EU Towards Post Euro 6/VI

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Some history on the EU regulatory framework

First emissions legislation in Europe in **1970**

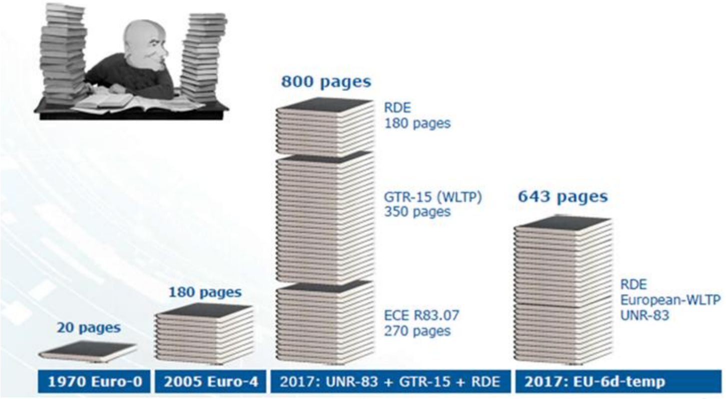
Since then…

- **Euro 1 to Euro 6 for Light Duty Vehicles (LDVs)**

  Regulation (EC) 715/2007 and implementing measures

- **Euro I to Euro VI for Heavy Duty Vehicles (HDVs)**

  Regulation (EC) 595/2009 and implementing measures



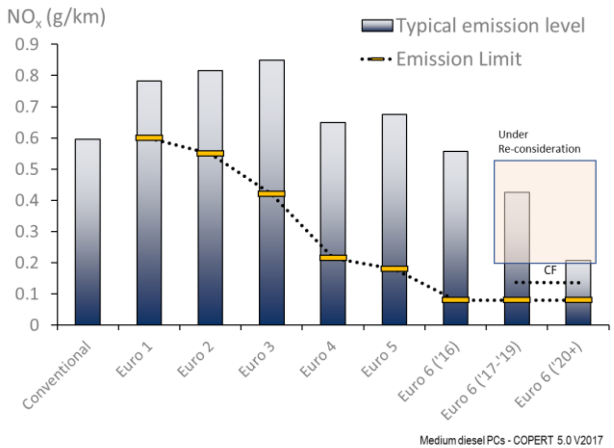
Source: AVL 2018

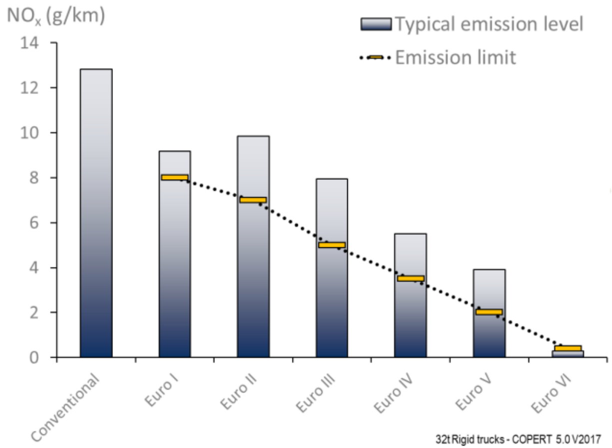
Compliance judged based on laboratory tests NEDC/WLTP, evaporative emissions, low-T, ATCT etc…

In the real world….

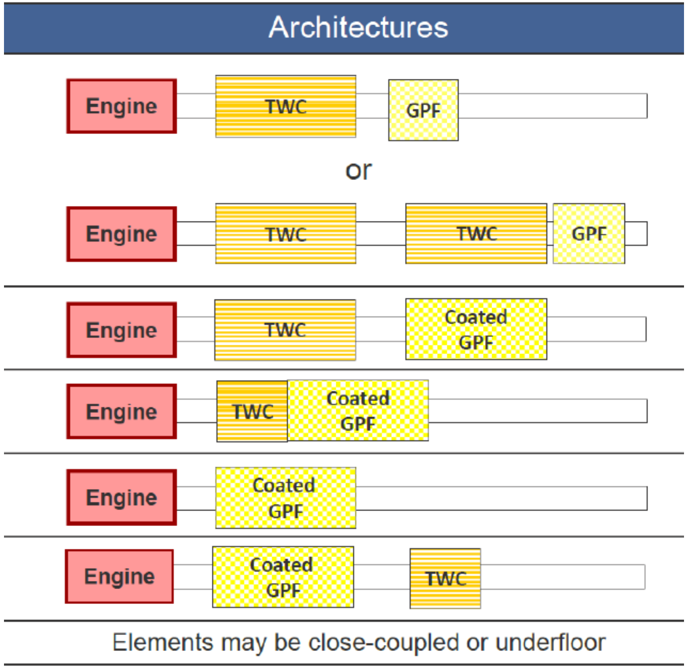
Emissions on the road did not improve to the same extent as the ones in the lab:

- JRC developed a PEMS test for HDV
- **PEMS was introduced in HDV** legislation in 2011
- In 2011 JRC published a report that showed LDV had similar problems…
- **RDE procedures for LDV** were developed (2011-2018)

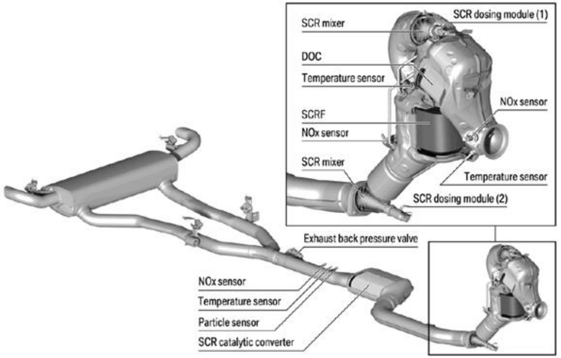




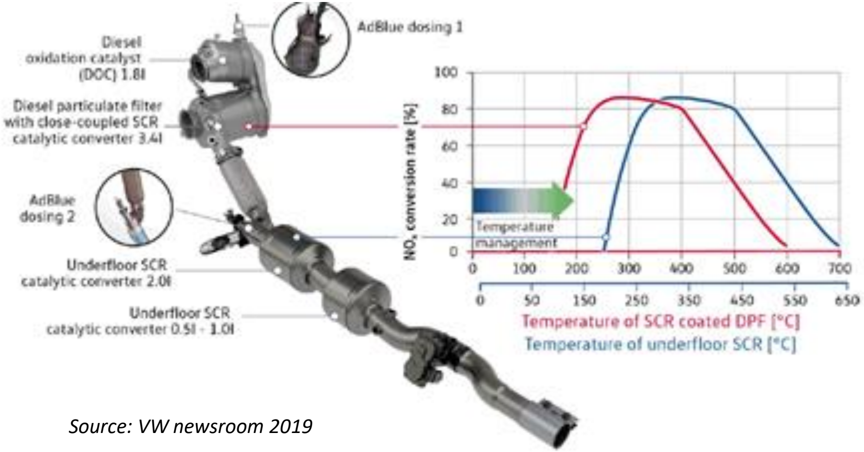
Emission control technologies to comply with RDE requirements



Source: Daimler, Vienna motor symposium 2020

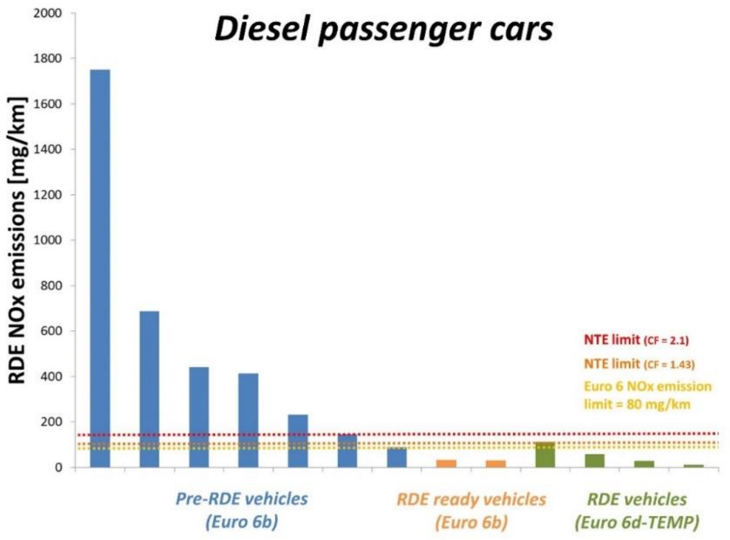


Source: BMW, Vienna motor symposium 2020

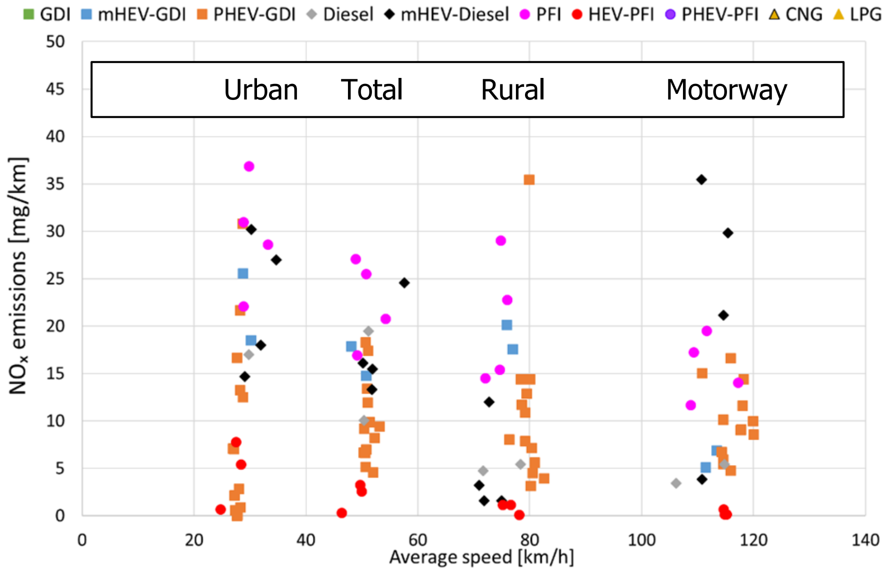


Source: VW newsroom 2019

Euro6d vehicle emission performance



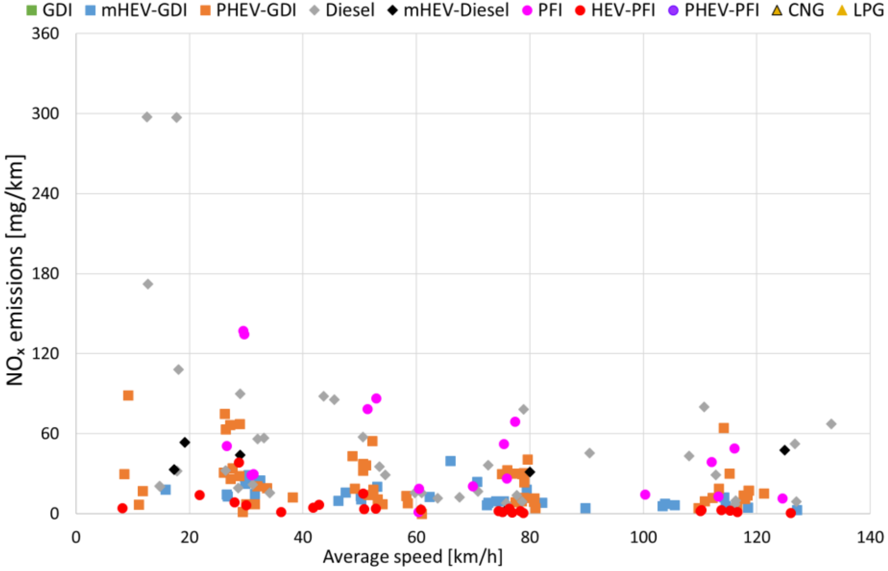
Testing within RDE boundaries

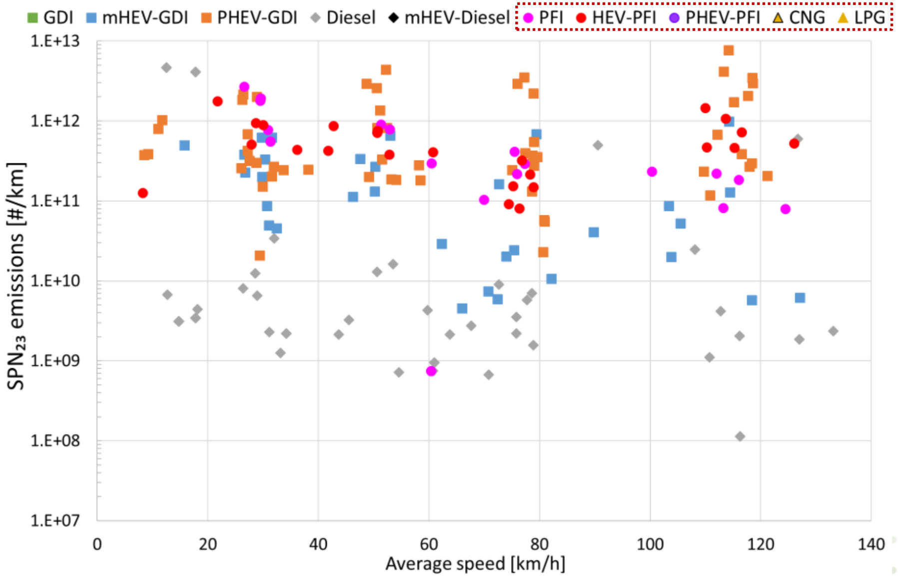


- **RDE results from various testing campaigns:**
  - Euro 6 diesel before RDE continued to emit much higher than limit
  - Latest Euro 6d/6d-temp fulfil emission limits under current RDE testing boundaries

Euro6d vehicle emission performance

Testing beyond RDE boundaries



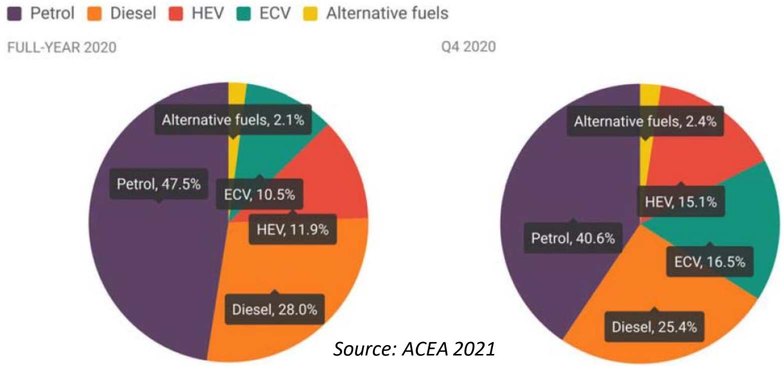


- **However, when testing beyond the RDE boundaries:**
  - Some technologies exhibit high NO_x, particle and CO (gasoline) emissions
  - Testing boundaries exceeded in terms of driving dynamics (mainly) and pos. elevation gain, trip length/distance, low temperature, DPF regeneration.

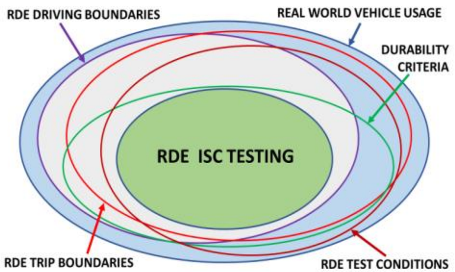
The bigger picture for the future

- The future will be largely based on electrification – enforced by CO_2 policy as well
- Vehicles with combustion engines will be part of the solution if they prove to be:
  - **as clean as possible under all conditions of use (i.e. within and beyond current boundaries)**
  - **and clean throughout their real lifetime**
  - **for both the currently regulated, as well as new pollutants**
- The above will be confirmed by testing and monitoring within a less complex, but most effective, regulatory framework
- The above are based on the analysis of CLOVE and do not represent a Commission position

Fuel types of new cars: electric 10.5%, hybrid 11.9%, petrol 47.5% market share full-year 2020

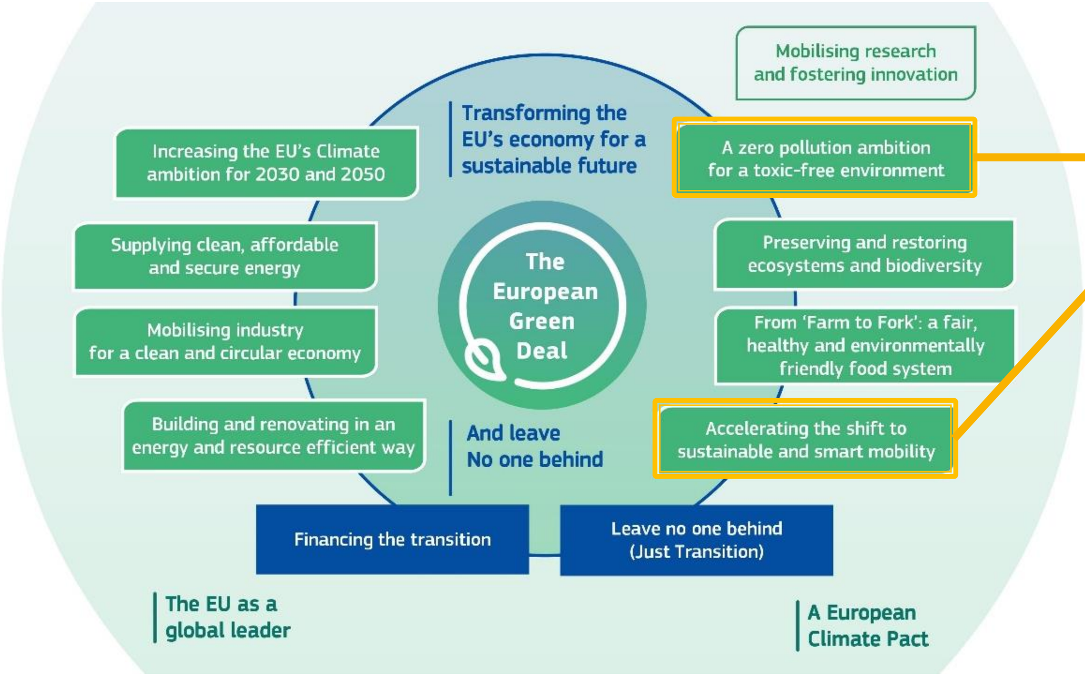


Source: ACEA 2021



Source: TNO 2019

Euro 7 in the context of European Green Deal



Euro 7

Proposal for more stringent pollutant-emission limits with wider coverage of driving conditions throughout entire lifetime

- Strategy for Sustainable and smart mobility
- Revise the CO_2 emissions performance legislation for light duty vehicles by June 2021
- Extend EU's Emissions Trading to the maritime sector, and to reduce the free allowances for airlines by June 2021
- Support public charging points: 1 million by 2025
- Boost the production and supply of sustainable alternative fuels for the different transport modes
- Review the Alternative Fuels Infrastructure Directive and the TEN-T Regulation in 2021
- **More stringent air pollutant emissions standards for combustion-engine vehicles (Euro 7)**

Post-Euro 6 emission standards development

- Stakeholder meeting in October 2018
- Formulation of Advisory Group on Vehicle Emission Standards (AGVES)
    - 6 meetings up to date with more than 200 participants from all stakeholders groups
- Two scientific studies by CLOVE (LAT, TUG, TNO, Ricardo, FEV, VTT, Emisia) in 2019-2021, from evaluation to impact assessment
- Scientific scrutiny by the JRC

Areas of study

- The post Euro 6/VI Type Approval should be able to guarantee that a vehicle is as clean as possible
  - under all driving conditions
  - over its entire useful life
  - for both the currently regulated, as well as new pollutants
- Zero (or near zero) emissions in urban areas
- Guaranteed via a combination of real-world on-road testing and On-Board Monitoring (OBM), including Geofencing

General concept

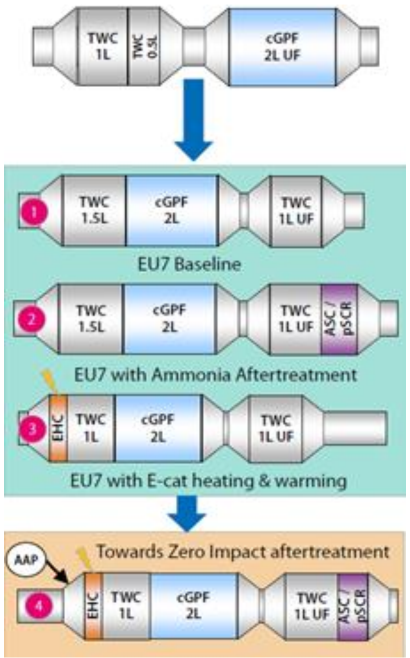
- Focus on whole vehicle testing
  - Laboratory testing is replaced by on-road testing with some exceptions
  - Component testing may no longer be necessary (e.g. durability or OBD - exceptions may be needed e.g. HDV and VECTO)
- On-road (RDE and PEMS) testing are and will remain the main TA process
- Simplification of rules
- Homogenised between vehicle categories

Particular elements of the study

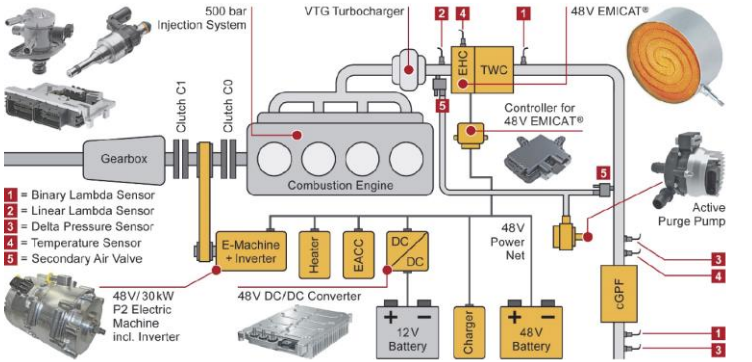
- In order to address all driving conditions and near zero emissions in cities, the new framework would need to cover all the following:
  - Average/max speeds
  - Types of driving dynamics
  - Types of driving distances with emphasis on short trips, cold and warm starts
  - Any trip composition
  - Ambient temperatures
  - Altitudes
  - Payloads
  - Extended lifetime
  - DPF regeneration

Future emissions control technologies

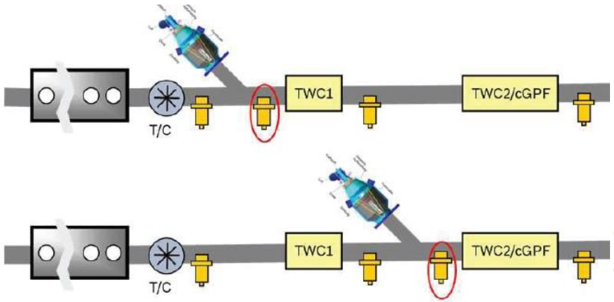
- Possible technologies to address future requirements
  - Larger catalysts
  - Particle filters with high filtration efficiency, even at the clean state
  - Close-coupled aftertreatment system (HDV)
  - Electrically Heated Catalyst – Burner, with preheating function
  - Twin urea dosing, for both LDV and HDV
  - Advanced gasoline injection systems with elevated injection pressures and multi-injection strategies
  - λ-1 operation with water injection for component protection
  - Hybridization – Mild/Full



Source: Ricardo



Source: Vitesco, Aachen colloquium 2019



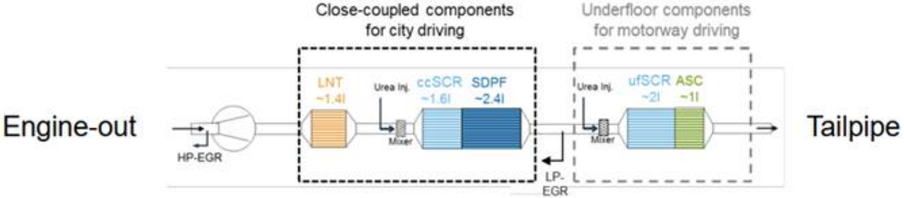
Source: Bosch, Vienna motor symposium 2020

Near-zero emission vehicles are a reality

- Prototypes with optimised use of available technologies

The demonstrator car used in the AECC/IAV/IPA programme achieved ultra-low NOx emissions

Wanting to make best use of the whole system, AECC used a modular approach (see diagram below) when designing its after-treatment system. The first section of after-treatment technology in the exhaust converted NOx into harmless nitrogen in slow city driving, where engine and exhaust temperatures are relatively low. The second section enabled low emissions at higher temperatures, including those generated during fast motorway driving.



MECA

Report Fact Sheet:

Technology Feasibility for Heavy-Duty Diesel Trucks in Achieving 90% Lower NOx Standards in 2027

February 2020

In this report, "Technology Feasibility for Heavy-Duty Diesel Trucks in Achieving 90% Lower NOx Standards in 2027," MECA presents test results from emission control and fuel efficiency technologies installed on heavy-duty diesel on-road engines that offer several cost-effective compliance pathways to reduce NOx emissions by 90% below today's certification levels with simultaneous CO_2 emission reductions in the 2027 timeframe.

The report is a companion to a report released by MECA in June 2019 in which we provided our assessment of technologies being commercialized by component suppliers to help their customers comply with a future NOx standard of 0.05 g/bhp-hr by model year 2024 ("Technology Feasibility for Model Year 2024 Heavy-Duty Diesel Vehicles in Meeting Lower NOx Standards").

The main conclusions in the new report include:

Engine and aftertreatment technologies can achieve a certification emission limit of 0.02 g/bhp-hr NOx and a low-load cycle (LLC) limit below 0.075 g/bhp-hr NOx.

New aftertreatment architectures that employ a close-coupled SCR catalyst before the DOC+DPF in a twin SCR system with dual-urea dosing can meet future NOx limits that phase in from 2024 to 2027. The approaches discussed for meeting these proposed 2027 NOx limits utilize commercially available engine technologies, improved thermal management, and advanced aftertreatment system designs based on high-efficiency catalysts and coating strategies.

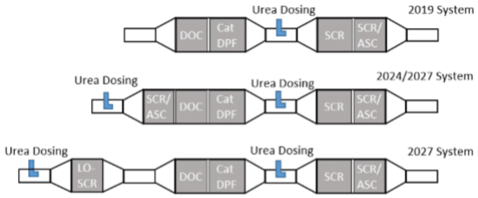


Figure 1. System configurations tested to demonstrate the feasibility of MY 2027 engine emissions. The first system is based on MY 2019 engines in production today. The second system employs a twin SCR arrangement that could be implemented in 2024. The third system adds a close-coupled SCR to a 2019-type underfloor system containing a

New species to be considered

- Currently non-regulated pollutants to be included in the regulation (for both LDV and HDV):
  - Gaseous pollutants (NH_3, CH_4, N_2O, CH_2O…)
  - Particles (sub-23 nm)
- To be measured on board the vehicle with portable devices (PEMS, portable FTIR, or other), if possible

Lab testing

- Lab testing would need to be kept for some cases
  - **<u>LDVs</u>**: WLTP for CO_2 measurement and check of compliance with the fleet based CO_2 emission targets
  - **<u>HDVs</u>**: WHTC for CO_2 measurement for input to VECTO and compliance with possible CO_2 emission targets
  - Currently non-regulated pollutants as long as there is no on-board measurement technology available
  - But all the above exceptions should be complemented/underpinned with verification in real driving
- Evaporation losses

Durability and OBD testing

- Durability testing:
  - Component testing and degradation factors incorporated in on-road testing
  - Increased mileage and OEM liability should be considered
- OBD:
  - The individual OTLs would need to be reconsidered in the framework of compliance with emission limits
  - MIL should be retained as a means to inform the driver
  - OBD functionality should be demonstrated under on-road testing
  - Introduction of the Testing Conformity Indicator (TCI) to support ISC/MaS

TCI Status 0
Vehicle Qualified for ISC / MaS

TCI Status 1
Portion of Test Not Qualified

Boundary conditions exceeded during test (e.g. AES encountered)

TCI Status 2
Vehicle **Not** Qualified for ISC / MaS

Inadequate servicing, faulty components, abuse or tampering detected

On-Board Monitoring

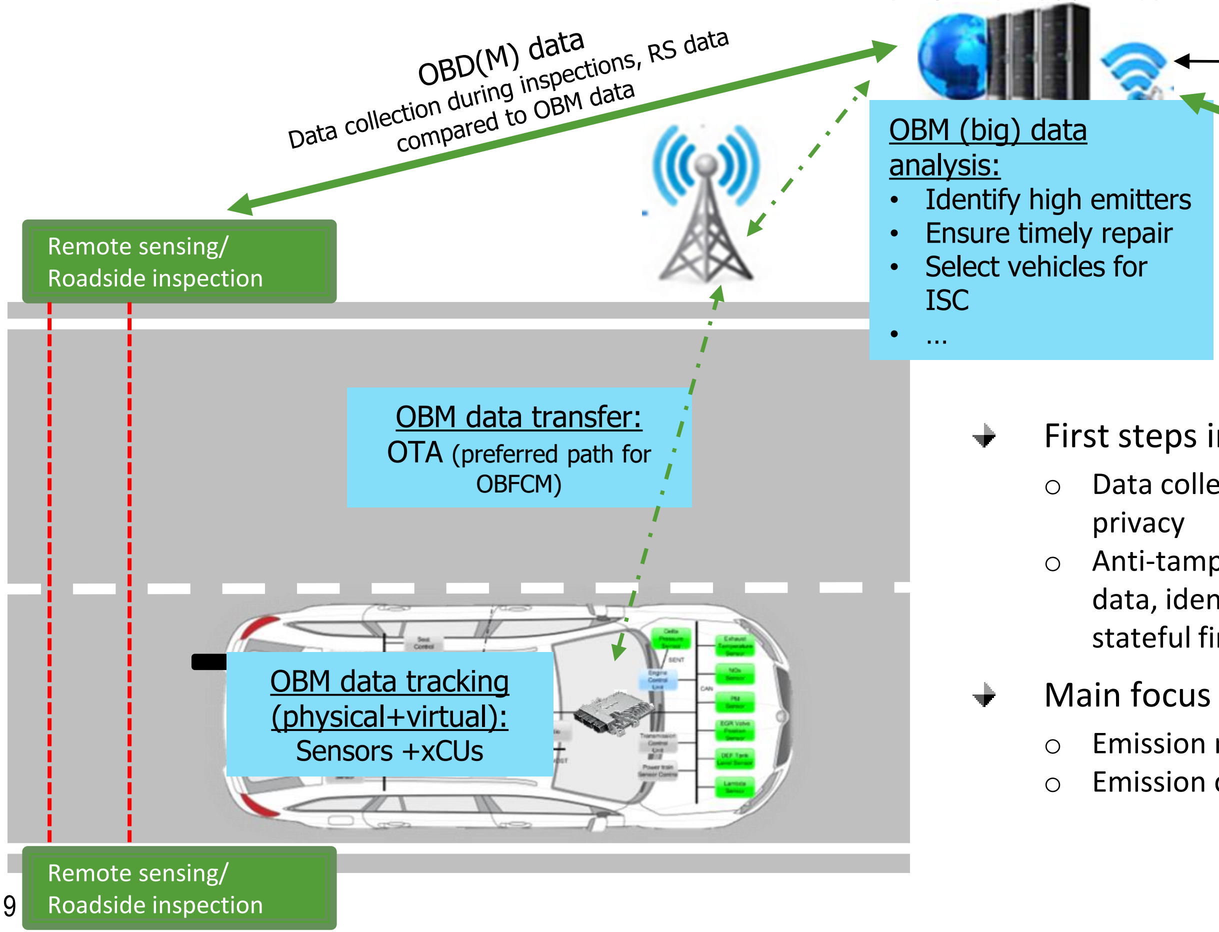
- Investigate
  - Availability and feasibility of sensors
  - Communication systems – experience gained with OBFCM
  - Reporting and analysis
- Close collaboration with sensor suppliers

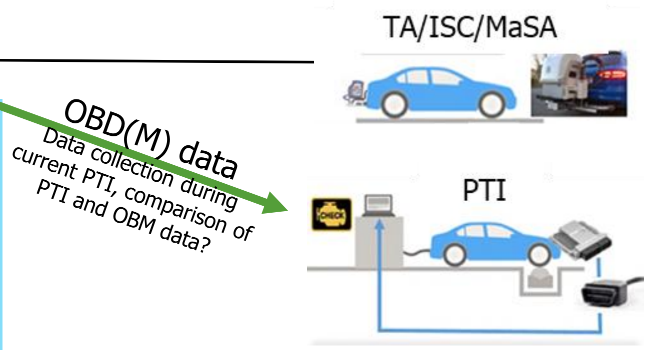
Pollutants	NO_x	PM/PN				NH_3	CO, HC, CH_4, N_2O
Operating principle	YSZ electrochemical	Resistive	Electrostatic	Diffusion charge	Laser-induced incandescence (LII)	Non-equilibrium eletrochemical	
Sensor output	Concentration [ppm]	Cumulative PM concentration [mg/m3]	PM concentration [mg/m^3]	PM and PN concentration [mg/m^3], [p/cm^3]	PM and PN concentration [mg/m^3], [p/cm^3]	Concentration [ppm]	
Availability	Commercially available	Commercially available	Commercially available	Commercially available?	Under development	Commercially available	Not yet for automotive, further development required
Comments		Only PM	Only PM, investigations for PN	Latest design with no pump or ion trap			Available for industrial and air quality applications
Response time	<1.8s	1 s	0.2 s	0.2 s	0.1 s	T_{60}<3 s, T_{90}<5 s	
Range	0-1500 ppm	0.1 - 25 [mg/m³]	0 - 600 [mg/m³]	0.001 - 50 [mg/m³], 125 - 1E+8 [p/cm³]		0-100 ppm	
Accuracy	±10 ppm (at low conc.)		±10% above 5 mg/m³, ±0,5 mg/m³ at 2-5 mg/m³	±10%			
Cold start effect		Dew point at 130°C					
Cross sensitivities	NH_3	NH_3 (moderate)	Exhaust flow				
Poisoning		Ash, sodium	Ash (moderate)				
Operating limits		T:<850°C	T:<550°C			T: 200-450°C	
Size/weight	Sensor: 'Spark-plug' size	Sensor: 'Spark-plug' size	Sensor: 'Spark-plug' size				
Implication on the use		Blind windows for regeneration			Cooling is needed		
Communication	CAN, SCU near the sensor	CAN, SCU near the sensor	CAN, SCU near the sensor				






OBM as part of an overall emissions compliance framework





- First steps in this direction:
  - Data collection/transfer/processing, standardization, privacy
  - Anti-tampering of OBM components, security of OBM data, identification and authentication, secured CAN, stateful firewalls, intrusion detection etc.
- Main focus on the vehicle
  - Emission measurements from physical sensors (HW)
  - Emission calculations (virtual sensors, models – SW)

Concluding remarks

- Many issues need to be addressed in the next emission legislation
- Complexity needs to be reduced, without any compromise in effectiveness
- (Near)zero emission vehicles with internal combustion engines are feasible with adaptations of current technology, in the short term
- Emissions OBM in the longer term
- Timeline (final decision not yet taken)
    - Commission proposal foreseen for Q4 2021
    - Date of first application not yet decided, because of co-decision process
    - But Euro 7 is planned as the last emission standard

On behalf of the CLOVE consortium: **Thank you!**