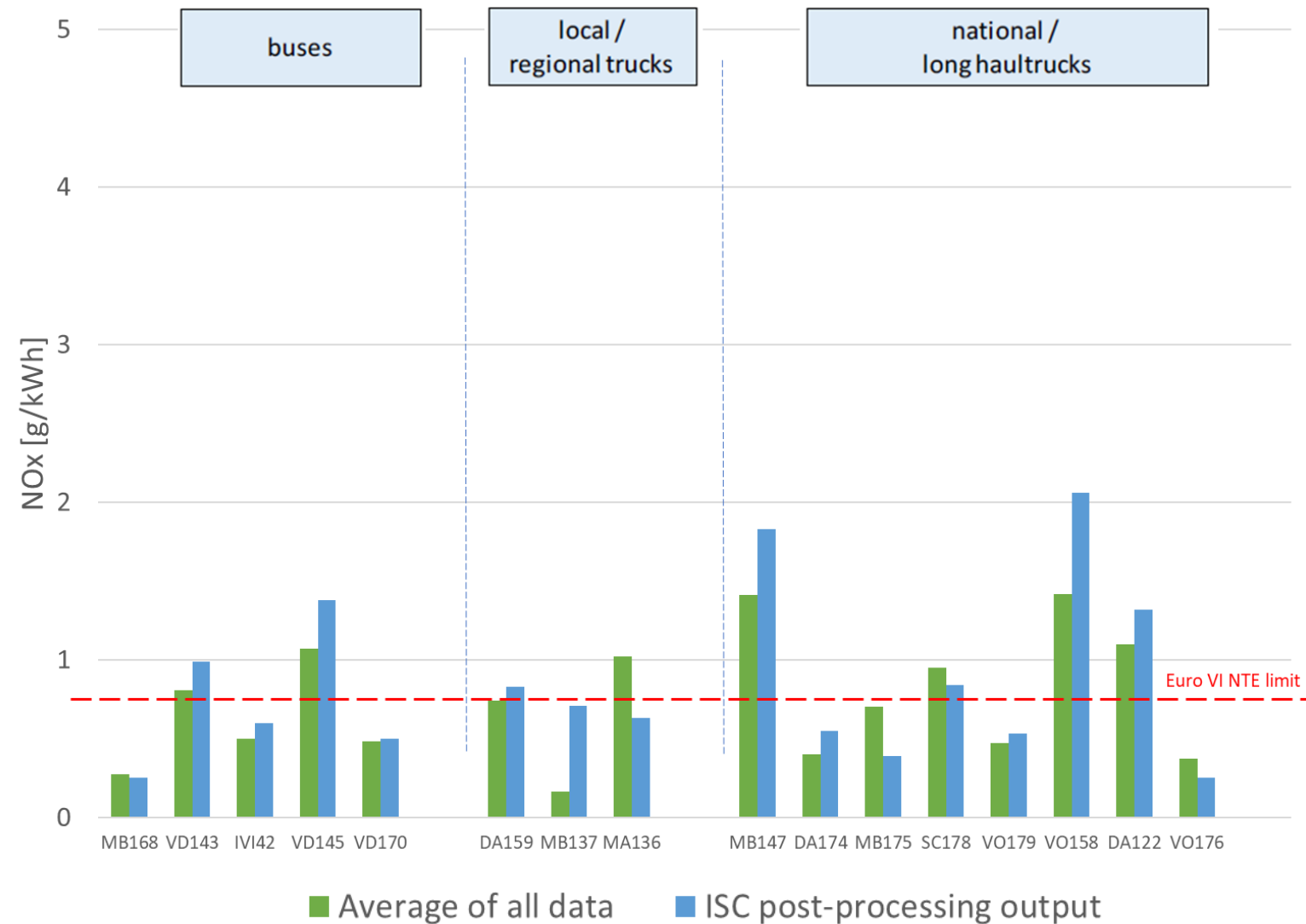
1. A. Kufferath, et al.; "EU6d – Analysis of Boundary Conditions and Evaluation of the Impact on Emissions using the Example of the Advanced Diesel Powertrain", 40th Vienna Motorsymposium, 2019
2. M. Schönen, et al.; "White Eco Diesel Powertrain with Pre-Turbine Exhaust Aftertreatment and Mild-Hybrid Concept for lowest NOx Emission under Urban Driving Condition", 40th Vienna Motorsymposium, 2019
3. G. Avolio, et al.; "Super Clean Electrified Diesel: Towards Real NOx Emissions below 35 mg/km", 27th Aachen Colloquium, 2018

Objective & scope of Heavy-duty test programmes

- Identify real-world emissions of Euro VI vehicles for broad range of applications
- Investigate
 - Impact of Euro VI-D/E
 - Actual real-world operation vs. Euro VI In-Service Conformity
 - Actual real-world value (=raw data integrated over test) vs. ISC data evaluation
- Available data for the study
 - Existing real-world operation database of 23 vehicles (Euro VI-A to VI-C)
 - Real-world operation data measured on 3 vehicles (Euro VI-D)
 - Detailed testing on 1 vehicle (N3 Euro VI-C distribution truck)
 - Euro VI ISC route
 - Actual real-world operation

Data confirms low emissions of Euro VI vehicles on average

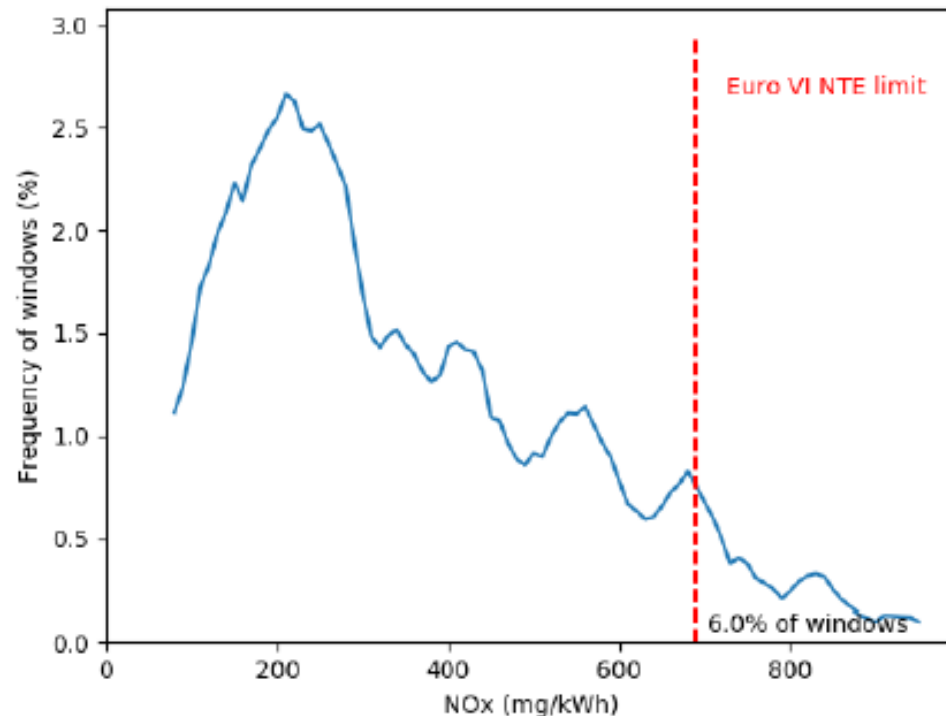
- Most vehicles in database have low emissions in real-world operation according to
 - Average of all data
 - ISC data post-processing



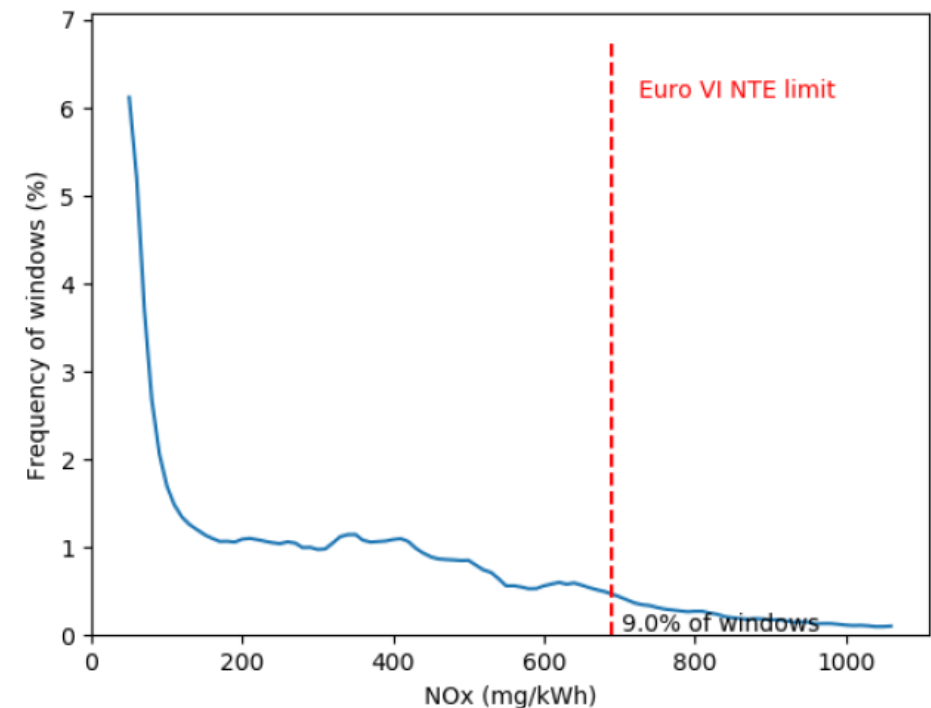
Data confirms low emissions of Euro VI vehicles on average

➤ Several vehicles stay below Euro VI NTE limit during most of real-world operation

➤ Euro VI-A regional bus

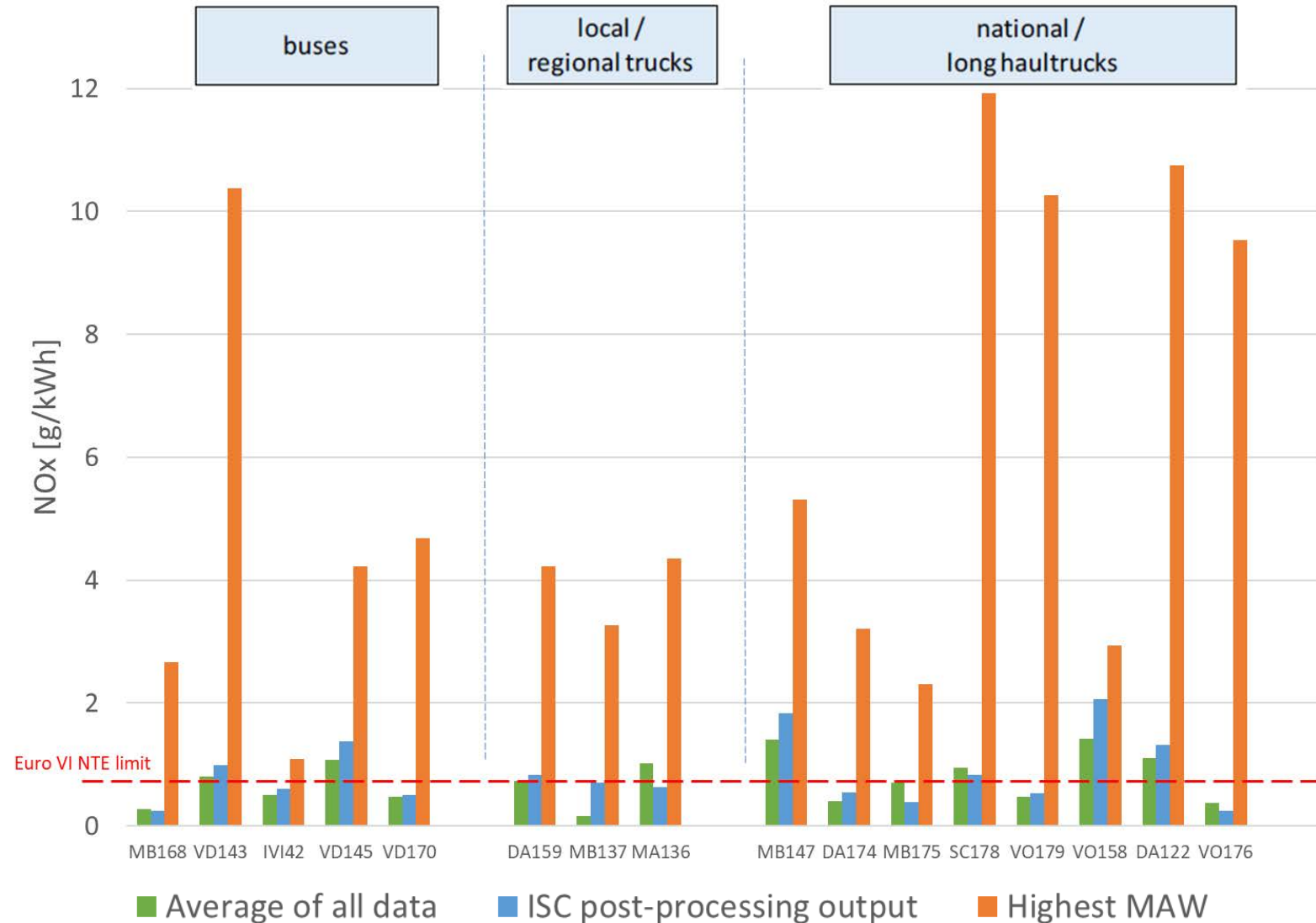


➤ Euro VI-C national distribution truck



ISC post-processing has significant impact

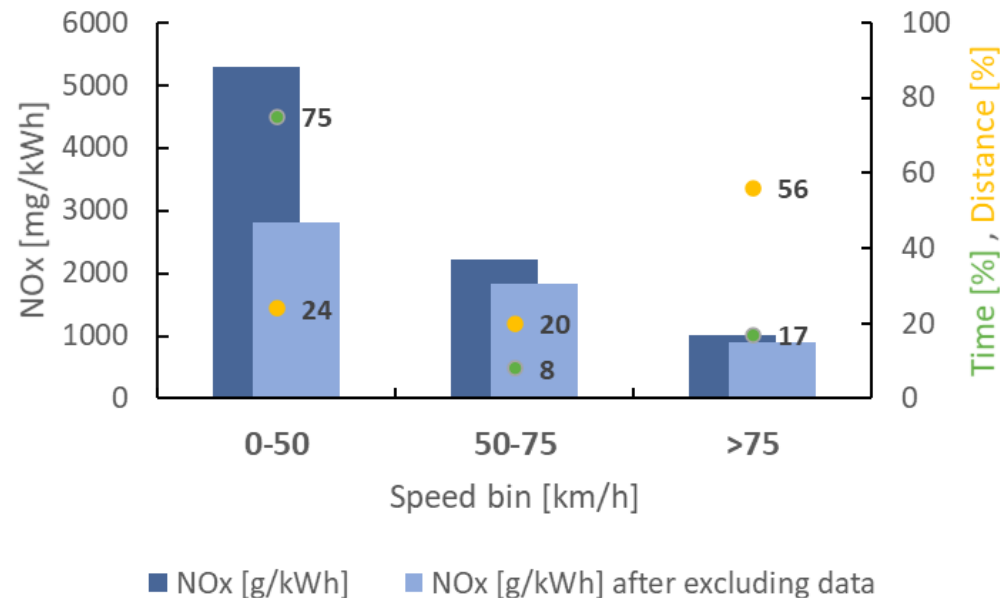
- Most vehicles in database have low emissions in real-world operation according to
 - Average of all data
 - ISC data post-processing
- Highest Moving Average Window in real-world operation can be factor of 5-10 higher
- Investigated next
 - Effect of data exclusions
 - Frequency of high emissions



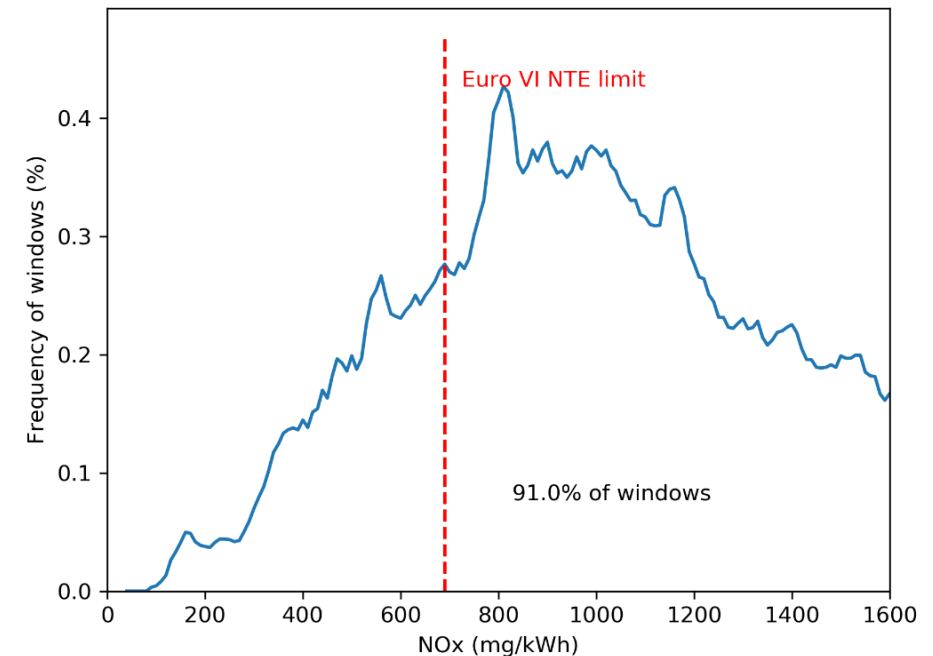
Data exclusions affect urban report value for Euro VI-A to VI-C

➤ Euro VI-A N3 vocational truck

- Urban operation: 75% of the total trip, maximum averaged emissions 11 times the current NOx limit



- 91% of MAW above Euro VI NTE limit

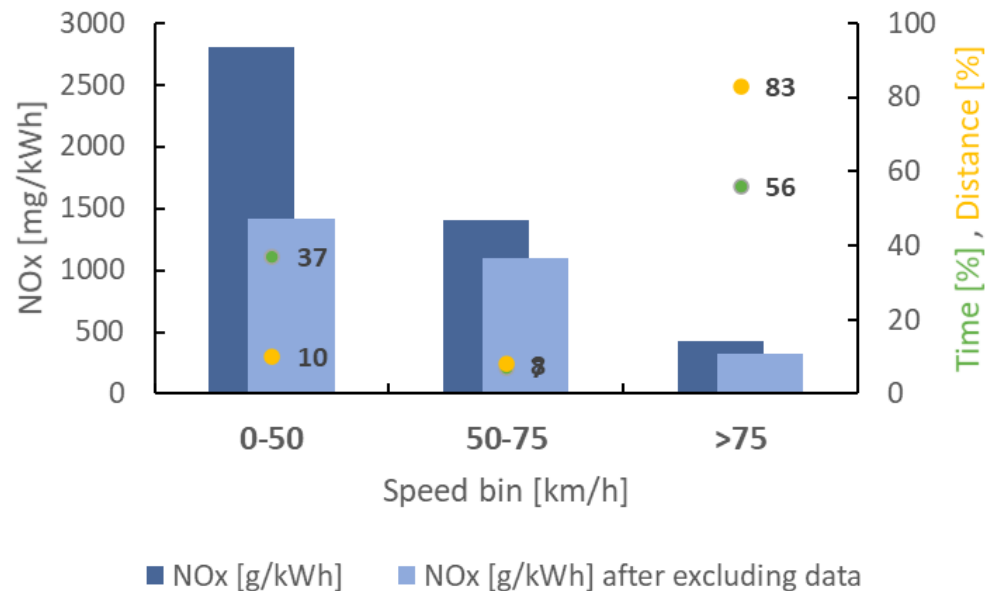


Data excluded: cold start, 20%PT, 90th cumulative percentile.

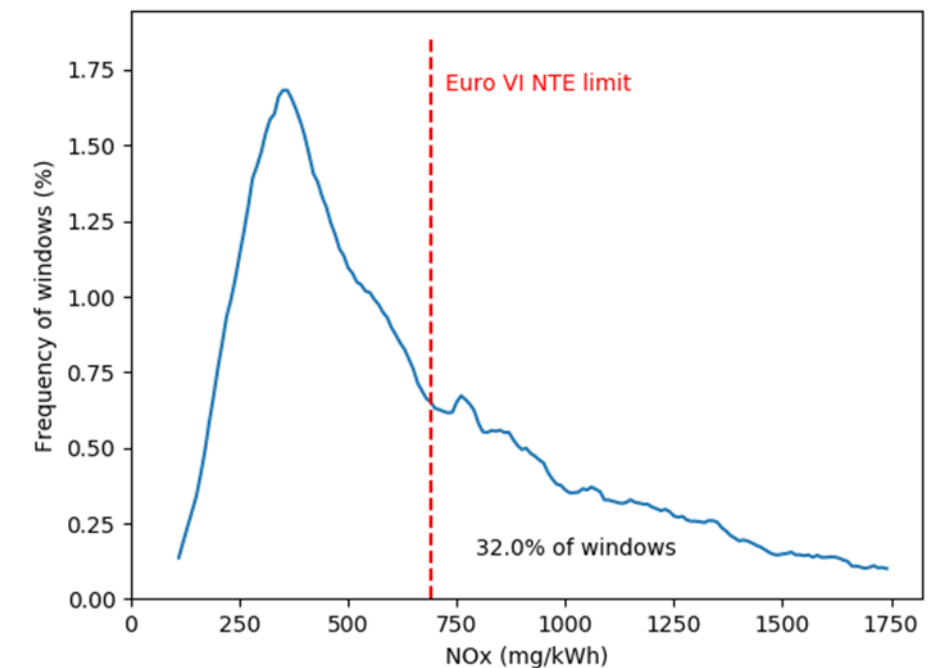
Data exclusions affect urban report value for Euro VI-A to VI-C

➤ Euro VI-C N3 long-haul truck

- Urban operation: 37% of the total trip, maximum averaged emissions 6 times the current NOx limit



- 32% of MAW above Euro VI NTE limit



Data excluded: cold start, 20%PT, 90th cumulative percentile.

Data exclusions affect urban report value for Euro VI-A to VI-C

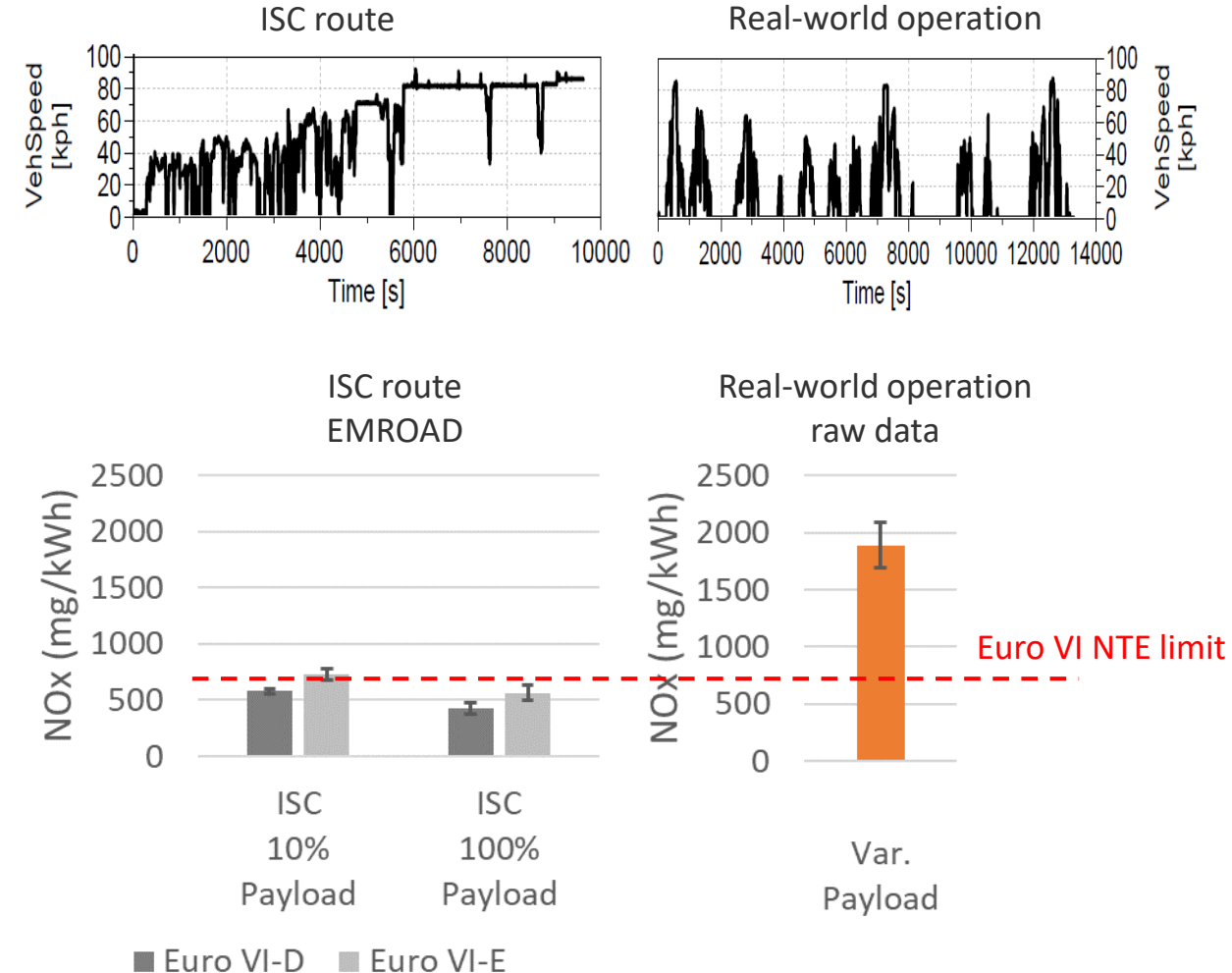
➤ Example of Euro VI-C distribution truck

➤ ISC route

- Stringency increases from Euro VI-D to VI-E
- Truck would comply up to Euro VI-D

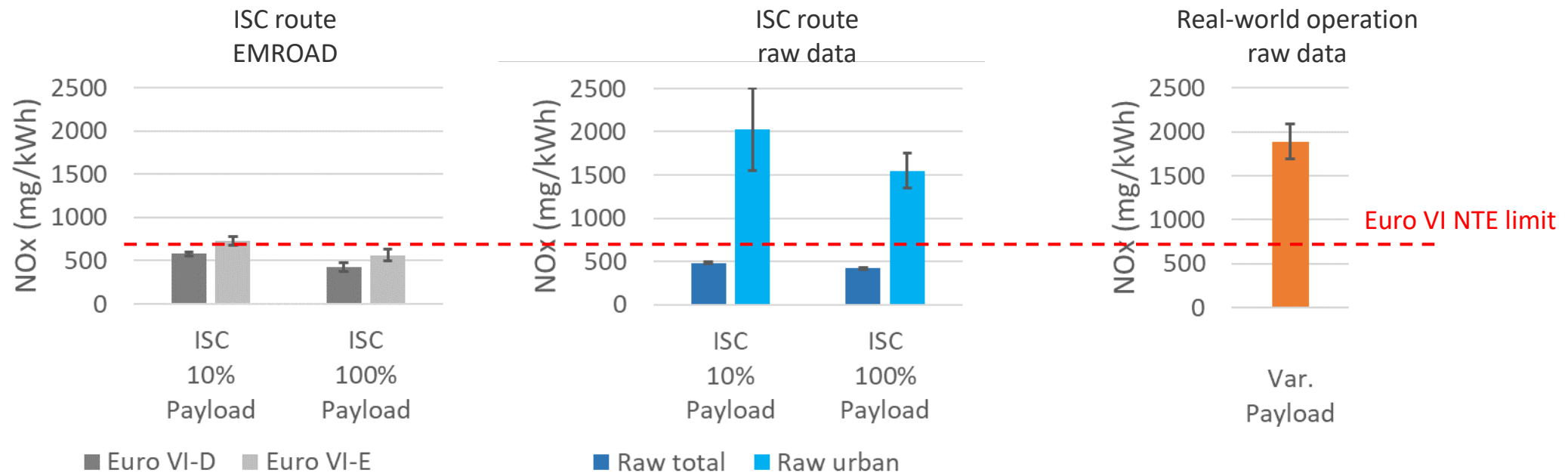
➤ Actual real-world operation

- 100% of time below 10% power threshold
→ Not covered by ISC up to Euro VI-E
- Raw data integrated over test is factor 4-5 higher



Data exclusions affect urban report value for Euro VI-A to VI-C

- Example of Euro VI-C distribution truck
 - Urban part of the ISC route reflects actual real-world emissions

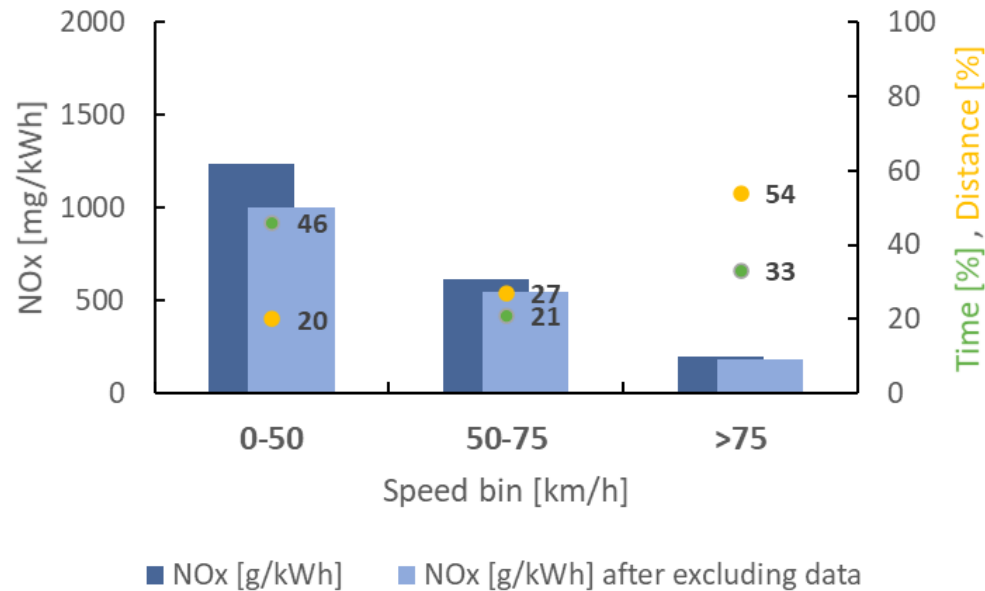


Improvements for Euro VI-D, but high emission events still occur

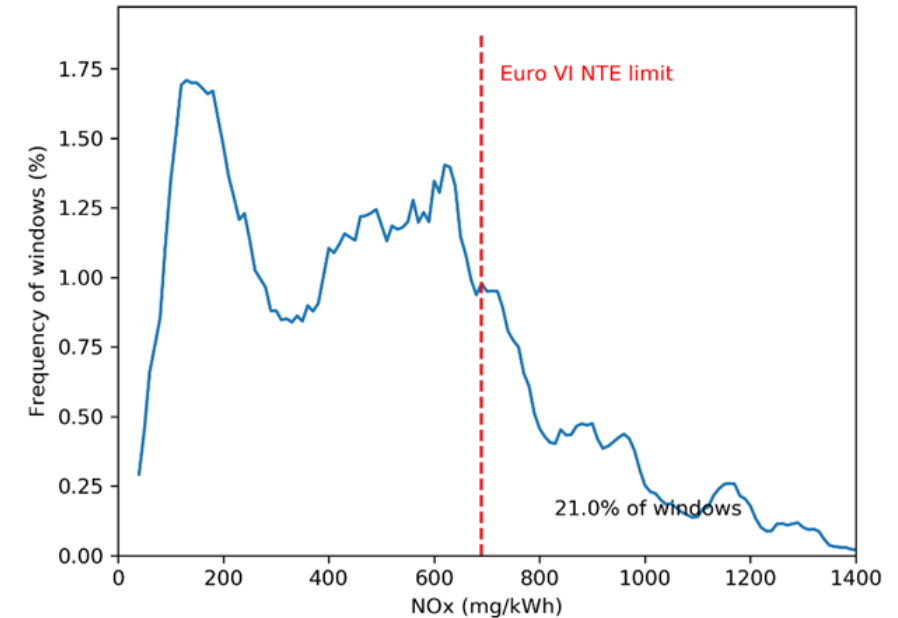
➤ Euro VI-D N2 rigid truck

- Urban operation: 46% of the total trip, maximum averaged emissions 3 times the current NOx limit

- 21% of MAW above Euro VI NTE limit

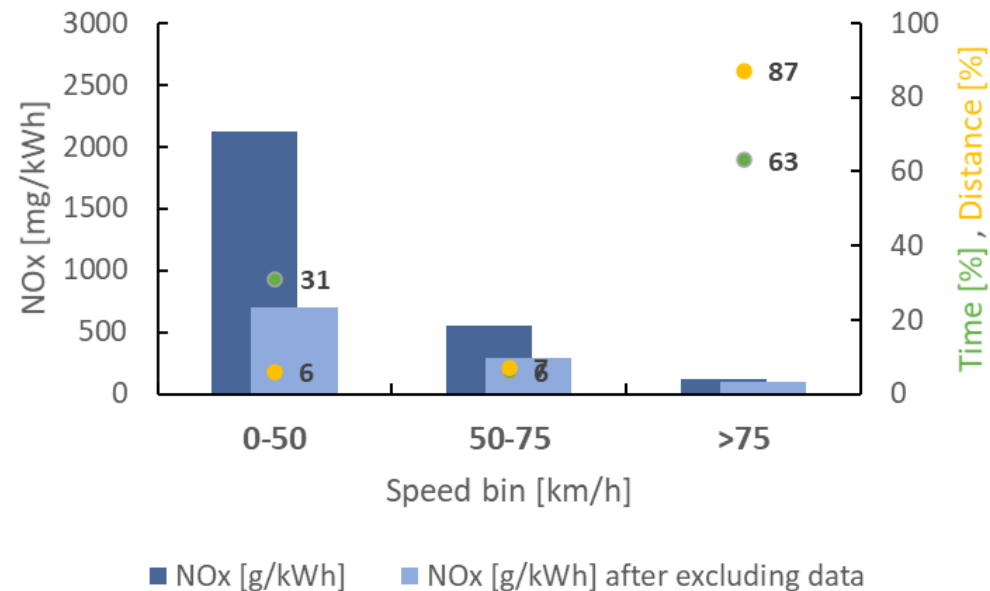


Data excluded: cold start, 10%PT, 90th cumulative percentile.



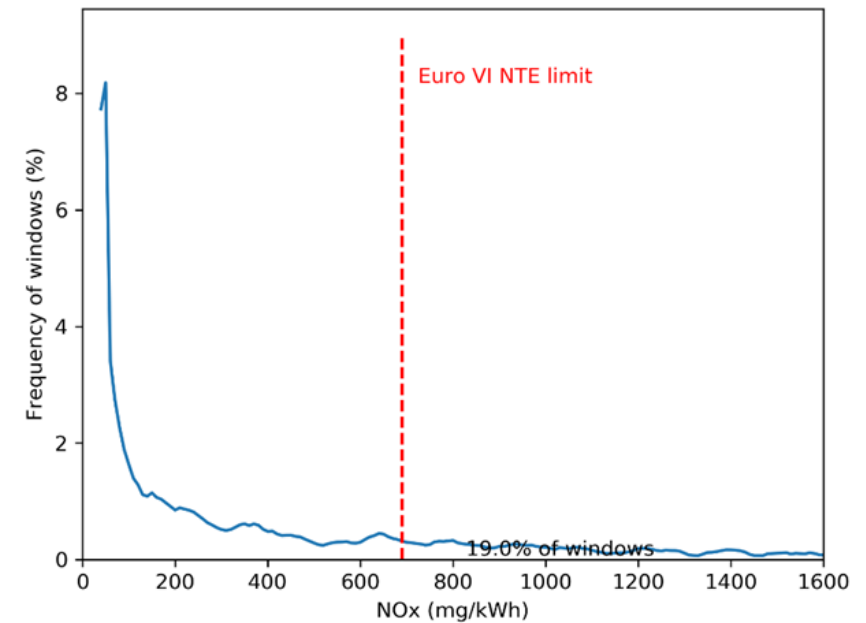
Improvements for Euro VI-D, but high emission events still occur

- Euro VI-D N3 tractor tanker semi-trailer
 - Urban operation: 31% of the total trip, maximum averaged emissions 5 times the current NOx limit



Data excluded: cold start, 10%PT, 90th cumulative percentile.

- 19% of MAW above Euro VI NTE limit



Summary and outlook

- AECC test programme data presented
 - Low NOx emissions from a diesel passenger car over a wide range of driving conditions
 - Heavy-duty ISC post-processing has significant impact on report value for urban operation
- AECC welcomes the EU Commission's legislative initiative to prepare Euro 7/VII
 - A new era for vehicle emissions control started under Euro 6/VI with the introduction of RDE (Euro 6d-TEMP) and PEMS testing (Euro VI-A) within the legislation
 - All predictions show the ICE will be included in the majority of the (electrified) powertrain mix in the medium term
 - There remain areas where improvements to the emission standards are required
 - Real-world emissions measurement framework
 - Setting emissions limits to ensure the health and well-being of everyone
- AECC will continue to demonstrate that technologies are available today to effectively control emissions from ICE under real-world operation towards near zero-impact on air quality

THANK YOU !

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