

Diesel is future proof

UBIA lezing • Brussel • 28 November 2019

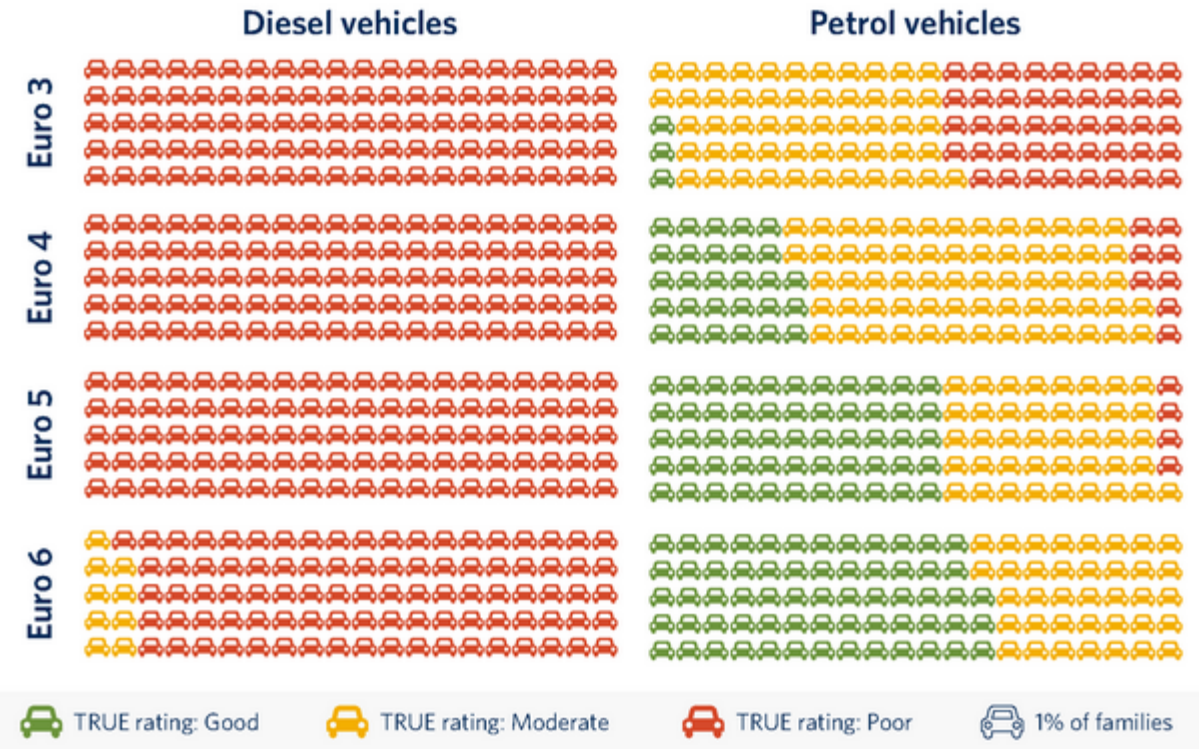
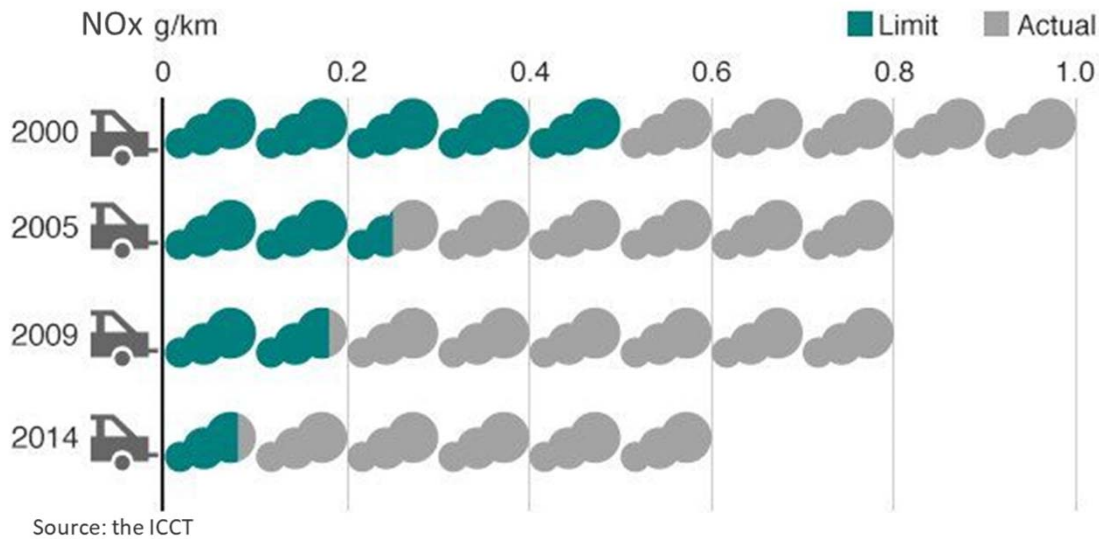
Association for Emissions Control by Catalyst (AECC AISBL)

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)

Real-world NOx emissions gap is issue of pre-RDE diesels



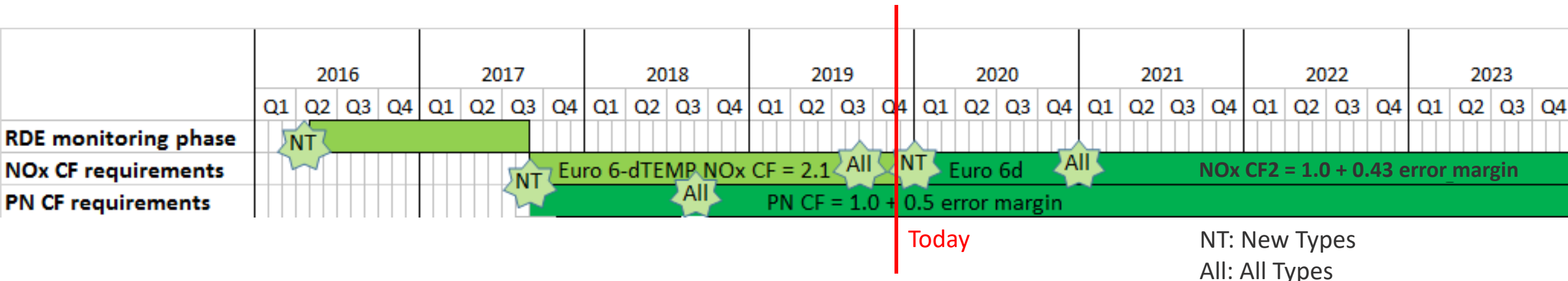
Source: TRUE initiative

Content

- EU Real-driving Emissions legislation
- Low NOx emission diesel cars: a reality
- AECC ultra-low emissions diesel demonstrator
- Gasoline PN emissions

EU-RDE legislation to close the gap between lab and real-world emissions

- Not To Exceed limit (NTE) = Euro 6 limit x Conformity Factor (CF)
 - CF defined for NOx and PN
 - CF applies to urban part and total trip
 - CF in final step accounts for PEMS error margin (Portable Emissions Measurement Systems)
- Two stages added to Euro 6 legislation: Euro 6d-TEMP and Euro 6d



PEMS equipment used to measure emissions on the road



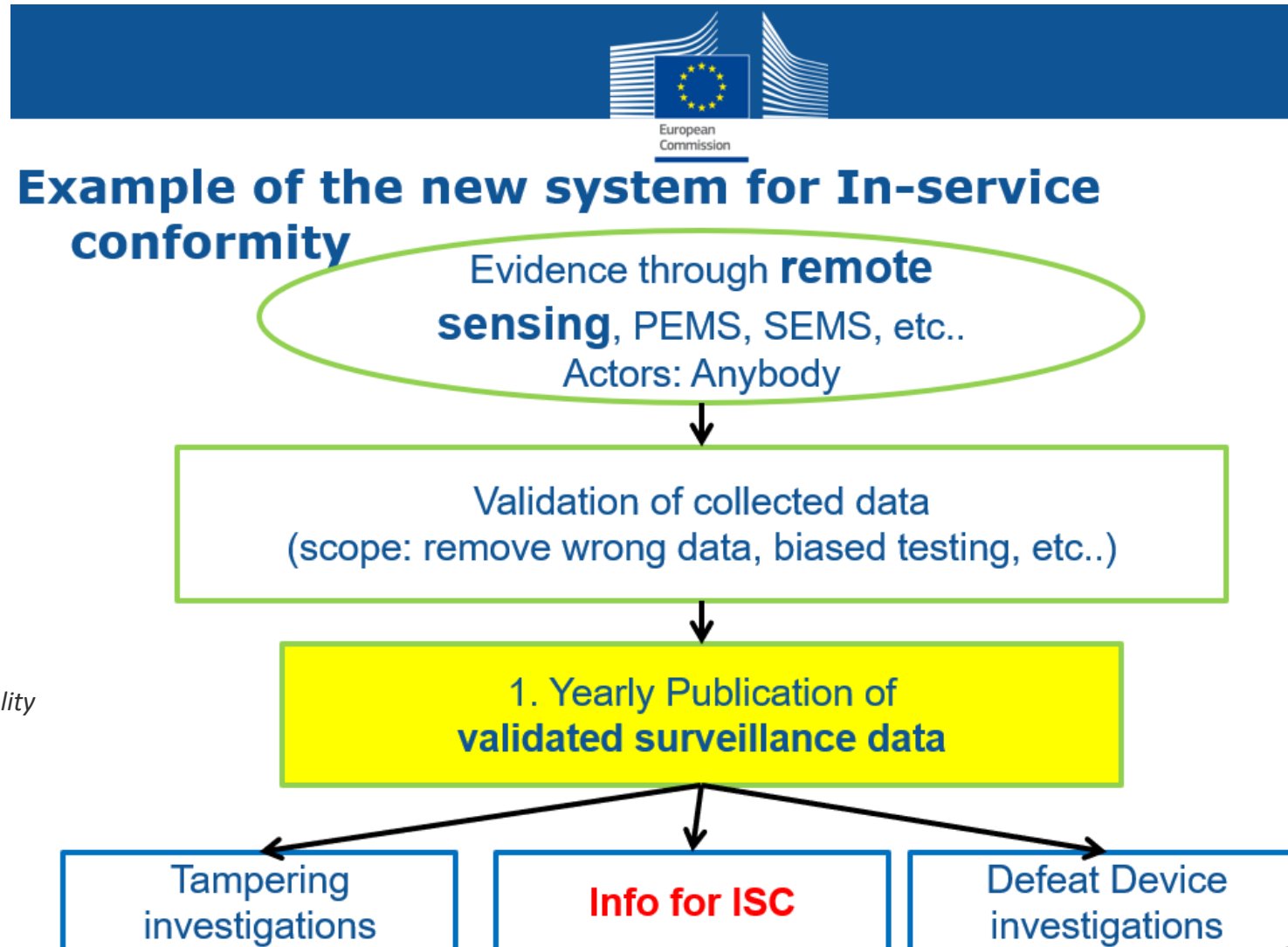
In-Service Conformity and Market Surveillance are key

Defined in 4th legislative EU-RDE package - Regulation (EU) 2018/1832

- Applies to New Types as of 1 January 2019 and All New Vehicles as of 1 September 2019
- Mandatory tests
 - Type 1: RDE
 - Type 1: WLTP
- Optional tests
 - Type 4: evaporative emissions
 - Type 6: low ambient temperature
- Some examples of process flow in next 2 slides

In-Service Conformity and Market Surveillance are key

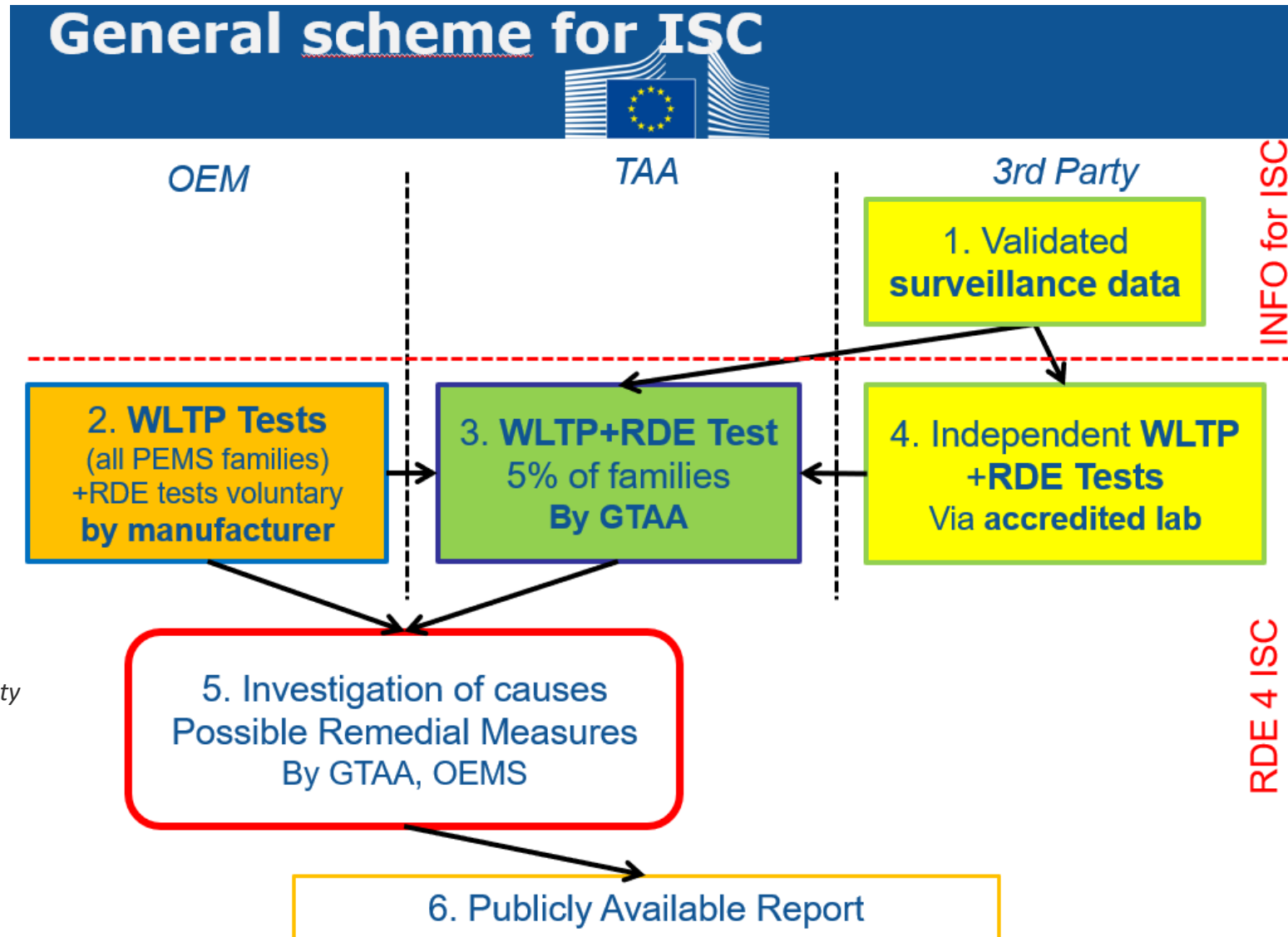
Defined in 4th legislative EU-RDE package



Source: Z. Kregar, "Update on EU Air Quality and vehicle emissions policies", EIONET meeting on environment and transport, 2018, Copenhagen

In-Service Conformity and Market Surveillance are key

Defined in 4th legislative EU-RDE package



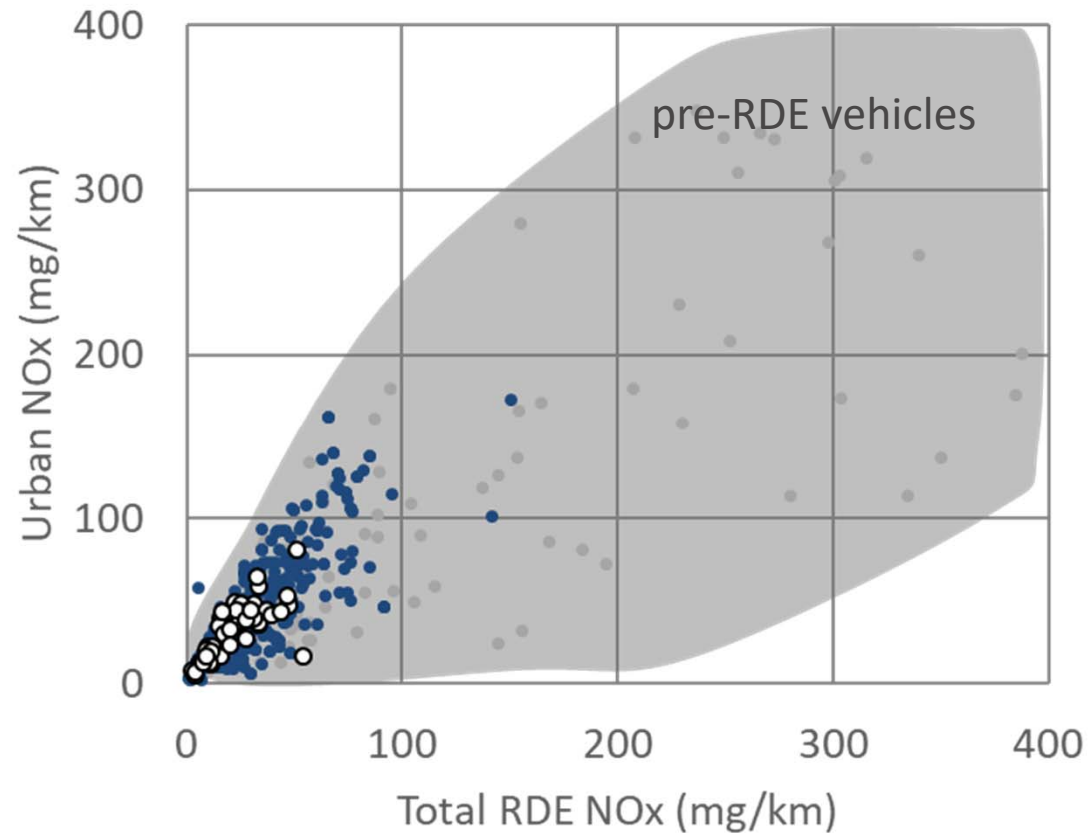
Source: Z. Kregar, "Update on EU Air Quality and vehicle emissions policies", EIONET meeting on environment and transport, 2018, Copenhagen

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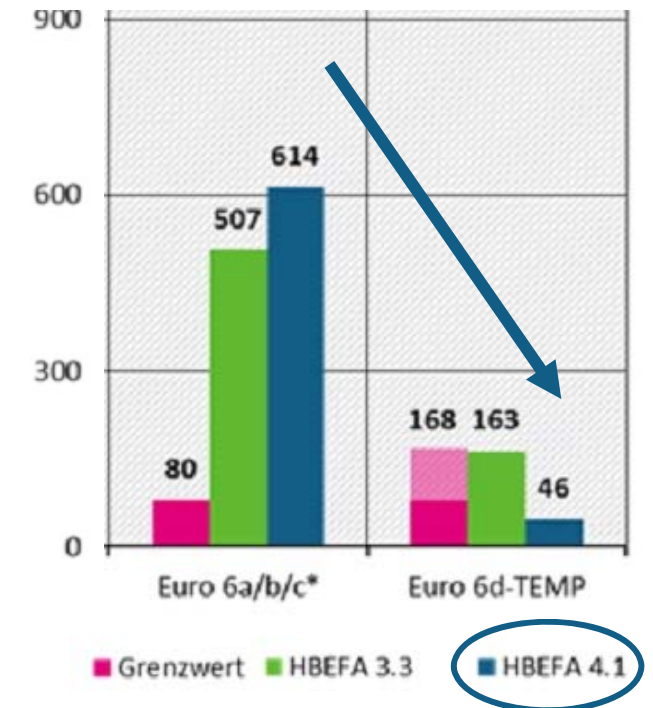
- EU Real-driving Emissions legislation
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RDE has significantly improved diesel NOx emissions

- On-road emissions of Euro 6d(-TEMP) cars are well within standards



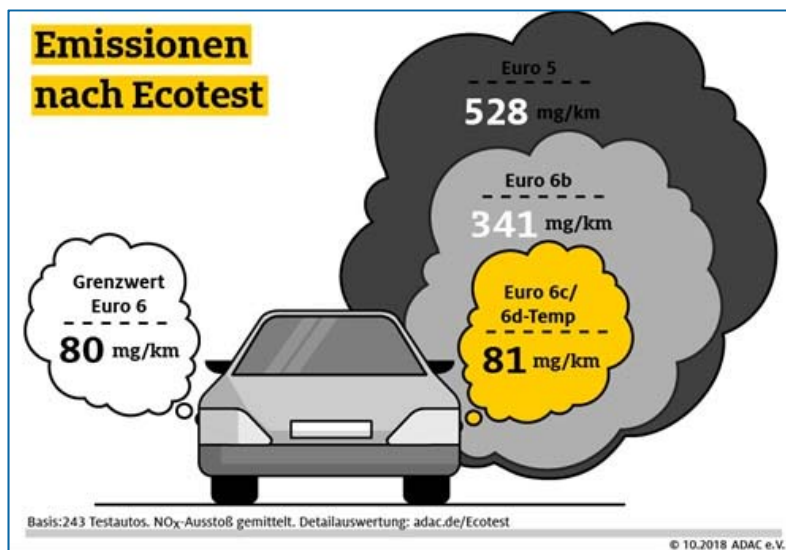
Source: ACEA/JAMA PEMS
data consulted
19 November 2019



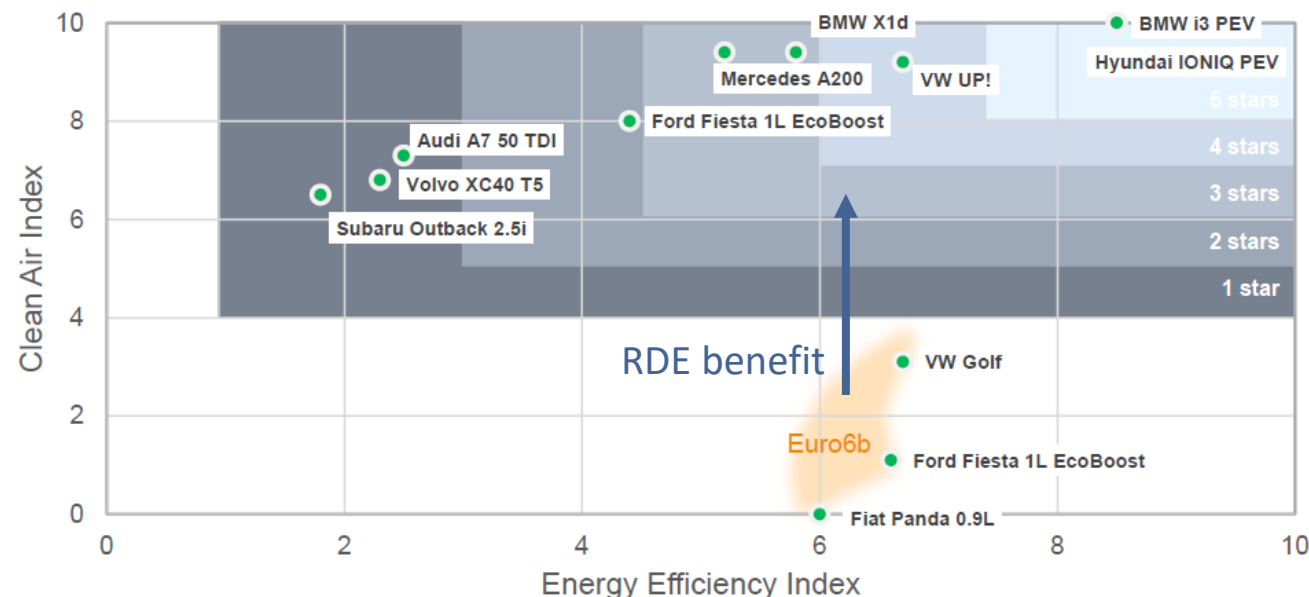
Source: Handbook of Emissions Factors 4.1,
UBA press release 11 September 2019

RDE has significantly improved diesel NOx emissions

➤ Trend is confirmed by 3rd party testing



Source: ADAC Ecotest



Source: Green NCAP

DIESEL NO_x AVERAGES (G/KM)



- EURO 5
0.814
- EURO 6 PRE-RDE
0.334
- EURO 6 POST-RDE
0.048



Source: Emissions Analytics

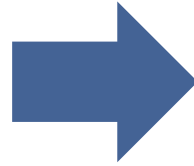
**Diesel und Benziner:
Jetzt sind beide sauber!**



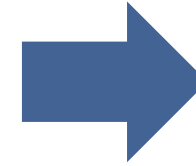
Source: Auto Motor und Sport

Light-duty diesel emissions control technology evolution

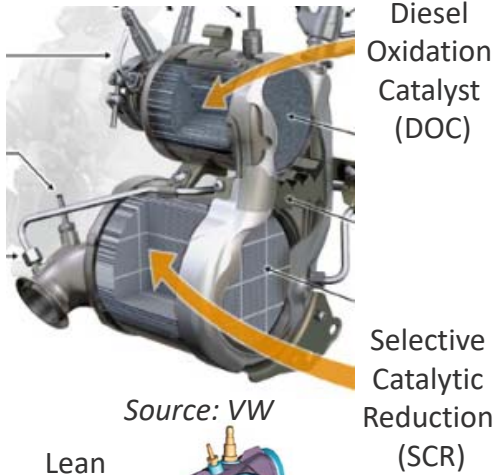
Introduction of individual deNOx technologies for Euro 6a/b



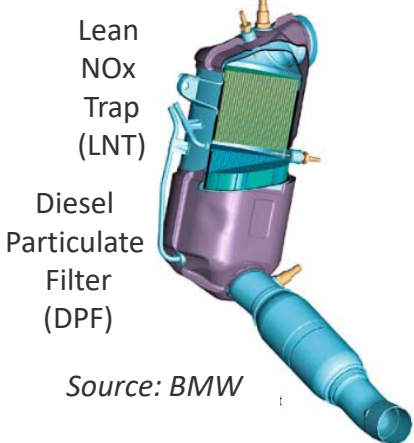
Combination of deNOx technologies for Euro 6d-TEMP



Further integration for Euro 6d



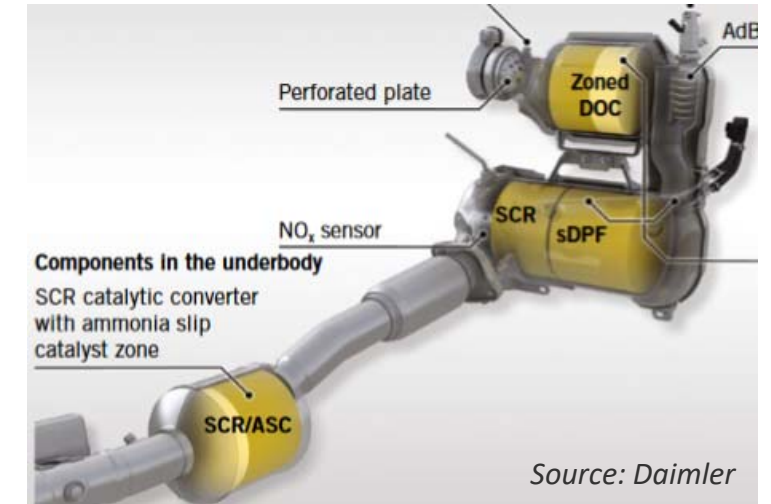
Source: VW



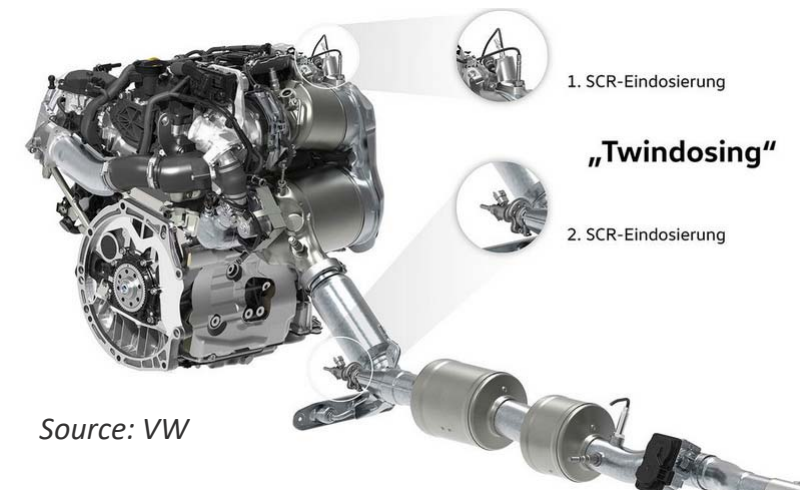
Source: BMW



Source: Hyundai



Source: Daimler



Source: VW

Content

- EU Real-driving Emissions legislation
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AECC ultra-low NOx emissions diesel demonstrator

➤ Robust NOx control over wide range of driving conditions

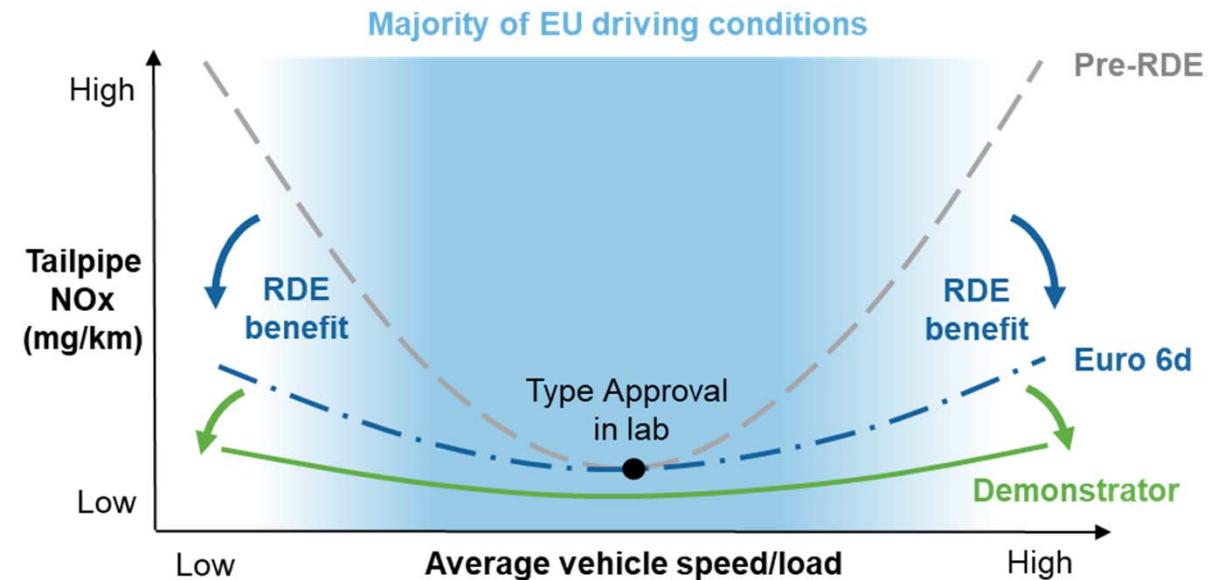
➤ Low speed/load
e.g. city driving



➤ High speed/load
e.g. motorway driving



➤ Transients
e.g. overtaking



More details: J. Demuynck, et al.; "Integrated Diesel System Achieving Ultra-Low Urban and Motorway NOx Emissions on the Road", 40th International 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>

Vehicle and powertrain characteristics

➤ Vehicle

- Renault Scenic – C-segment
- 1700 kg

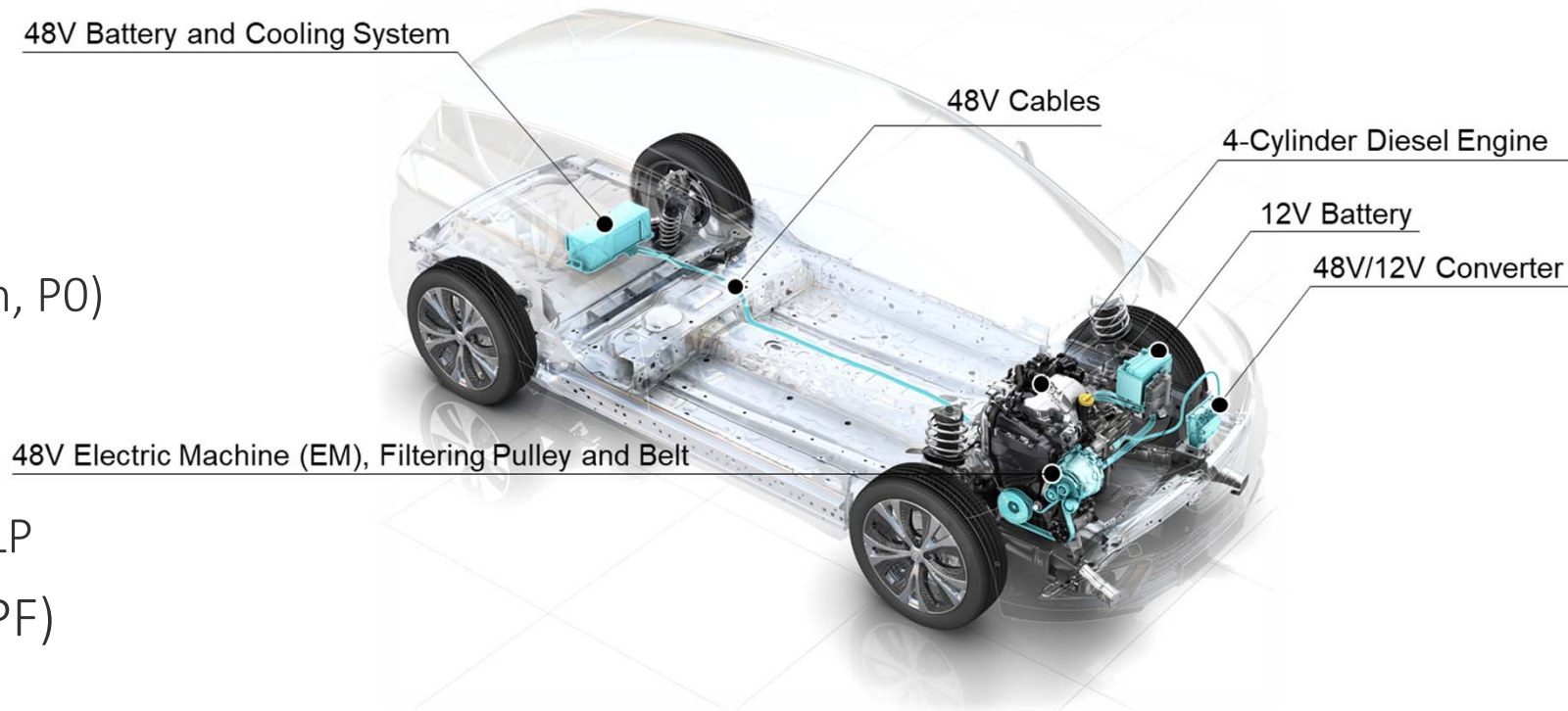
➤ Drivetrain

- Manual gearbox, 6-speed
- 48 Volt mild-hybrid (belt-driven, P0)

➤ Engine

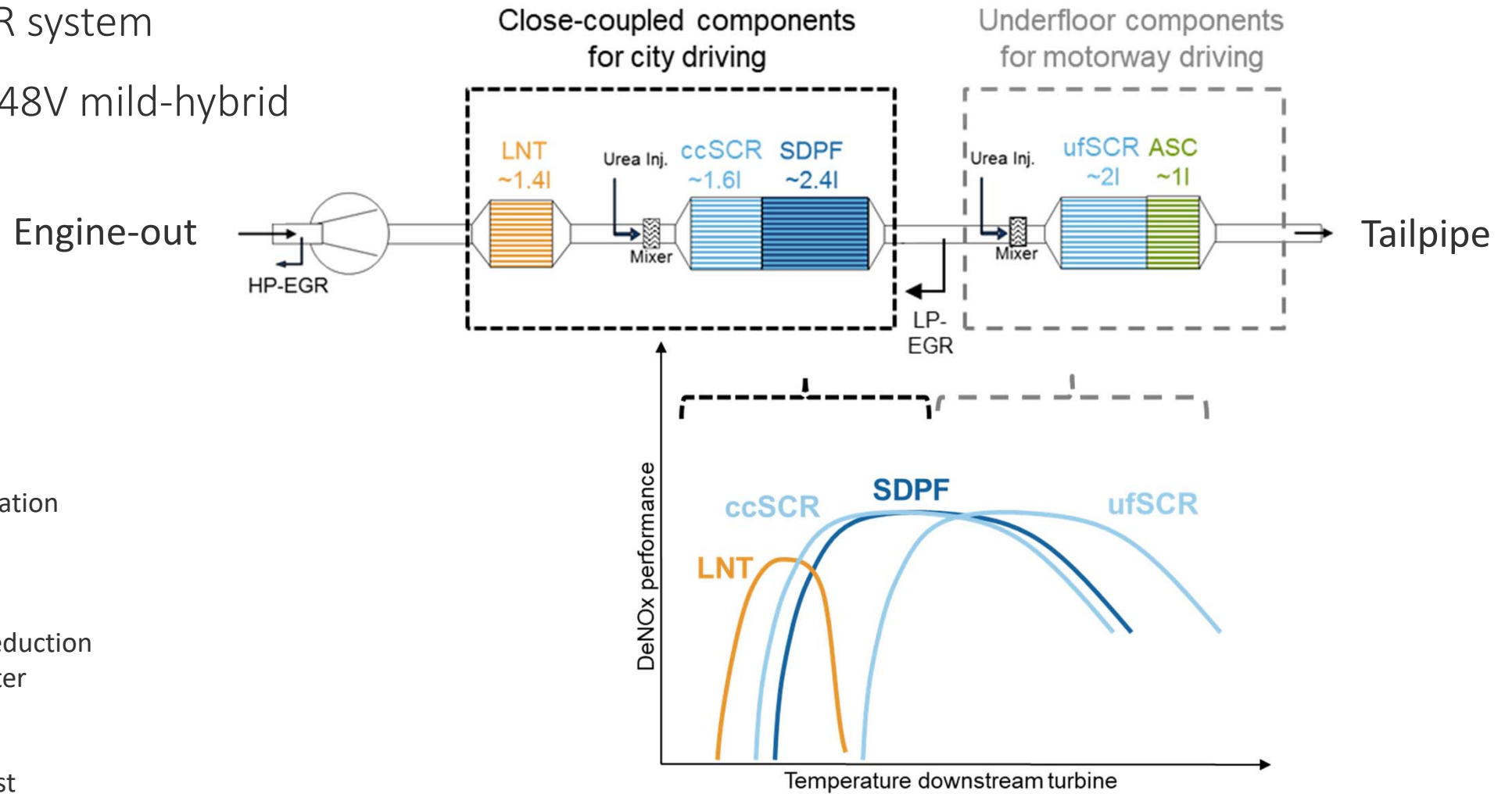
- 1.5l, 4-cylinder, 2-valve
- EGR: uncooled HP and cooled LP

➤ Euro 6b type-approval (LNT + DPF)



Emissions controls to cover wide range of driving conditions

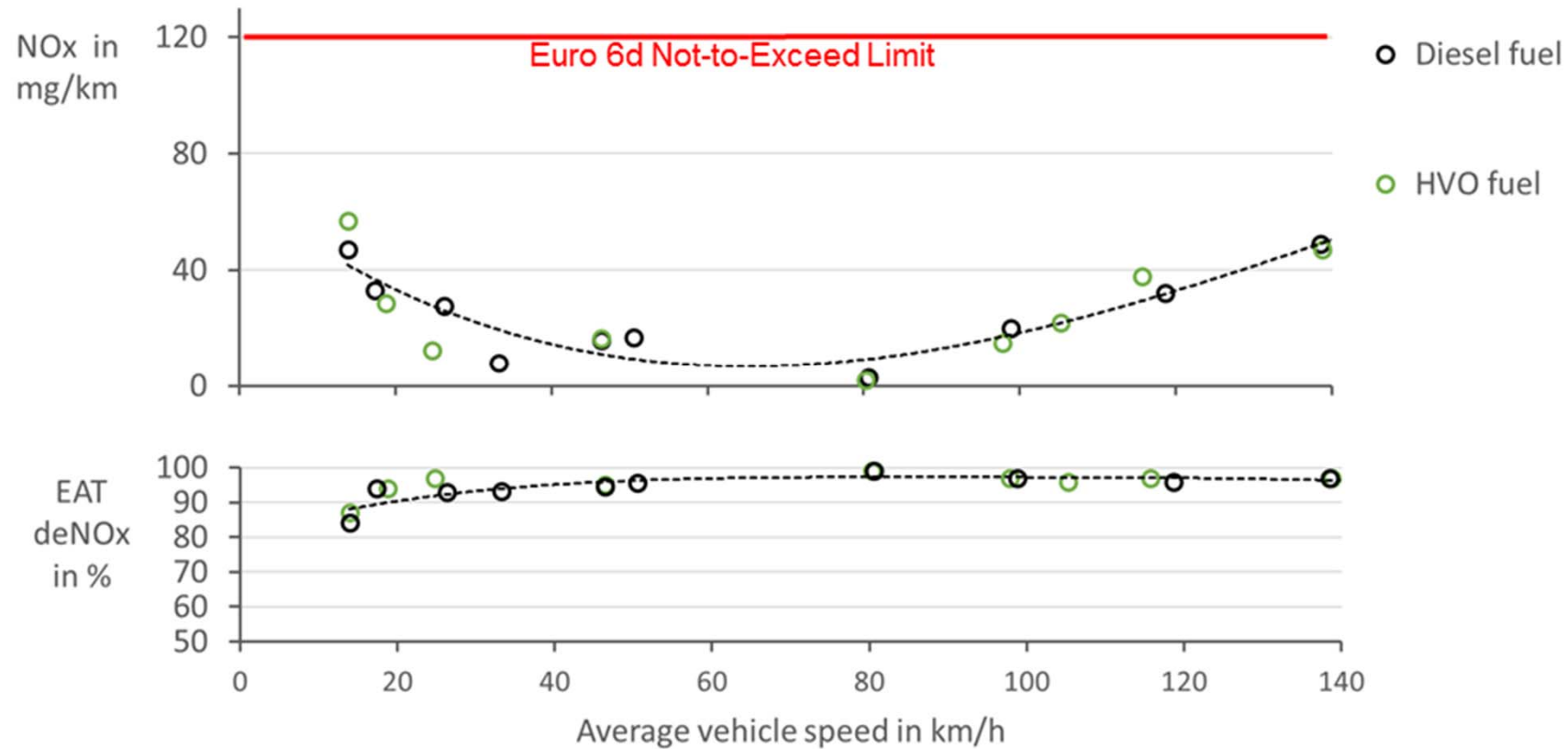
- LNT + dual-SCR system
- Supported by 48V mild-hybrid



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

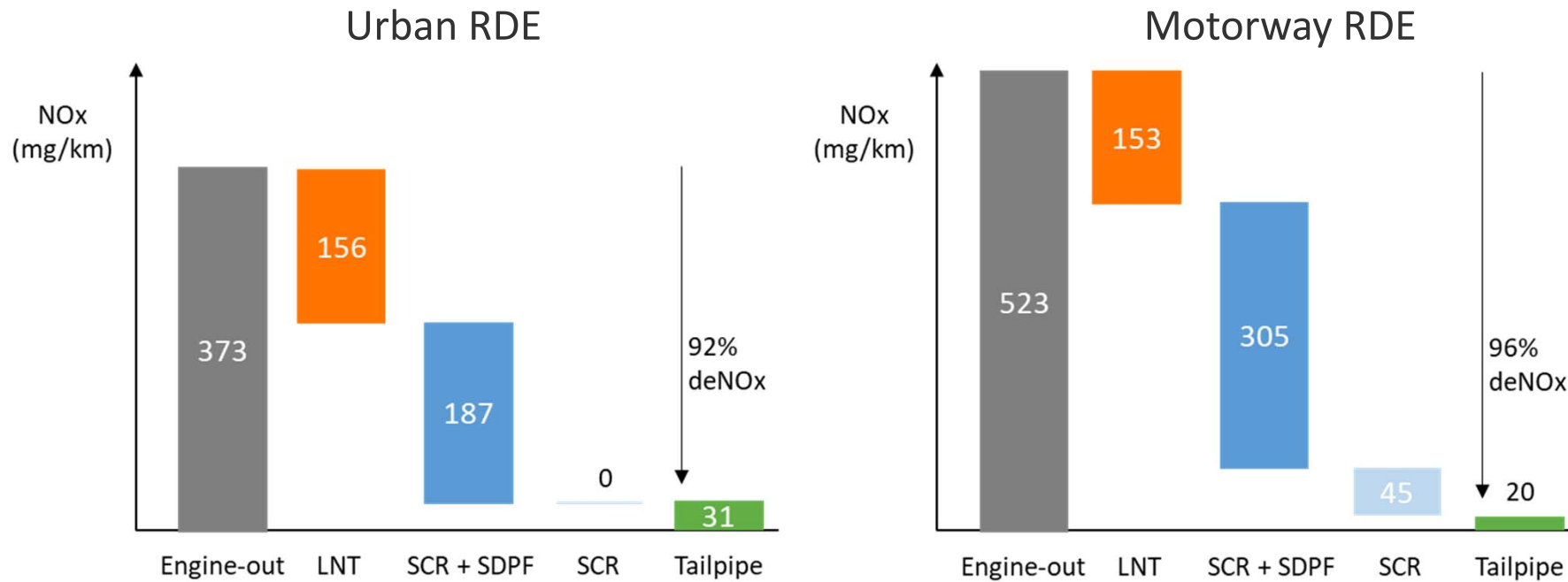
Robust NOx control achieved

- Also on a renewable fuel which offers reduced CO₂ emissions on lifecycle basis



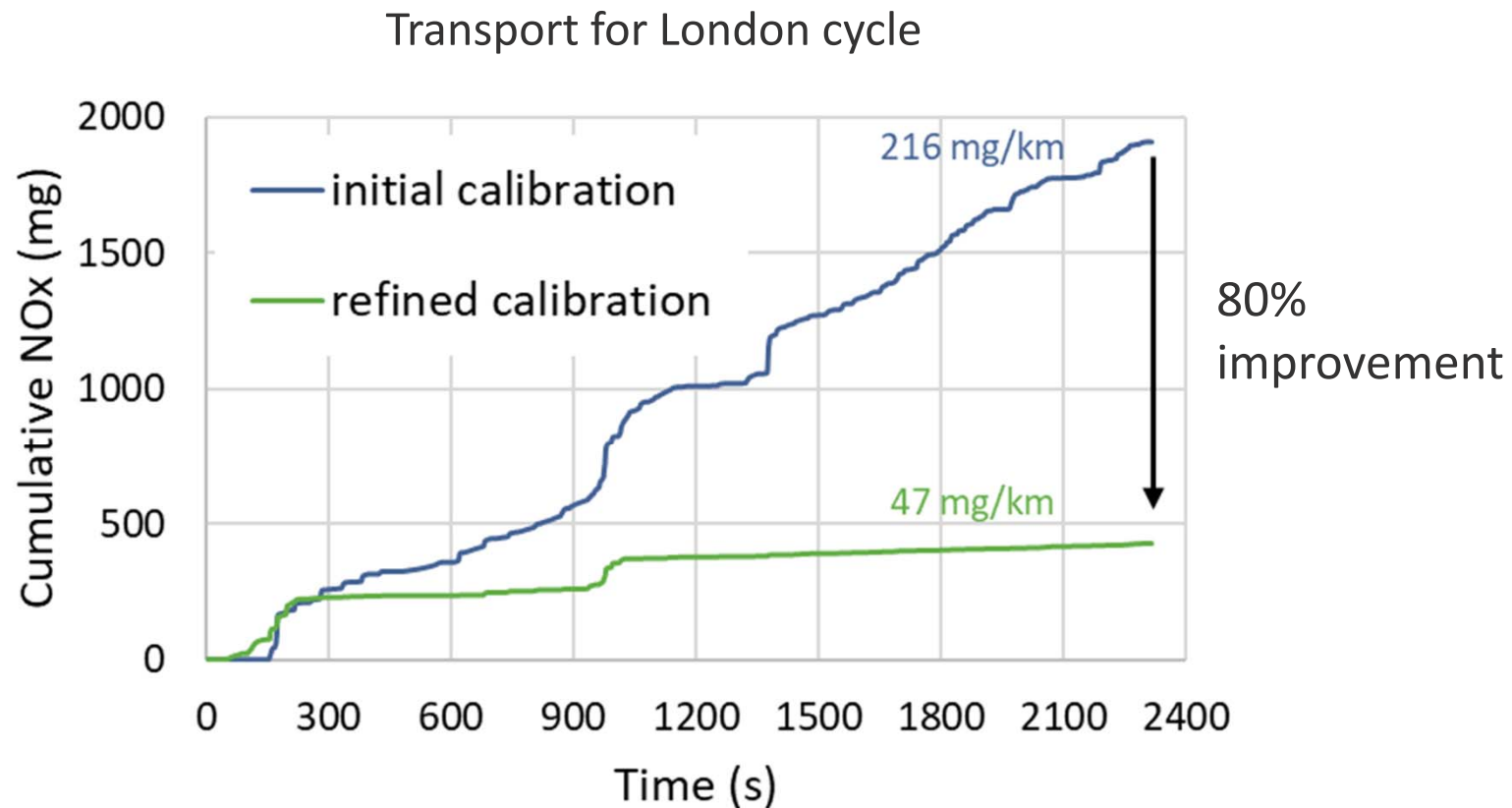
All aftertreatment components contribute to NO_x control

- City driving: LNT and close coupled SCR+SDPF
- Motorway driving: underfloor SCR required to secure robust emissions control



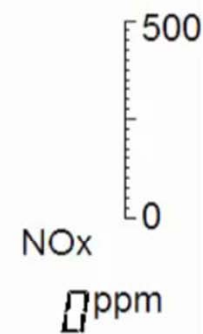
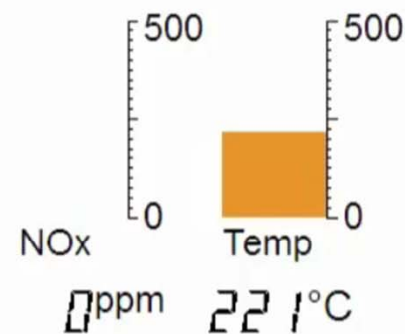
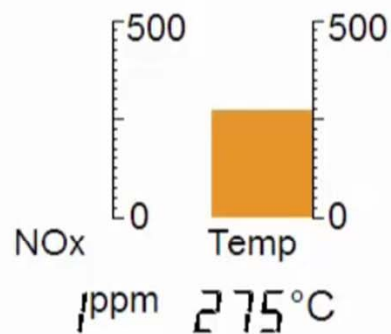
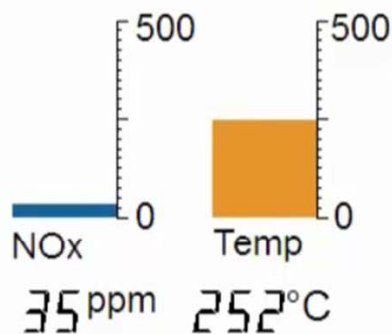
Robust NO_x control in the city directly after cold-start

- 80% improvement due to LNT regeneration stabilisation and active thermal management
- Near-zero emissions in the city after the cold-start phase





Engine load: 11% Vehicle speed: 0 km/h



Engine
heat-up

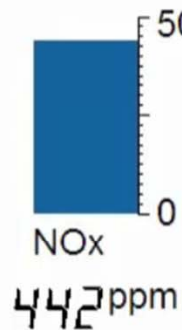
LNT
regeneration

Urea
doser 1

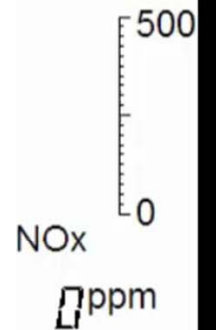
Urea
doser 2



Engine load: 57% Vehicle speed: 118 km/h



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



Engine heat-up



LNT regeneration



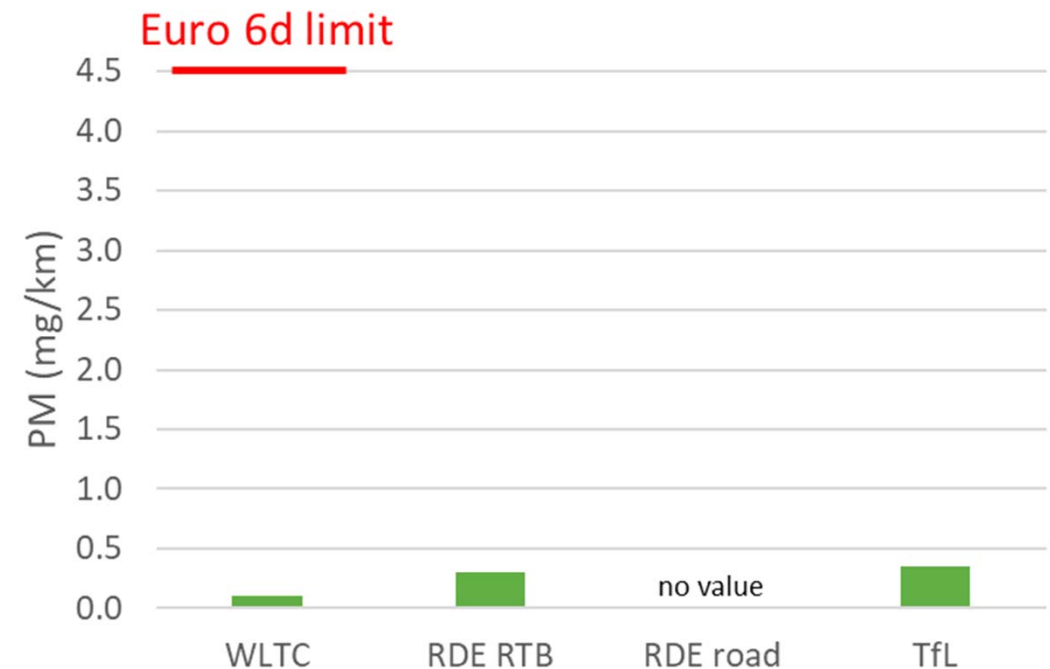
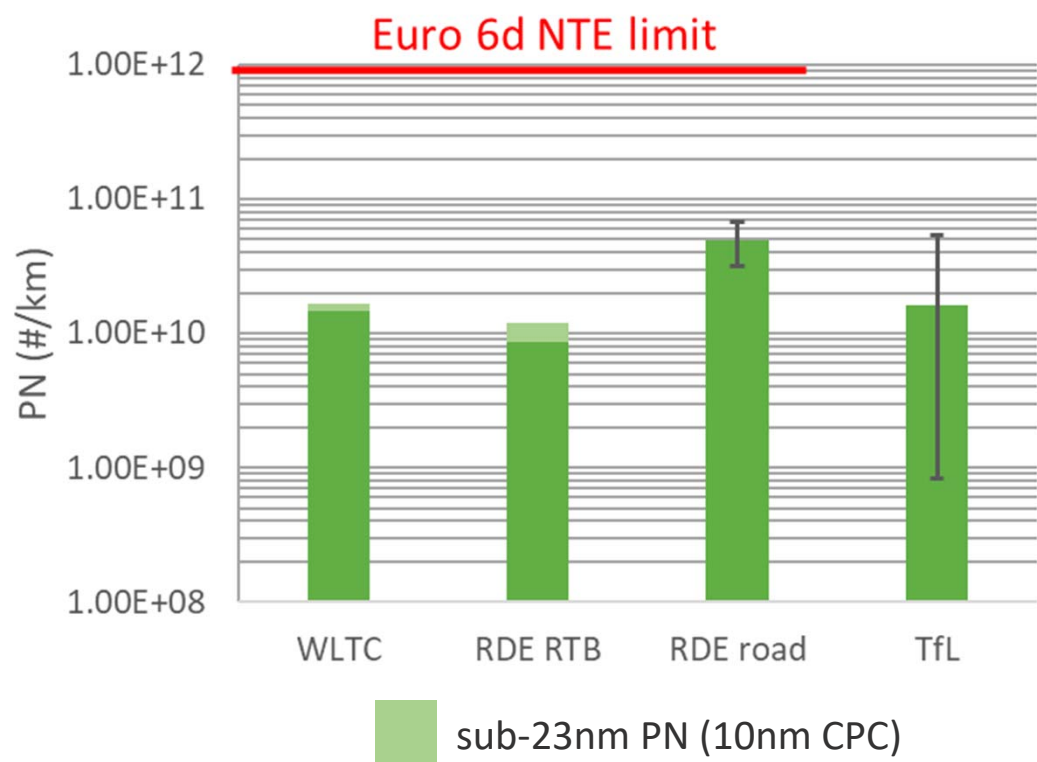
Urea doser 1



Urea doser 2

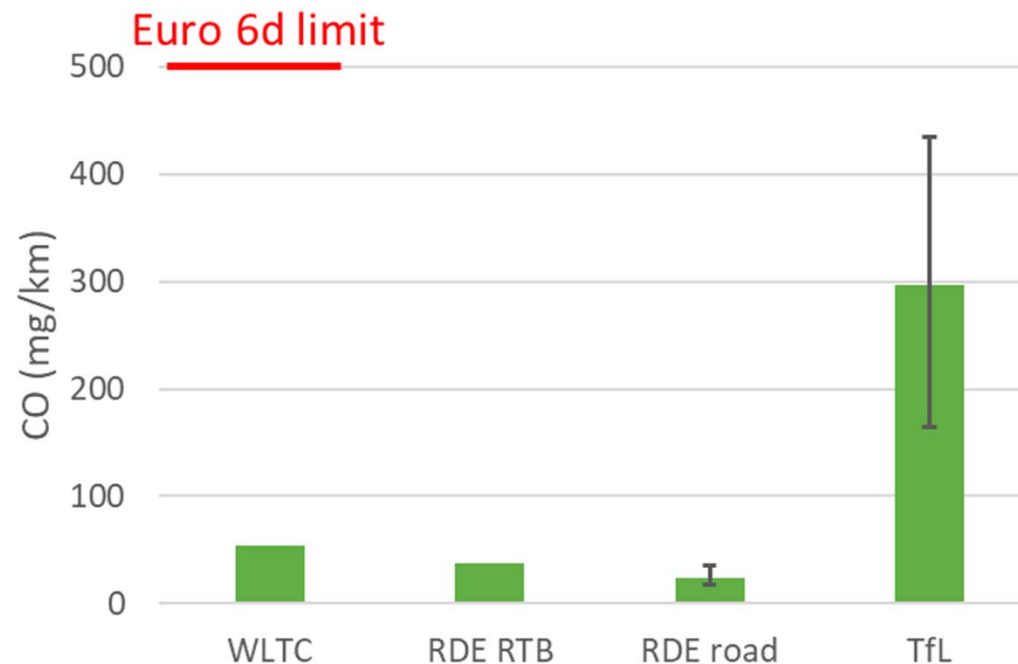
PN and PM controlled by SDPF under all driving conditions

➤ PN of all tests has order of magnitude between 10^9 and 10^{10} #/km



CO emission well within standards on WLTC and RDE

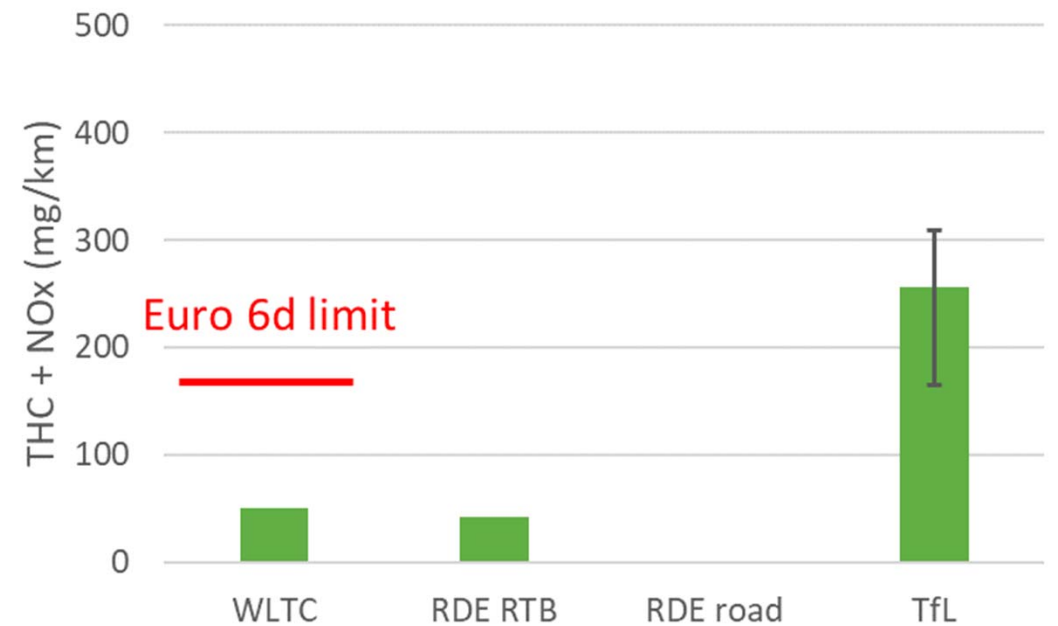
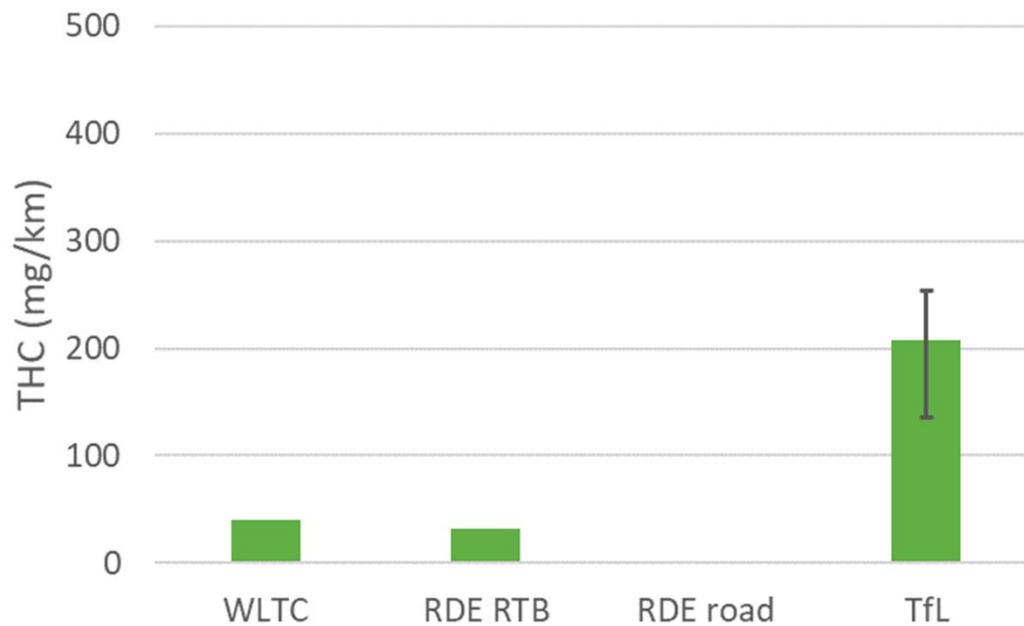
- Remains below 50 mg/km on WLTC and RDE
- Increases on TfL due to impact of thermal management (optimisation was outside programme scope)



UBIA – 28 November 2019

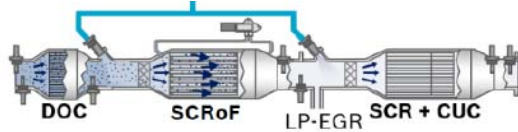
THC emission well within standards on WLTC and RDE

- THC+NOx remains below 50 mg/km on WLTC and RDE
- Increases on TfL due to impact of thermal management (optimisation was outside programme scope)

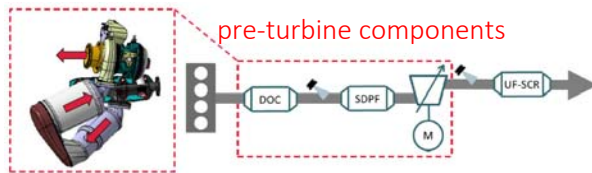


Other approaches are available to achieve low NOx

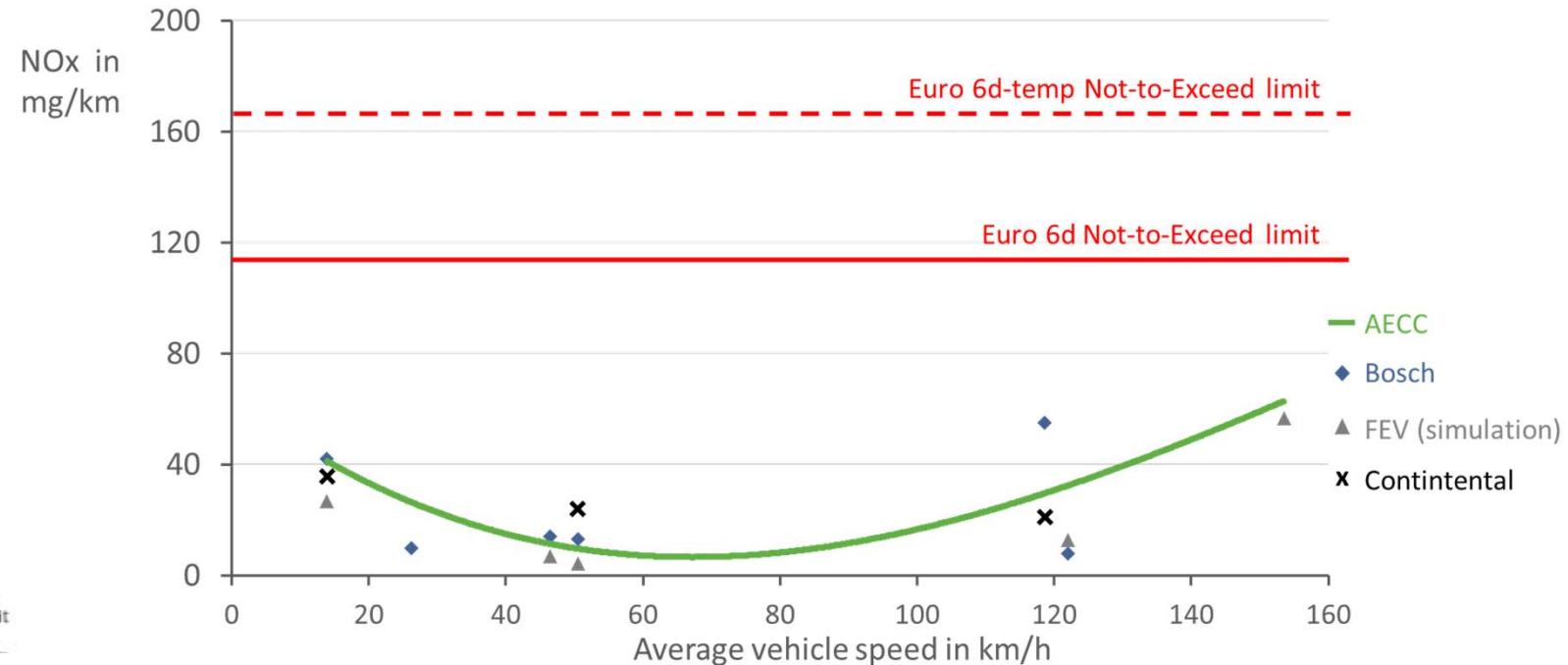
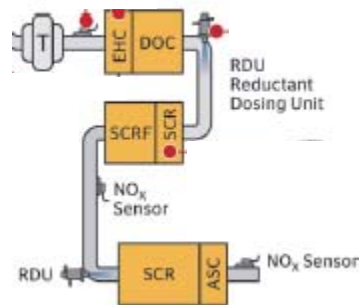
➤ Bosch [1]: DOC + dual-SCR



➤ FEV [2]: DOC + dual-SCR

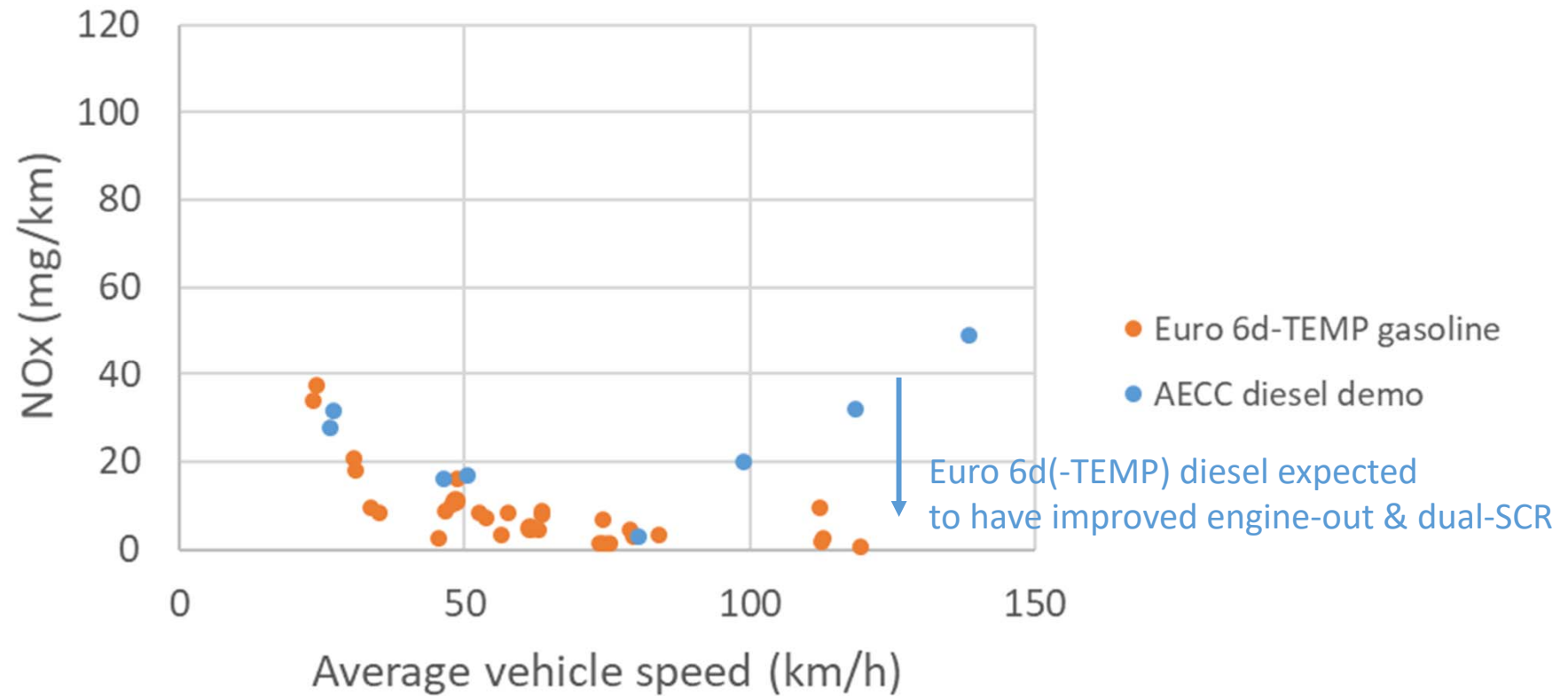


➤ Continental [3]: eDOC + dual-SCR



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

Diesel achieves similar NOx emissions as gasoline



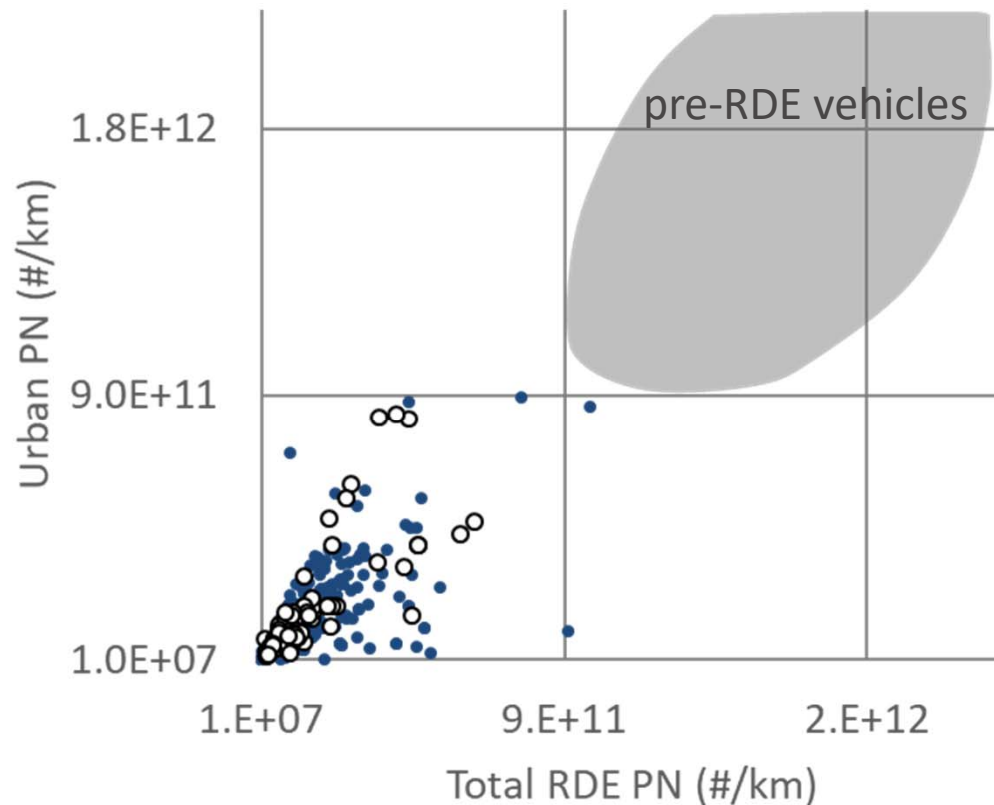
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RDE has significantly improved GDI PN emissions

➤ On-road emissions of Euro 6d(-TEMP) cars are well within standards

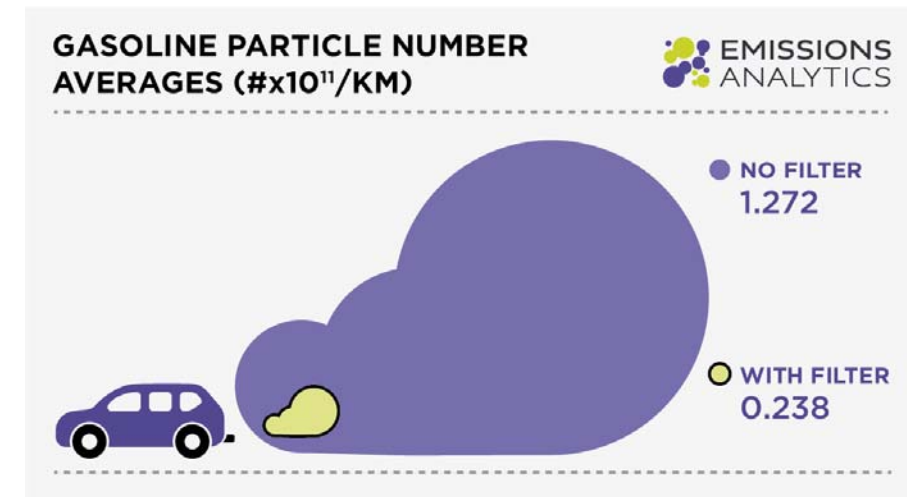
➤ Trend is confirmed by 3rd party testing



- Euro 6b/c
- Euro 6d-temp
- Euro 6d

Source:

- ACEA/JAMA Euro 6d(-TEMP) PEMS data consulted 19 November 2019
- pre-RDE emissions factors from B. Giechaskiel, *Int. J. Environ. Res. Public Health*, 2018



Source: Emissions Analytics

Light-duty gasoline emissions control technology evolution

Single Three-Way Catalyst
for Euro 6a/b

Three-Way Catalyst (TWC)

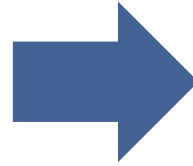


Source: Volvo



TWC

Source: VW



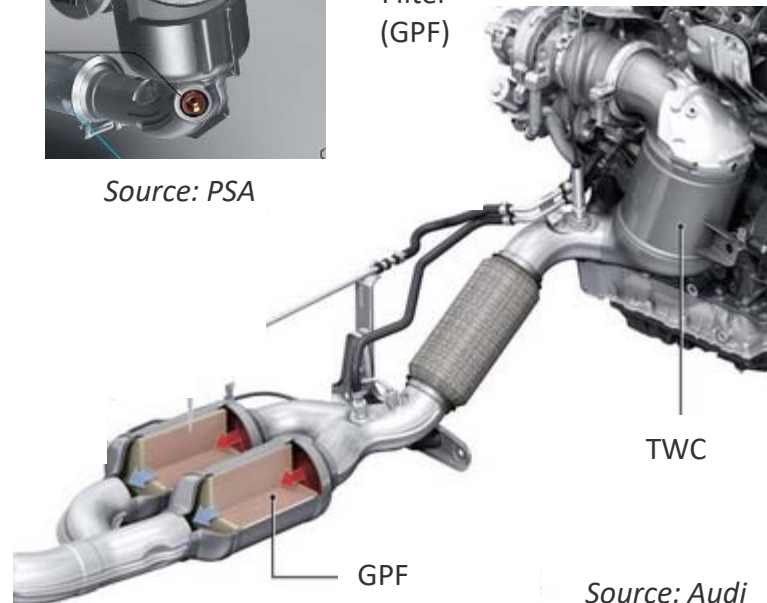
Introduction of Gasoline Particulate Filter on cars with direct injection and
integration with Three-Way Catalyst for Euro 6d(-TEMP)



TWC

Gasoline
Particulate
Filter
(GPF)

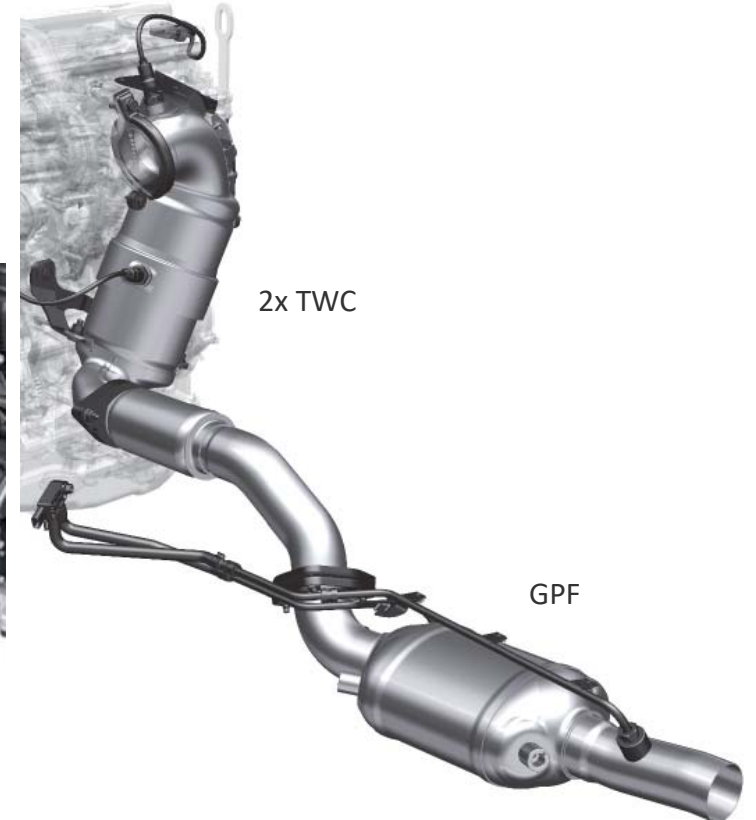
Source: PSA



TWC

GPF

Source: Audi



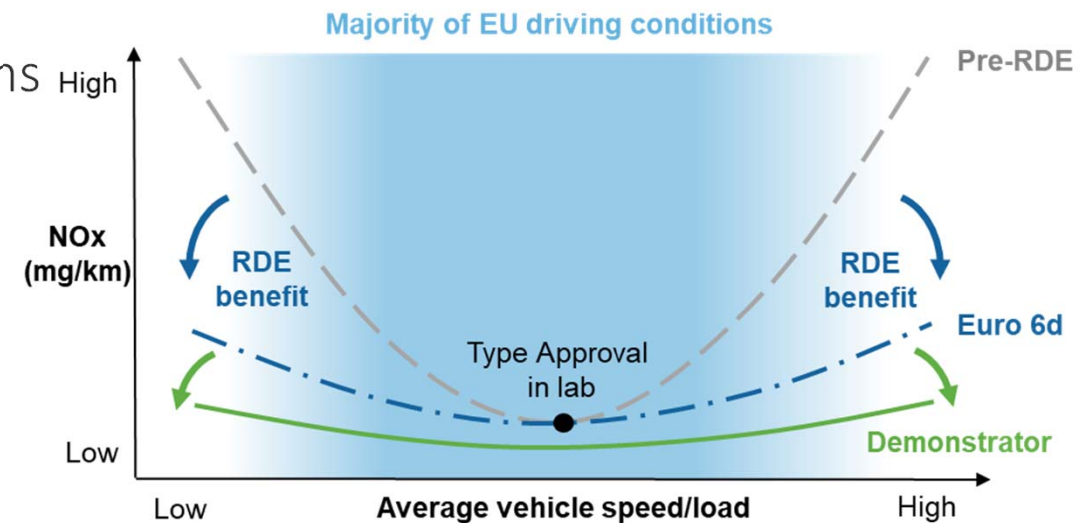
2x TWC

GPF

Source: Opel

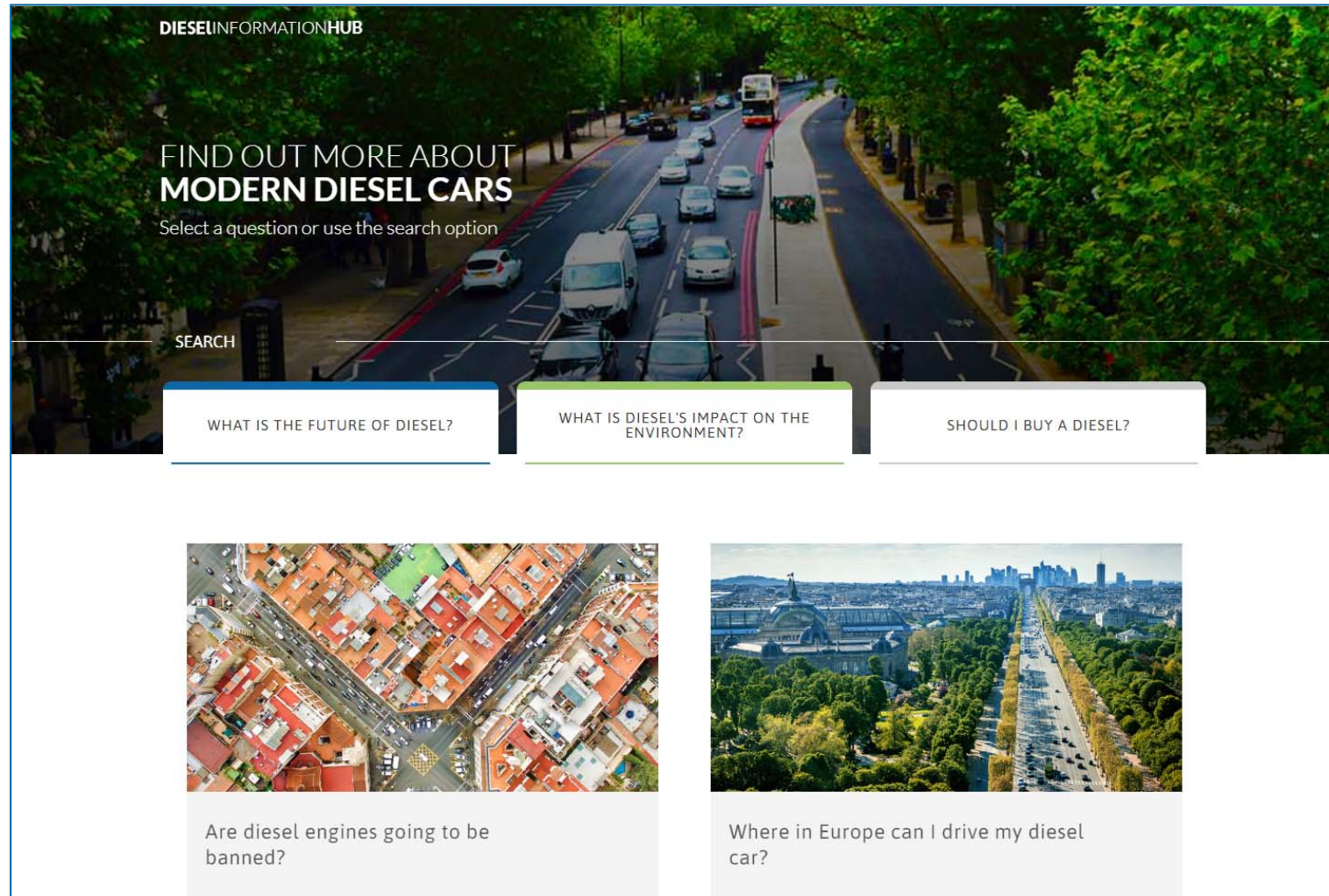
Conclusions

- RDE requirements have ensured better control of NOx & PN emissions under most EU driving conditions on both diesel and gasoline vehicles – these Euro 6d(-TEMP) cars are on the road today
- AECC's diesel demo car shows that diesel NOx emissions can be kept at a very low level in a consistent way, over a wide range of driving conditions
- This is achieved by combining existing catalyst technologies with improved engine and aftertreatment control functions supported by hybrid technology.



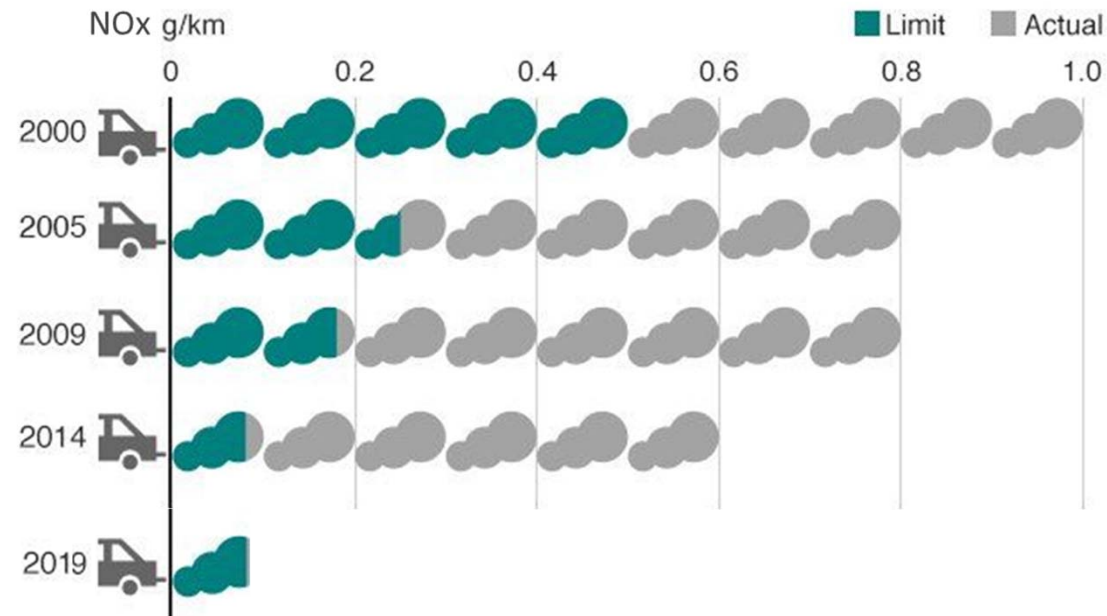
Diesel Information Hub

<https://dieselinformation.aecc.eu>



The screenshot shows the Diesel Information Hub website. At the top, the text "DIESELINFORMATIONHUB" is visible. Below it, the main heading reads "FIND OUT MORE ABOUT MODERN DIESEL CARS" with a subtext "Select a question or use the search option". A search bar with the label "SEARCH" is present. Below the search bar are three buttons: "WHAT IS THE FUTURE OF DIESEL?", "WHAT IS DIESEL'S IMPACT ON THE ENVIRONMENT?", and "SHOULD I BUY A DIESEL?". At the bottom, there are two more buttons: "Are diesel engines going to be banned?" (accompanied by an aerial view of a city street) and "Where in Europe can I drive my diesel car?" (accompanied by a view of a city street with a large building in the background).

Real-world NOx emissions gap is issue of pre-RDE diesels



THANK YOU !

www.aecc.eu
dieselinformation.aecc.eu



@AECC_eu



AECC (Association for Emissions Control by Catalyst)



@aecibrussels



AECC eu

