LDV Exhaust

Presenter: Prof. Zissis Samaras

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With lots of contributions from our colleagues

- Dr. A. Balazs, Dr. M. Ehrly (FEV)
- Dr. A. Kontses, Dr. A. Dimaratos, Dr. D. Kontses (LAT/AUTh)
- P. Aakko (VTT)
- Dr. N. Ligterink (TNO)
- J. Andersson, T. Scarbrough (Ricardo)
- Prof. L. Ntziachristos (Emisia)

Contents – LDV exhaust

- Objectives and Methodology
- Pollutants for inclusion in Euro 7
- Findings from Euro 6 LDV
  - Emission performance of current state-of-the-art technologies (reg/non-reg species)
  - Identification of operating/testing conditions that are related with emission excursions
- Testing conditions for Euro 7 – LDV
- Euro 7 limits and technologies – LDV
  - Technology packages
  - Emission performance (simulations + demos)
  - Emissions limits scenarios (for PO2)

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  - Costs
  - Emissions limits scenarios (for PO2)

Methodology

Step 1

Development of emissions database with performance of latest technology vehicles within and beyond current testing boundaries

Step 2

Analysis of emissions database and identification of current best performing vehicles and technologies

Step 3

Identification of critical operating conditions, identification of future technologies, building of technology packages for further evaluation

Step 4

Development of test protocol and evaluation of emissions performance of future technology packages and cost estimates

Step 5

Proposal of emissions limits and technology scenarios and costs, as inputs for the CBA/IA study

Comments

Emissions database

Wide range of test conditions within and beyond the current boundaries: urban short trips, Stop&Go, regeneration events, new pollutants etc.

Technology assessment

Characterisation of technologies using test data, demo cars and simulation

Input from stakeholder consultations and literature

Outcome of the analysis

Limit scenarios, technologies and costs

Euro 7 testing conditions

Potential side effects (e.g. technology implications, CO_2 penalty/benefit etc.)

Euro 7 options (ToR of our Part A and B Studies)

- Euro 7 options examined in the Impact Assessment study
  - ✓ Option 0: BaU – **same limits as today**
  - ✓ Option 1: Refined architecture (simplification) – **same limits as today (adoption of the strictest today's limits)**
  - ✓ Option 2: Option 1 + lower AP limits (reg/unreg)/advanced tests – **lower limits**
  - ✓ Option 3: Option 2 + lifetime compliance/OBM/geofencing – **lower limits**

In a nutshell: CLOVE Euro 7 proposal advancements

- All driving conditions covered
  - Normal conditions of use → significantly wider coverage of driving conditions compared to current RDE
  - Extended conditions of use → Almost all driving conditions are included
- Coverage of driving conditions:
  - Any trip distance and composition (U/R/M share) is allowed
  - No restriction for dynamic driving (except from first 2km under the normal driving conditions)
  - Coverage of all ambient temperature, altitude relevant for Europe
  - Emissions with trailer towing are also controlled

In a nutshell: CLOVE Euro 7 proposal advancements

- Stricter limits compared to Euro 6
  - e.g NOx limit at least 50% lower (normal conditions) than Euro 6
- Wide market introduction of mature technologies and optimization
  - EHC, higher filtration efficiency particle filters
- Introduction of new pollutants, both exhaust and non-exhaust
  - PN_{10}, NMOG, NH_3, N_2O, HCHO, CH_4, brake emissions
- Extended durability
- Evolution from OBD to OBM
- Simplification of the regulatory framework

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Proposed species to be included in Euro 7

Species	Groups	PEMS available Traditional/New	Technologies in-laboratory /on-board
Nitrogen Oxides, NO_x	AQ (1,2,3,4,5,8)	Yes/Yes	Dual CLD, NDUV, QCL, FTIR / on-board PEMS could be by QCL or FTIR.
Carbon Monoxide, CO	AQ (1)	Yes/Yes	NDIR, FTIR /PEMS currently poor. Improvement needed by using e.g. FTIR.
Solid particles, SPN	AQ (1)	- /Yes	PN23 available. PN10 at the market-ready stage. PMP work.
Particulate matter, PM	AQ (1,7,8)	Yes (not for cars)	PM-PEMS used for HDVs is not practical for cars.

New species

Ammonia, NH_3	AQ (1,3,4,8)	- /Yes	LDS, QCL, FTIR / on-board PEMS could be by QCL or FTIR.
Nitrous Oxide, N_2O	GHG & AQ (1, 6)	Yes/Yes	GC-ECD, QCL, NDIR, FTIR / on-board could be FTIR or QLC.
Methane, CH_4	GHG & AQ (1, 5)	Yes (not for cars)/Yes	FID with cutter, GC-FID, FTIR / on-board could be FTIR.
Formaldehyde, HCHO	AQ (1,2,5)	- /Yes	DNPH&HPLC, PTR-MS, FTIR / on-board could be FTIR.
Non-Methane Organic Gases, NMOG	AQ (1,2,5,8)	- /Calculated	NMOG could be FID (THC) minus CH_4 plus HCHO. If other than FID (THC), oxygenates to be analysed by FTIR, GC.

(1) health (2) vegetation (3) acidification (4) eutrophication (5) tropospheric ozone (6) stratospheric ozone (7) GWP black carbon (8) sec. aerosols

Recommendation for limitation on-road/laboratory

	NO_x	CO	SPN_{10}	PM	NH_3	N_2O	CH_4	HCHO	NMOG	THC
Measured or not	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Calc. (2)	Yes
LIMIT on-road	Yes	Yes	Yes	No (3)	Yes	Yes (1)	Yes (1)	Yes	No (3)	No (3)
LIMIT in-lab	No (4)	No (4)	No (4)	Yes	No (4)	Yes (1)	Yes (1)	No (4)	Yes	No (4)

(1) **Option a.** To limit N_2O and CH_4 individually. **Option b.** N_2O and CH_4 for calculation of CO_2e for potential GHG certification and GHG in-use monitoring.

(2) THC, HCHO, CH_4 for calculation of NMOG: *THC (FID) minus CH_4 plus HCHO*. FID has response factor for carbonyls other than HCHO. If THC not measured with FID, aldehydes and alcohols analysed separately.

(3) If PEMS is sufficiently accurate, CH_4, THC and PM can be measured on-road subject to the same limits as in-lab.

(4) On-road limits apply, if measured in-laboratory (chassis or engine dynamometer) at the same time as CO_2.

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The emissions database

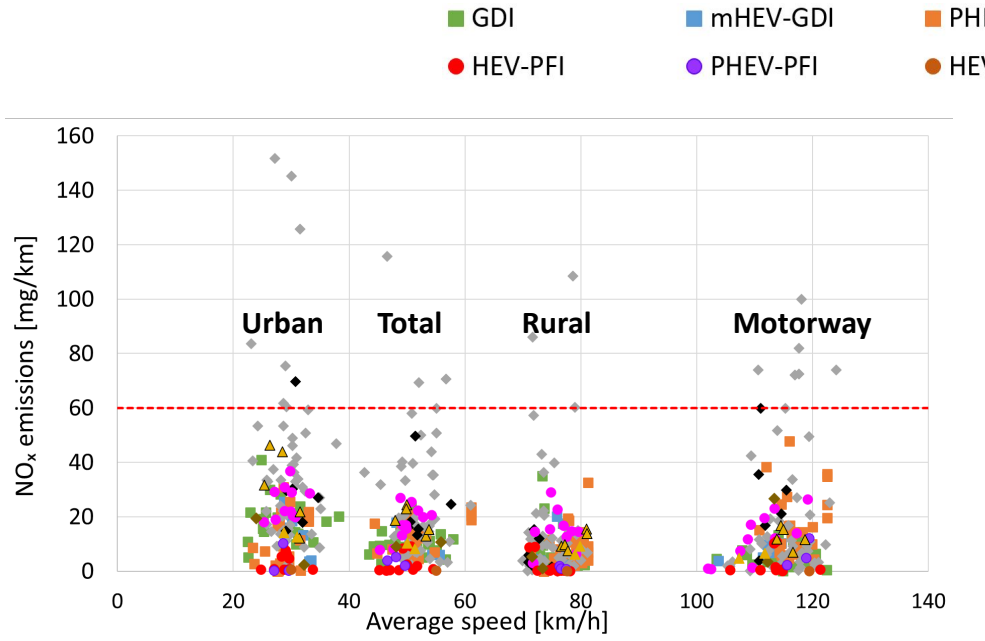
- Sources:
  - CLOVE “Euro 7” measurement campaigns and own data
  - JRC “Euro 7” measurement campaigns and own data
  - H2020 projects (DownToTen, GVI - Green NCAP)
  - Stakeholders (AECC, Vitesco, Bosch, DENSO, IFPEN)

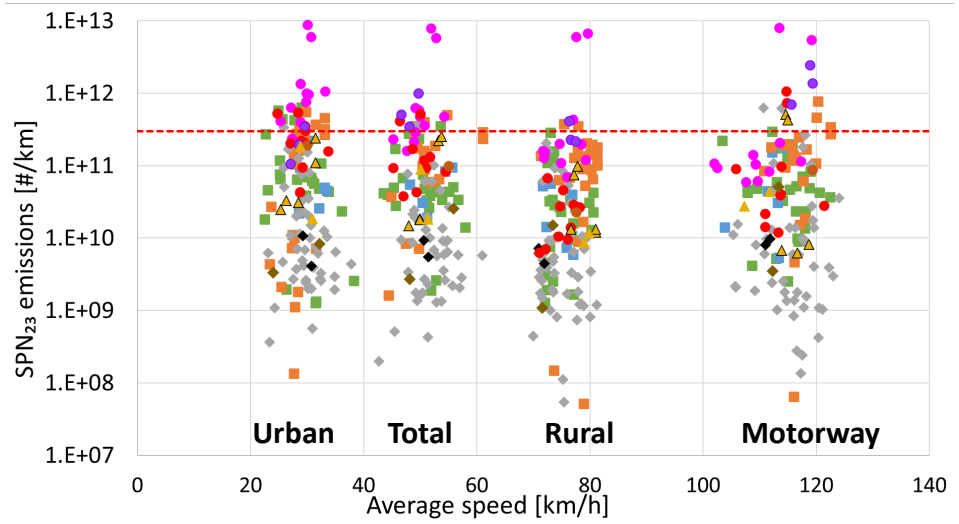
Based on selected data from the above sources a CLOVE LDV database was developed comprising:

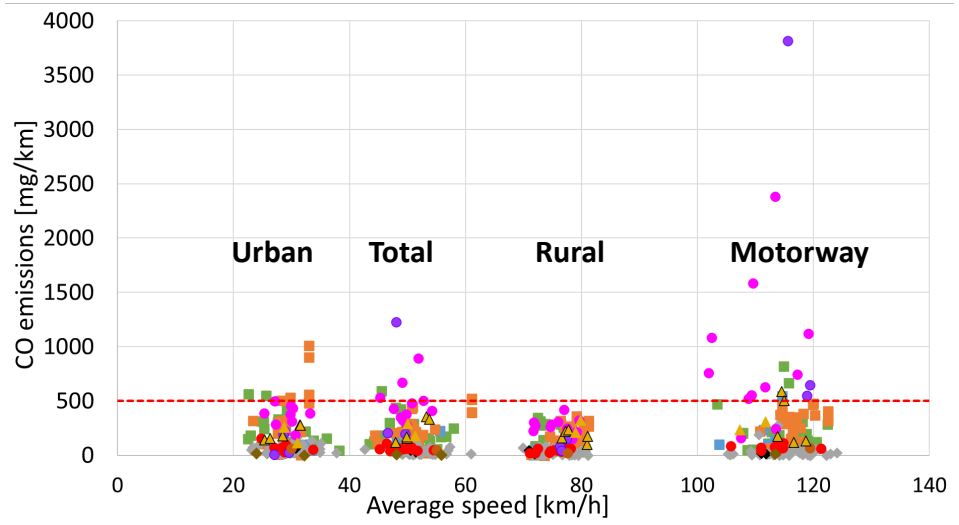
- 71 vehicles (19 Euro 6d and 52 6d-temp)
- ~700 tests (on-road and lab)

Emission performance within current RDE boundaries
Euro 6d and 6d-temp

On-road tests







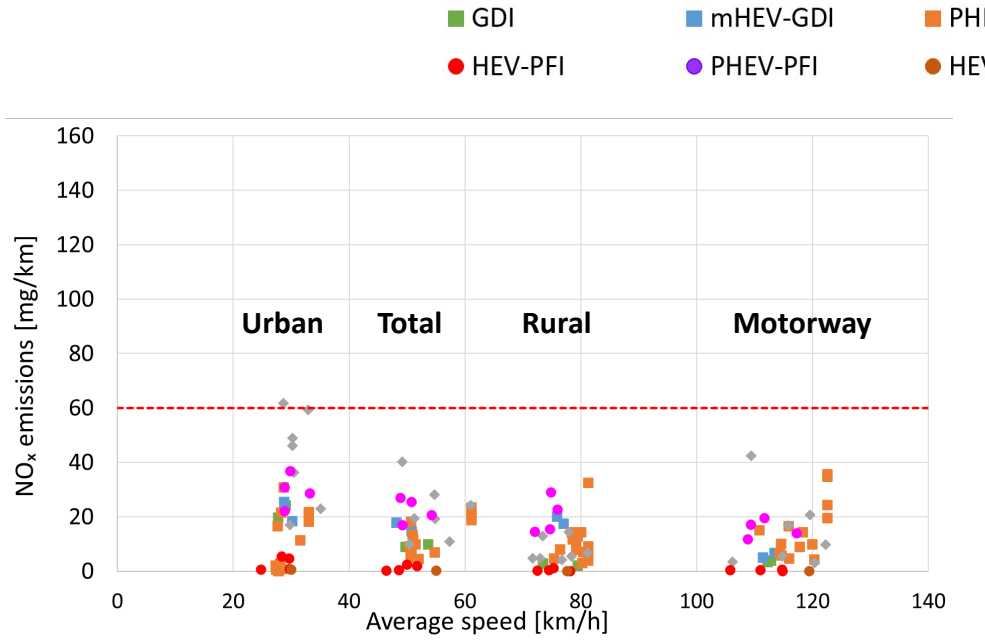
- Most vehicles already at low levels, well below the current limits when tested within current RDE, although further development is needed in some cases
- High SPN observed only in technologies currently not included in regulation (PFI)

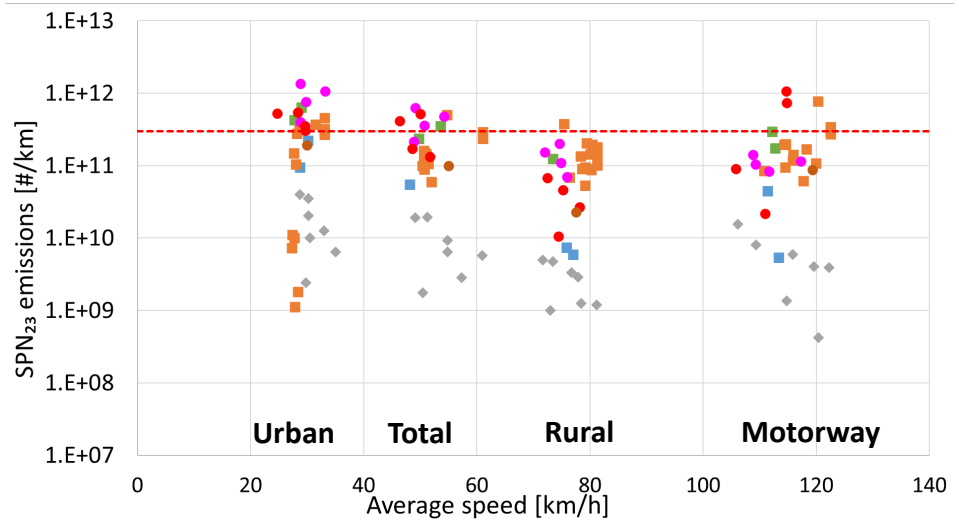
Fraction [%] of tests (urban | total) below:	NOx	CO	SPN_{23}
Limit*	94% | 98%	95% | 94%	93% | 97%
0.5×Limit*	75% | 87%	80% | 78%	81% | 87%

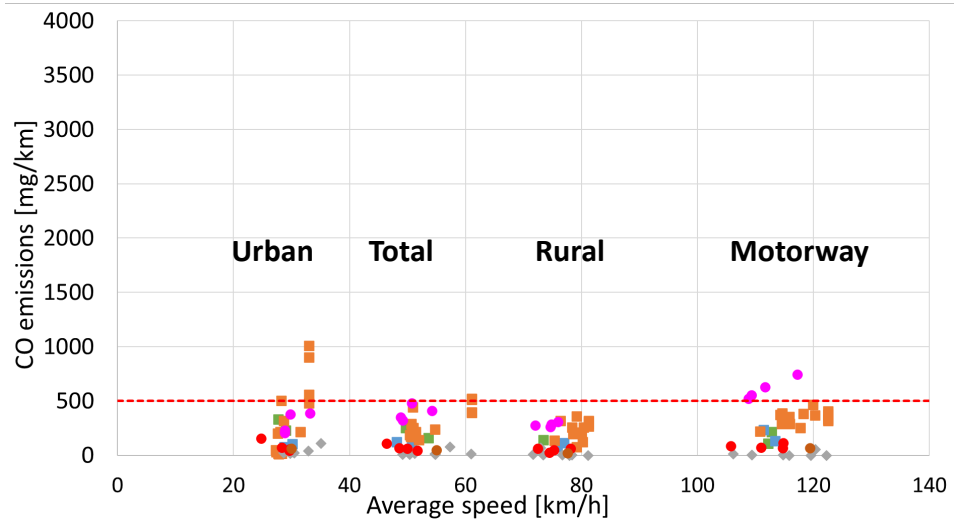
* Refers to the lowest current limit without conformity factor (e.g. 60 mg/km NOx)

Emission performance within current RDE boundaries
Euro 6d only

On-road tests







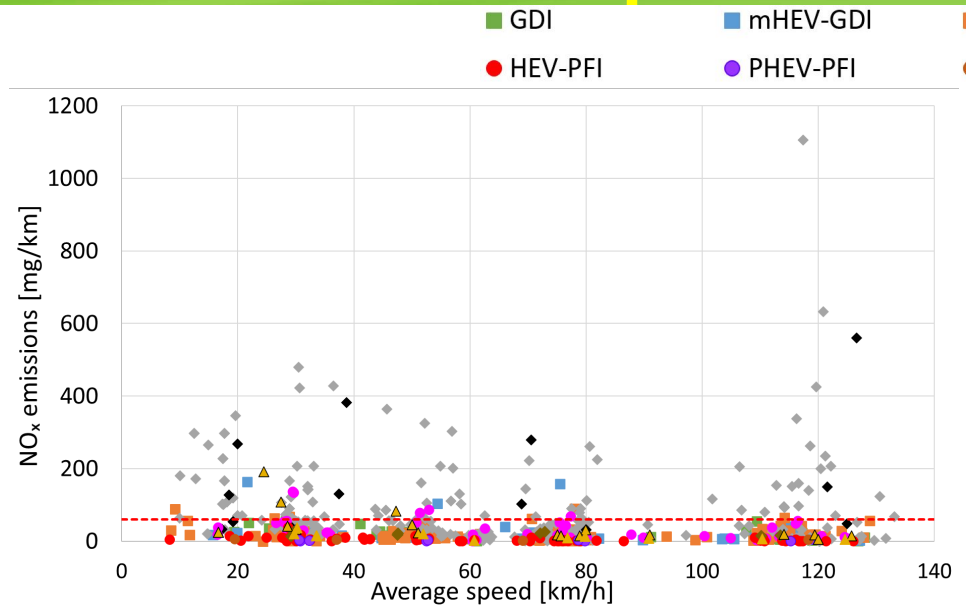
- Similar trends compared to all Euro 6d and d-temp vehicles regarding fuel/technologies comparison
- The highest emitters in all species are mainly from Euro 6d-temp vehicles

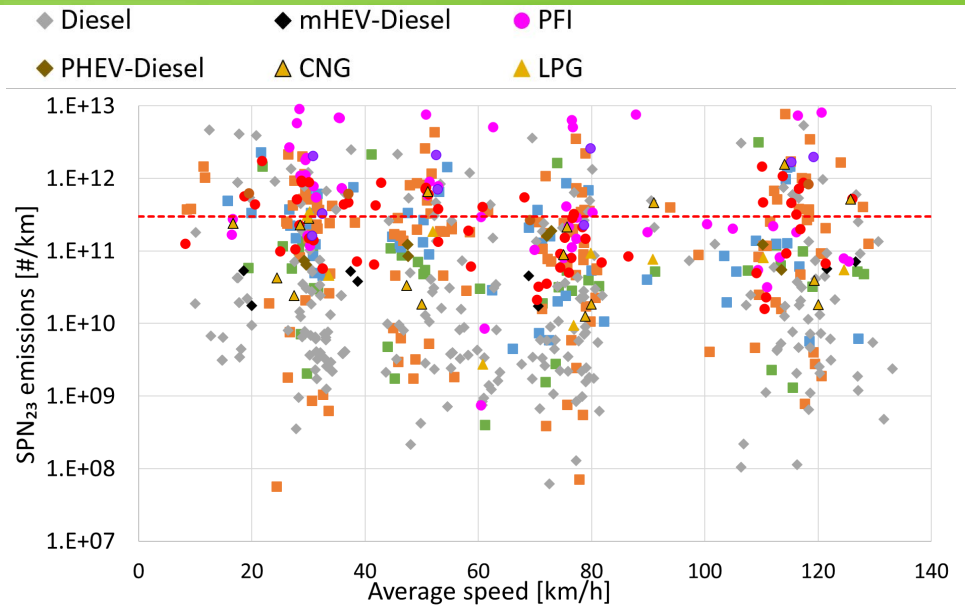
Fraction [%] of tests (urban | total) below:	NOx	CO	SPN_{23}
Limit*	97% | 100%	88% | 94%	88% | 97%
0.5×Limit*	76% | 97%	74% | 65 %	59% | 79%

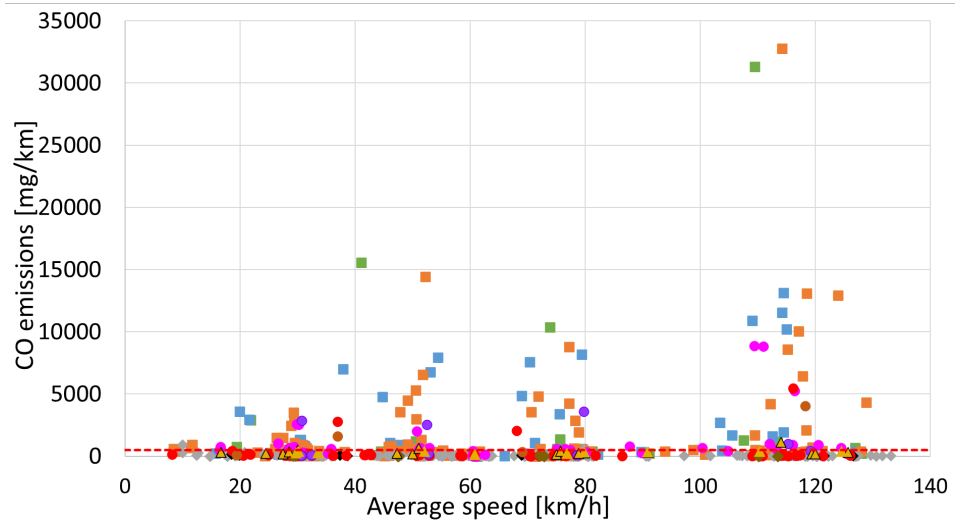
* Refers to the lowest current limit without conformity factor (e.g. 60 mg/km NOx)

Emission performance beyond current RDE boundaries
Euro 6d and 6d-temp

On-road tests







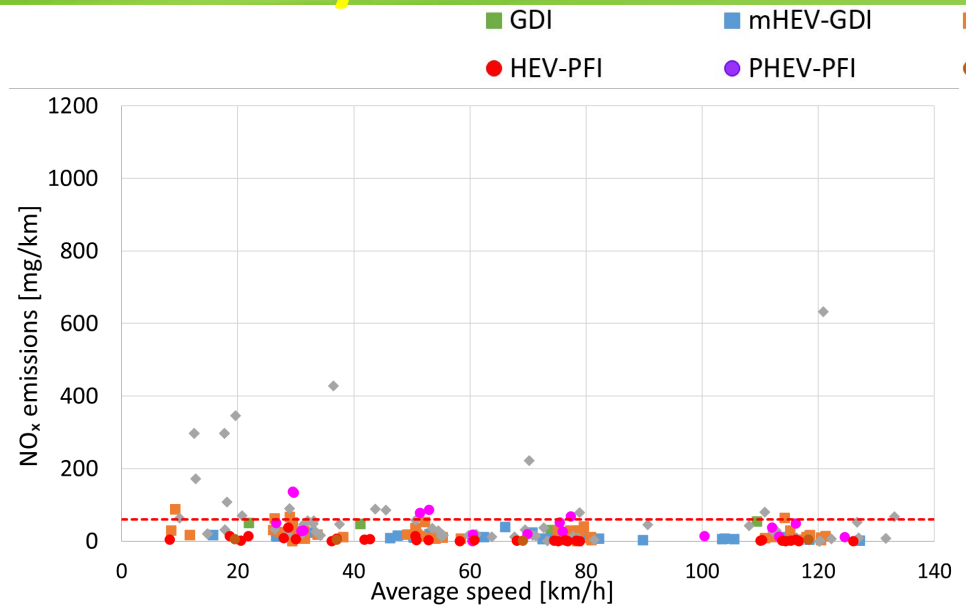
- Tests beyond current RDE boundaries in terms of: driving dynamics (high v*a), high positive elevation gain, trip composition (U/R/M shares), DPF regeneration
- NOx: challenging for diesel
- SPN: challenging for diesel mainly during regen, also for some GDI with GPF
- CO: challenging for gasoline, mainly GDI
- Emission excursions are related to specific driving conditions → next slides

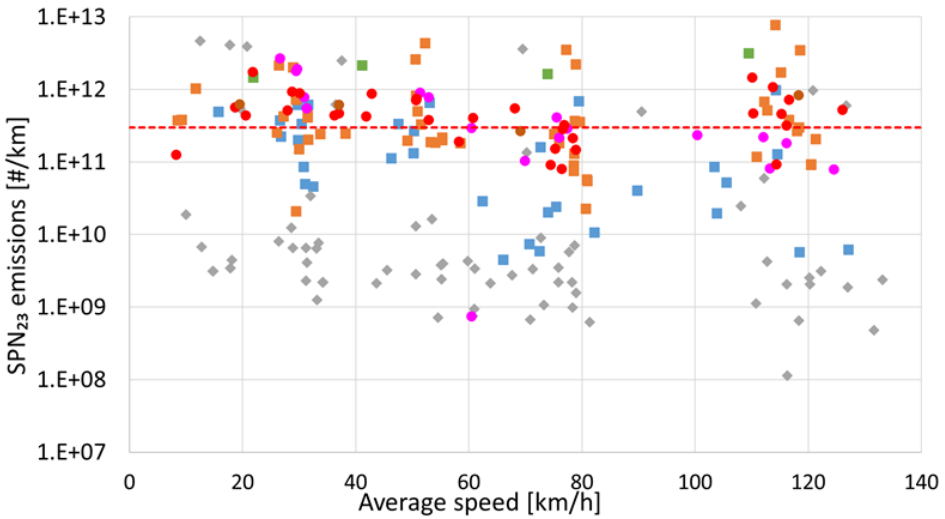
Fraction [%] of tests (urban | total) below:	NOx	CO	SPN_{23}
Limit*	77% | 80%	78% | 78%	78% | 80%
0.5×Limit*	51% | 65%	64% | 63%	64% | 68%

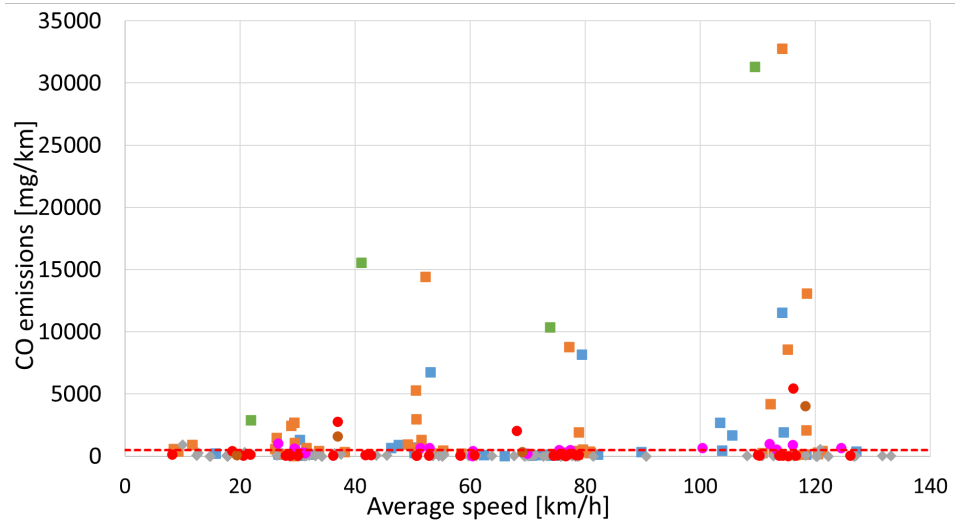
* Refers to the lowest current limit without conformity factor (e.g. 60 mg/km NOx)

Emission performance beyond current RDE boundaries
Euro 6d only

On-road tests





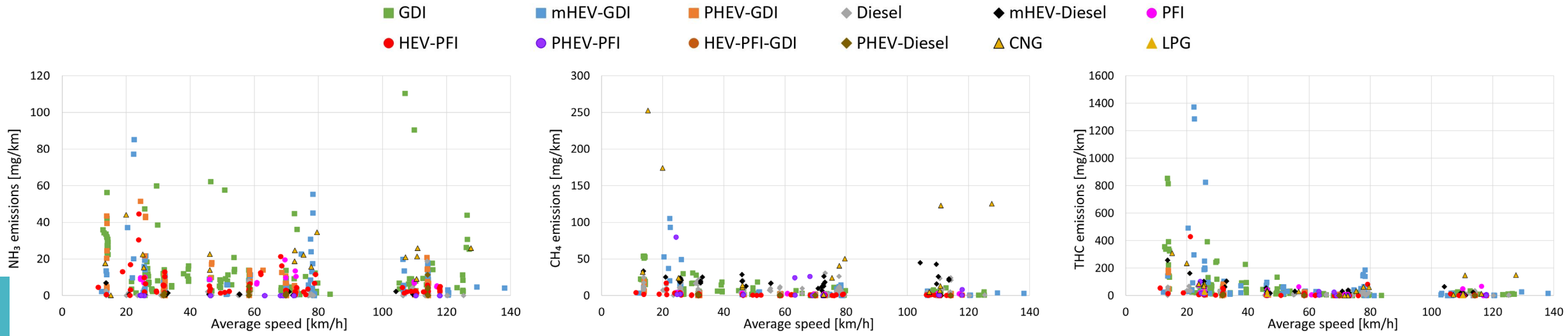


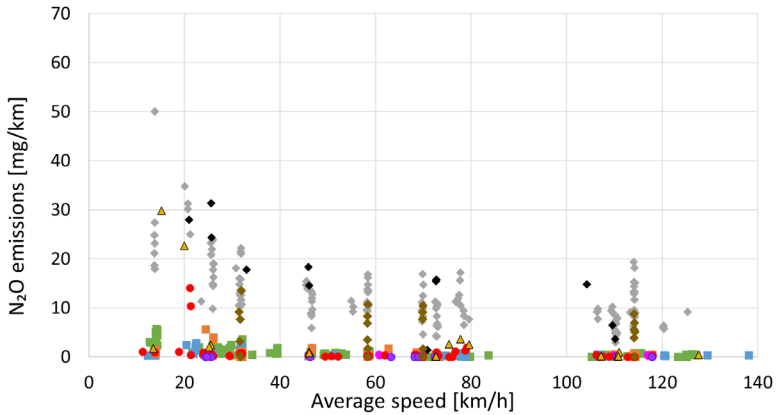
- Similar trends compared to all Euro 6 vehicles regarding fuel/technologies comparison
- Most high emitters of diesel NOx, gasoline CO and PFI SPN are from Euro 6d-temp vehicles

Fraction [%] of tests (urban | total) below:	NOx	CO	SPN_{23}
Limit*	78% | 86%	75% | 69%	68% | 71%
0.5×Limit*	56% | 69%	61% | 54%	44% | 53%

* Refers to the lowest current limit without conformity factor (e.g. 60 mg/km NOx)

Emission performance – Other species





Lab tests

- Lab tests include: WLTC, US06, TfL, BAB130, RDE on-dyno. Separation of U/R/M parts for these graphs was done based on RDE velocity bins
- Higher emissions detected in:
  - NH_3: in gasoline (related to rich operation). Much lower emissions in diesel with SCR, even without ASC
  - CH_4: CNG but also in some gasoline
  - THC: mainly gasoline
  - N_2O: mainly diesel (SCR, NO_x-N_2O trade-off)
  - Limited data for HCHO and NMOG (not presented here)

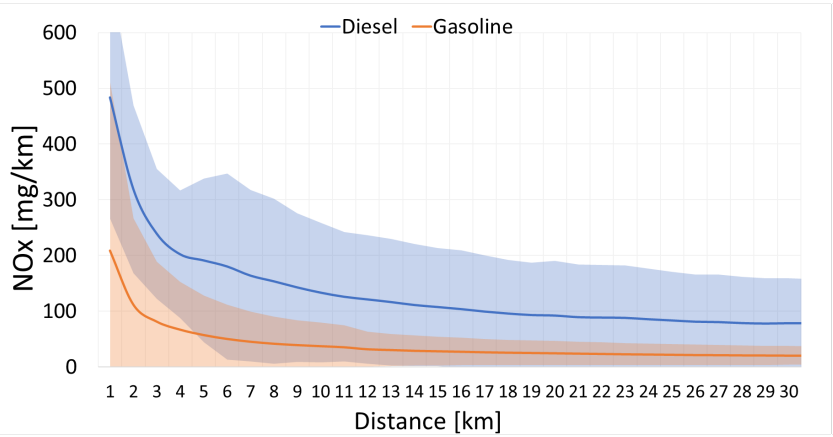
*Limited results

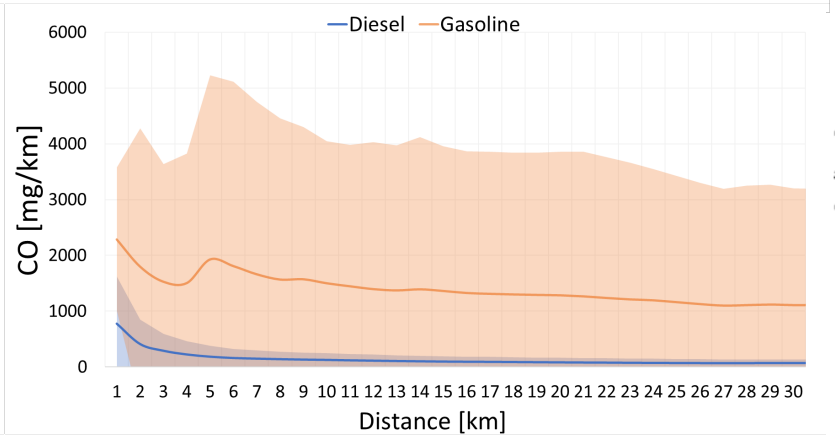
RDE emissions are low but increased emissions observed at:

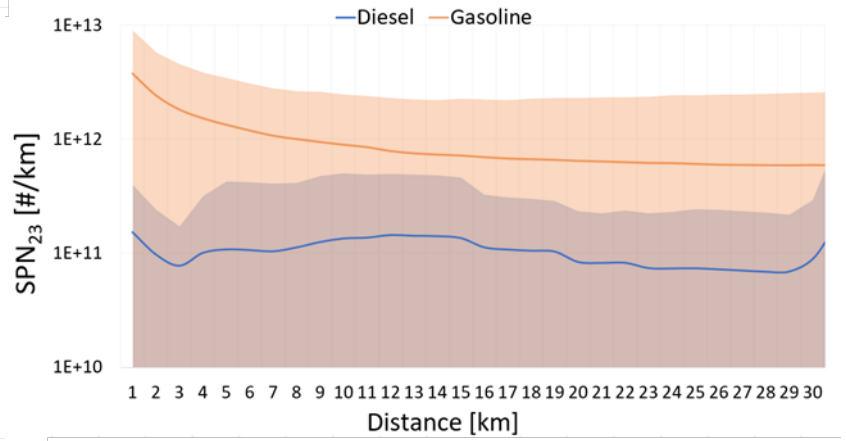
- Cold start – short trips
- Low ambient temperature
- High engine power events/periods
  - Harsh accelerations
  - Uphill driving, high vehicle payload and/or trailer pulling
  - High vehicle speed
- Idling and low load driving which may occur during traffic congestion (severe stop-and-go situations).
- DPF regeneration and when filter is clean
- High SPN from technologies currently not included in regulation (PFI and NG)

Cold start – short trips

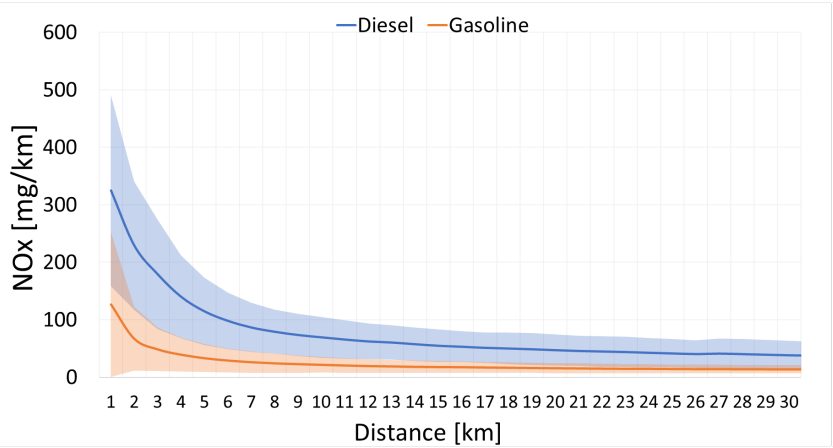
All tests

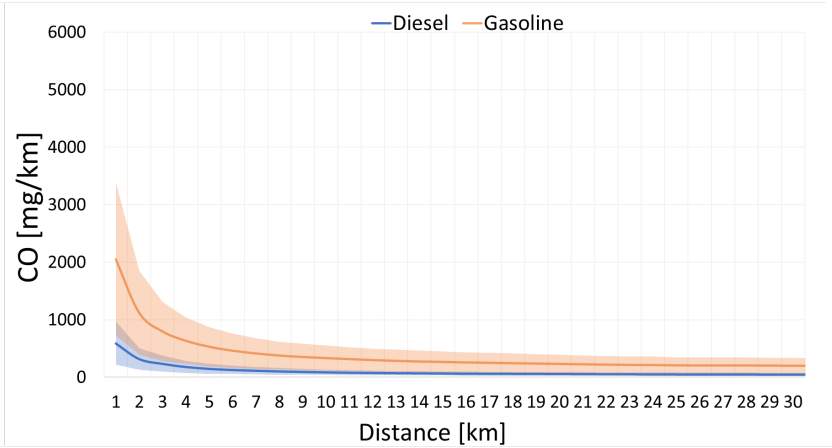


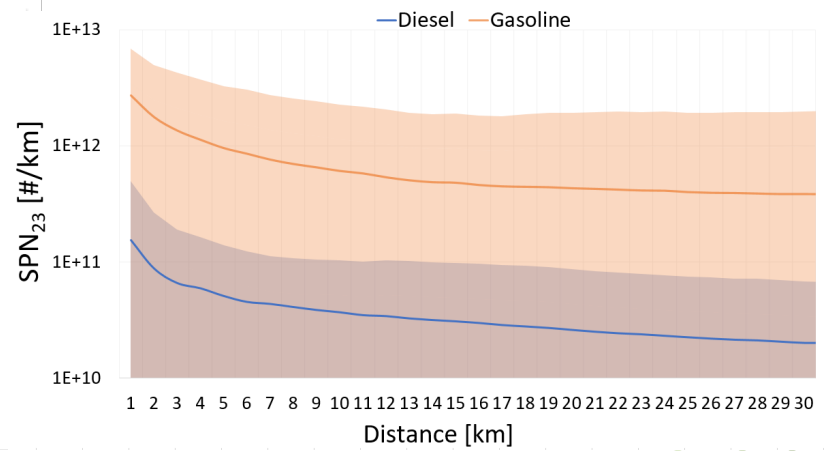




Within current RDE





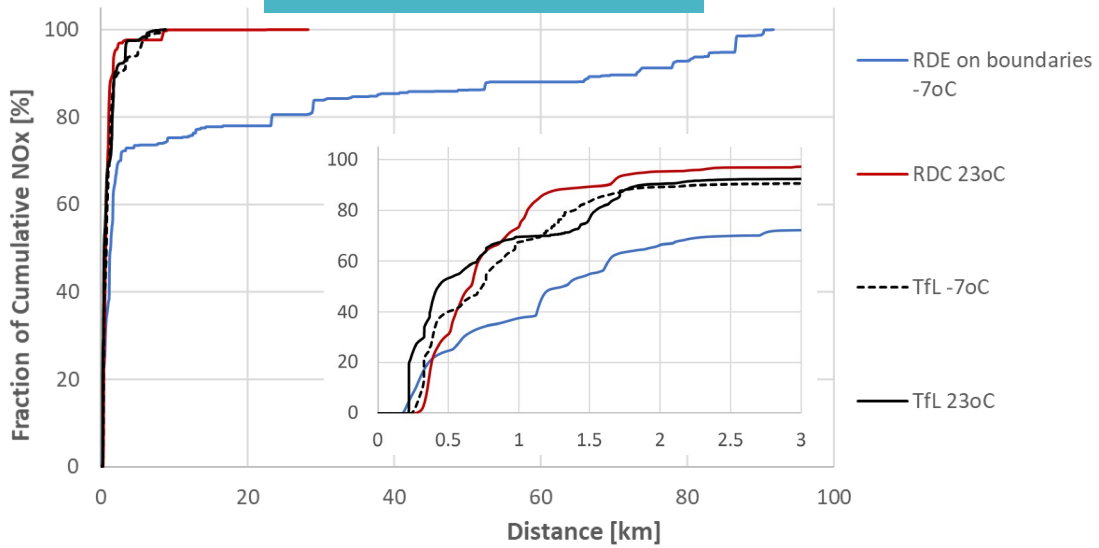


- High contribution of cold start, especially in short trips. NOx emissions at 2 km are 3.3 times higher compared to 16km (avg of all vehicles, all tests)

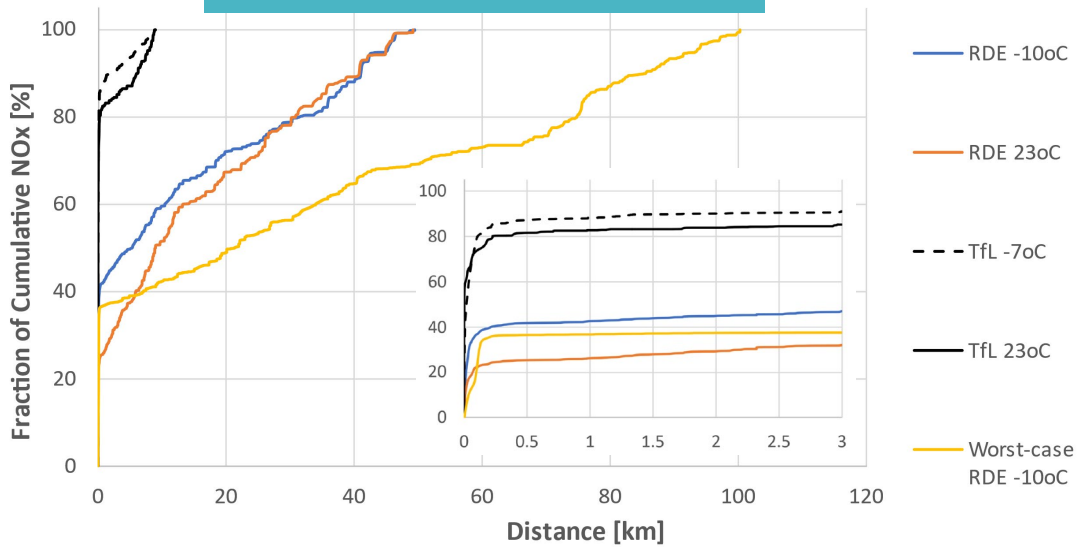
Areas above and below mean values: standard deviation

Cold start – short trips, example tested vehicles

Euro 6d diesel vehicle

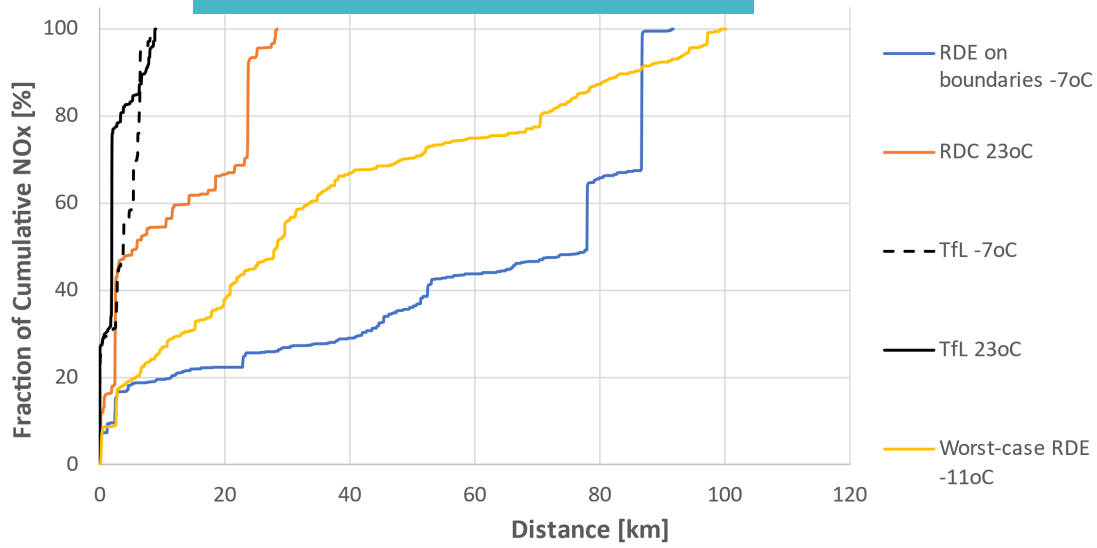


Euro 6d-temp gasoline vehicle



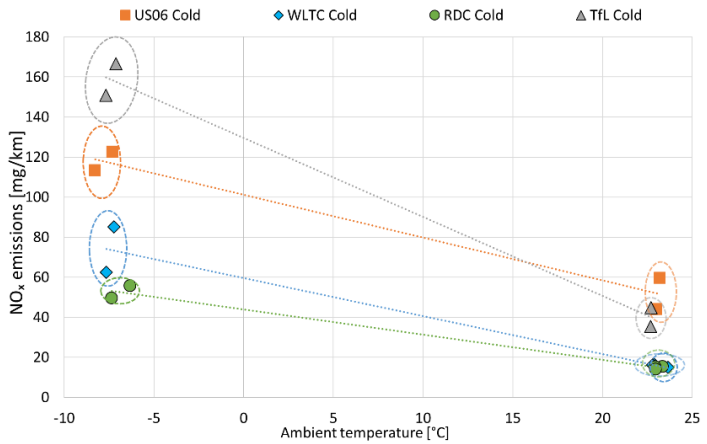
- In all vehicles high cold start effect in short cycles
- Higher cold start contribution in diesel compared to gasoline for the same cycles e.g. TfL
- Shorter “cold start period” in gasoline compared to diesel
- PHEV: similar trends with gasoline, but high emission peaks also during the cycle duration

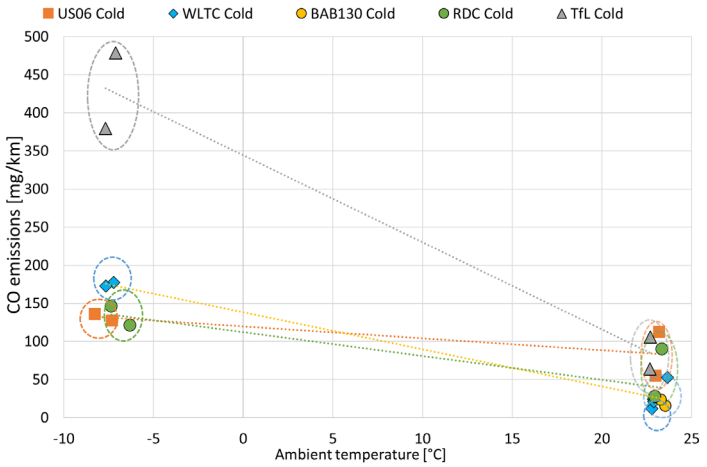
Euro 6d gasoline PHEV



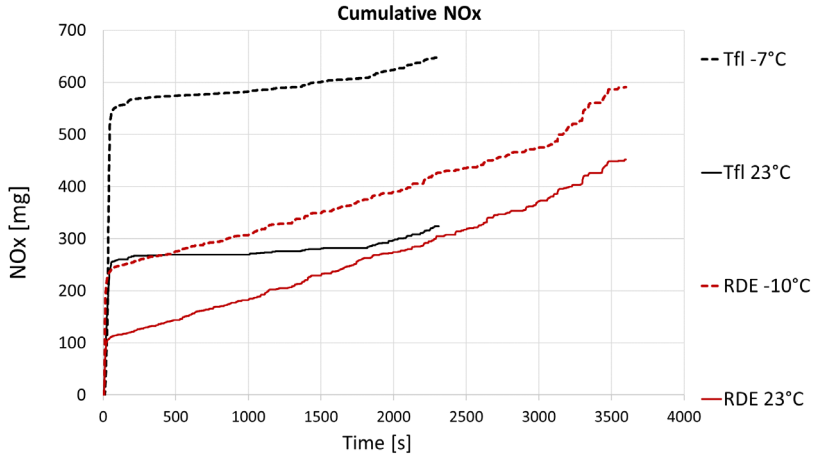
Low ambient temperature

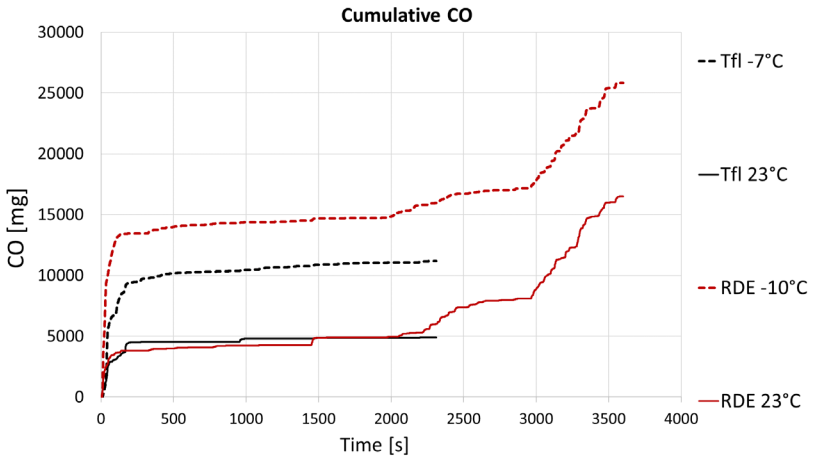
Euro 6d diesel vehicle





Euro 6d-temp gasoline vehicle



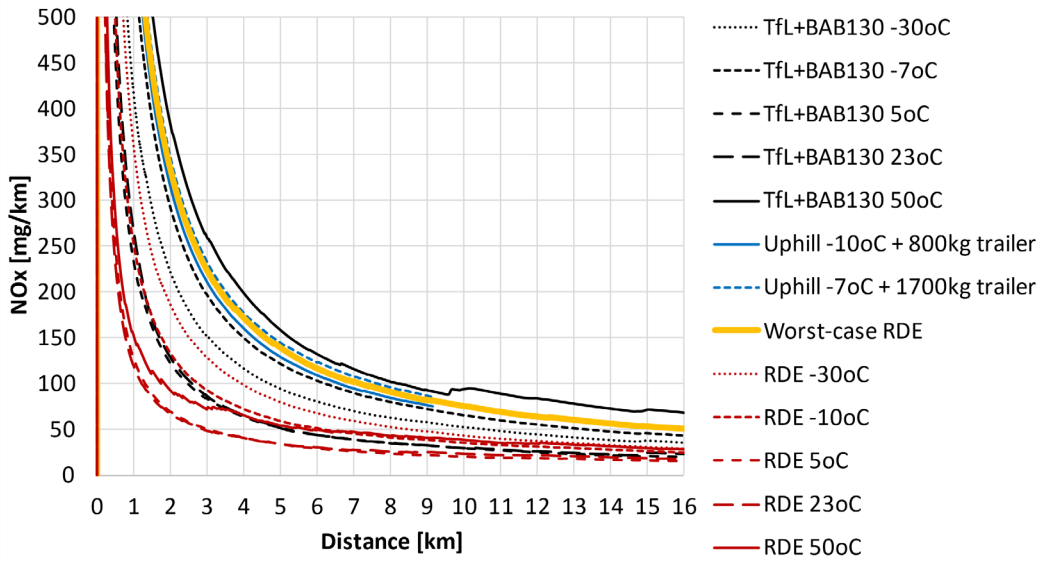


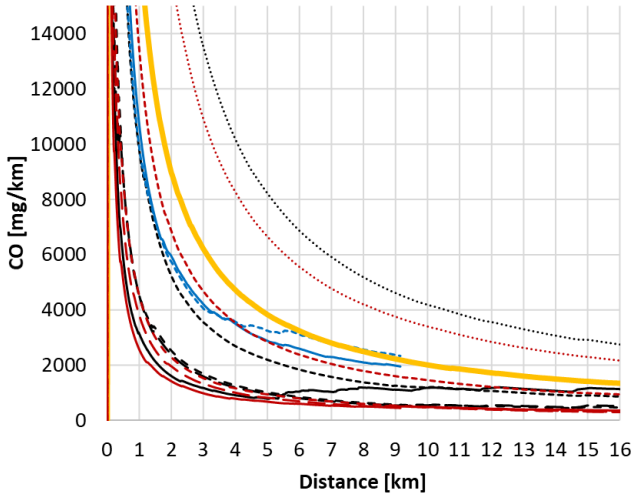
- Clear effect of low ambient temperature over different test cycles
- Main difference observed in cold-start

High engine load

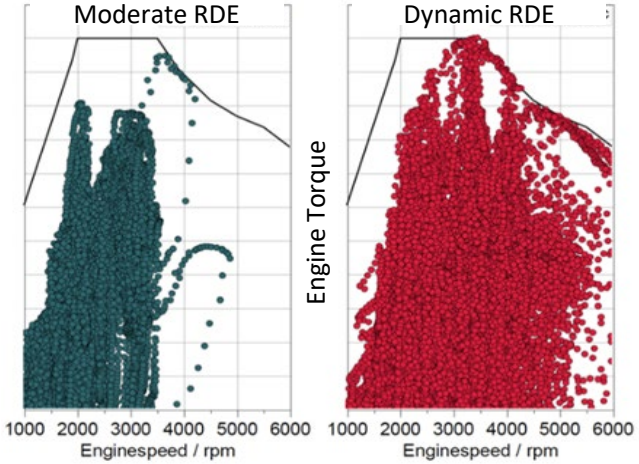
High-load test conditions/events causing high emissions:

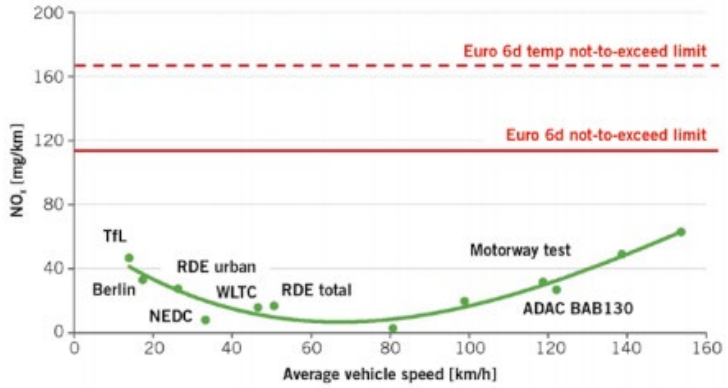
- Harsh accelerations
- Uphill driving especially when combined with high vehicle payload and/or trailer pulling
- High vehicle speed





Driving dynamics and engine load

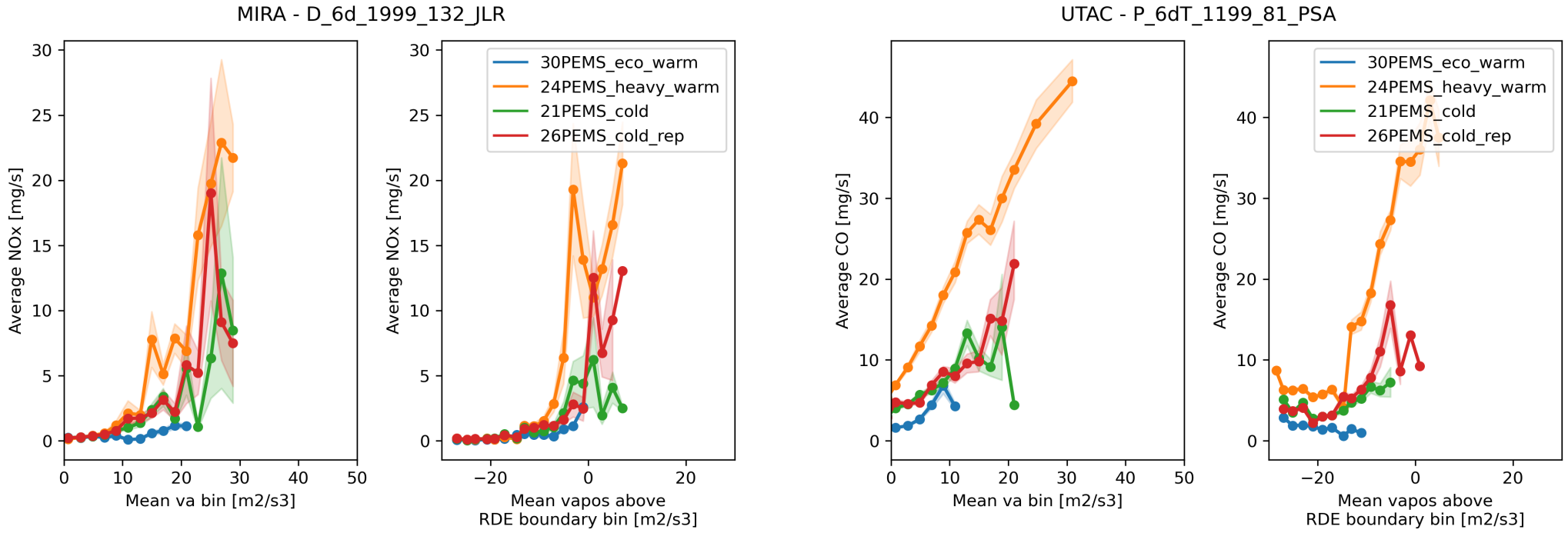




https://www.aecc.eu/wp-content/uploads/2020/05/200107-UltraLowNOx-MTZ.pdf

High engine load effects (from H2020 GVI)

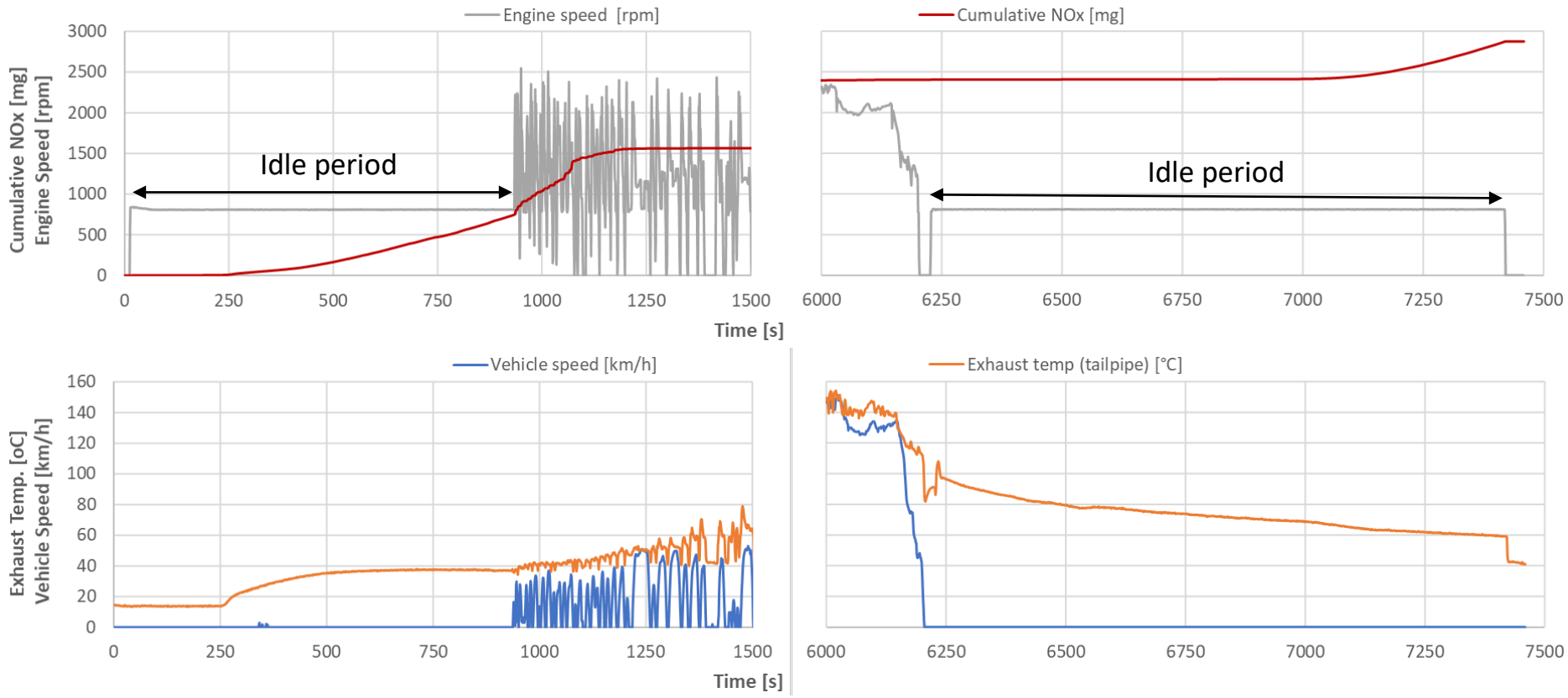
- High $v \times a_{pos}$ is associated with high NO_x (diesel) and CO (petrol).
- The PEMS heavy trip generally has higher emissions than the cold (regular) trips for the same high(er) $v \times a_{pos}$ bins.



Each point has at least 20 seconds of data

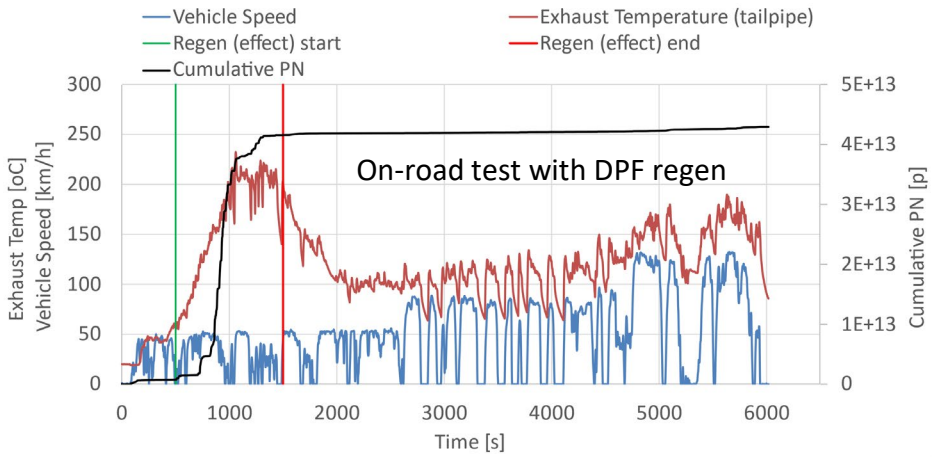
Low load – idling

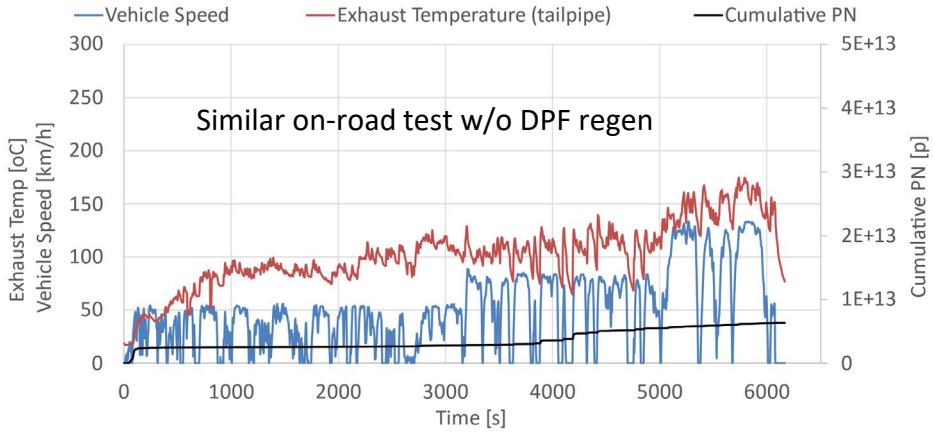
Diesel



- Emissions during long idling were found to increase in some diesel vehicles due to EATS low temperature
- No similar issue for gasoline
- Start&Stop system can eliminate this issue, but this may not always be possible e.g. air-condition on, low battery level
- Request for heating measures in the future regulation to keep the EATS warm in long idle phases

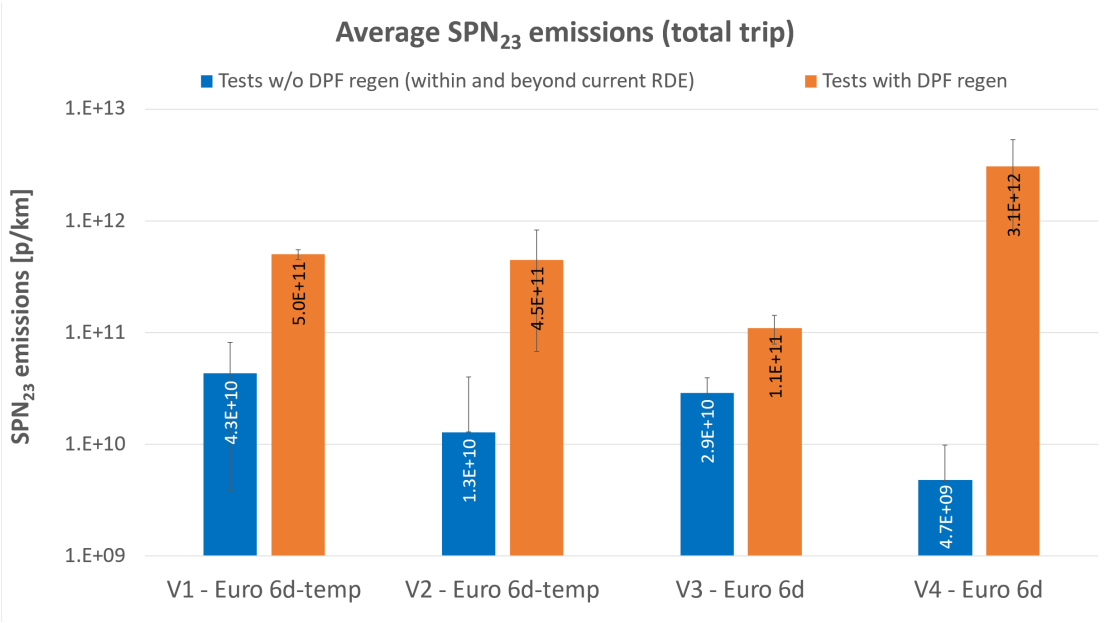
DPF regeneration – SPN emissions





Test/Phase	PN emissions [p/km]
Total test w/ DPF regen	5.4E+11
DPF regeneration period	4.9E+12
Total test w/o DPF regen	7.9E+10

7:1



- Significant effect of DPF regeneration on PN emissions. Emissions on tests with DPF regeneration can be more than 2 orders of magnitude higher compared to tests without regen.
- Filtration efficiency of “clean” filters still an issue both in diesel (during and after regen) and GPF (passive regen)
- Increase of NOx emissions was also observed during DPF regeneration, but this issue is expected to be eliminated already at (late) Euro 6 stages

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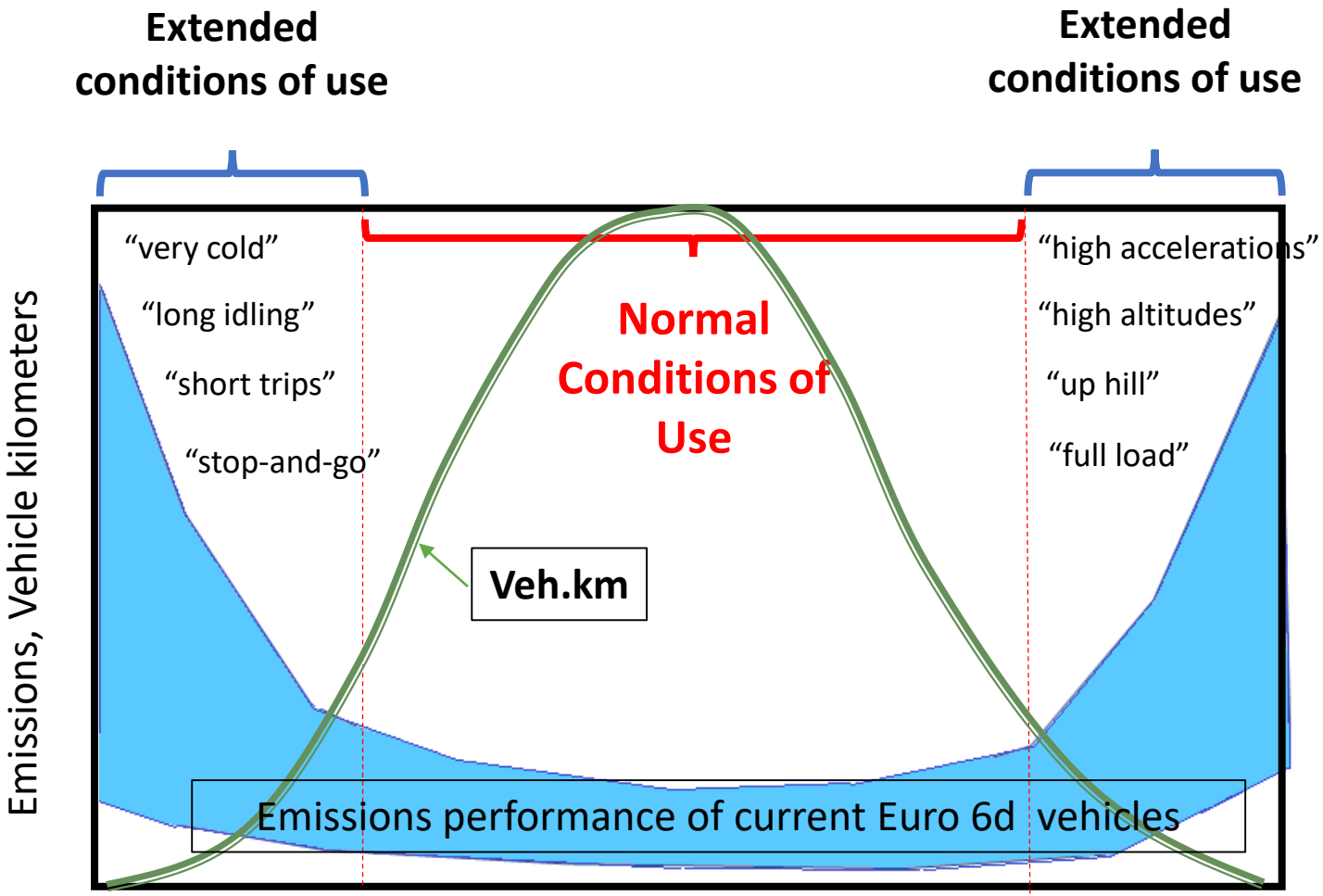
  - Identification of operating/testing conditions that are related with emission excursions
- Testing conditions for Euro 7 – LDV
- Euro 7 limits and technologies – LDV
  - Technology packages
  - Emission performance (simulations + demos)
  - Emissions limits scenarios (for PO2)

Testing conditions for Euro 7

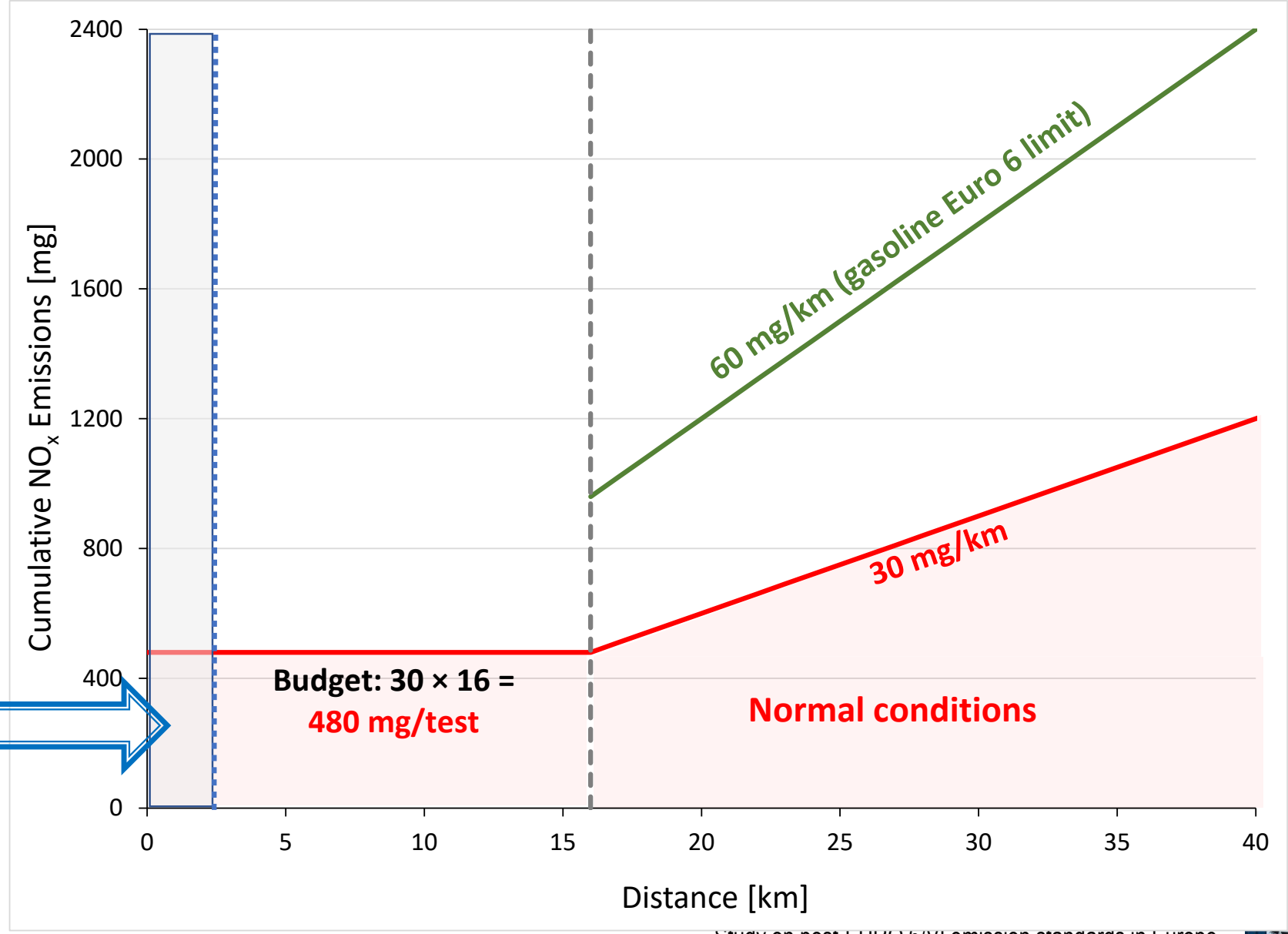


Driving conditions used for the assessment of Euro 7 technology packages (next section)

- **Normal conditions of use**
  - Fully compliant with current RDE test boundaries
  - Corresponding to "moderate" RDE conditions
- **Extended conditions of use**
  - Worst-case RDE

Functional form of emission limits

- CLOVE approach to emissions limitation recognises the challenges of short tests, idle and “stop and go” on per km basis
- Limit approach: a budget up to 16 km and a constant value in mg/km or #/km above 16 km
- A restriction is applied to the maximum power developed for the first e.g. 1 to 2 km and 1 to 2 min

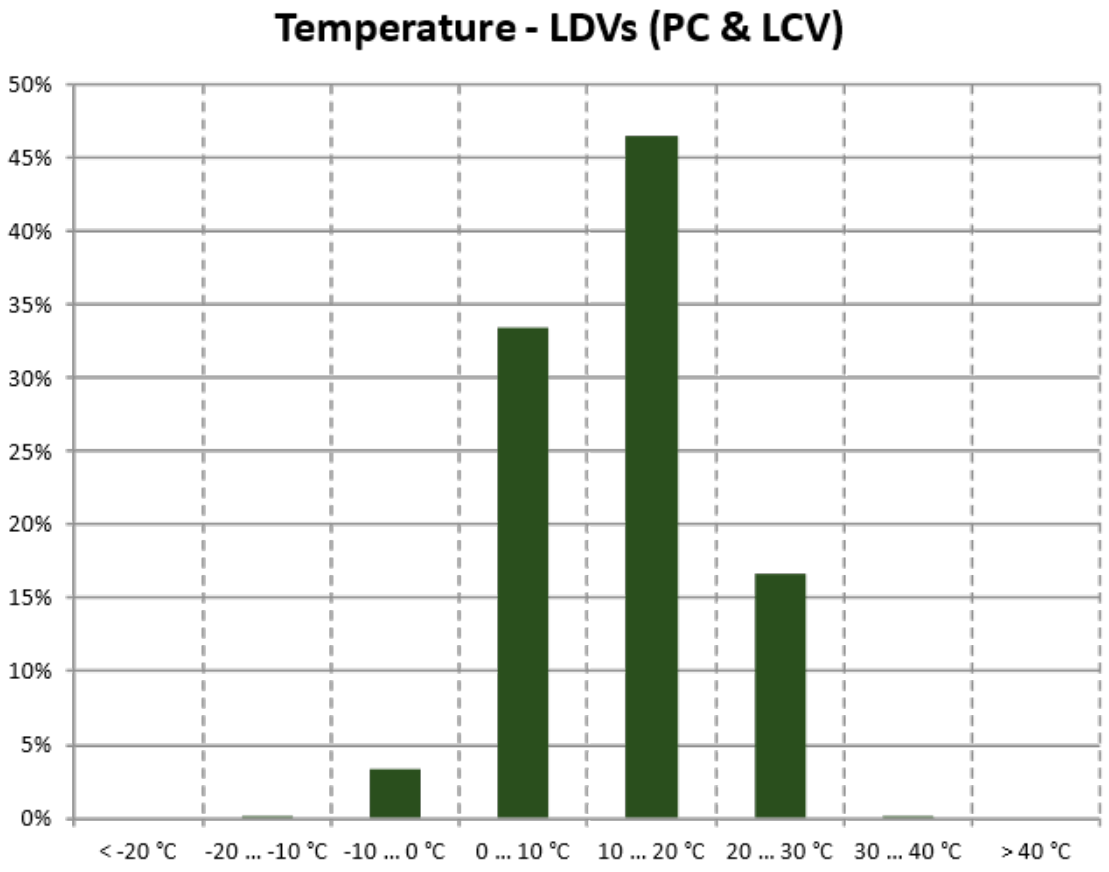


Proposed testing conditions for Euro 7

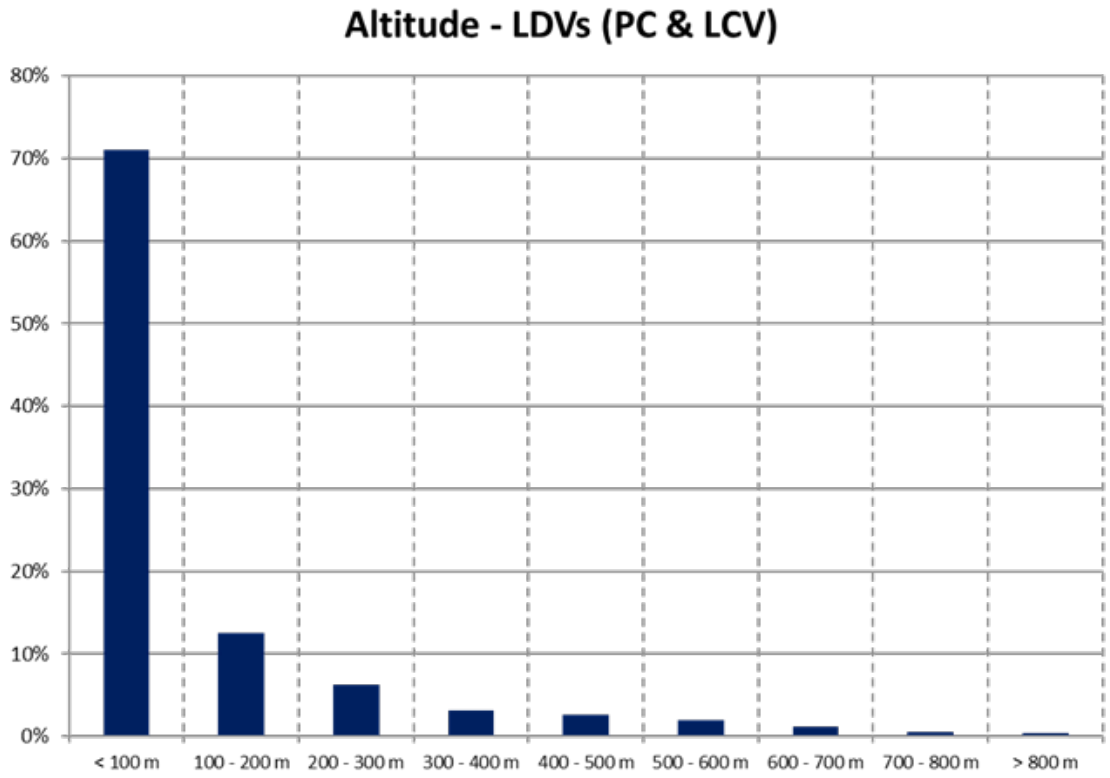
Parameter	Current RDE boundaries	EURO 7 Normal Conditions of use	EURO 7 Extended Conditions of use
Emission Limit Form	Constant value in mg/km or #/km	A budget up to 16 km and a constant value in mg/km or #/km above 16 km	3 times the limit of normal conditions
Ambient temperature [°C]	Moderate: 0 – 30°C | Extended: -7 – 0°C & 30 – 35°C	-7 to 35°C	-10 to +45°C
Average speed [km/h]	Urban: 15-40 km/h, Limitations for trip distance and duration, and speed range coverage	As per normal use	As per normal use
Trip composition	33% urban, 33% rural, 33% highway	As per normal use	As per normal use
$v \times a_{pos}$ [95th] [W/kg]	Speed-based calculated maximum limits	**A restriction is applied to the maximum power developed for the first e.g. 1 to 2 km and 1 to 2 min (The exact approach and values are under investigation and testing)**	As per normal use
Relative positive acceleration RPA m/s^2	Speed-based calculated minimum limits		As per normal use
Drive-off	—		As per normal use
Positive elevation gain [m/100km]	Total: <1200 [m/100km] Urban: <1200 [m/100km]		As per normal use
Max. altitude [m]	Moderate: 0 – 700m | Extended: 700 – 1300m	1600 m	2200 m
Towing/aerodynamic modifications	Not included	Not included	Allowed
Age/Mileage of Vehicle [km]	ISC 100k | MaS 160k	Up to 240k km or 10 years (1)	Up to 240k km or 10 years (1)
Minimum mileage before testing	15000 km (ISC testing)	3000 km	As per normal use
Trip distance [km]	U/R/M >16 km each	Any	Any
Max. speed	145 [160] km/h	Any <160 km/h	All European conditions

(1) The durability of the emission control systems until the end of their lifetime will be dealt separately

Vehicle kilometer distribution in the EU



Only a small fraction of about 0.1% in temperatures below -10°C.



Less than 0.1% of all veh-km are driven in altitudes above 800 m

Temperatures: www.weatherbase.com; Elevation: Eurostat; Population density: Eurostat; v-km: own database on vehicle fleets, compiled from data by many different sources such as ACEA, Eurostat, DG MOVE statistical pocketbook, etc.

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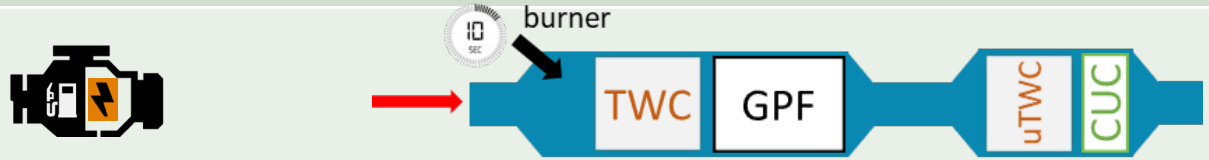
Euro 7 technologies

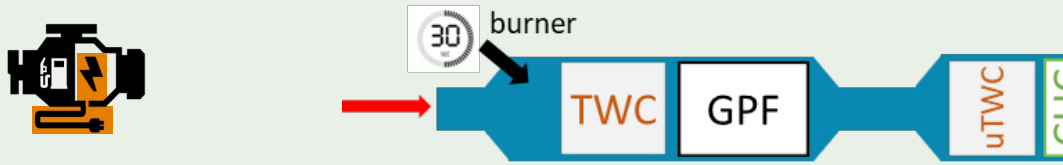
High emissions events/conditions	Technologies to tackle emissions
Cold start – short trips	Heating systems (EHC, burner) with pre-heating functionality and secondary air injection
Low ambient temperature	Heating systems (EHC, burner) for keeping the aftertreatment system warm
Idling, low load driving	Heating systems (EHC, burner) for keeping the aftertreatment system warm
High engine power	Larger aftertreatment systems to manage higher exhaust gas flow
Particle filter regeneration	Optimized filter with high filtration efficiency from the clean state
NO_x emissions from diesel vehicles	Twin urea injection with close-coupled SCR
PN emissions from vehicles w/o filter	Application of particle filters in all types, e.g. gasoline PFI, CNG
NH_3 emissions from gasoline vehicles	NH_3 oxidation catalyst (ASC/CUC) in gasoline vehicles with secondary air injection

Euro 7 technology packages – gasoline 1/2

Main technologies

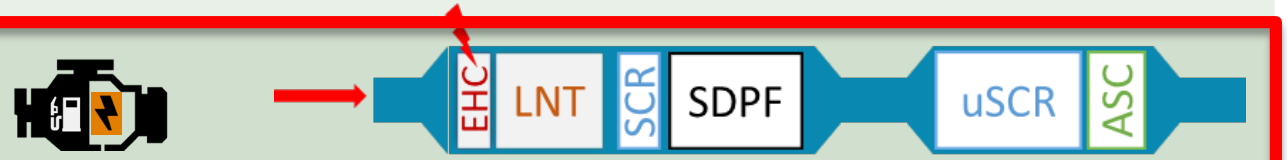
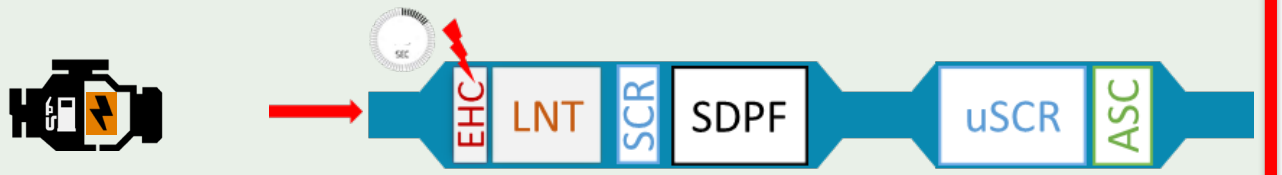
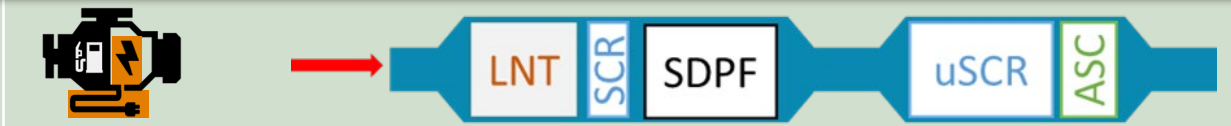
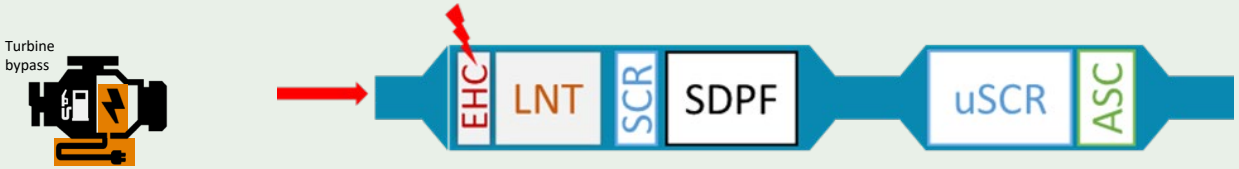
Gasoline		
Short name	Technologies/components integrated	
G1 – Base 2020	Base TWC, base GPF	
G2 – Base 2025 opt	Advanced calibration, larger TWC, improved GPF	
G3 – MHEV Base 2020	Mild hybrid, base TWC, base GPF	
G4 – MHEV 2025 opt	Mild hybrid, advanced calibration, larger TWC, improved GPF	
G5 – MHEV 2025 opt e-cat	Mild hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC	
G6 – MHEV 2025 opt e-cat 10s	Mild hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC, 10s preheating, secondary air injection, CUC (NH_3 catalyst)	
G7 – MHEV 2025 opt burner 10s	Mild hybrid, advanced calibration, larger TWC, improved GPF, 15kW fuel burner, 10s preheating, secondary air injection, CUC (NH_3 catalyst)	

Euro 7 technology packages – gasoline 2/2

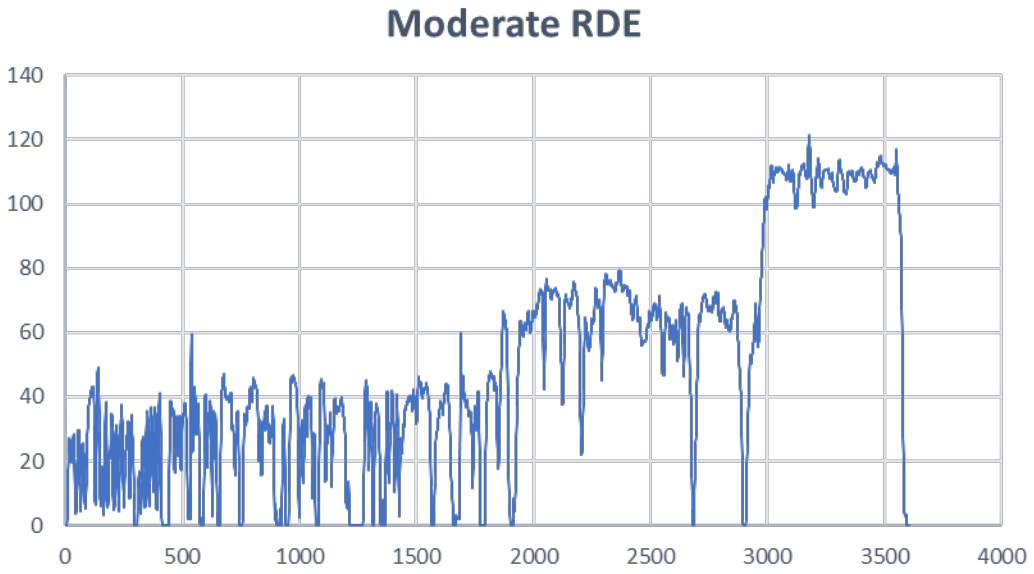
Gasoline		
Short name	Technologies/components integrated	
G8 – PHEV Base 2020	Plugin hybrid, base TWC, base GPF	
G9 – PHEV 2025 opt	Plugin hybrid, advanced calibration, larger TWC, improved GPF	
G10 – PHEV 2025 opt e-cat	Plugin hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC	
G11 – PHEV 2025 opt e-cat 60s	Plugin hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC, 60s preheating, secondary air injection, CUC (NH_3 catalyst)	
G12 – PHEV 2025 opt burner 30s	Plugin hybrid, advanced calibration, larger TWC, improved GPF, 15kW fuel burner, 30s preheating, secondary air injection, CUC (NH_3 catalyst)	
G13 – PHEV 2025 opt e-cat 60s 8kW	Plugin hybrid, advanced calibration, larger TWC, improved GPF, 8kW EHC, 60s preheating, secondary air injection, CUC (NH_3 catalyst), passive SCR, LNT	

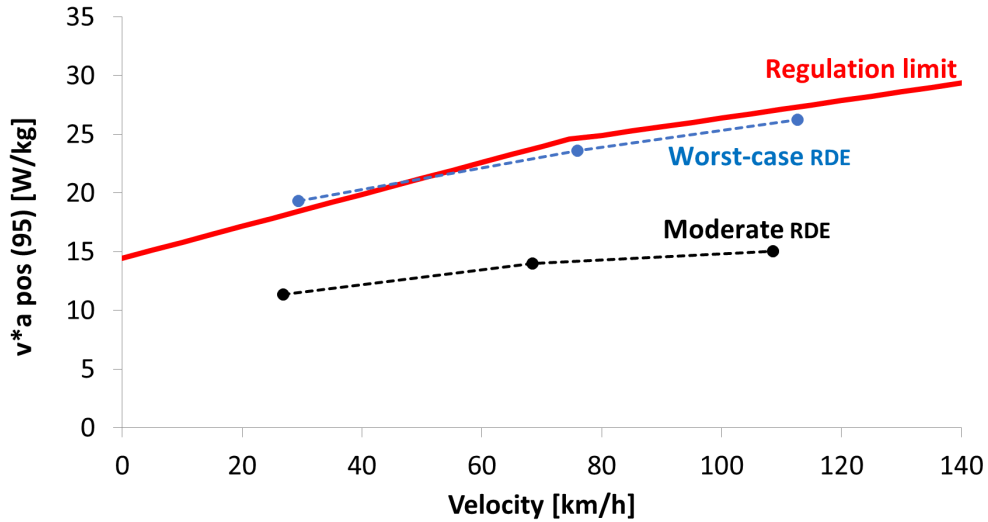
Euro 7 technology packages – diesel

Main technologies

Diesel		
Short name	Technologies integrated	
D1 – MHEV P0 2025 opt	Mild hybrid, advanced heating calibration, larger EATS	
D2 – MHEV P0 2025 opt e-cat	Mild hybrid, advanced heating calibration, larger EATS, EHC	
D3 – MHEV P0 2025 opt e-cat preheating	Mild hybrid, advanced heating calibration, larger EATS, EHC, preheating, secondary air injection	
D4 – PHEV P2 2025 opt	Plugin hybrid, advanced heating calibration, larger EATS	
D5 – PHEV P2 2025 opt e-cat	Plugin hybrid, advanced heating calibration, larger EATS, EHC, turbine bypass	

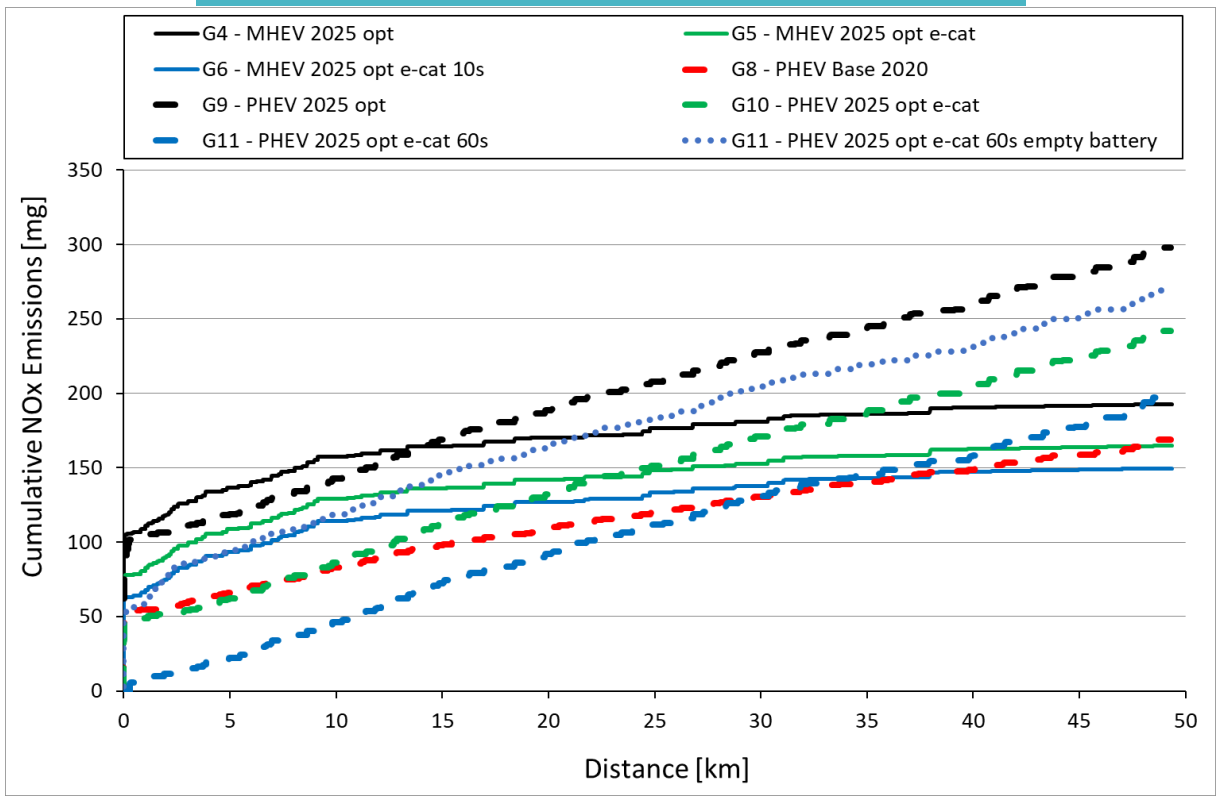
Cycles used for the evaluations: Moderate and Worst-case RDE



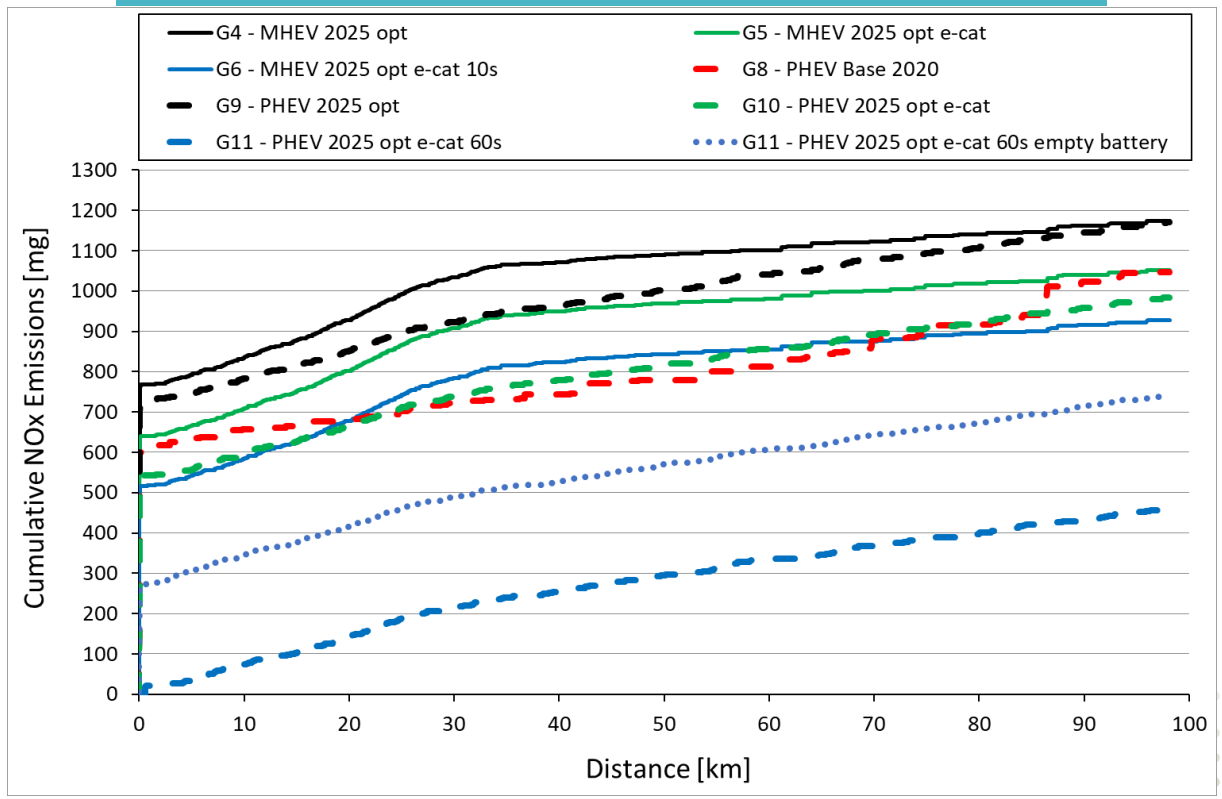


Euro 7 emission performance – LDV gasoline, NOx

Normal conditions of use – moderate RDE



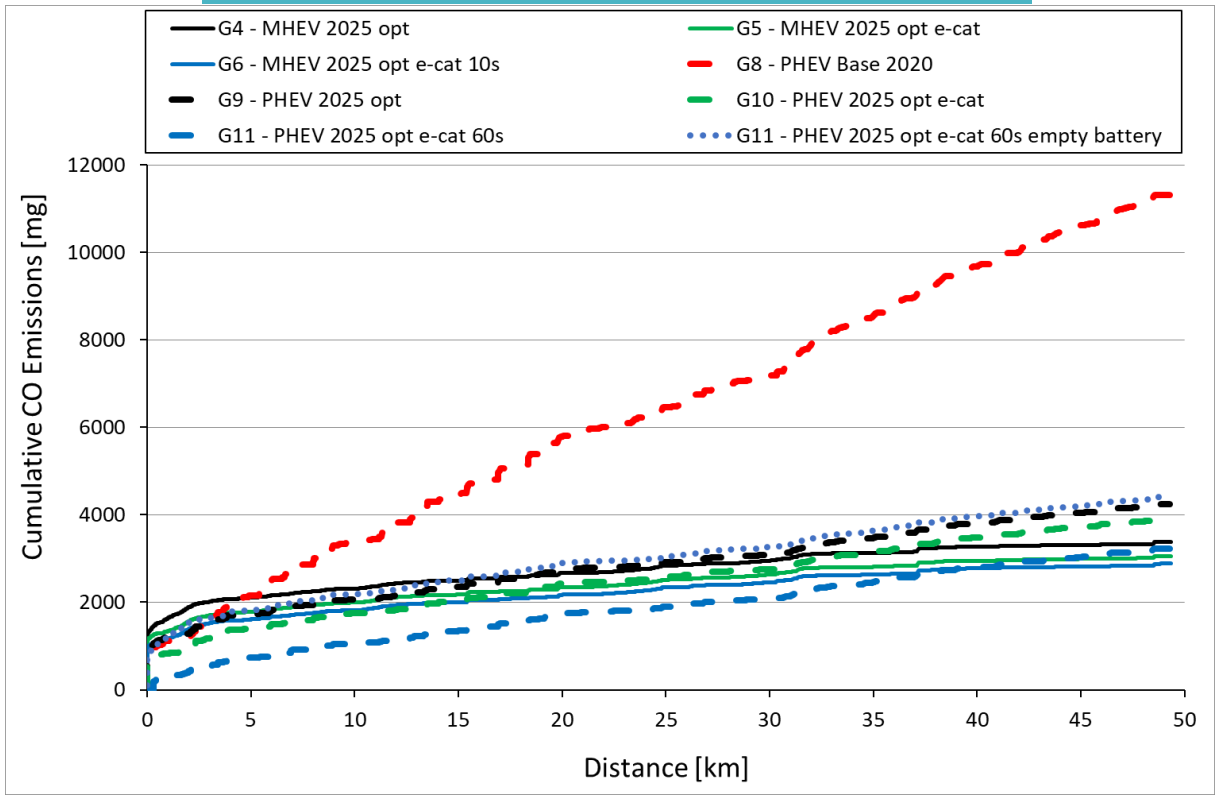
Worst-case RDE*



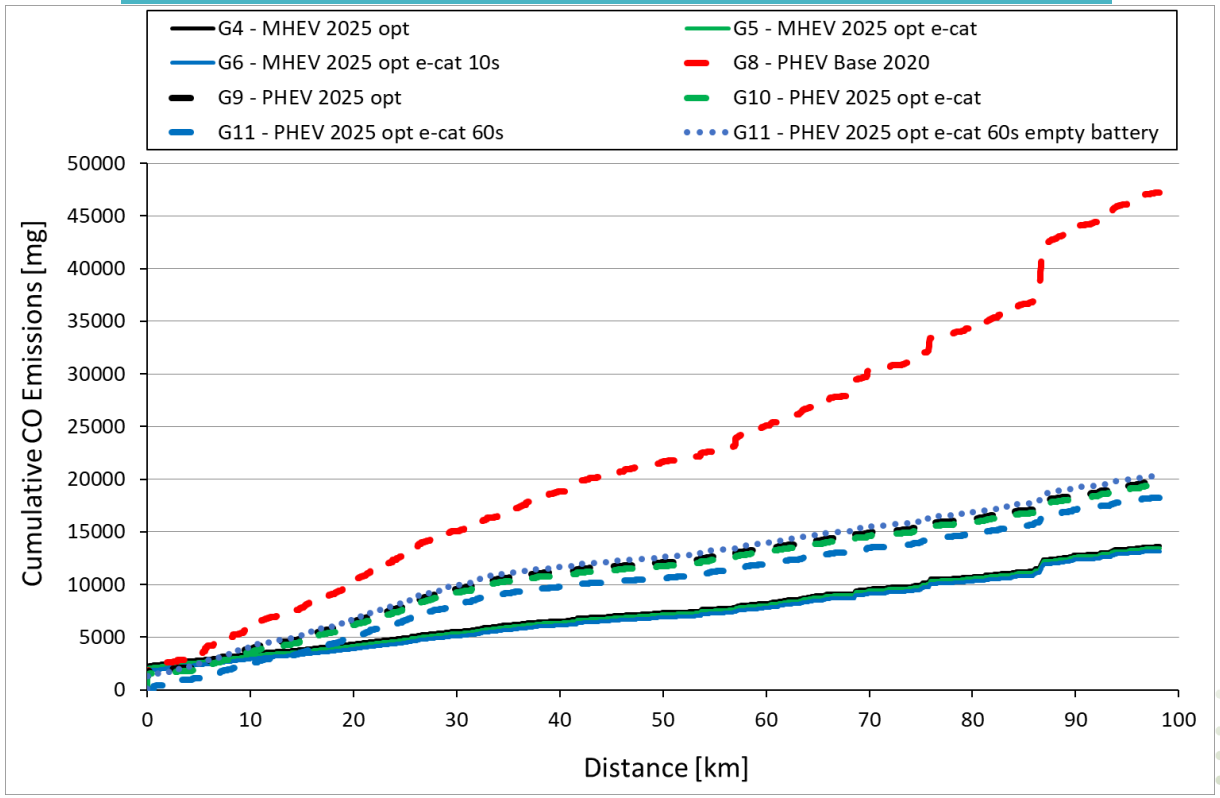
*Worst-case RDE is used here as an example of extended conditions of use. Higher emission values can be observed in more extreme conditions e.g. -15°C, trailer towing, direct acceleration to max permissible speed.

Euro 7 emission performance – LDV gasoline, CO

Normal conditions of use – moderate RDE



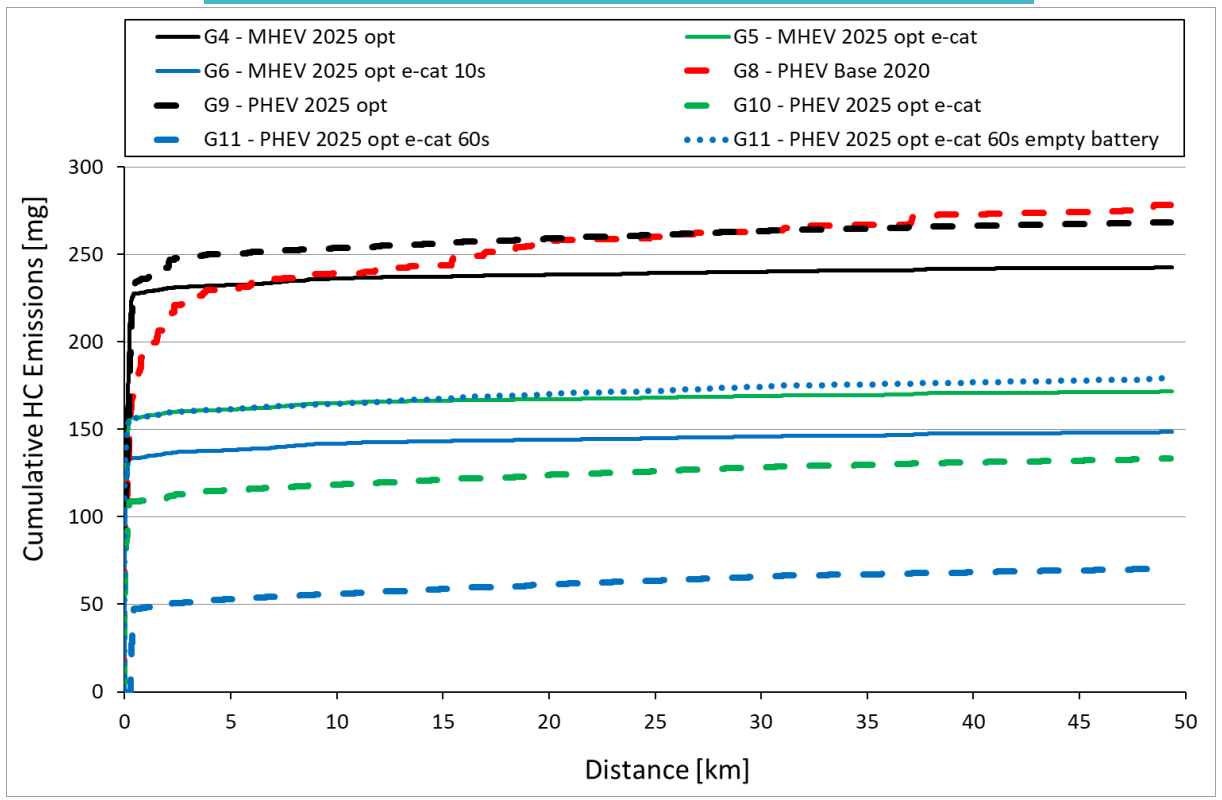
Worst-case RDE*



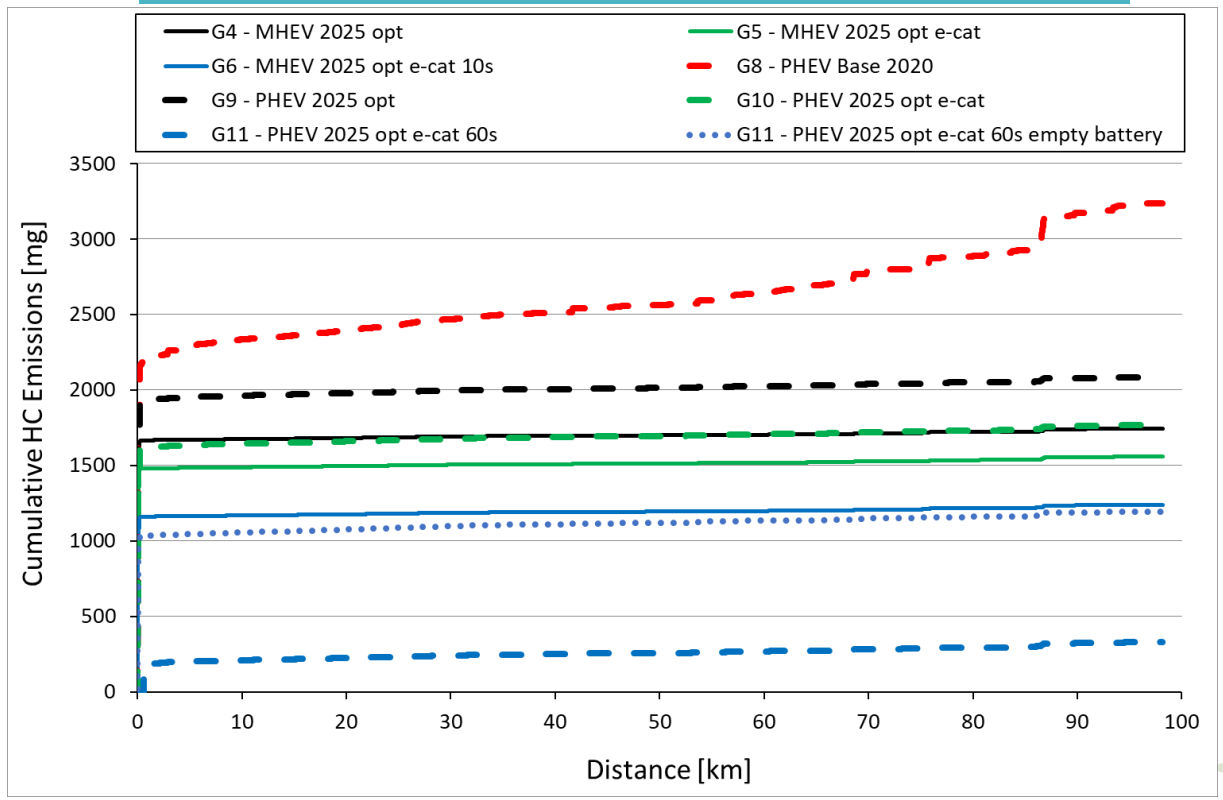
*Worst-case RDE is used here as an example of extended conditions of use. Higher emission values can be observed in more extreme conditions e.g. -15°C, trailer towing, direct acceleration to max permissible speed.

Euro 7 emission performance – LDV gasoline, HC

Normal conditions of use – moderate RDE



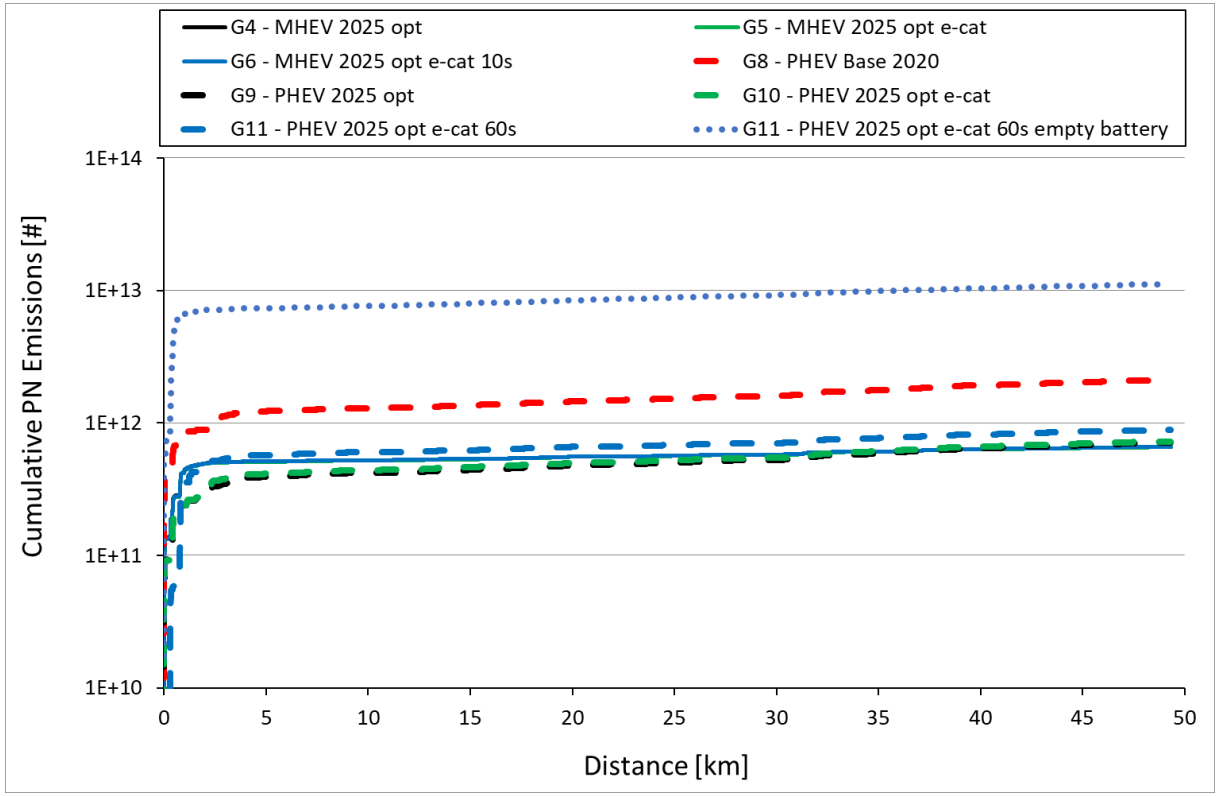
Worst-case RDE*



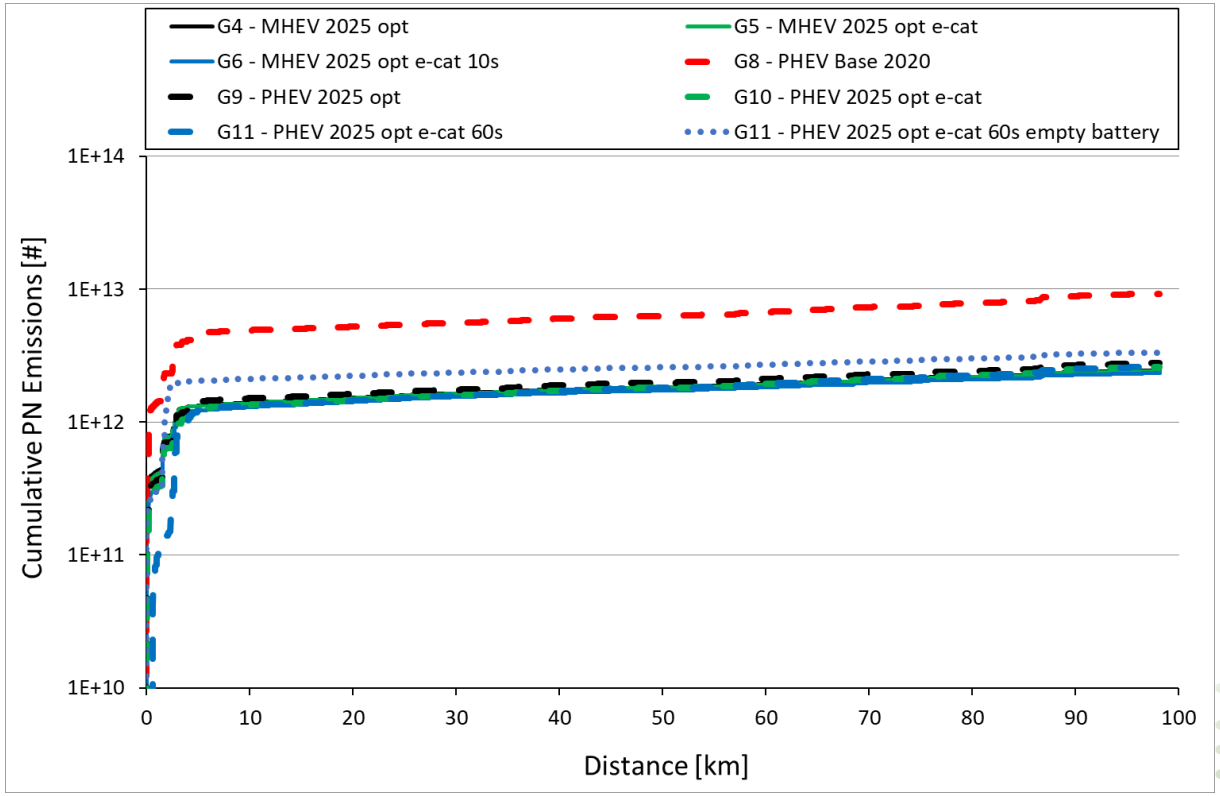
*Worst-case RDE is used here as an example of extended conditions of use. Higher emission values can be observed in more extreme conditions e.g. -15°C, trailer towing, direct acceleration to max permissible speed.

Euro 7 emission performance – LDV gasoline, PN

Normal conditions of use – moderate RDE



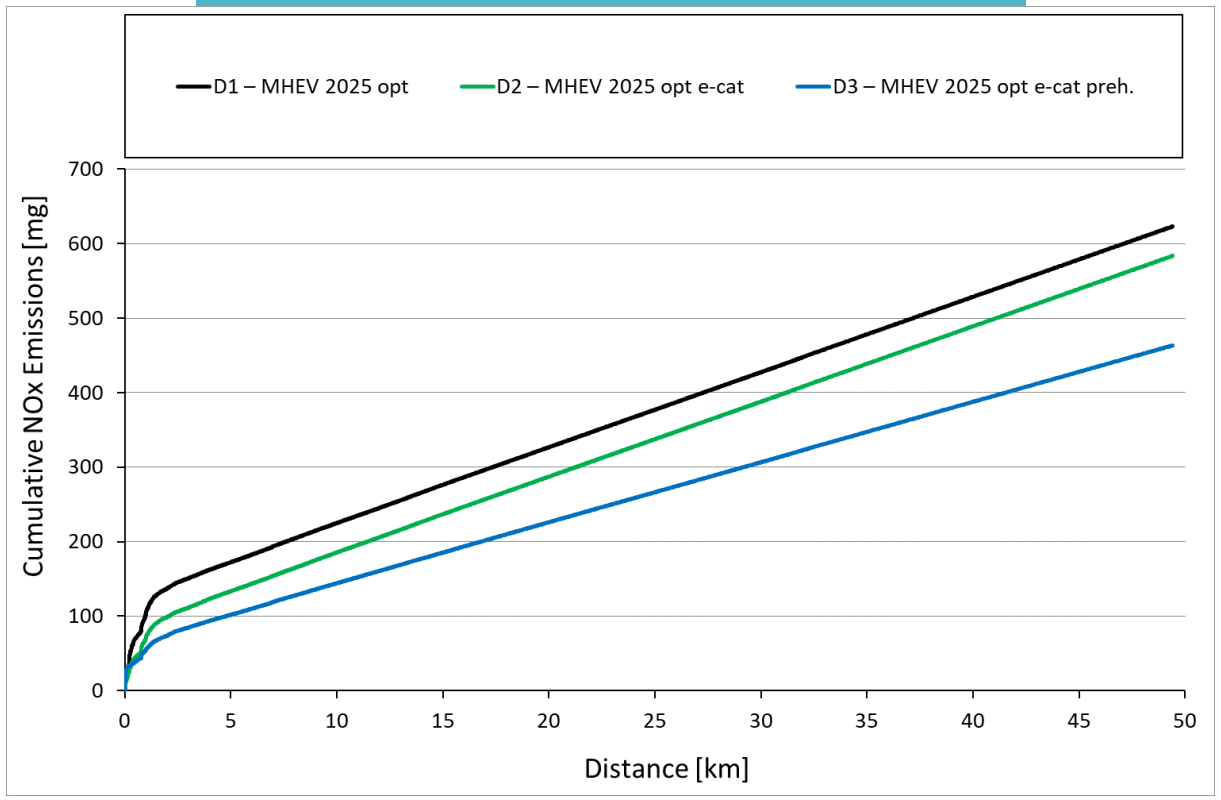
Worst-case RDE*



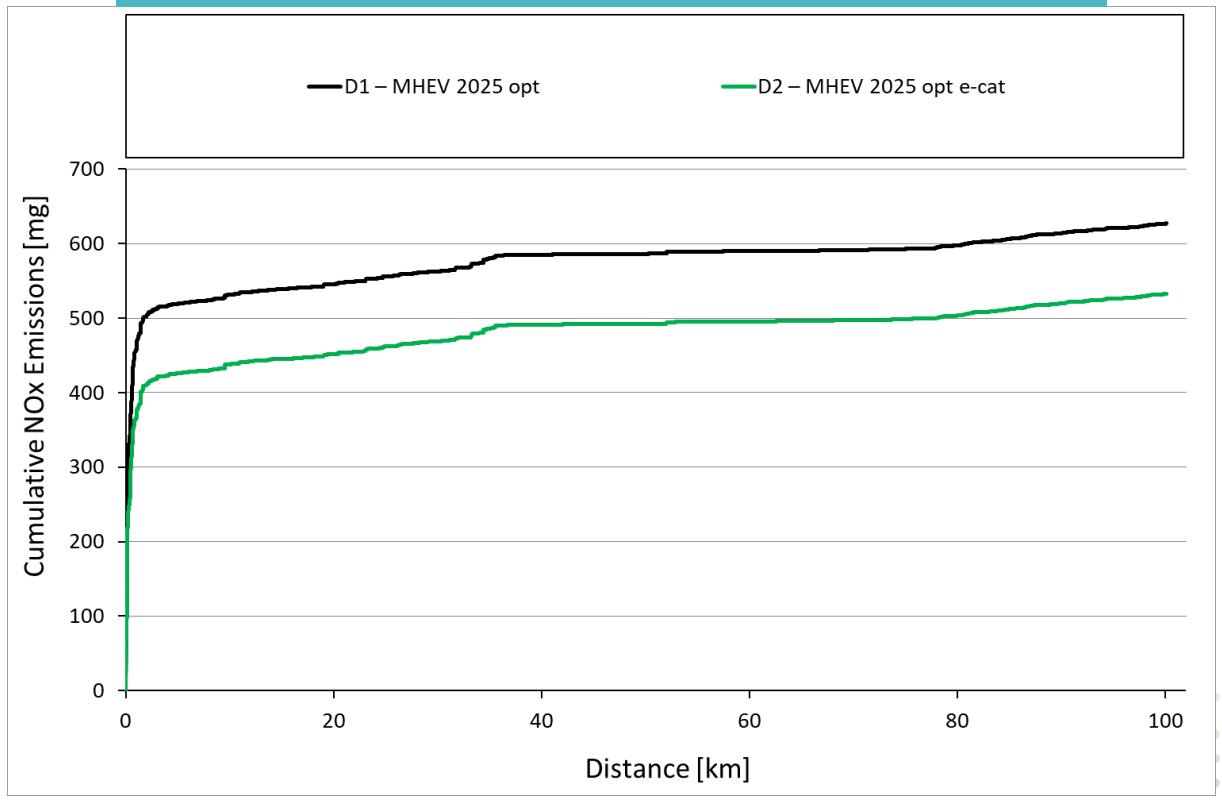
*Worst-case RDE is used here as an example of extended conditions of use. Higher emission values can be observed in more extreme conditions e.g. -15°C, trailer towing, direct acceleration to max permissible speed.

Euro 7 emission performance – LDV diesel, NOx

Normal conditions of use – moderate RDE



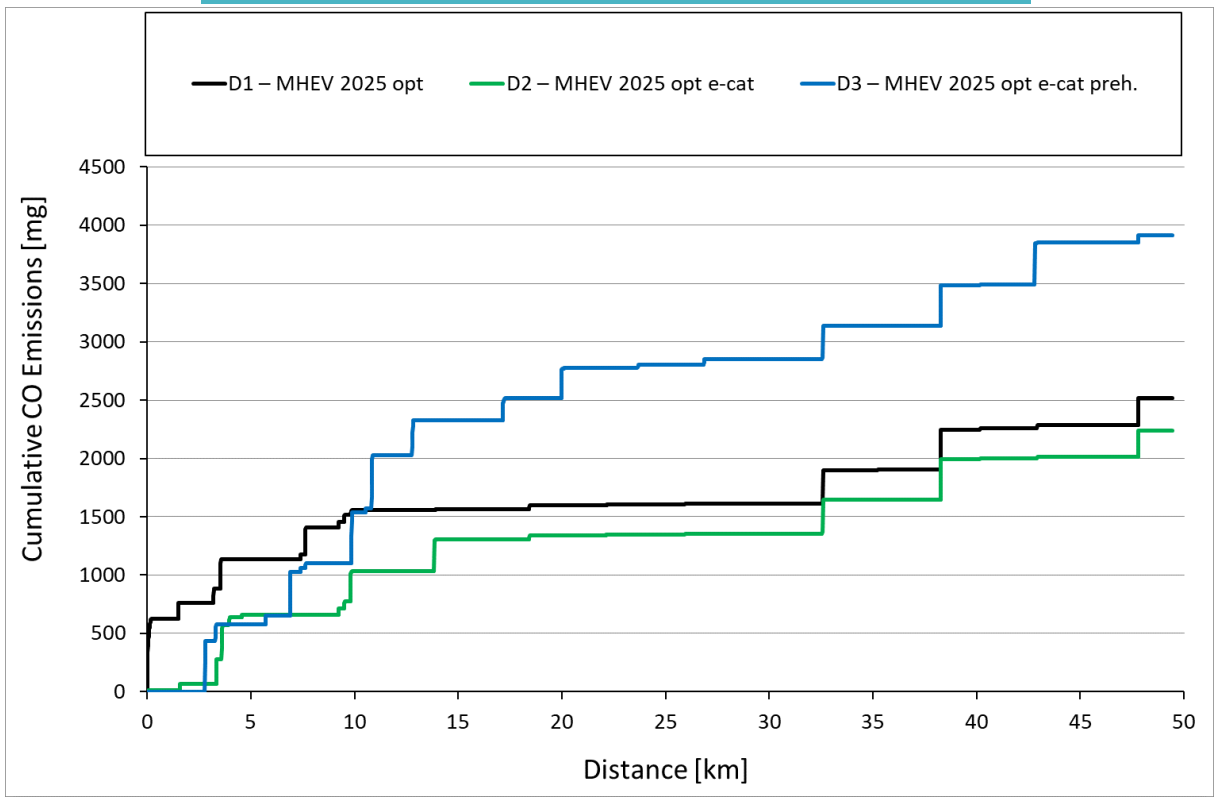
Worst-case RDE*



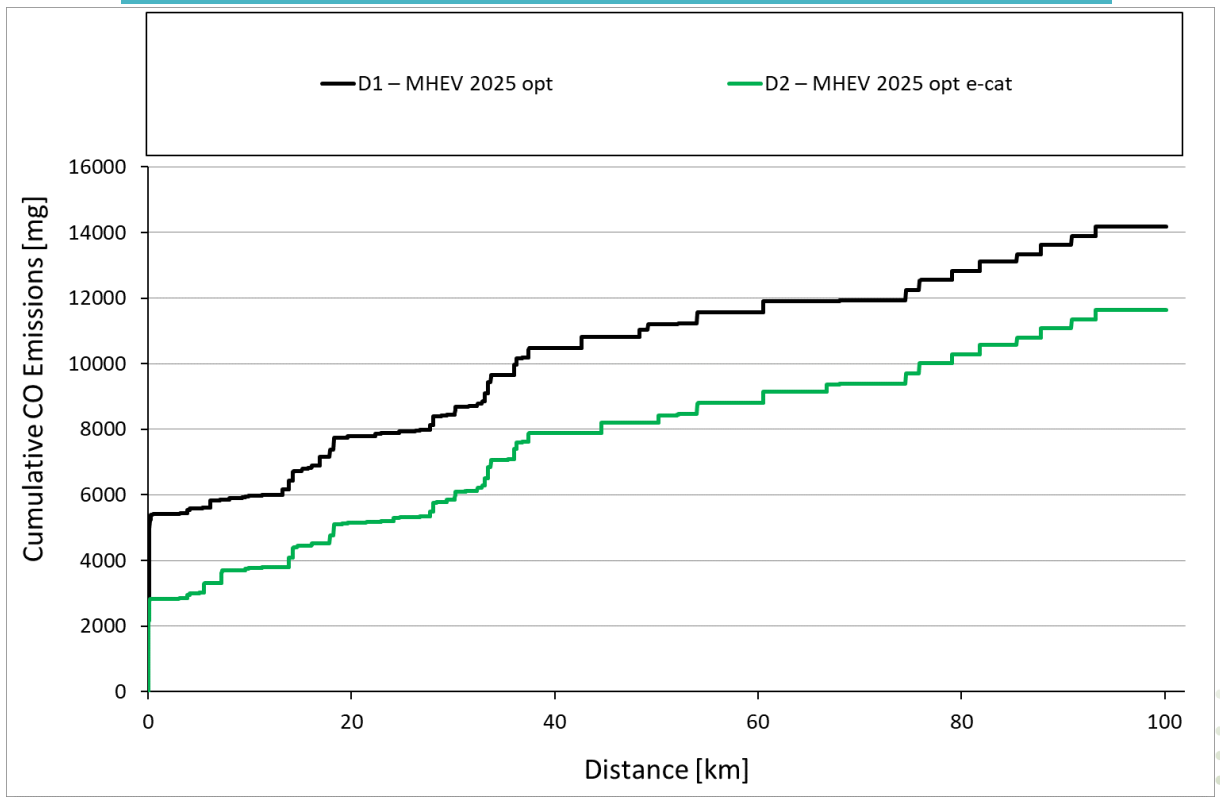
*Worst-case RDE is used here as an example of extended conditions of use. Higher emission values can be observed in more extreme conditions e.g. -15°C, trailer towing, direct acceleration to max permissible speed.

Euro 7 emission performance – LDV diesel, CO

Normal conditions of use – moderate RDE



Worst-case RDE*



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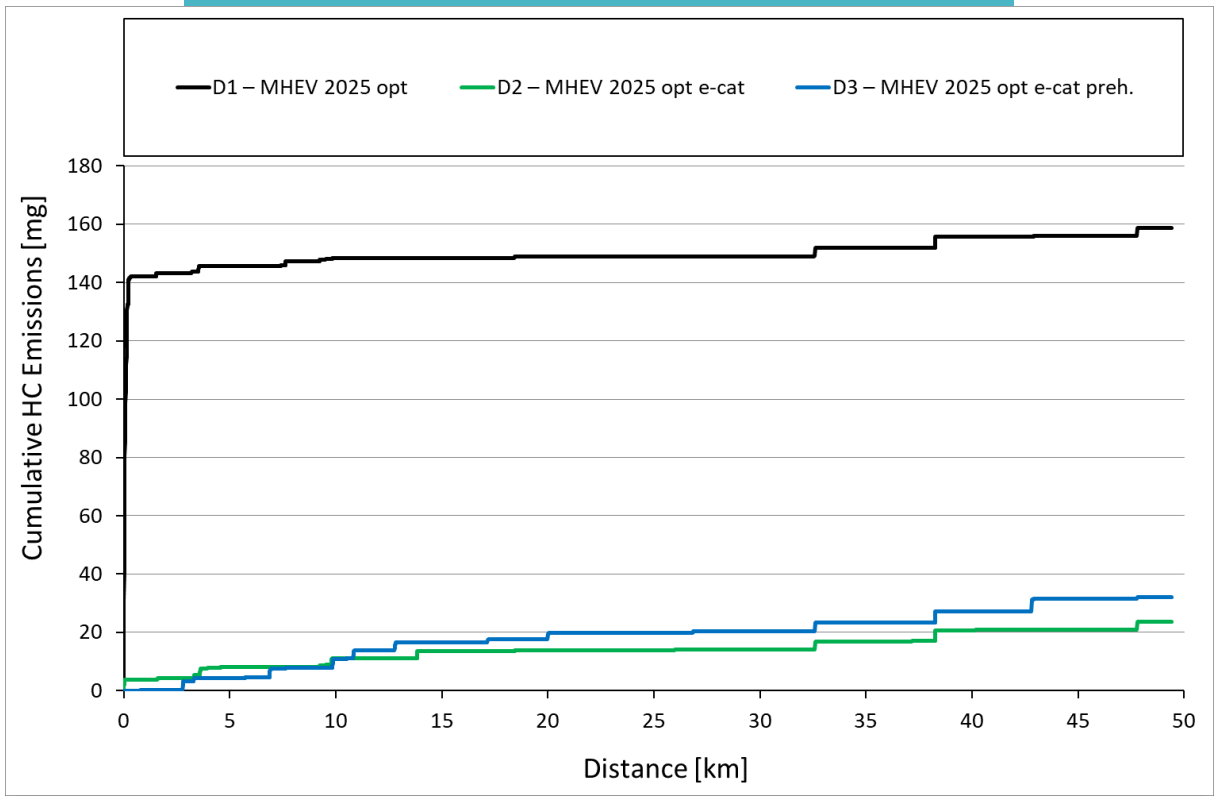
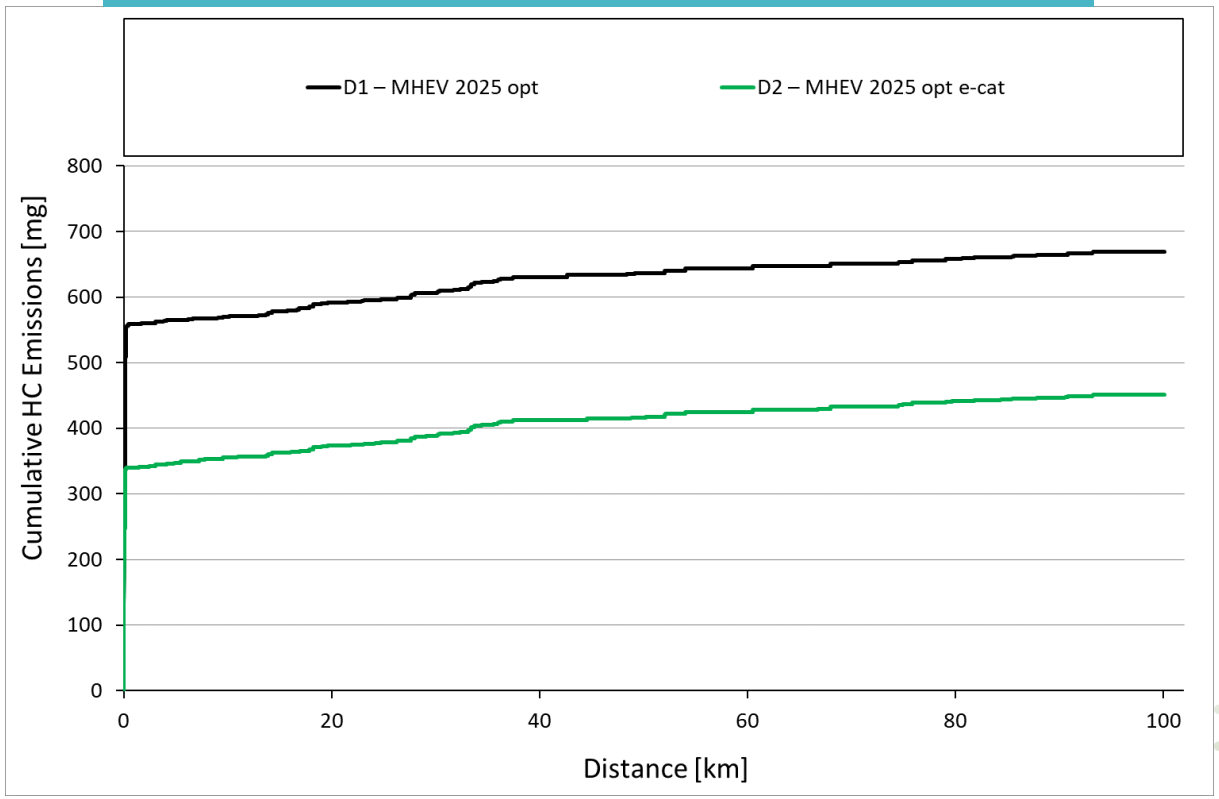
Euro 7 emission performance – LDV diesel, HC

Normal conditions of use – moderate RDE

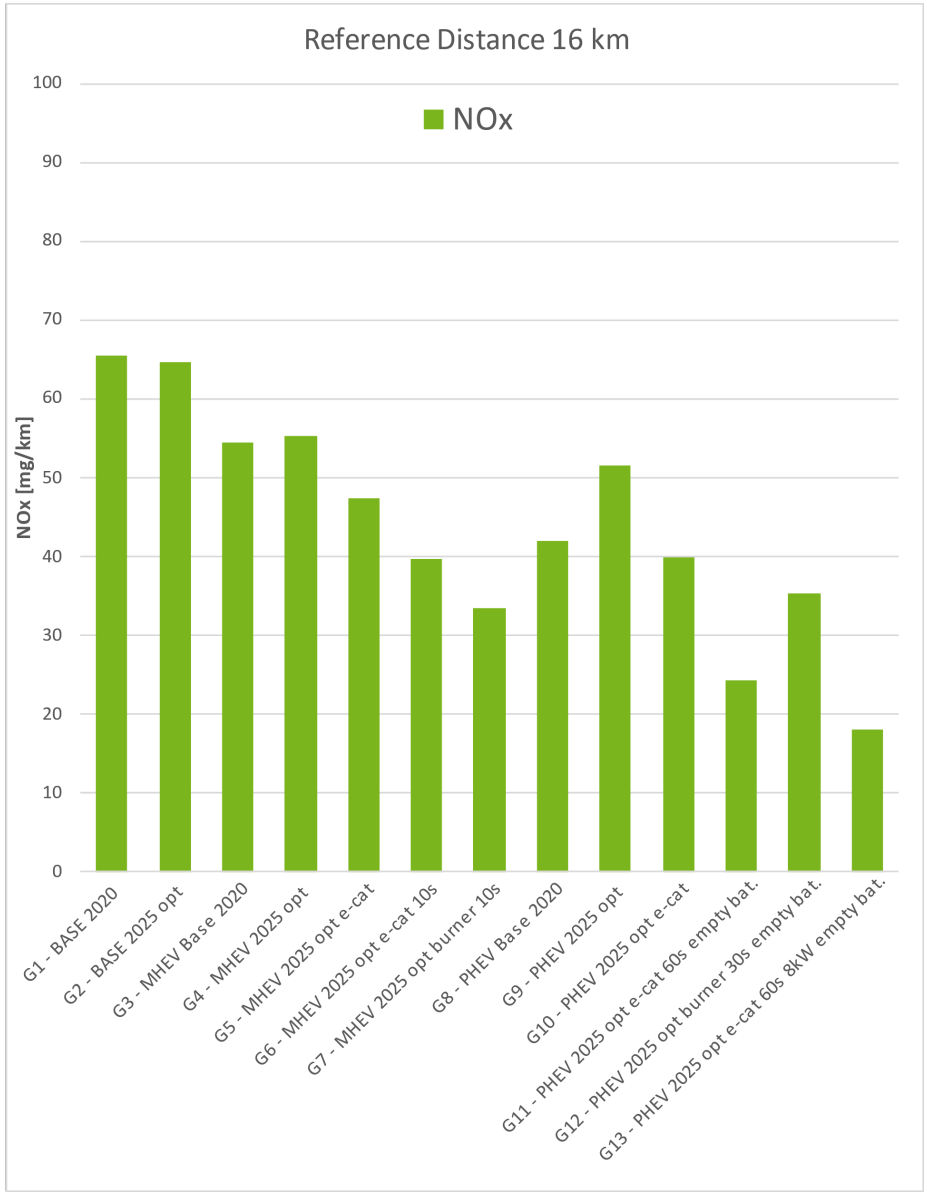


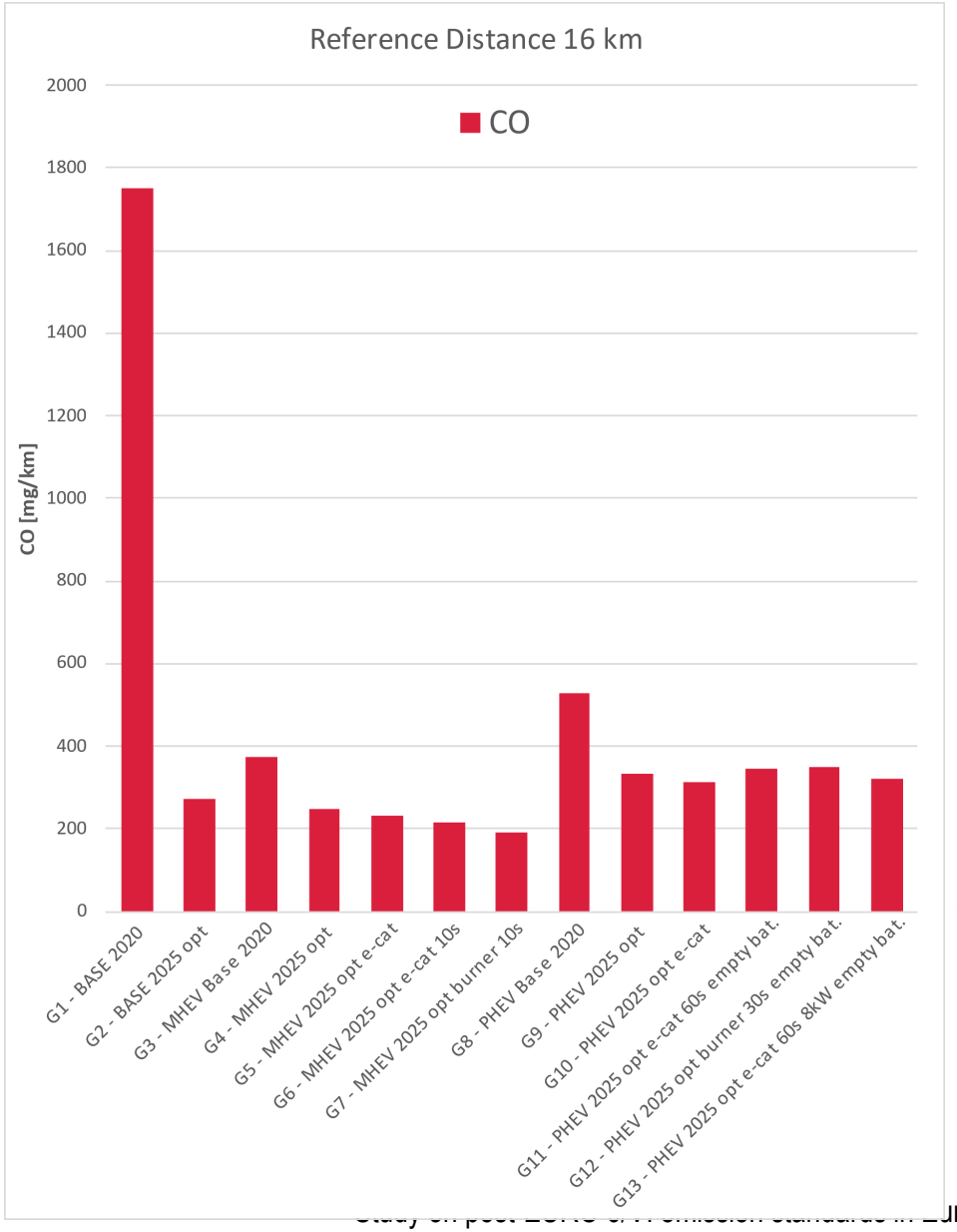
Worst-case RDE*



*Worst-case RDE is used here as an example of extended conditions of use. Higher emission values can be observed in more extreme conditions e.g. -15°C, trailer towing, direct acceleration to max permissible speed.

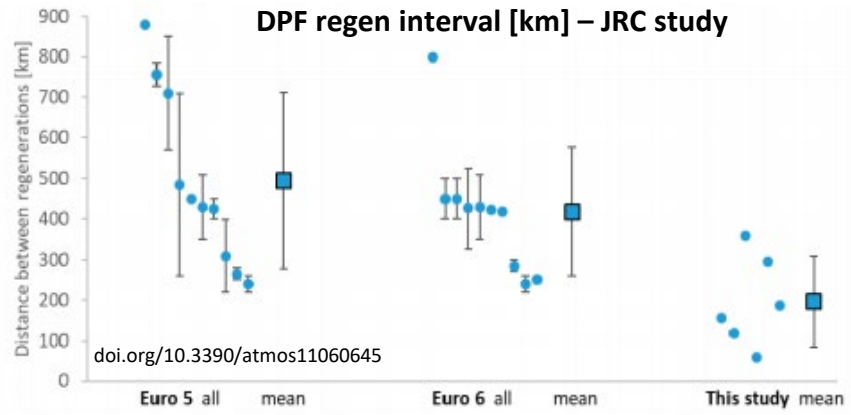
CO and NOx over Worst Case RDE at -10ºC





Inclusion of filter regeneration

- Tests including a DPF regeneration will be valid tests in Euro 7
- Extra PN emissions due to DPF regeneration will be considered based on regeneration interval
- Determination of average regeneration interval:
  - derived by OBM system based on last ~10 regenerations. New vehicle start with a declared regeneration frequency from OEM.
  - OEM shows to the tester regeneration start and end, as well as estimated end and estimated mileage until next regeneration start



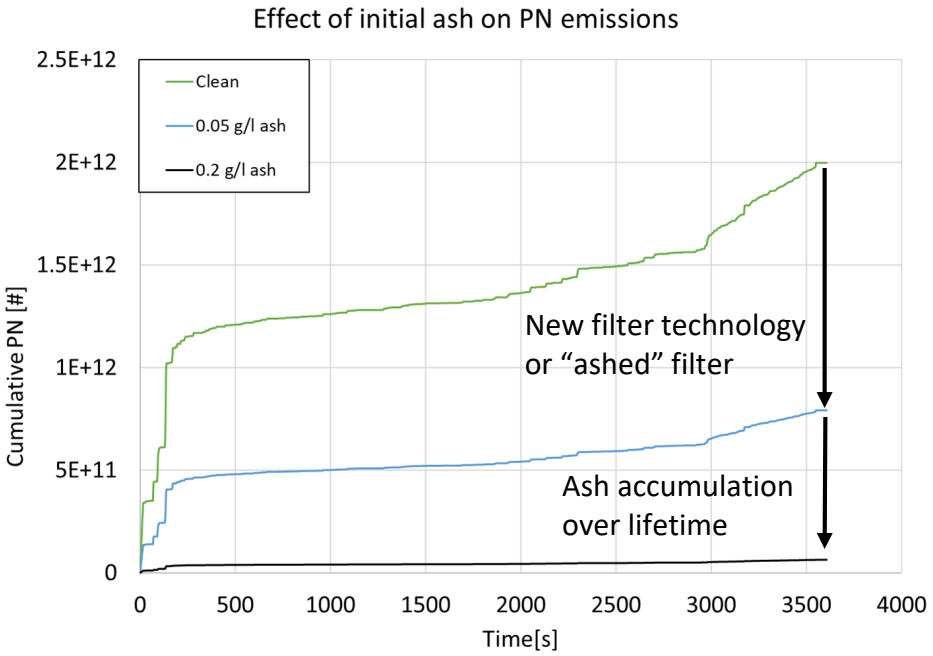
DPF regeneration interval of Euro 6d-temp and 6d vehicles included in CLOVE database: **145-440 km**

- Proposed approach:
  - 2 tests: one including regeneration (full) and one without, >16 km each
  - Weighted average emissions:

$$PN\left[\frac{p}{km}\right] = \frac{PN_{regen\_cycle}\left[\frac{p}{km}\right] * d_{regen\_cycle}[km] + PN_{w/o\_regen}\left[\frac{p}{km}\right] * (regen\_interval - d_{regen\_cycle})[km]}{regen\_interval\ [km]}$$

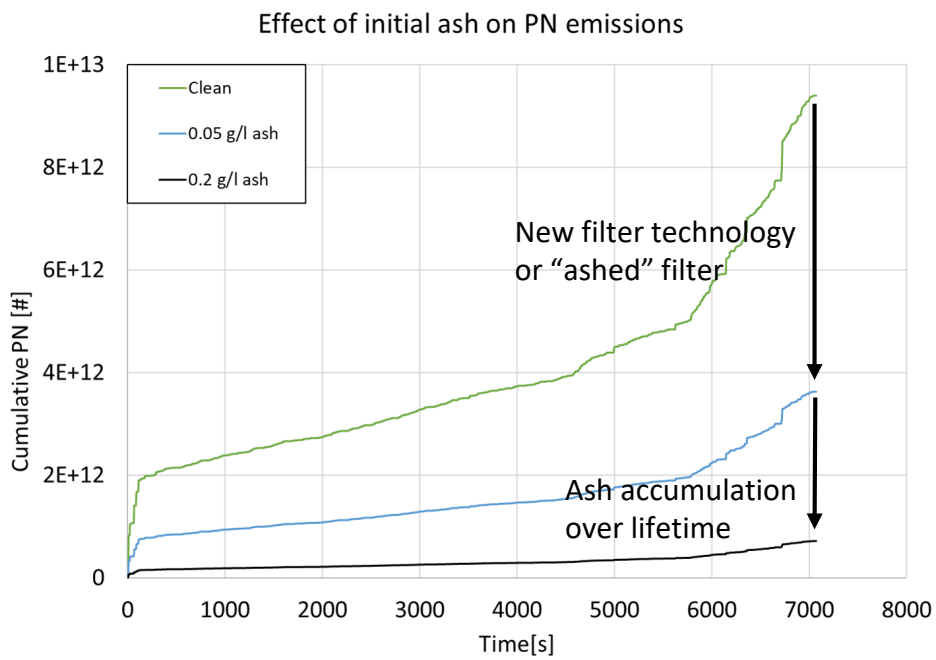
Effect of ash on PN emissions - GPF

Moderate RDE



Ash state	PN emissions [p/km]
Clean	~4E+10
0.05g/l	~1.5E+10
0.2 g/l	~1.5E+09
Engine-out	1.6E+11

Worst-case RDE



Ash state	PN emissions [p/km]
Clean	~9.4E+10
0.05g/l	~3.6E+10
0.2 g/l	~8E+09
Engine-out	2.5E+11

- Ash loading can significantly affect filtration efficiency
- "Negative deterioration" of filtration efficiency is expected due to continuous ash loading
- **A minimum mileage of 3000km is proposed for Euro 7 valid testing**

Limit approach for LCVs

- There should no longer be an artificial separation between N1 and M1. Many N1 vehicles have twins in M1, for example, taxi vans and campers.
- One exception is the low-powered LCV, which is unique in its GVW and power and therefore usage. This was recognized in RDE4 (EC/2018/1832), and testing was restricted for these vehicles.
- If such vehicles are tested in the same manner as all light duty vehicles, i.e., lifting boundary conditions, the emission limit should be appropriately higher, as this testing is more demanding for such vehicles.
- The sole criteria for this separate class of true LCVs (or “small HD”) is: TPMLM > 2500 kg and PWR < 35 kW/t (TPMLM based and continuous system power).

Euro 7 emission limits scenarios – LDV in mg/km, #/km

Euro 7 scenarios	NOx	SPN_{10}	CO	CH_4 (1)	N_2O (1)	NH_3
EURO 6	60/80 (PI/CI)	6×10^{11} (SPN_{23})	1000/500 (PI/CI)	-	-	-
A	**30**	**1×10^{11}**	**300**	**10**	**10**	**5**
B	**10**	**6×10^{10}**	**100**	**5**	**5**	**2**

- **One comprehensive limit with no conformity or other correction factor**
- **Limits fuel and technology agnostic**
- **The same limits also applicable to PCs and LCVs**
- **All limits applicable during particle filter regeneration**
- Possible emission limits still being discussed for:
  - NO_2
  - THC and NMOG/NMHC
  - HCHO

Proposals from AGVES October 2020
No longer under consideration

(1) Suggested to limit weighted sum of CH_4 and N_2O instead of separate limits

Emissions limits for cars/vans for normal conditions of use

Pollutant	CO	NMOG	NO_x	PM	PN_{10}	NH_3	CH_4	N_2O	HCHO
Unit	mg/km	mg/km	mg/km	mg/km	#/km	mg/km	mg/km	mg/km	mg/km
Scenario 1									
Cars with and Vans	400	45	30	2	1×10^{11}	10	10	10	5
Vans with TPMLM>2500 kg & PWR<35 kW/t	600	45	45	2	1×10^{11}	10	10	10	5
Scenario 2									
Cars and Vans	400	25	20	2	1×10^{11}	10	10	10	5
Vans with TPMLM>2500 kg & PWR<35 kW/t	600	25	30	2	1×10^{11}	10	10	10	5

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

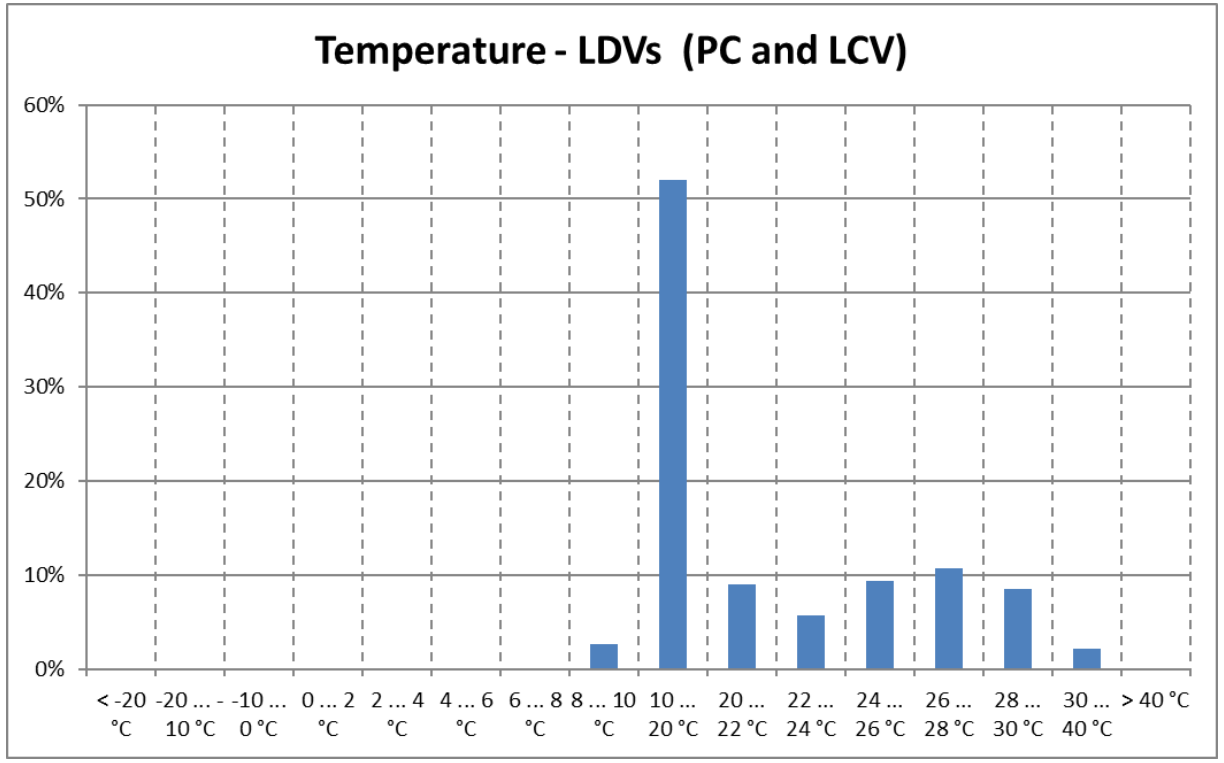
Backup slides

General objectives of “Part A Study”

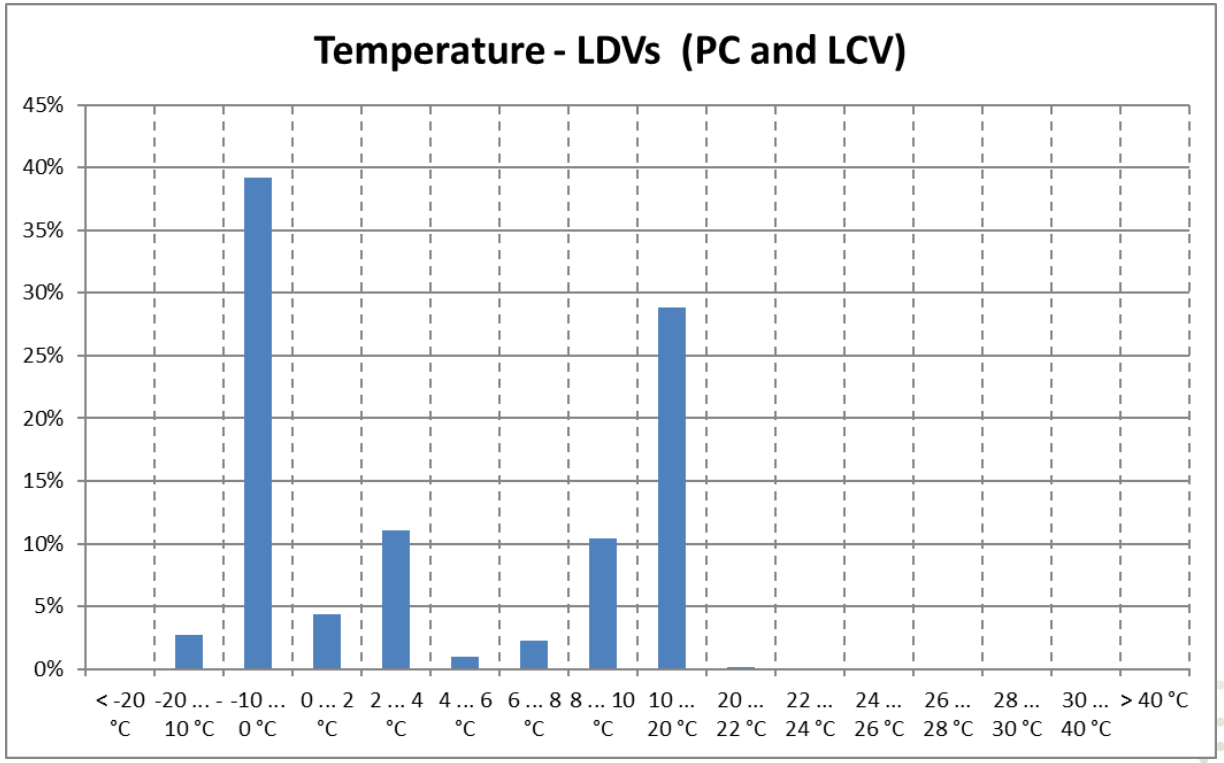
- Propose limit values for each emissions species of interest
  - Need for more stringent emission limits in a more complex external environment with the required agility and flexibility to adapt to the most advanced clean technologies
- Emission species
  - Already regulated (tightening the limits)
  - Not currently regulated in EU (introducing limits)
  - Exhaust and non-exhaust
- More complete coverage of driving conditions
- Technology-based approach – assessing potential emissions performance and costs
  - Culmination of work from “Part A” study
- Fuel and technology agnostic limit values
- Input to the Impact Assessment study of “Part B” study (marginal costs and benefits compared to Euro 6/VI)

Vehicle kilometer distribution in Finland and Greece

Greece



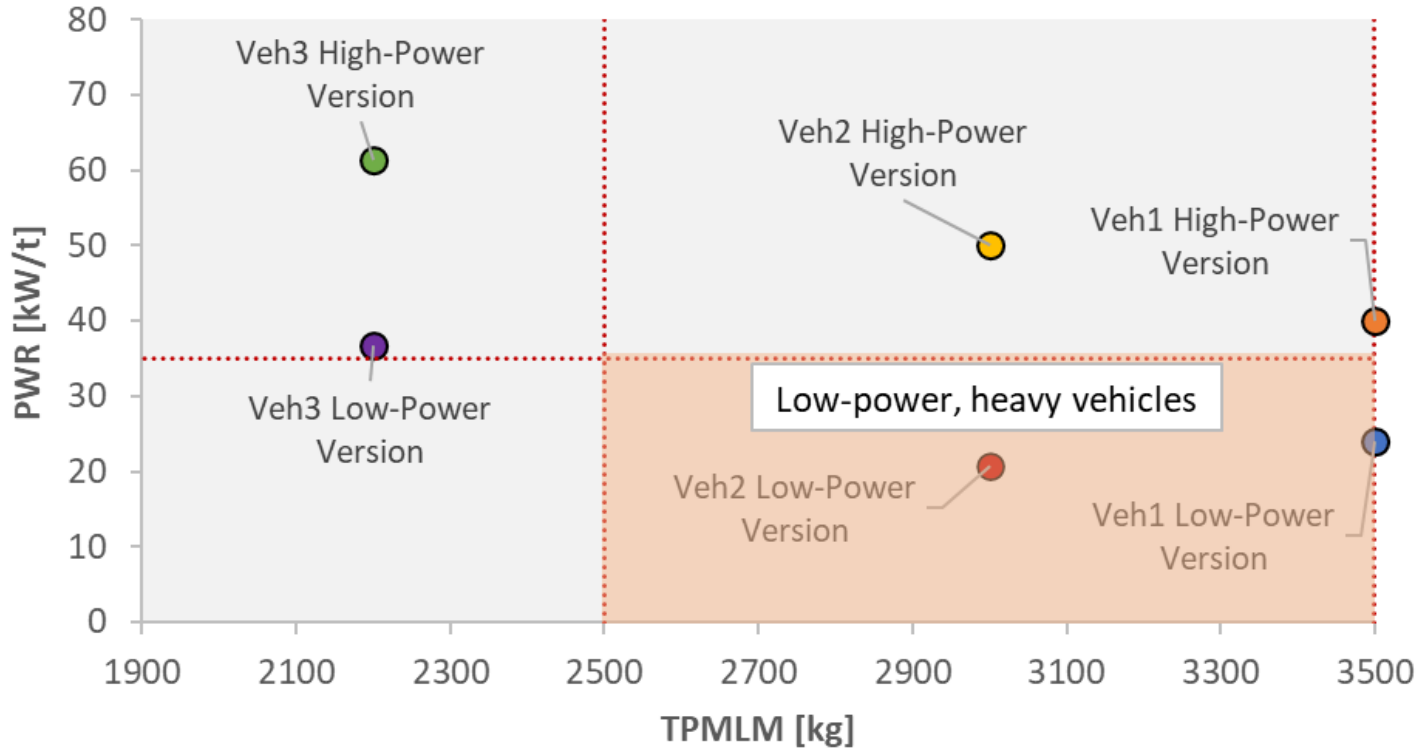
North Finland



Temperatures: www.weatherbase.com; Elevation: Eurostat; Population density: Eurostat; v-km: own database on vehicle fleets, compiled from data by many different sources such as ACEA, Eurostat, DG MOVE statistical pocketbook, etc.

Limits approach for LCV

The sole criteria for the separate class of true LCVs (or “small HD”) is: TPMLM > 2500 kg and PWR < 35 kW/t (TPMLM based and continuous system power).



Euro 6 Emission Limits for LCVs

Pollutant		CO	THC	NMHC	NO_x	THC+NO_x	PM	SPN_{23}	NH_3	CH_4
Category		(mg/km)	(mg/km)	(mg/km)	(mg/km)	(mg/km)	(mg/km)	(km^{-1})	(ppm)	(mg/km)
Euro 6 Cars & Vans with RM≤1305 kg	PI	1000	100	68	60	-	4.5 (DI)	6×10^{11} (DI)	-	-
	CI	500	-	-	80	170	4.5	6×10^{11}		
Euro 6 Vans with 1305<RM≤ 1760 kg	PI	1810	130	90	75	-	4.5	6×10^{11} (DI)		
	CI	630	-	-	105	195	4.5	6×10^{11}		
Euro 6 Vans with RM>1760 kg	PI	2270	160	108	82	-	4.5	6×10^{11} (DI)		
	CI	740	-	-	125	215	4.5	6×10^{11}		

Euro 6 Emission Limit Ratios (CI engines)	NO_x	CO	PN	THC
Class II/ Class I	105:80=1.31	630:500=1.26	= 1 (6×10^{11})	
Class III/Class I	125:80=1.56	740:500=1.48	= 1 (6×10^{11})	[90:90=1]