New results from a 2015 PEMS testing campaign on a Diesel Euro 6b vehicle

Cécile Favre, Dirk Bosteels, John May – AECC

Jon Andersson, Simon de Vries – Ricardo

11th Integer Emissions Summit & AdBlue® Forum Europe 2015

18 June 2015, Brussels, Belgium

Association for Emissions Control by Catalyst AISBL

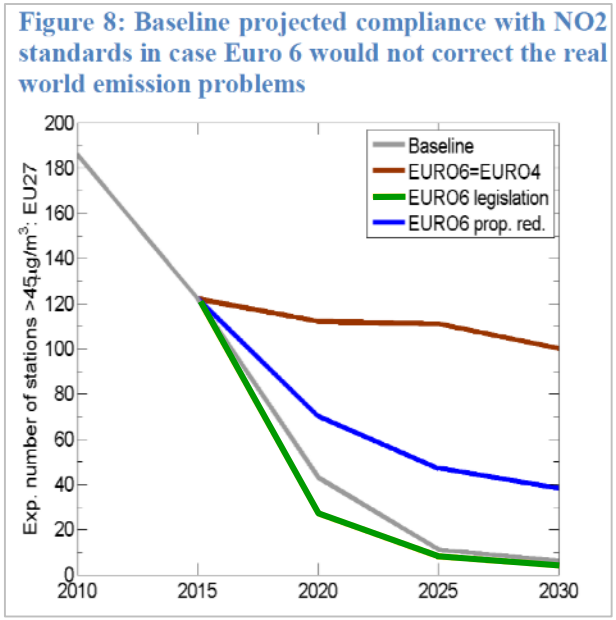
Association for Emissions Control by Catalyst (AECC) AISBL

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.

Diesel NOx and air quality

- The 2007 Euro 6 Regulation (EC 715/2007) requires emissions to be effectively limited throughout the normal life of the vehicles under normal conditions of use.
  - Control of Diesel NOx in real-world driving conditions is an essential step towards EU Member States meeting air quality targets.
- Emissions inventory and projections by DG Environment for different NOx Conformity Factors:
  - Baseline CF=1.5
  - Euro 6 does not reduce real-world NO_2 further compared with Euro 4 (CF~10)
  - Euro 6 NOx RDE reduce proportionally (CF=4)
  - CF=1, Euro 6 limits met in real-world
  - With a CF~4, NO_2 non-compliance in 2020 is 3 times higher than in the baseline (CF=1.5) scenario ("stations substantially above the NO_2 limit would increase from 3 to 10%").



Source: European Commission Staff Working Document – Impact Assessment accompanying the Clean Air Package, SWD(2013)531, 18 December 2013.

Context of AECC test programme

- AECC recently demonstrated[1] NOx Deviation Ratios between 1.1 and 1.6 on a development vehicle, under specific boundary conditions, and with advanced calibration of existing Euro 6 Diesel emissions control technology.
- Emissions Analytics identified some Euro 6 cars with low on-road NOx emissions. AECC decided to evaluate one of them, according to the EU RDE procedure.
- AECC investigated at Ricardo, UK the real-world emissions performance of a commercially available Euro 6 Diesel car equipped with an advanced emissions control system.

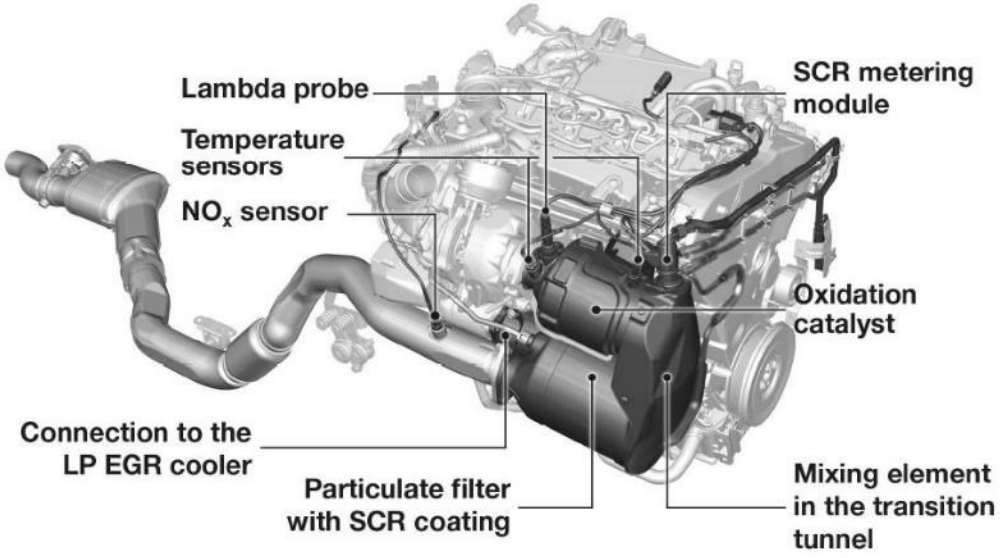
[1] "Potential for Euro 6 Passenger Cars with SCR to meet RDE Requirements", 36th International Vienna Motor Symposium, May 2015, www.aecc.eu/content/pdf/150507%20FEV-AECC%20paper%20Potential%20for%20Euro%206%20Passenger%20Cars%20with%20SCR%20to%20meet%20RDE.pdf.

Test vehicle

- 2.0l Euro 6b Diesel car, 120 kW
- Emission Control System: Close Coupled DOC + SCR on DPF, High and Low Pressure EGR
- Vehicle and exhaust ageing ~5800 km
- Pump grade EN590 Diesel fuel (~9 ppm S, 2.6% FAME)

	Emissions
CO_2	111 g/km
CO	203.4 mg/km
NOx	56.4 mg/km
THC+NOx	82.4 mg/km
PM	0.15 mg/km
PN	2 x 10^9/km

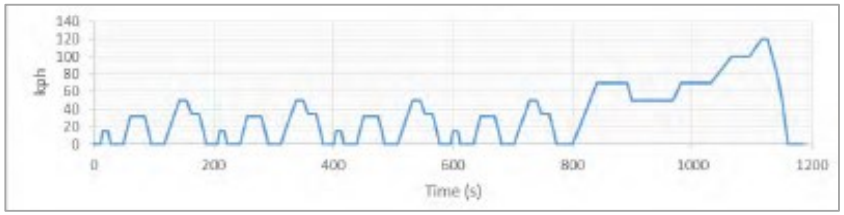
Source: CoC



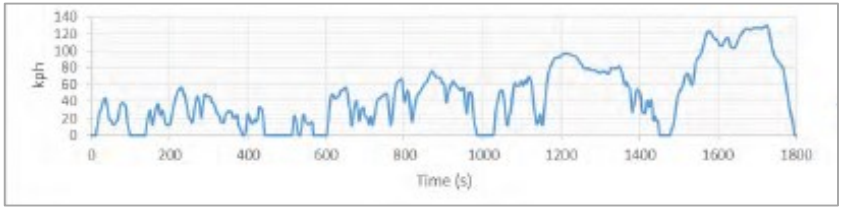
Source: Lörch, Aachen Colloquium 2013

Emissions test regime

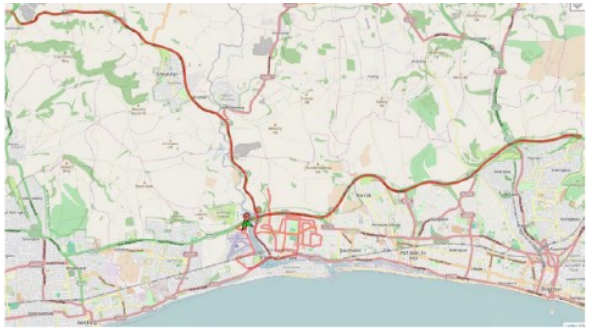
- NEDC



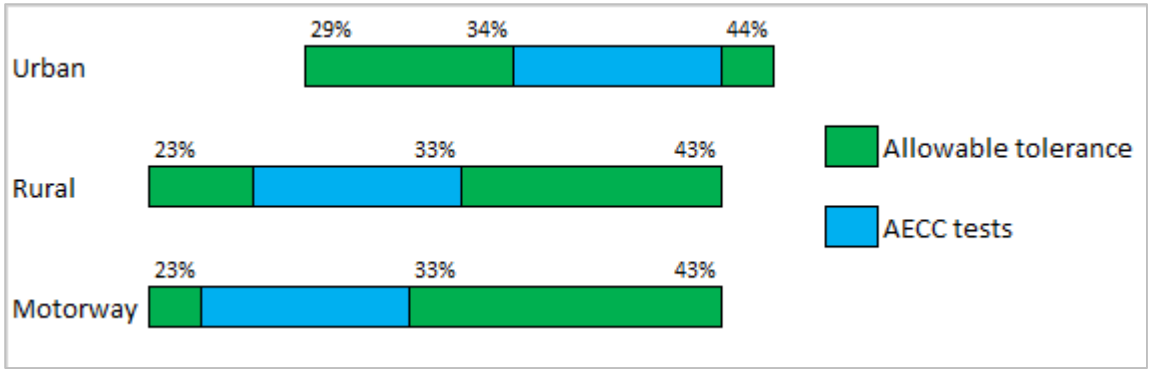
- WLTC



- Real-Driving Emissions (RDE) route around Ricardo Technical Centre

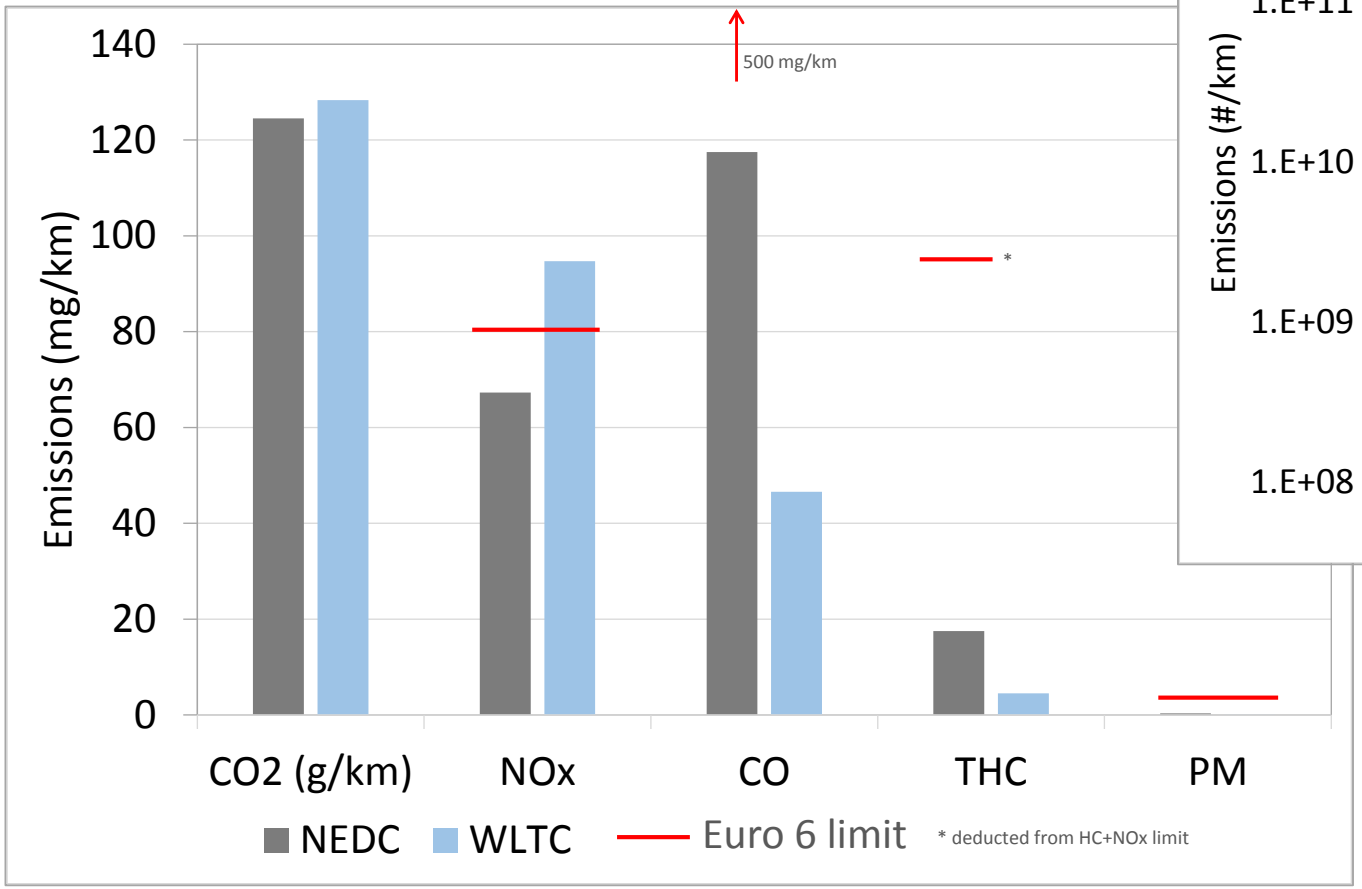


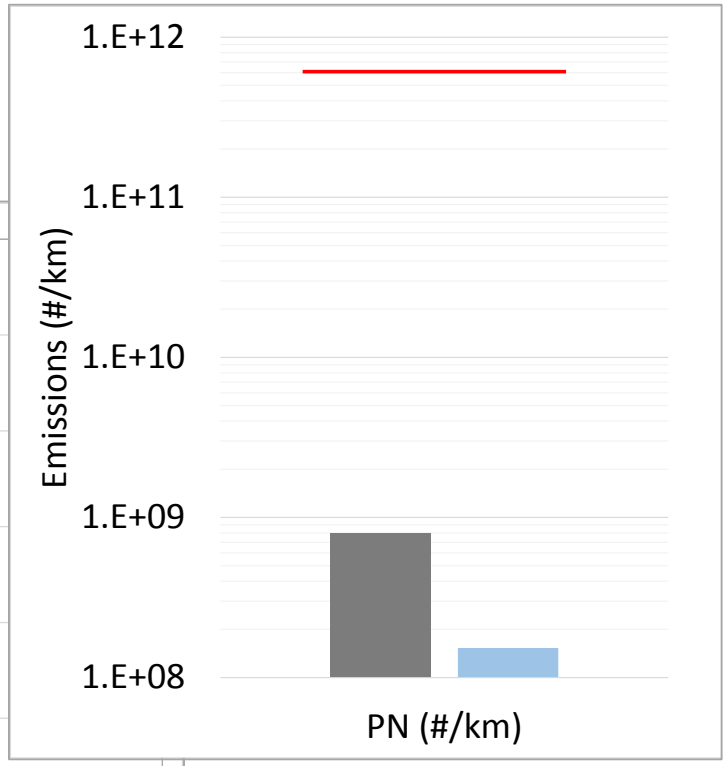
Duration	103 to 112 min
Ambient temperature	8 to 29°C
Altitude	-8 to 130 m
Max. speed	121 to 130 km/h



Tailpipe emissions on NEDC and WLTC

- Euro 6 limits met for all pollutants, except NOx on WLTP.

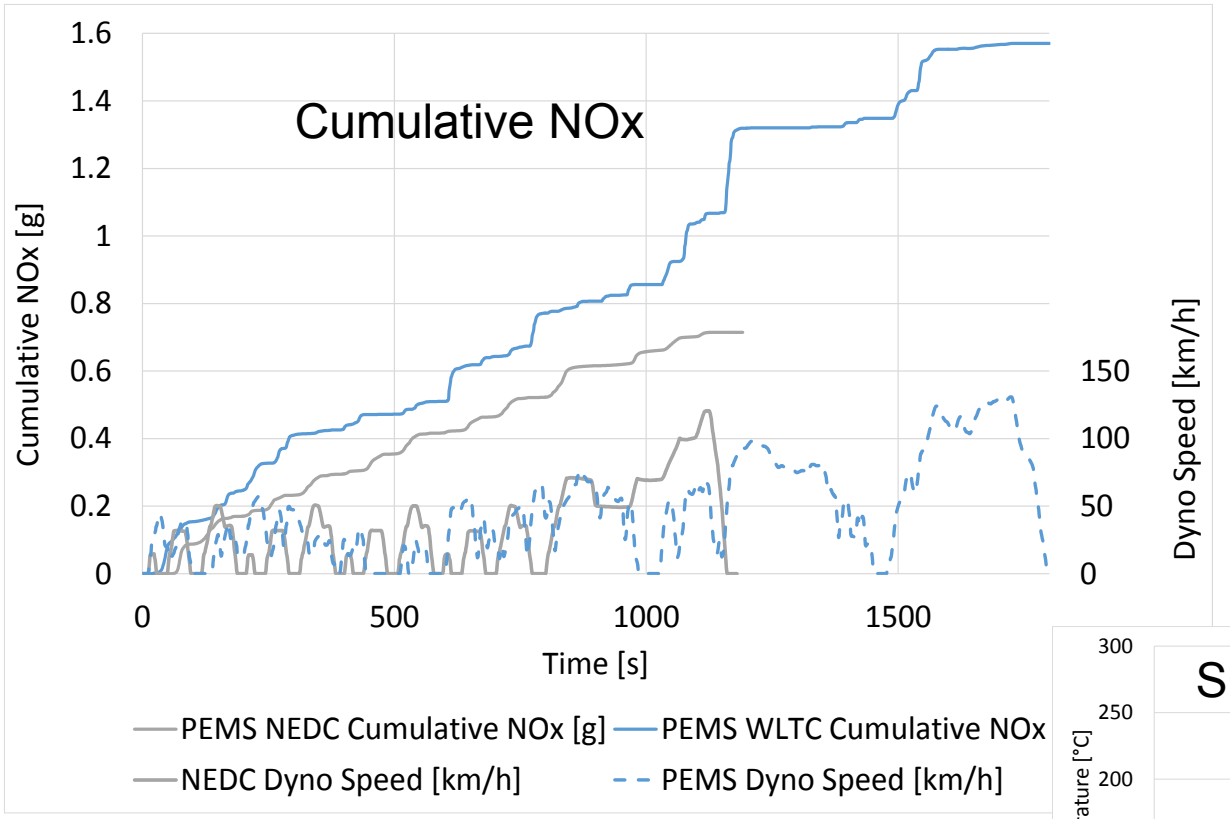


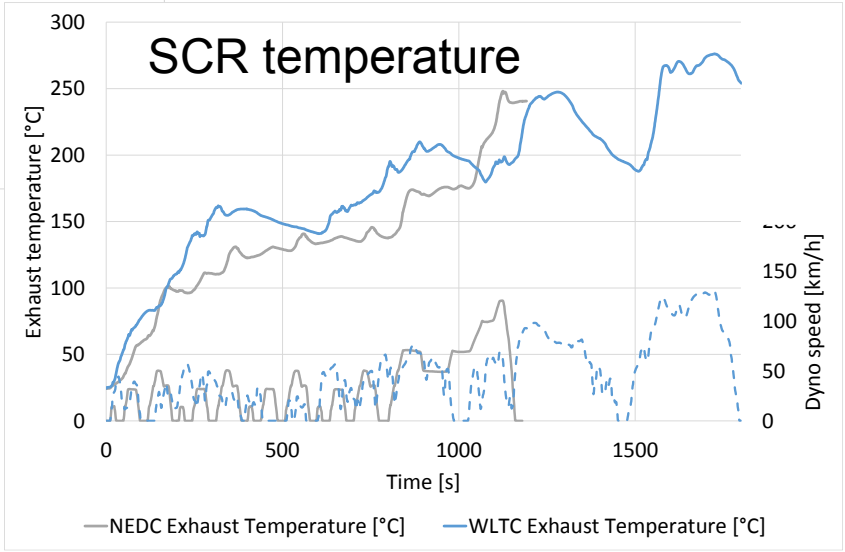


Vehicle inertia

- NEDC: 1590 kg
- WLTC: 1680 kg

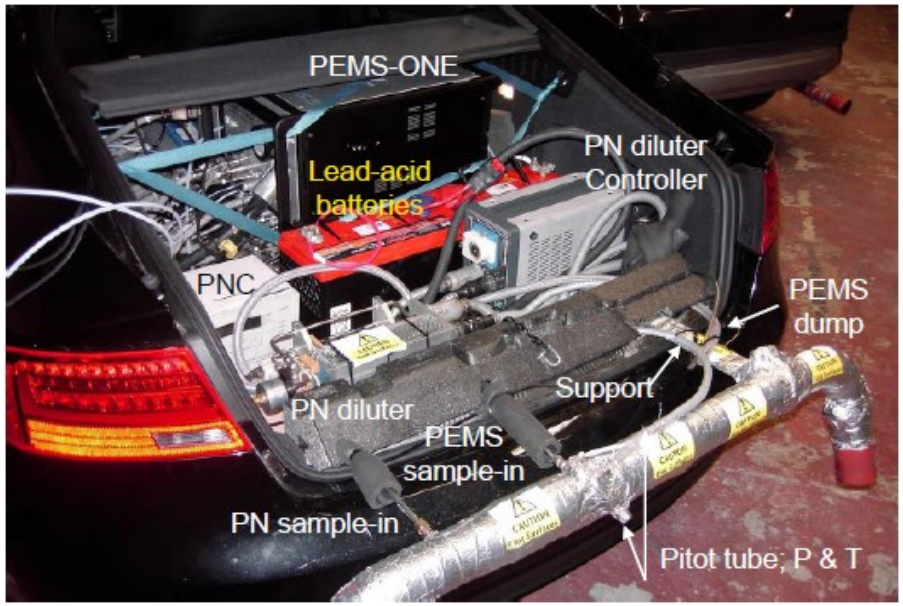
Tailpipe NOx emissions on test cycles





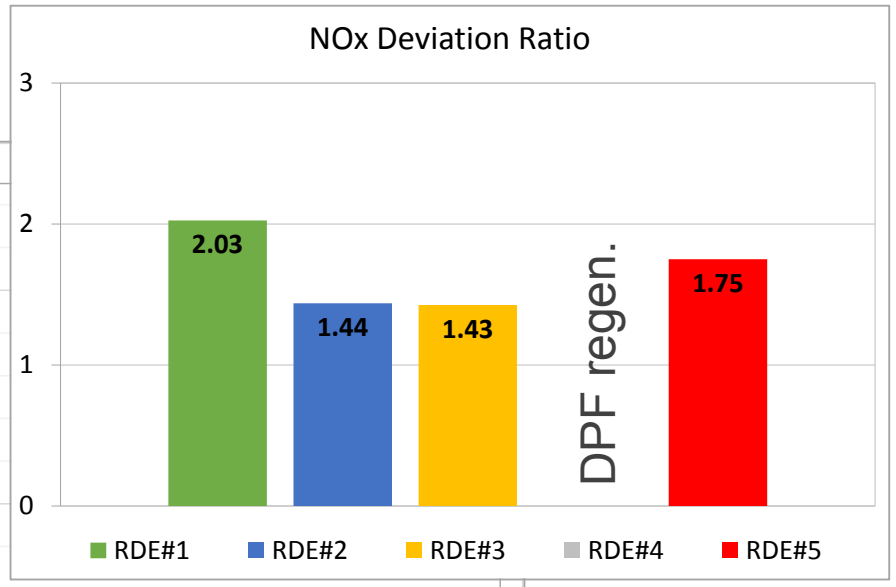
Portable Emissions Measurement System (PEMS)

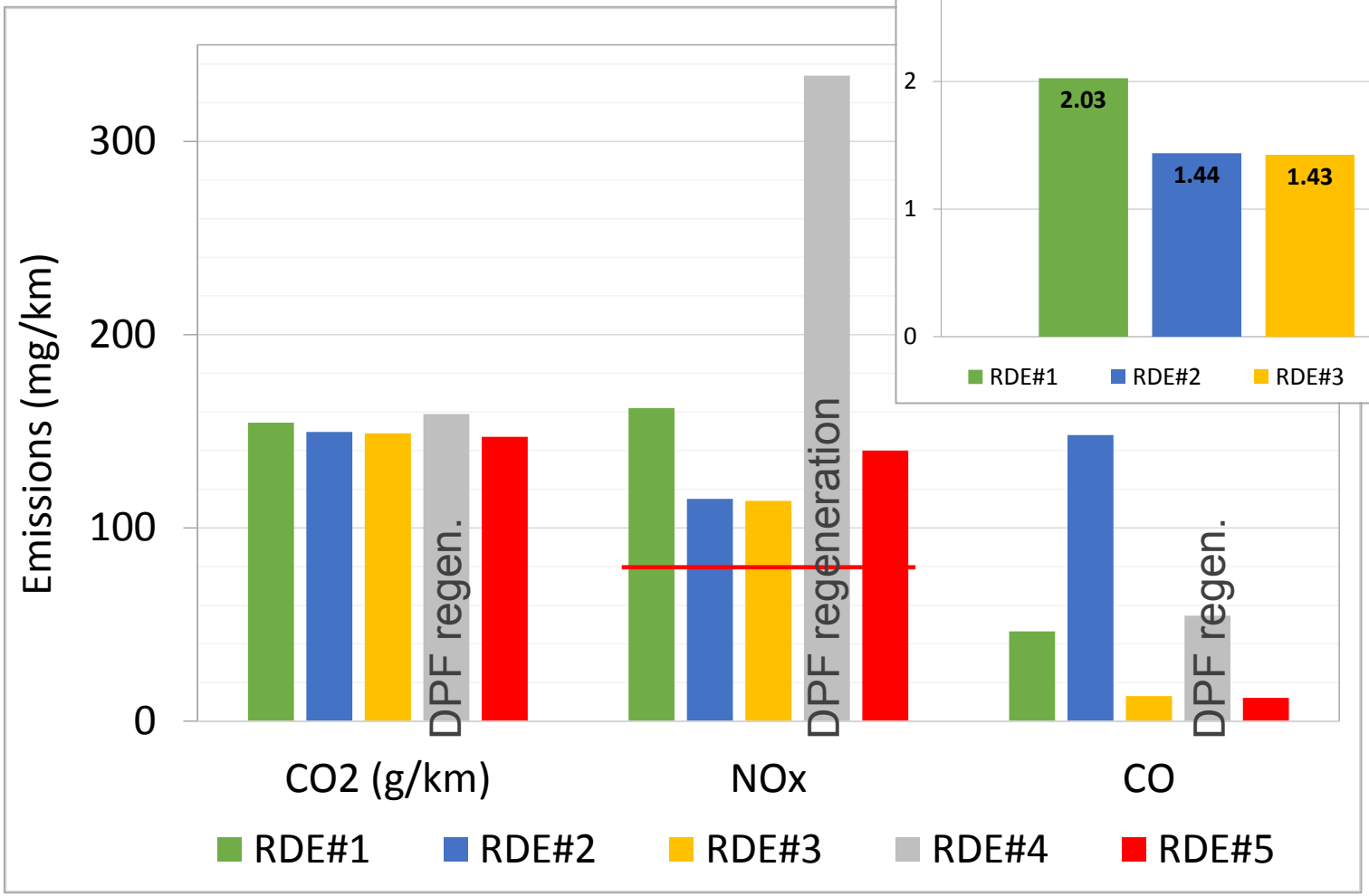
- Horiba PEMS ONE for gaseous emissions (CO, CO_2, NO, and NOx).
- Matter Engineering MD19-2E hot diluter with TSI 3010 particle number counter modified to provide a ~23 nm counting efficiency (d_{50}) comparable to lab-based PMP for particle number.



Real-Driving Emissions

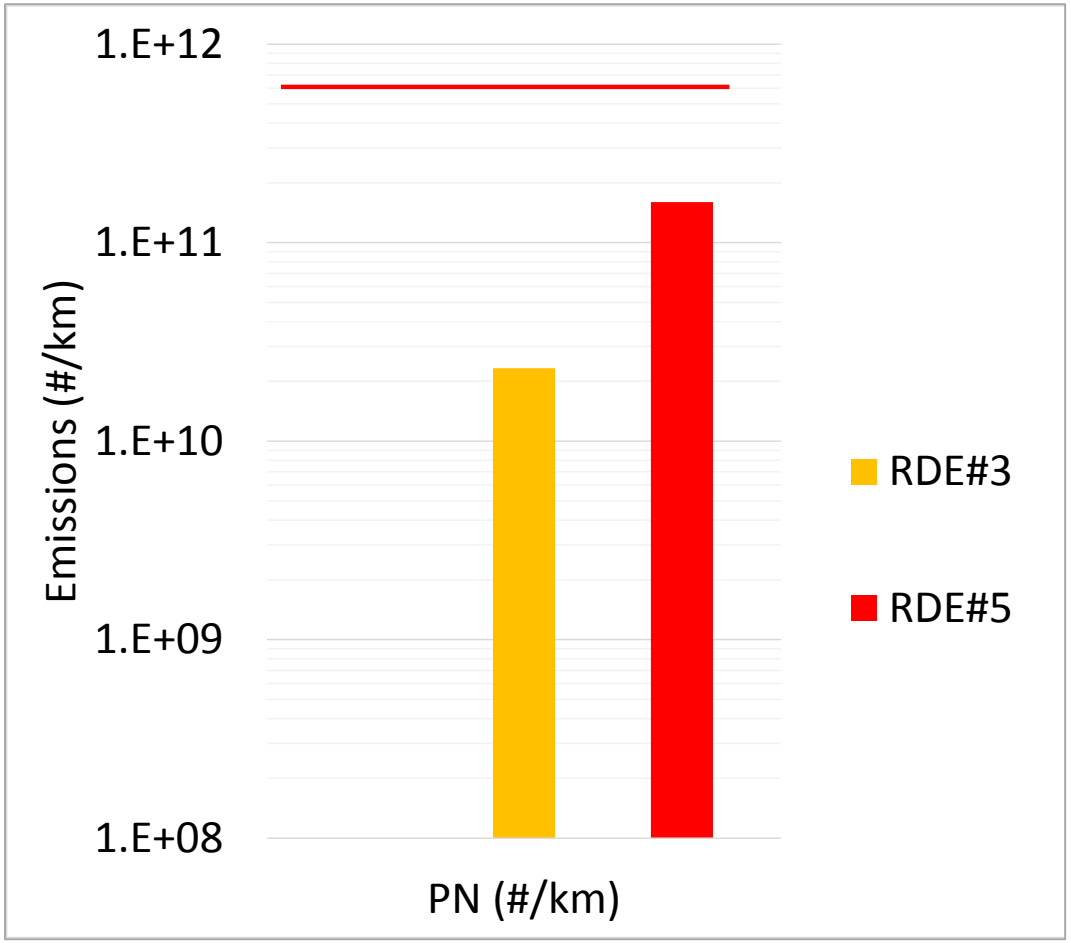
- 5 repeats of same RDE route.



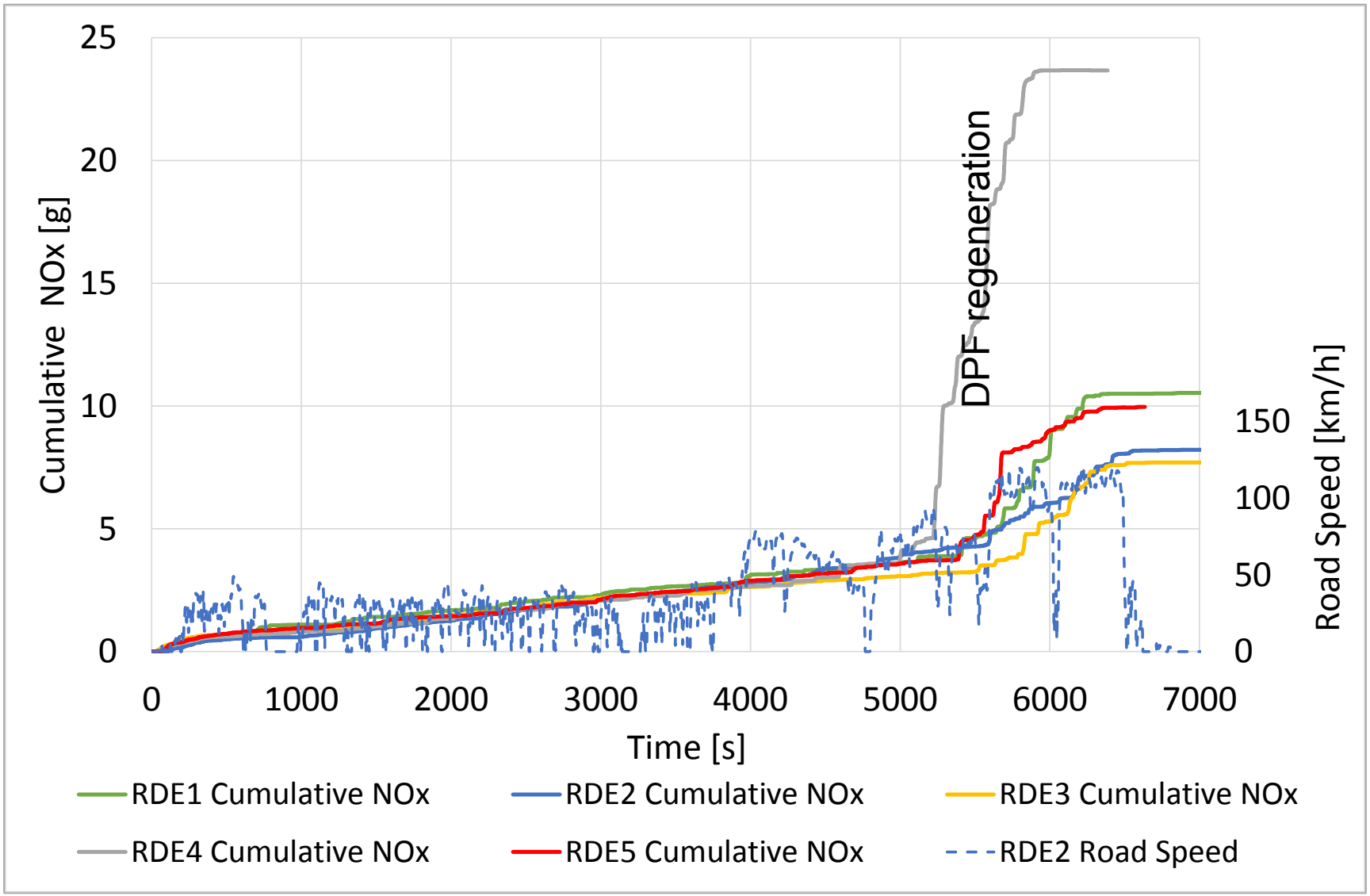


Particle Number is controlled under real-world conditions

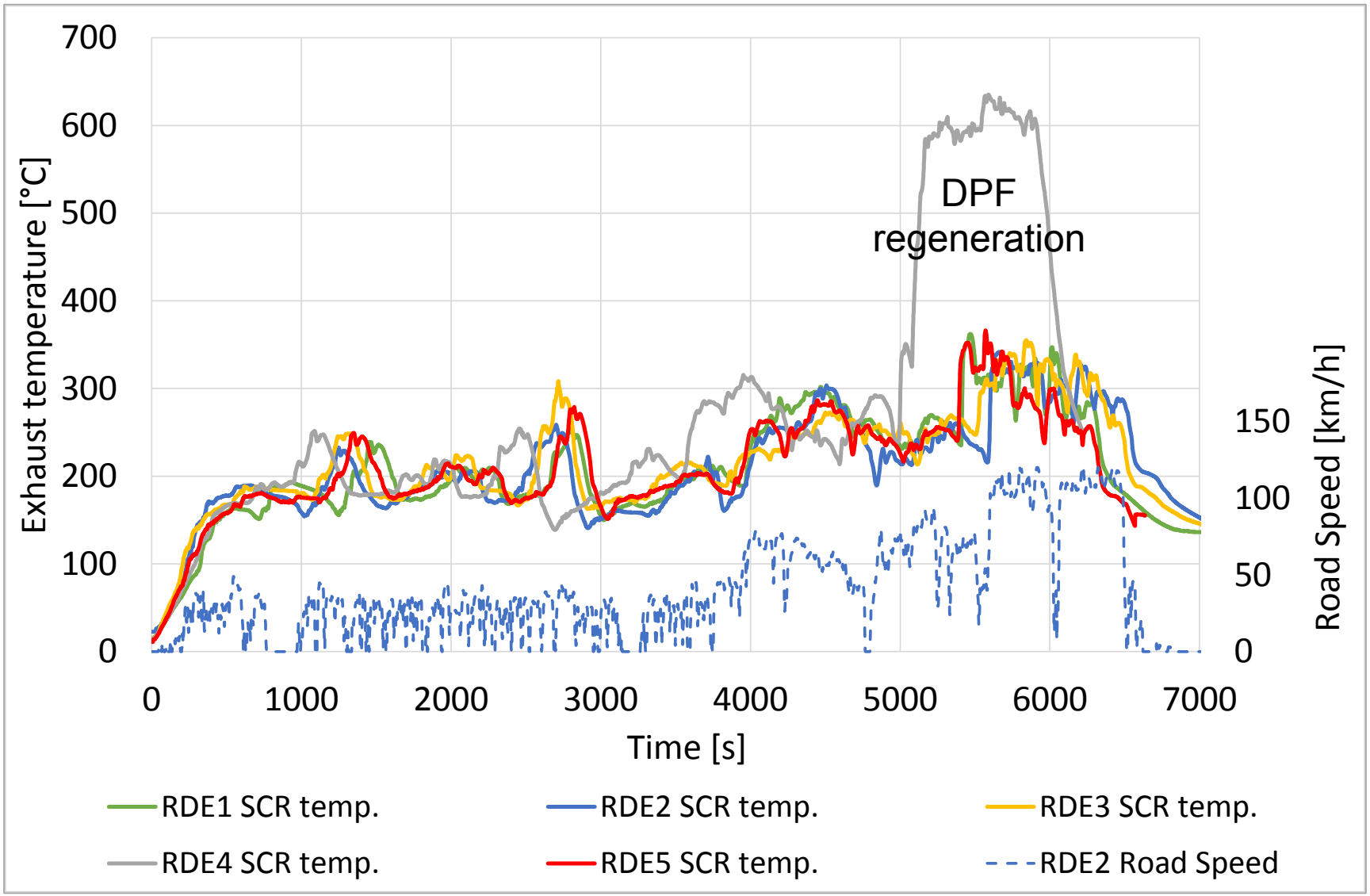
- Power supply issue on RDE#1, 2, and 4.
- PEMS PN available only for RDE#3 and RDE#5.



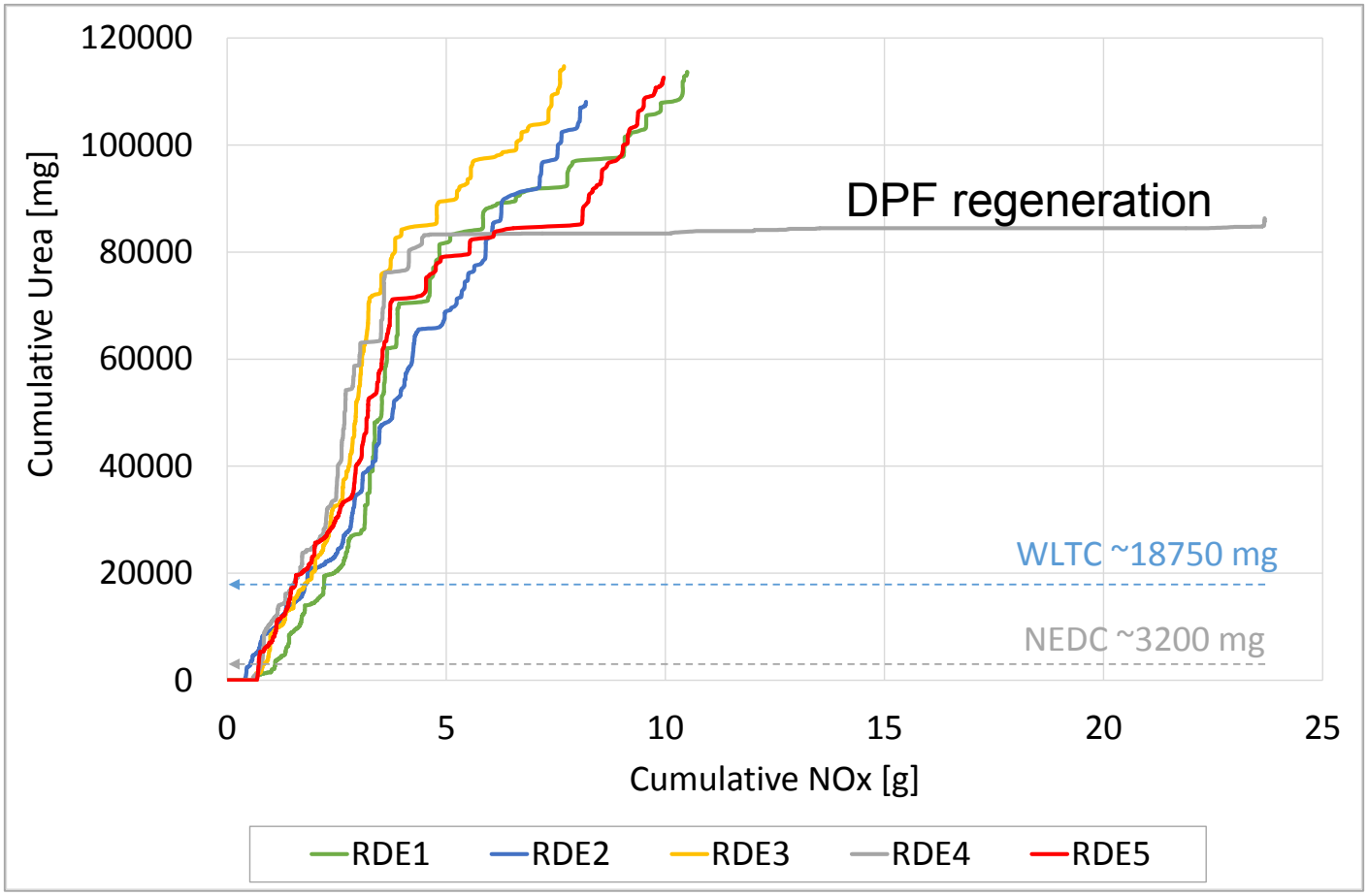
On-road NOx emissions



On-road SCR temperature



Urea dosing and tailpipe NOx emissions



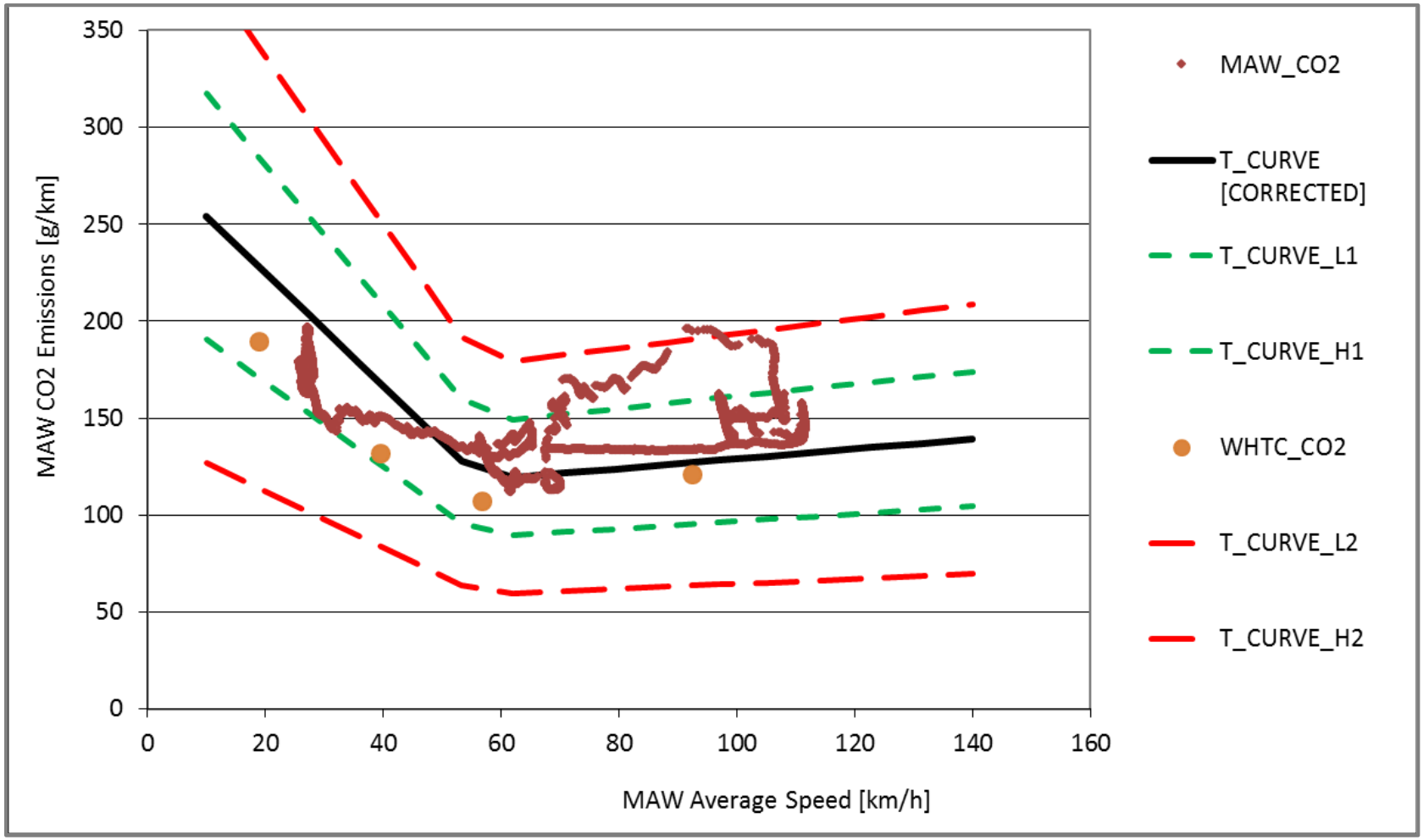
- Urea dosing on RDE tests: 1.31 l/1000km
- Tank size: 17.1 l ➔ AdBlue® refill interval: 13000 km

PEMS data analysis with EMROAD

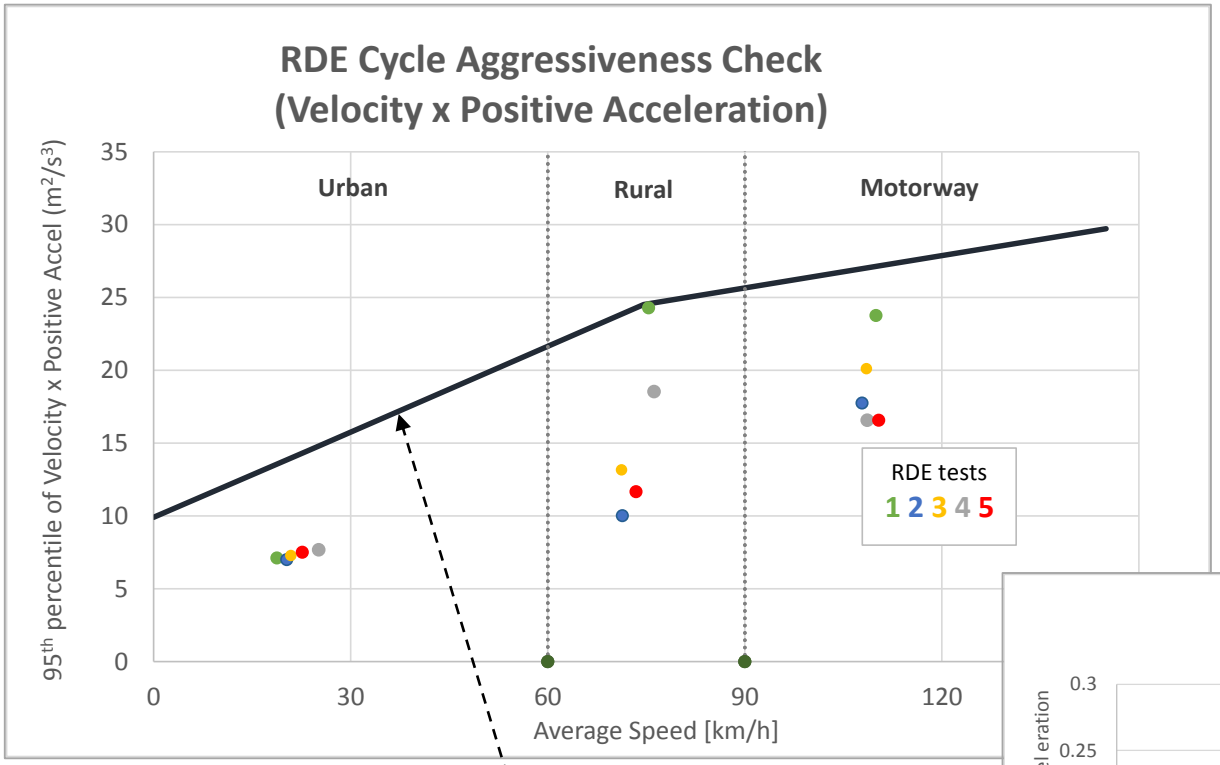
Test	Route validity				Emissions		EMROAD processing				
	Duration (min)	% Distance by phase			CO_2	NOx	Valid MAW >15%			EMROAD driving style	NOx DR
		Urban <60kph	Rural	Mway >90kph	(g/km)	(mg/km)	Urban <60kph	Rural	Mway >90kph	≥50% valid MAW "normal" in each phase	
RDE#1	111	39%	30%	31%	154.5	162	55%	32%	13%	yes	2.03
RDE#2	110	42%	26%	32%	149.7	115	52%	32%	16%	yes	1.44
RDE#3	115	42%	33%	25%	148.9	114	54%	34%	12%	yes	1.43
RDE#5	115	37%	33%	30%	147.1	140	57%	30%	13%	yes	1.75

- Only RDE#2 is fully valid, including share of Moving Average Windows in Motorway conditions > 15%.
- RDE#2 achieves a NOx Deviation Ratio of 1.44 when calculated by EMROAD (vs. 1.2 based on unprocessed on-road emissions).

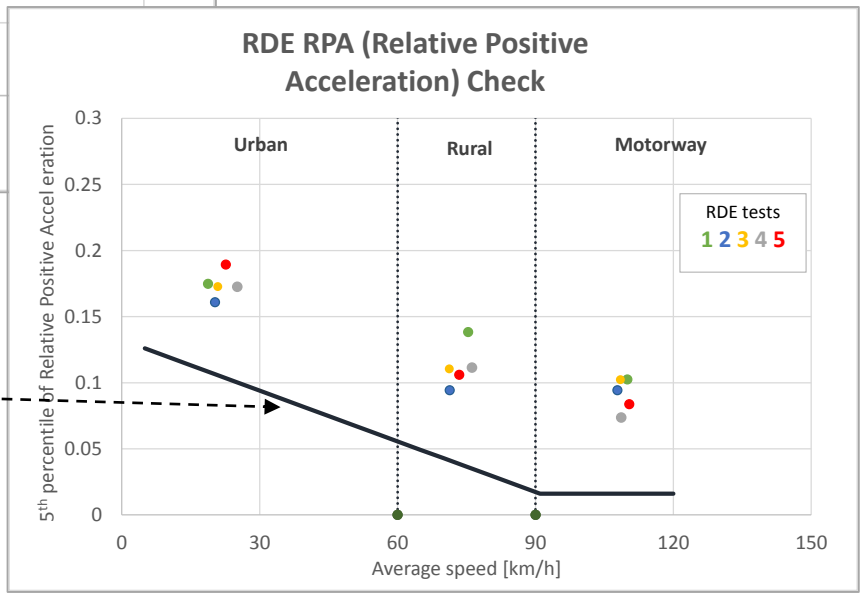
EMROAD Post-processing – RDE#2



Dynamic characteristics of RDE trips



Currently proposed thresholds

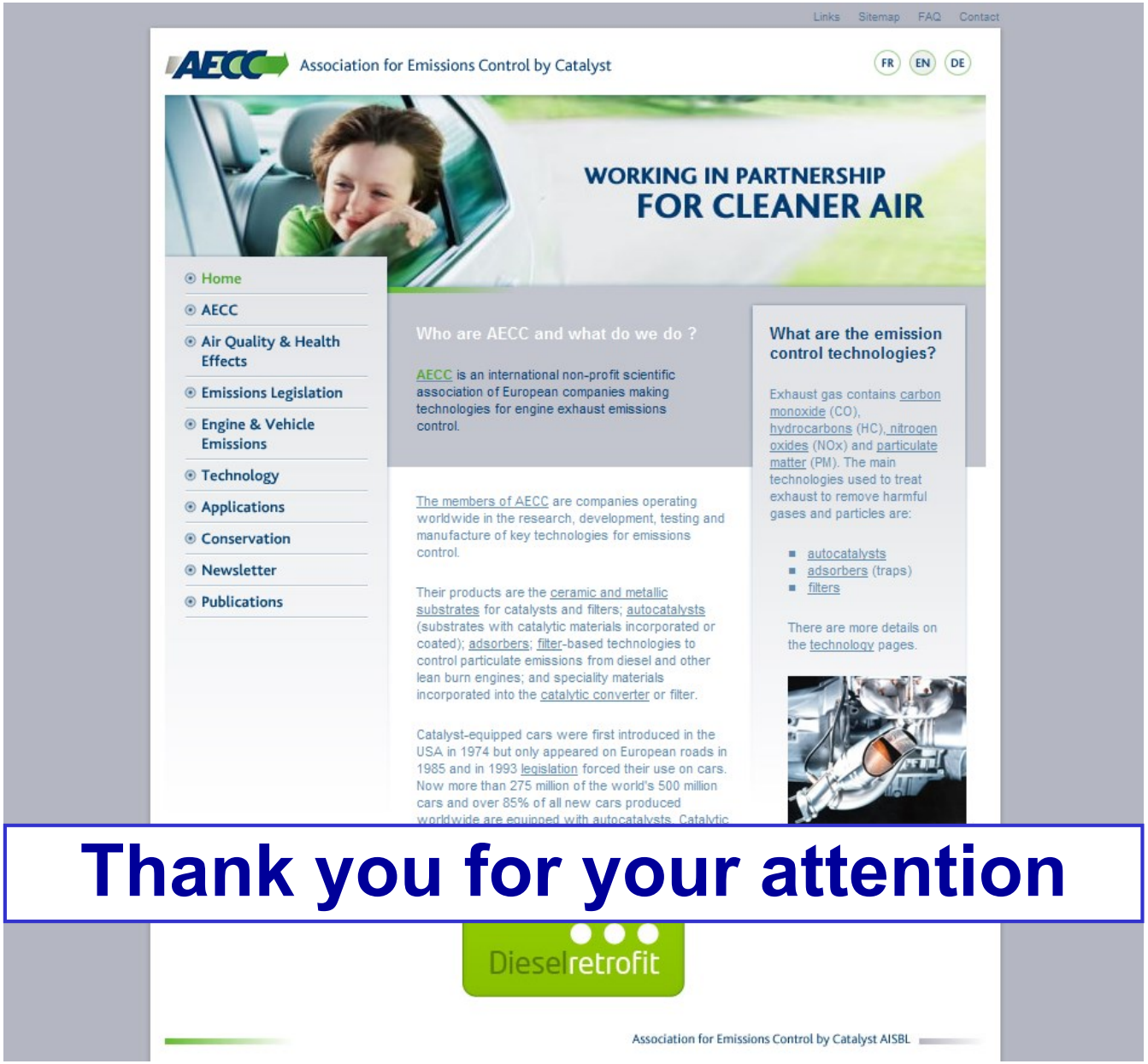


Conclusions

- Challenges were encountered to obtain a valid test with EMROAD.
- A commercially available Euro 6b Diesel car using an advanced emissions control system showed a NOx Deviation Ratio of 1.44 when tested under specific boundary conditions and according to current RDE procedure (incl. data post-processing).
- This was achieved with a urea consumption of 1.31 l/1000km, corresponding to a 13000 km refill interval, requiring customer intervention.

Acknowledgments

- Thanks to Ricardo for their expertise in conducting repeatable testing, providing robust results and analysing the data in a timely manner.



Thank you for your attention