

# Energy Transition and Green Mobility towards Net Zero

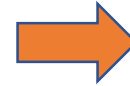
ECMA Presentation  
World Future Fuels Summit -2023

- We are a non-profit Association, representing seventeen manufacturers of exhaust aftertreatment for mobile & stationary sources. We are committed to collaboratively lead India towards Cleaner Air.
- We work with the Industry, Government Regulators, Oil Companies and the Public at large, to be a credible source of knowledge on emission control and we strive to increase awareness in emissions management by providing relevant technical solutions for this.
- We achieve this through assimilation of technologies, providing and disseminating knowledge enabling emission control. We hold Seminars and Conferences, pertaining to reducing pollution from automotive and powertrain exhaust sources

# Introduction

A very appropriate Session Topic

Transition towards Net Zero for Green Mobility



Starts with the transition to 'Near – Zero'

Focusing on Mobility and Net-Zero ....., the 'Buzz' word is **ELECTRIC VEHICLES** !

However there are multiple issues with **Electrification of Mobility**

Nascent Technology



Charging infrastructure



Recycling and Disposal

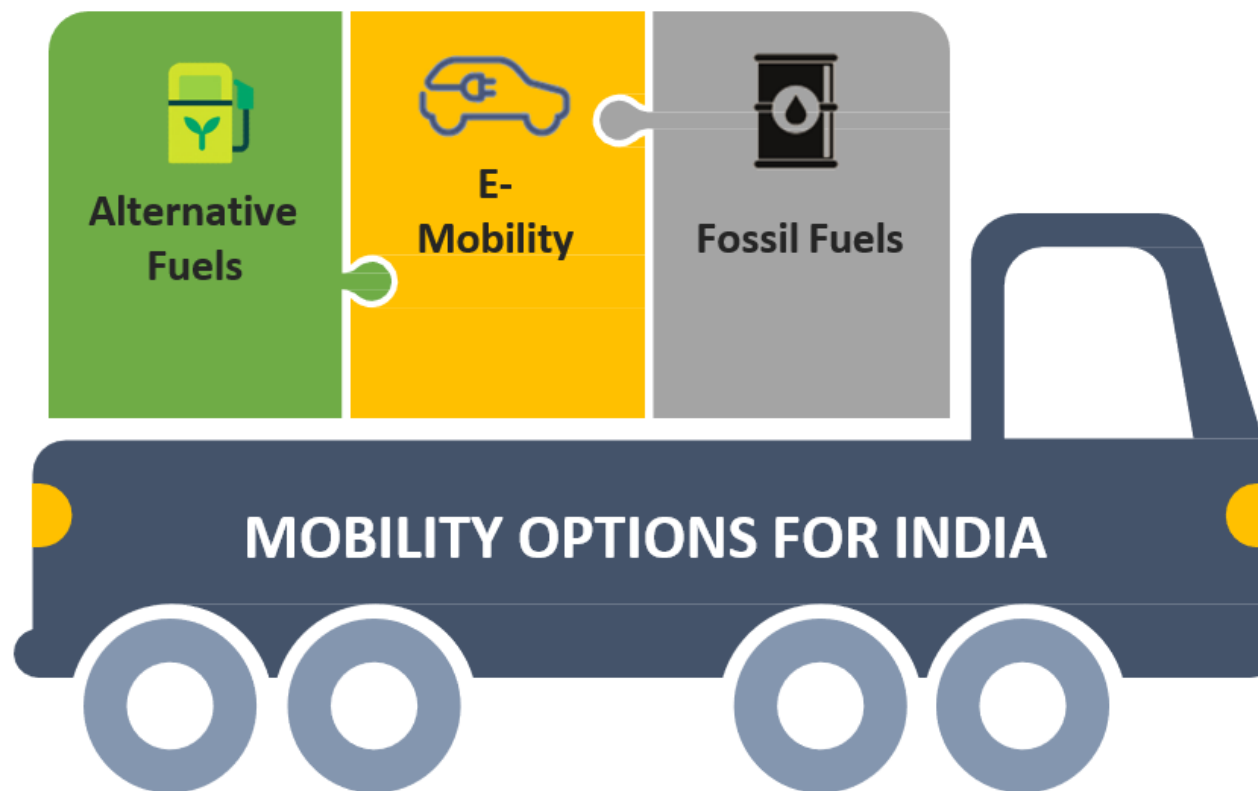


Source of Energy



In near-long term transition to near-zero with  
**Future Fuels and Aftertreatment**

## MOBILITY OPTIONS FOR INDIA



# The Combustion Engine Refuses to Die

*Internal combustion is surviving by adapting.*



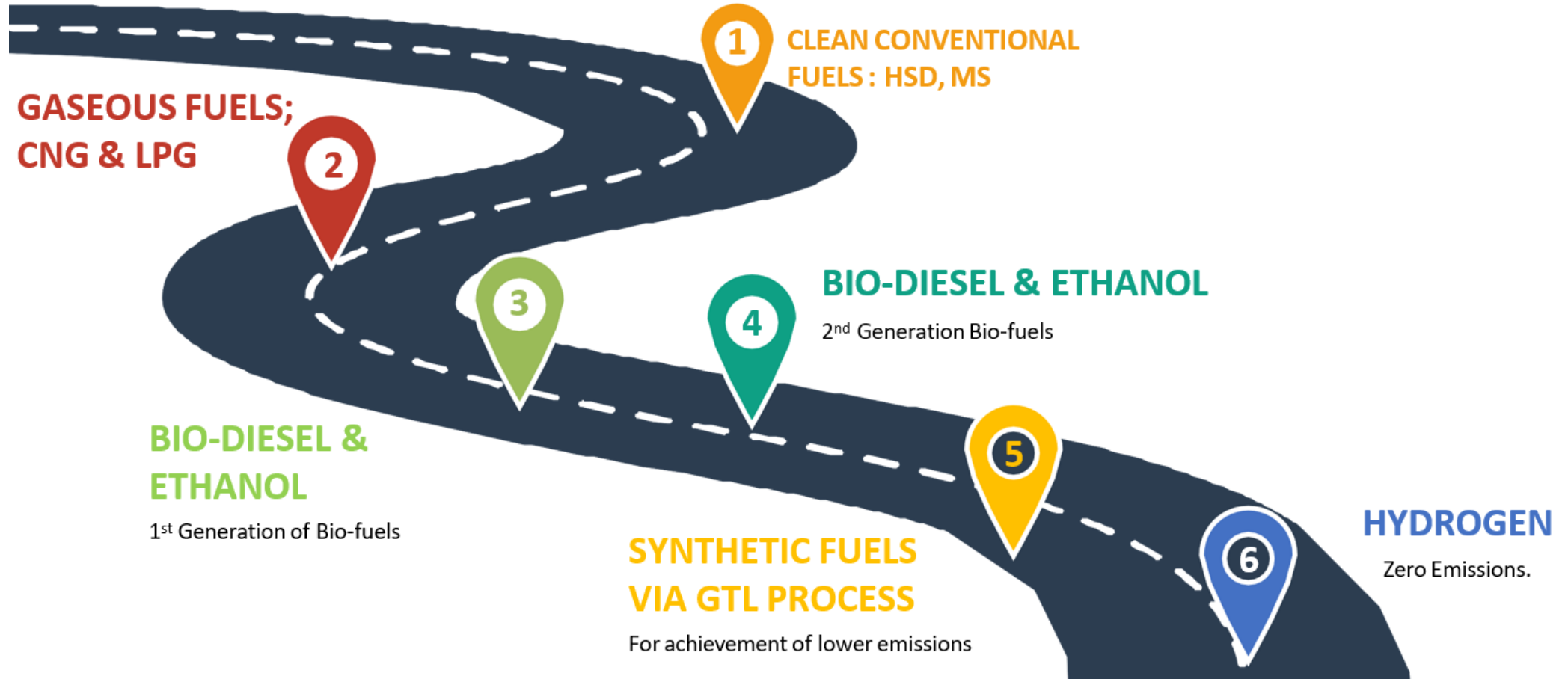
In Thousands of Dollars at Present Value

Impact Area	ADL
Total Cost of Ownership	BEV is 44% more expensive than ICEV
Global Warming Potential	BEV has 23% less GWP impact than ICEV
Secondary Environmental Impacts	BEV has 3 times greater Human Toxicity Potential

## Arthur Little Study on BEV Vs ICEV

Even the average engine may soon approach its electric rival in terms of grams of carbon dioxide output of 97 grams per kilometer. In the 2040 time frame, the value will reduce to 30 grams, which makes internal combustion engines competitive with electric vehicles

## ROADMAP FOR ALTERNATIVE FUELS

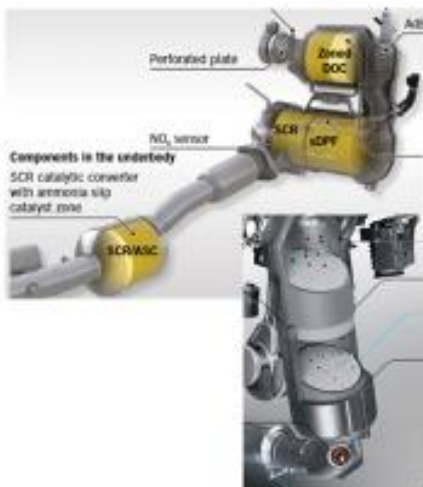


Internal Combustion Engines  
running on Natural Gas and Future Fuels  
controlled by Regulation  
that is achieved by Aftertreatment  
delivers emissions from mobility  
to Near-Zero

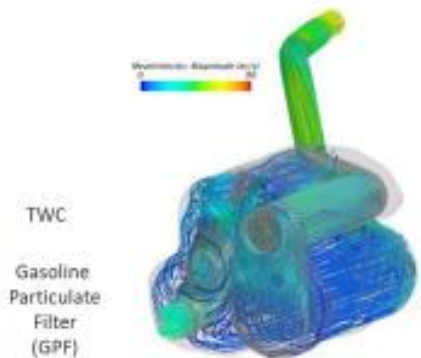
# Regulation

## Euro 6/VI significantly reduced impact on air quality

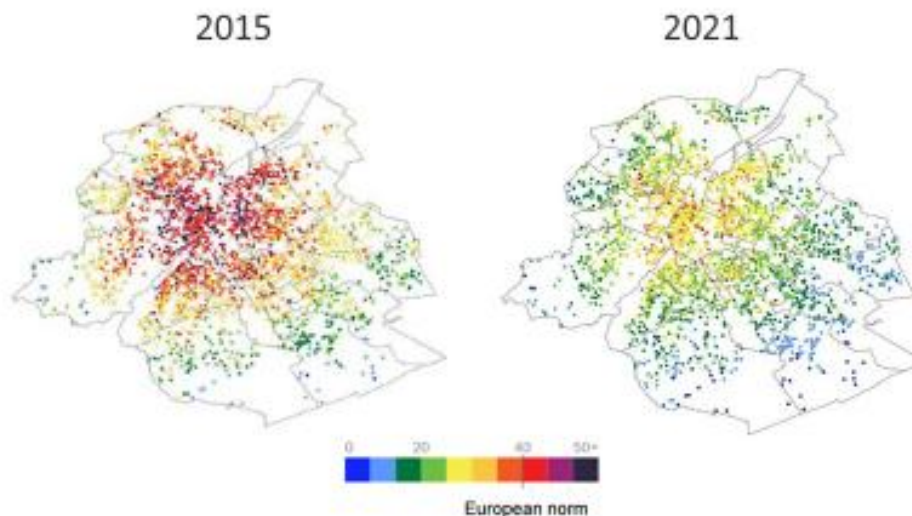
- Evolution in emission control systems
  - LD diesel - combination of deNOx technologies
  - LD gasoline - introduction of particulate filter
  - HD diesel - compact design of SCR and filter
- Several reports about improved air quality
- Example of NO<sub>2</sub> in Brussels



Source: PSA



Source: Daimler 2022



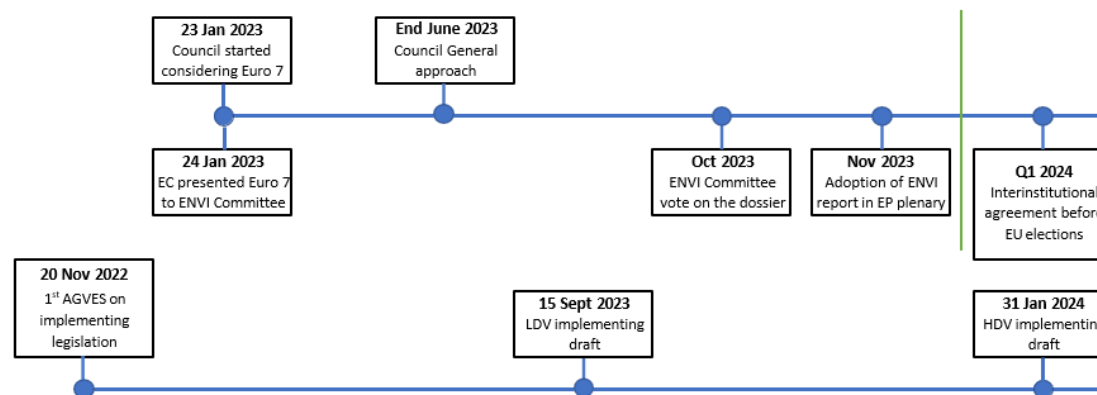
Source: CurieuzenAir report air quality in Brussels, 2022



# Regulation

## Further evolution expected towards Euro 7

- The European Commission published the Euro 7 proposal on 10 November 2022
- Two parallel processes have started
  - The ordinary legislative process by European Parliament and Council to discuss the proposal
  - Development of implementing legislation by the European Commission involving
    - AGVES expert working group
    - CLOVE consortium



Tentative timeline based on preliminary information

Euro 7 Implementing Regulations
1. LDV Vehicle Types
2. HDV Vehicle Types
3. HDV Engines
4. OBM/OBD systems
5. Anti-tampering, security and cybersecurity systems
6. Replacement pollution control systems types and their parts
7. Brake system types and their replacement parts;
8. Tyre types in respect to tyre abrasion
9. CO <sub>2</sub> + range determination for LDV
10. CO <sub>2</sub> + range determination for HDV

# Regulation

## Euro 7 proposal for cars and vans

- Entry into force as of 1/7/2025
- Driving conditions
  - Focus on on-road driving
  - Definition of normal and extended area
  - Procedures to be further defined by implementing legislation
- Lifetime
  - Main: up to 160k km or 8 years
  - Additional: up to 200k km or 10 years

	Normal	Extended*
Ambient temperature	0 to 35 °C	-10 to 0 °C or 35 to 45 °C
Ambient altitude	0 to 700 m	700 to 1800 m
Max speed	<145 km/h	145 to 160 km/h
Towing or aerodynamic modifications	Not allowed	Allowed according to manufacturer specifications and up to the regulated speed
Auxiliaries	Possible as per normal use	-
Max. avg. wheel power during first 2 km after cold-start	<20% of max	>20% of max
Trip composition	Any	-
Min. mileage	10000 km	3000 to 10000 km

\* The same emission strategy shall be used when a vehicle is run outside those conditions, unless there is a technical reason approved by the type approval authority

# Regulation

## Euro 7 proposal for cars and vans

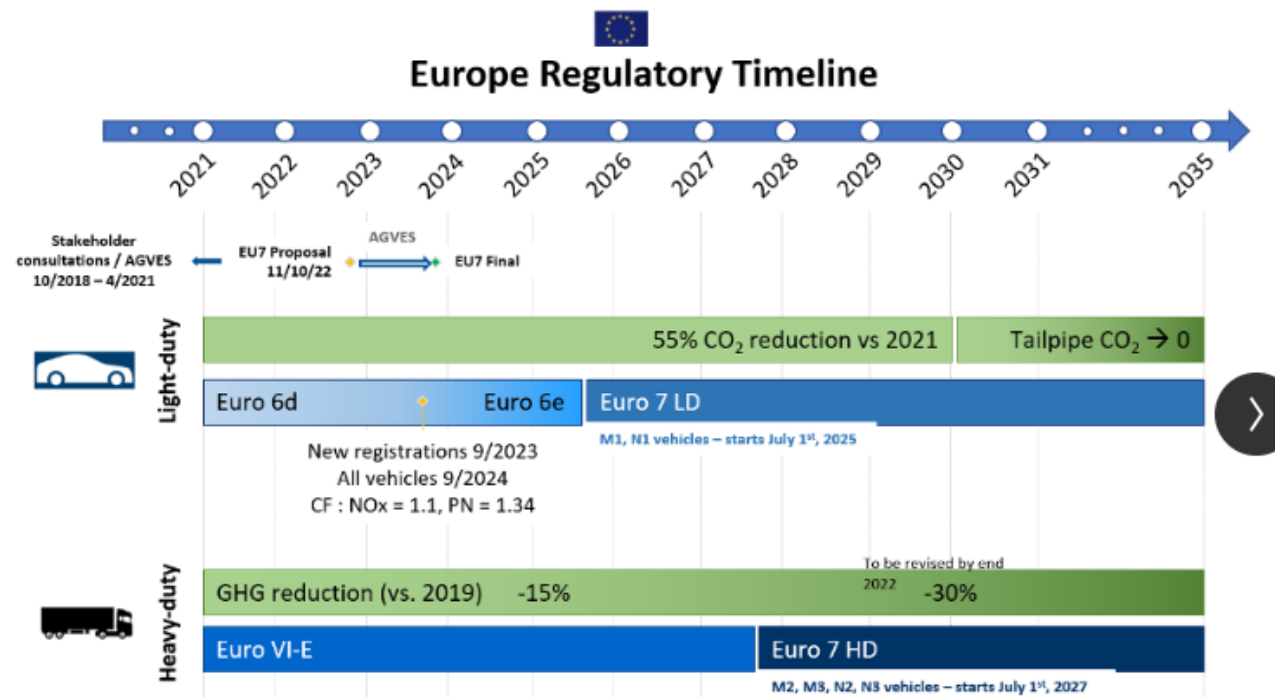
- Fuel-neutral limits
  - Lowest Euro 6 level for currently regulated pollutants
  - New limit for NH<sub>3</sub>
  - Emissions budget for trips < 10 km (= mg/km limit x 10 km)
  - Extended driving divider: emissions / 1.6
  - Additional lifetime: limit x 1.2 (for gaseous pollutants)
  - Additional requirements for
    - Evaporative emissions
    - Brake and tyre particulate emissions
    - Battery durability

	M <sub>1</sub> , N <sub>1</sub> (/km)	N <sub>1</sub> PMR < 35 kW/t (/km)	M <sub>1</sub> , N <sub>1</sub> cold-start budget (/trip)	N <sub>1</sub> PMR < 35 kW/t cold-start budget (/trip)
NOx in mg	60	75	600	750
PM in mg	4.5		45	
PN in # (>10 nm)	6x10 <sup>11</sup>		6x10 <sup>12</sup>	
CO in mg	500	630	5000	6300
THC in mg	100	130	1000	1300
NMHC in mg	68	90	680	900
NH <sub>3</sub> in mg	20		200	

# Regulatory Timeline

## Section 1: Timeline of post Euro 6d & CO2 Regulations

The Euro 7 proposal was published on November 10<sup>th</sup>, 2022 and represents the culmination of several years of stakeholder consultations and “AGVES” meetings which made recommendations on a few options. Note that there is still a Euro 6e step that starts in 2023, primarily affecting tailpipe criteria emissions through reductions of conformity factors.

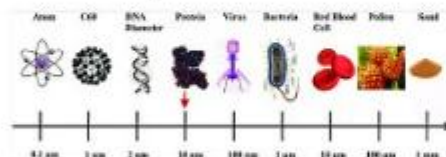


## Section 2: Euro 7







Here are some of the overarching changes proposed in Euro 7, for both light- and heavy-duty vehicles

- Fuel/technology neutral revised limits
  - › For light-duty: same limits for cars and vans (so effectively tighter limits for vans)

- Inclusion of particles down to 10 nm



- Measure emissions on “random and worst-case” RDE test cycles using PEMS
- Increased durability requirements to “average expected lifetime” of vehicles
- New species regulated e.g., NH<sub>3</sub> for light-duty, N<sub>2</sub>O for heavy-duty

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- On-board (continuous) monitoring of criteria & CO<sub>2</sub> emissions, fuel & energy consumption
    - › Register emission exceedances, communicate emissions sensor and exhaust flow data information over the air, trigger repair of vehicle
  - “Environmental Vehicle Passport” for each vehicle with CoP, type-approval documentation
  - Provision to amend regulation in case vehicles running on CO<sub>2</sub> neutral fuels are approved post 2035
  - Provision to certify vehicles to Euro 7+ levels based on other technologies such as geofencing
  - Non-tailpipe emissions – evaporative, brake and tires
  - Battery state-of-health and durability requirements for passenger cars
    - › 80% to 5 yrs/100K km and 70% beyond to 8 yrs/160K km



### Section 3: Light-Duty Limits, Boundary Conditions and Compliance Tests

#### Euro 7 Proposal : Light-Duty Released on Nov 10<sup>th</sup>, 2022

Vehicles : M1, N1 (passenger cars & LCVs)  
Start date: July 1, 2025 (new vehicles)

Test conditions	Normal	Extended Emissions/1.6
Ambient T (°C)	0 – 35	- 10 to +45
Max. Altitude (m)	< 700	< 1,800
Max. Speed (km/h)	≤ 145	≤ 160
Max. avg. P < 2km after cold start	< 20% P <sub>max</sub>	> 20% P <sub>max</sub>
Trip composition	Any	
Min. mileage (km)	>10,000	> 3,000

Units mg/km #/km (PN)	Euro 6 (Pass cars) WLTP, RDE : x 1.1 NOx, x 1.34 PN		Euro 7 Limits <b>No CFs</b>	Budget (mg or #) Trips < 10 km
	Gasoline	Diesel		
NOx	60	80	60	600
PM	4.5		4.5	45
PN (#/km)	6x10 <sup>11</sup> > 23 nm GDI only	6x10 <sup>11</sup> > 23 nm	6x10 <sup>11</sup> > 10 nm	6x10 <sup>12</sup> > 10 nm
CO	1000	500	500	5000
THC	100	HC+NOx=170	100	1000
NMHC	68	-	68	680
NH <sub>3</sub>	-		20	200
Lifetime / Durability	160,000 km / 5 yrs.		160,000 km / 8 yrs. Ext. : 200,000 km / 10 yrs. Limits x 1.2	

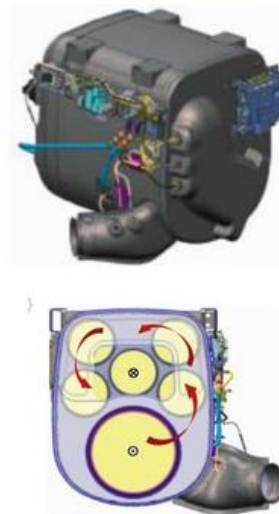
	Type Approval	Conformity of Production	In-service Conformity
On-road testing of PN & gas emissions	Yes, + Declaration for all fuels, payloads & vehicle types	No	Optional*
Lab testing of PN & gas emissions CO <sub>2</sub> , fuel consumption, electric range	Required where pollutants cannot be measured on road	Yes	Required where pollutants cannot be measured on road
CO <sub>2</sub> ambient T correction (WLTP @ 14 °C)	Declaration	No	Optional
Emissions / battery durability	Declaration	No	No
Lab test of low T for emissions & range	Yes	No	Optional
OBD	Declaration	No	Optional
OBM	Declaration & demonstration	No	Yes



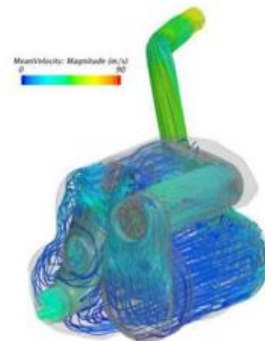
# Heavy Duty ( Truck ) Demonstrator with Diesel/e-Fuel and HVO

## Euro VI-D/E significantly reduced impact on air quality

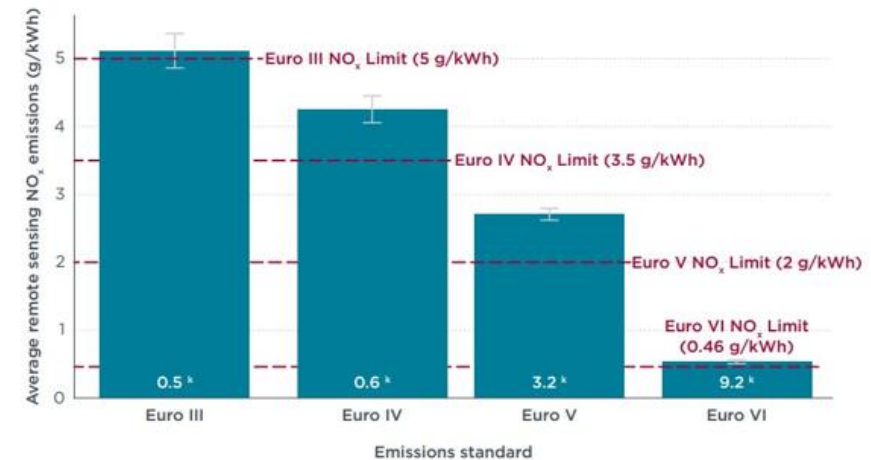
- Implementation of advanced emission control systems in a compact design
- Actual emissions reduction in the fleet confirmed by remote sensing data



Source: DAF



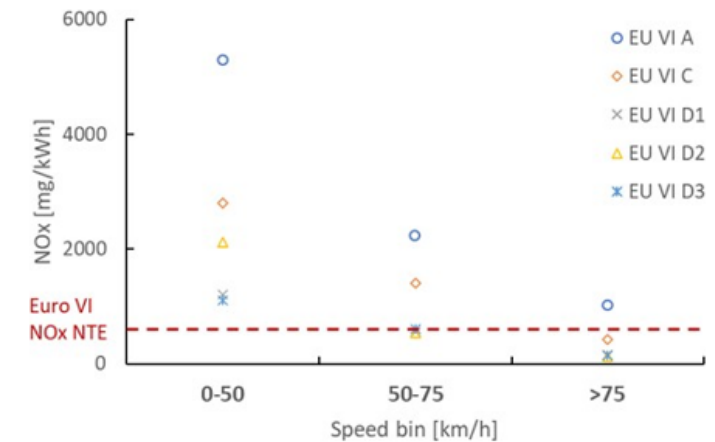
Source: Daimler



Source: Average NO<sub>x</sub> emissions of heavy-duty trucks by European emission standards for Flanders remote sensing campaign, [ICCT, 2022](#)

## Further evolution expected towards Euro 7

- Analysis of real-world emissions of Euro VI vehicles
  - Highest emissions mainly occur in 0-50 km/h speed bin
    - Initial cold-start peak
    - Low-load operation
  - Emissions reduced from Euro VI-A to VI-D
  - Euro VI-D/E post processing still excludes critical data



Source: P. Mendoza Villafuerte, et al.; [“Real-World Emissions of Euro VI Heavy-Duty Vehicles”](#), SAE Technical paper, 2021-01-5074, 2021

- Euro 7 proposal further focuses on on-road emissions performance with introduction of RDE test procedure for Heavy-duty vehicles

## HD diesel demonstrator concept

- Base vehicle description
  - MB Actros 1845 LS 4x2
  - Engine OM 471
    - Euro VI C certified
    - 12.8 litres, 6 cylinder in-line
    - High Pressure EGR + DOC + DPF + SCR
- Acknowledgement of project partners



- Scientific papers with full details

P. Mendoza Villafuerte, et al.; [“Demonstration of Extremely Low NOx Emissions with Partly Close-Coupled Emission Control”](#), 42<sup>nd</sup> Vienna Motor Symposium 2021

P. Mendoza Villafuerte, et al.; [“Future-proof heavy-duty truck achieving ultra-low pollutant emissions”](#), Transportation Engineering, Volume 9, September 2022, 100125, 2022

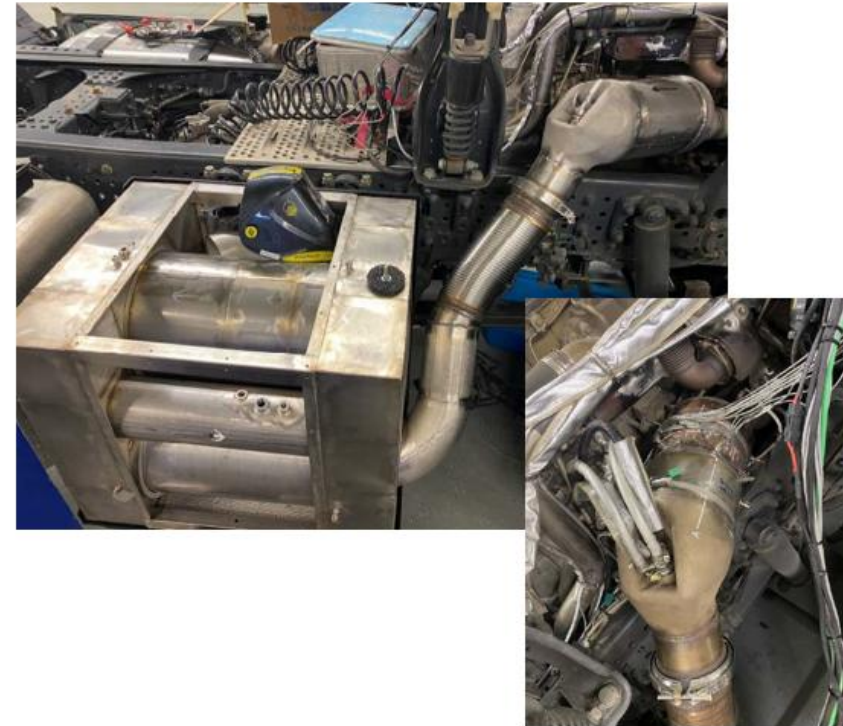
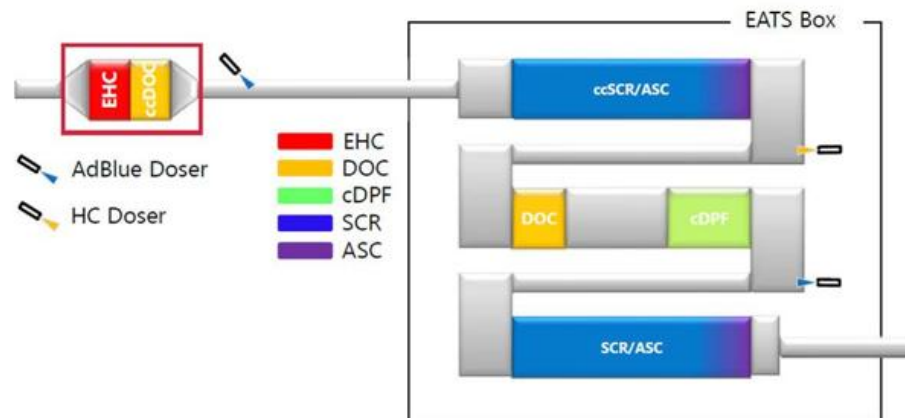


SAE HD Diesel Sustainable Transport Symposium – 3 May 2023

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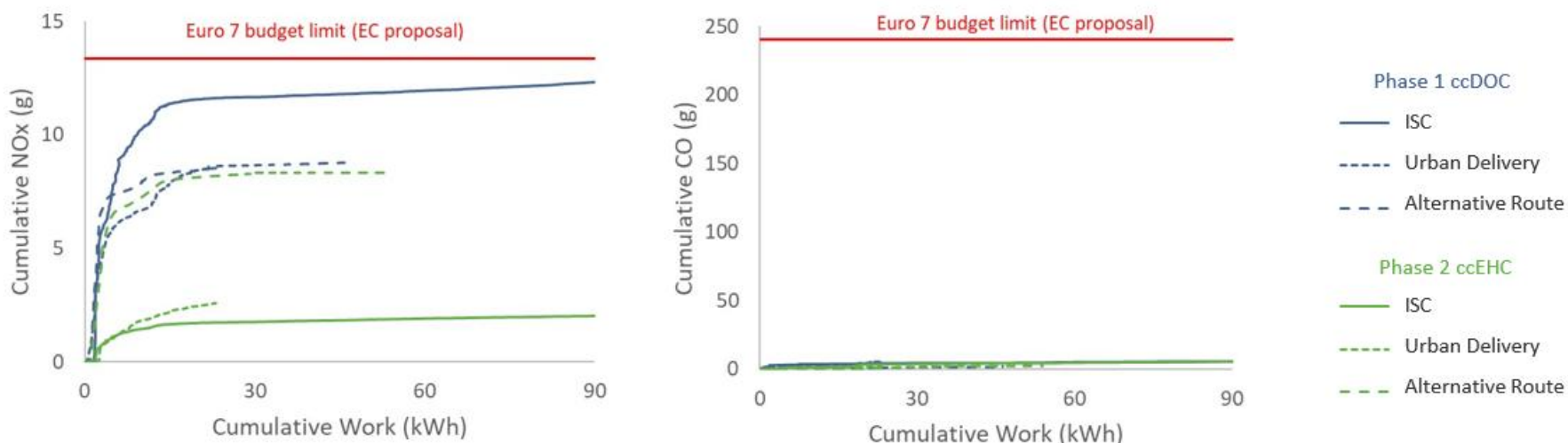
## HD diesel demonstrator concept

- AECC emissions control system
  - Phase 1: ccDOC, ccSCR/ASC+ ufDOC+cDPF+ SCR/ASC, twin AdBlue dosing and HC doser
  - Phase 2: additional EHC as part of the ccDOC
  - Components are hydrothermally aged targeting 500k km



## All data is below the proposed emission budget limit

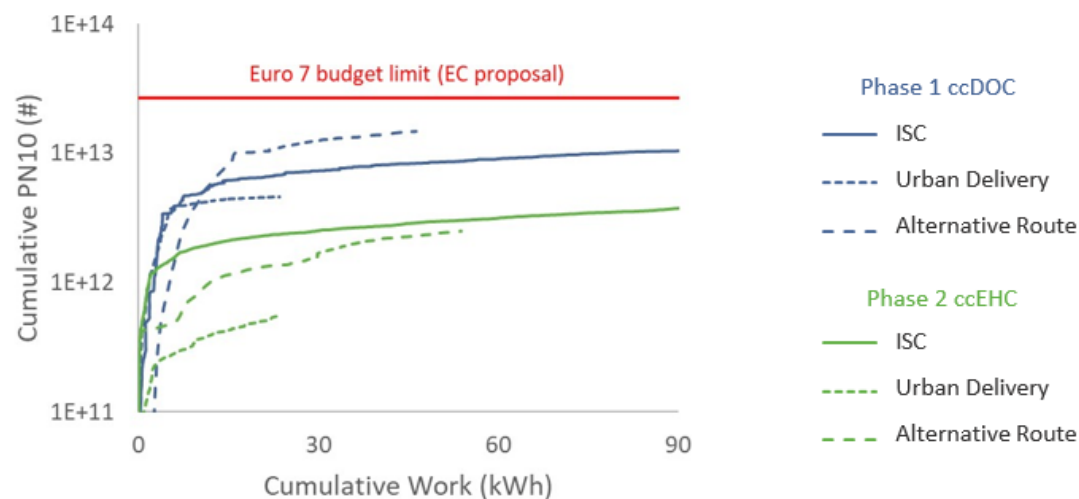
- Gaseous pollutants
  - All data shown is with empty SCR at the start of the test
  - NOx emissions are highest challenge
  - All data is significantly below the limit for CO, NH<sub>3</sub> and N<sub>2</sub>O



Note: Hot WHTC reference value used is 29.7 kWh

## All data is below the proposed emission budget limit

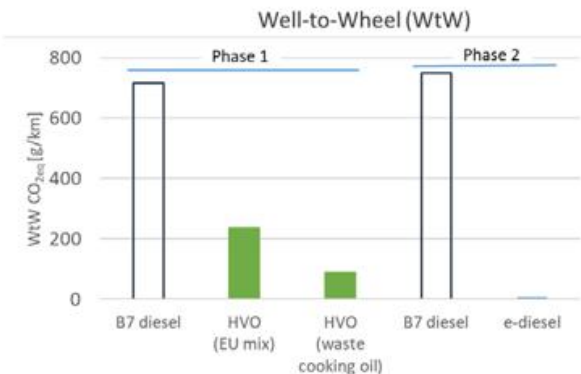
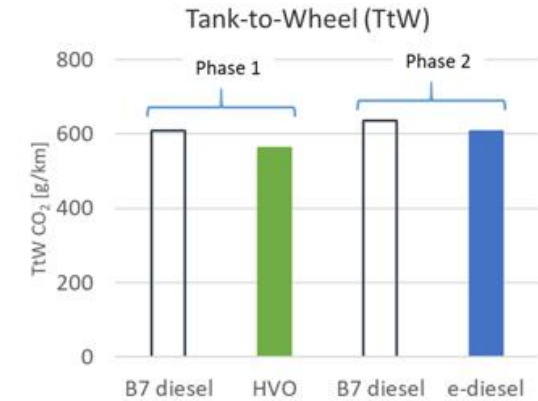
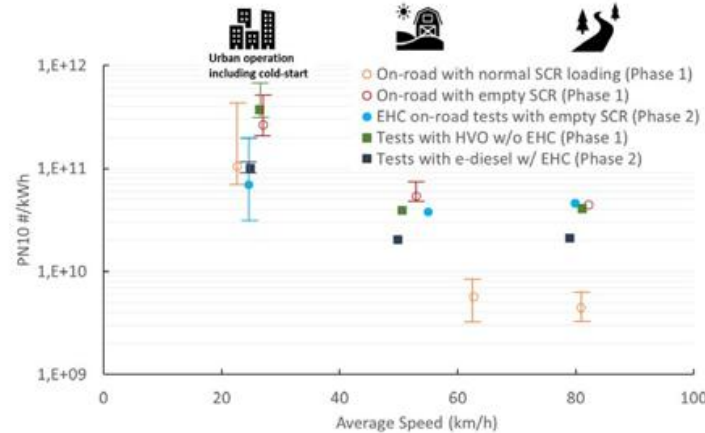
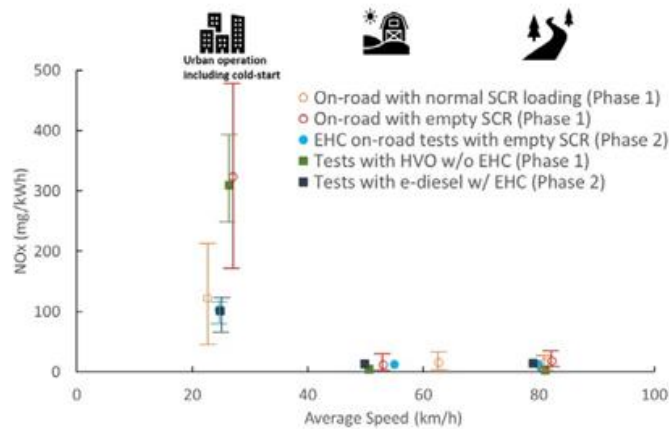
- Particulates
  - All data shown is with partially regenerated filter at the start of the test
  - All tests are below the limit
  - Data indicates lower PN10 with ccEHC, but no repetitions available to further investigate



Note: Hot WHTC reference value used is 29.7 kWh

# HD diesel demonstrator with sustainable renewable fuels

- Ultra-low pollutant emissions confirmed on HVO and e-diesel
- HVO already offers today up to 90% WtW CO<sub>2</sub> reduction
- E-diesel has the potential to nearly eliminate WtW CO<sub>2</sub> emissions



D. Bosteels, et al.; "Combination of advanced emission control technologies and sustainable renewable fuels on a long-haul demonstrator truck", SIA Powertrain & Energy conference, 2022

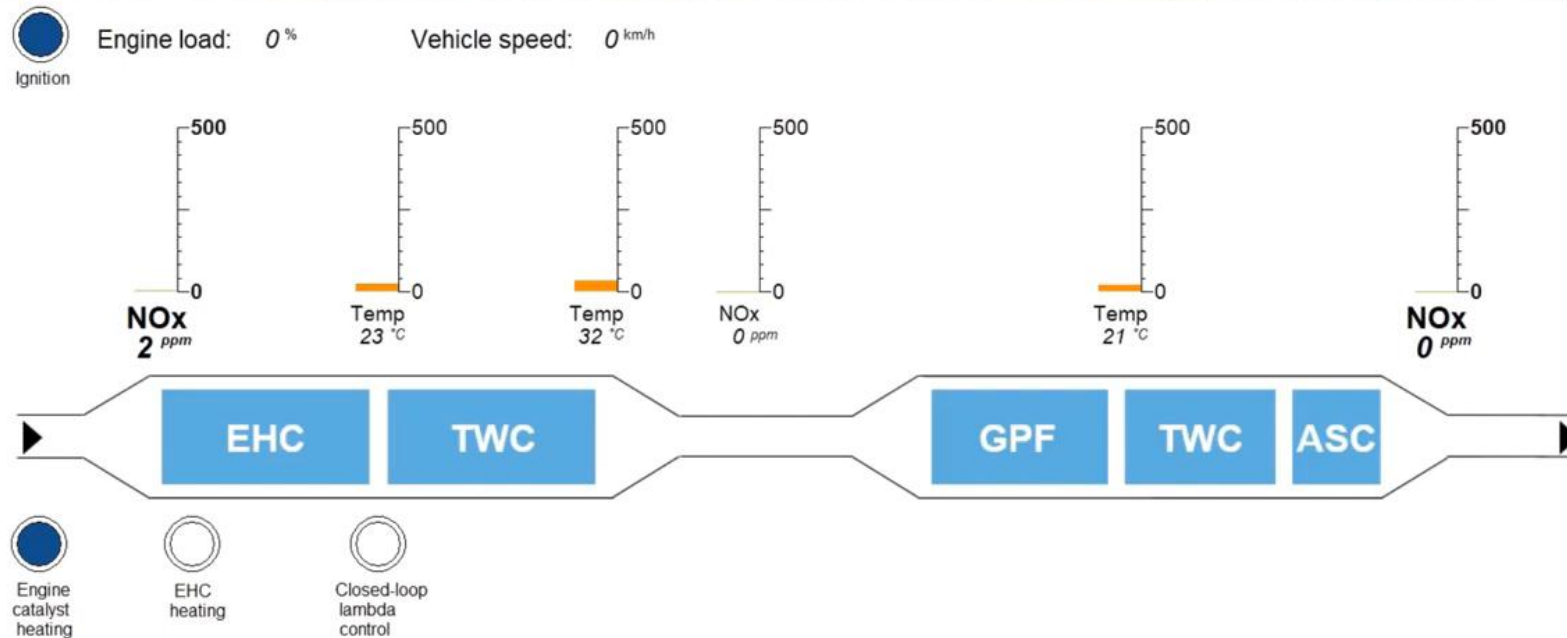
## Summary

- An advanced emission control system was implemented on a demonstrator diesel truck, including
  - A catalyst in close-coupled position in combination with an electrically heated catalyst
  - Dual-SCR with twin urea-dosing system
  - Catalysed particulate filter
- Ultra-low gaseous and particulate emissions were demonstrated over a broad range of driving conditions
  - Significant reduction of initial cold-start peak
  - Near-zero emissions after initial cold-start
- Ultra-low pollutant emissions were confirmed on HVO and e-diesel enabling significant reductions in WtW CO<sub>2</sub> emissions





# Conclusions



Founder Members



Associate Members



THANK YOU