Particulate emissions Euro 3 to Euro 6 light-duty vehicles

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15th ETH Conference on Combustion Generated Nanoparticles

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Technology for exhaust emissions control on all new cars (OEM and Aftermarket) and an increasing number of commercial vehicles, non-road applications and motorcycles.

Work Programme

Over the last 3 years AECC has conducted test programmes to provide data on the emissions of current and future light duty vehicles.

The tests included measurement of particulate mass and particle number emissions using the UNECE-developed PMP procedures.

All vehicles were tested over the standard EU legislative cycle (NEDC) and over the full Common Artemis Driving Cycles (CADC).

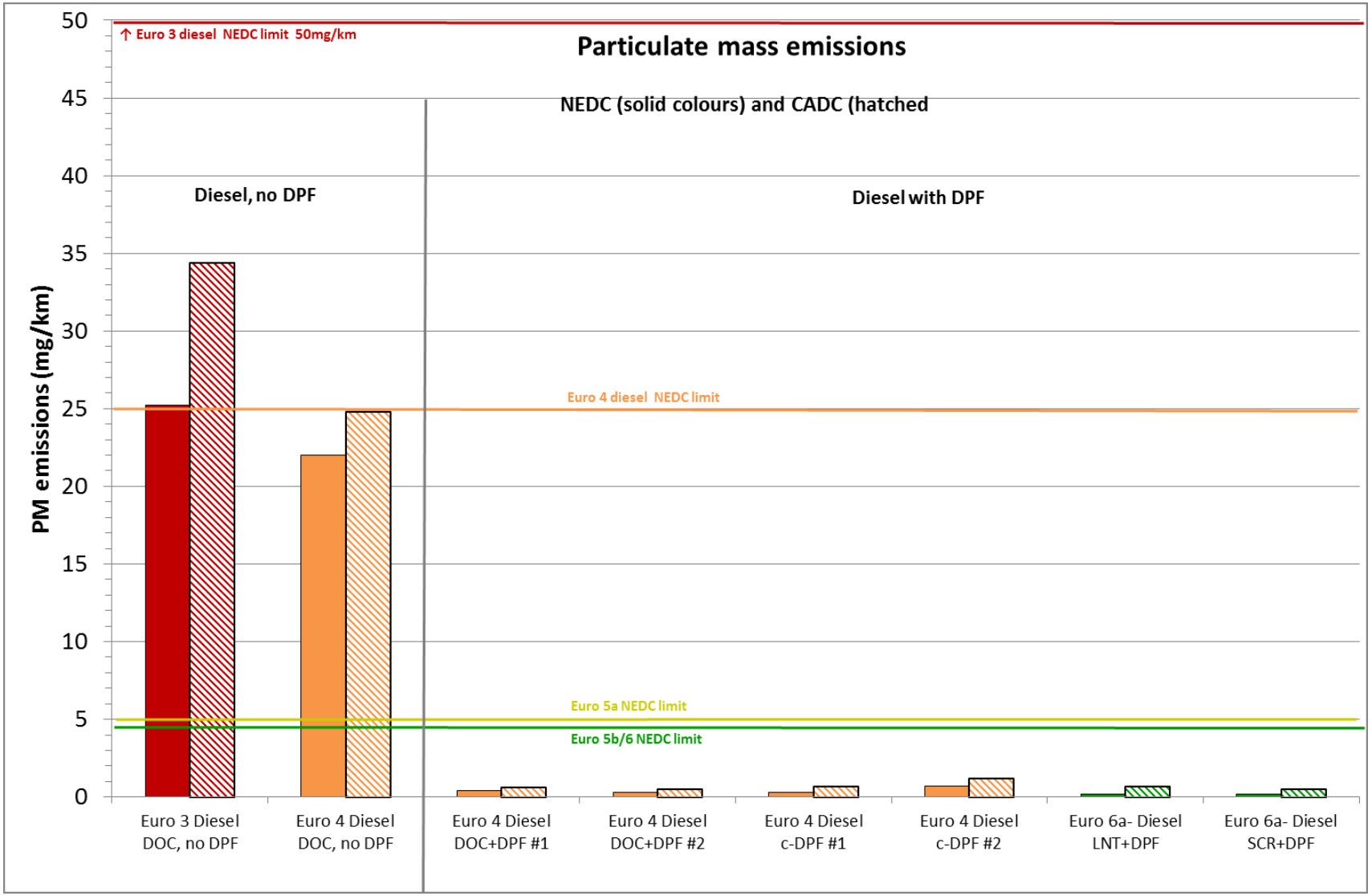
Diesel Vehicles

Working Principle	Emission Approval	Engine capacity	Power (kW)	Registration year	Gearbox	Mileage (km)	Date of test
DI diesel, DOC, no DPF	Euro 3	1.9 litre	85	1999	M6	180000	April 2008
DI diesel, DOC, no DPF	Euro 4	1.9 litre	77	2005	M6	45000	June 2008
DI diesel with DOC & DPF, #1	Euro 4	2 litre	100	2005	M6	15500	May 2008
DI diesel with DOC & DPF, #2	Euro 4	2 litre	100	2008	M6	15000	September 2008
Di diesel with c-DPF, #1	Euro 4	1.9 litre	77	2006	M6	61000	August 2008
Di diesel with c-DPF, #2	Euro 4	1.9 litre	77	(2007)	M6	14250	October 2008
DI diesel with LNT+DPF	Euro 6a-	3 litre	180	2009	M6	25000	February 2010
DI diesel with SCR+DPF	Euro 6a-	3 litre	155	2010	AT7	8750	May 2010

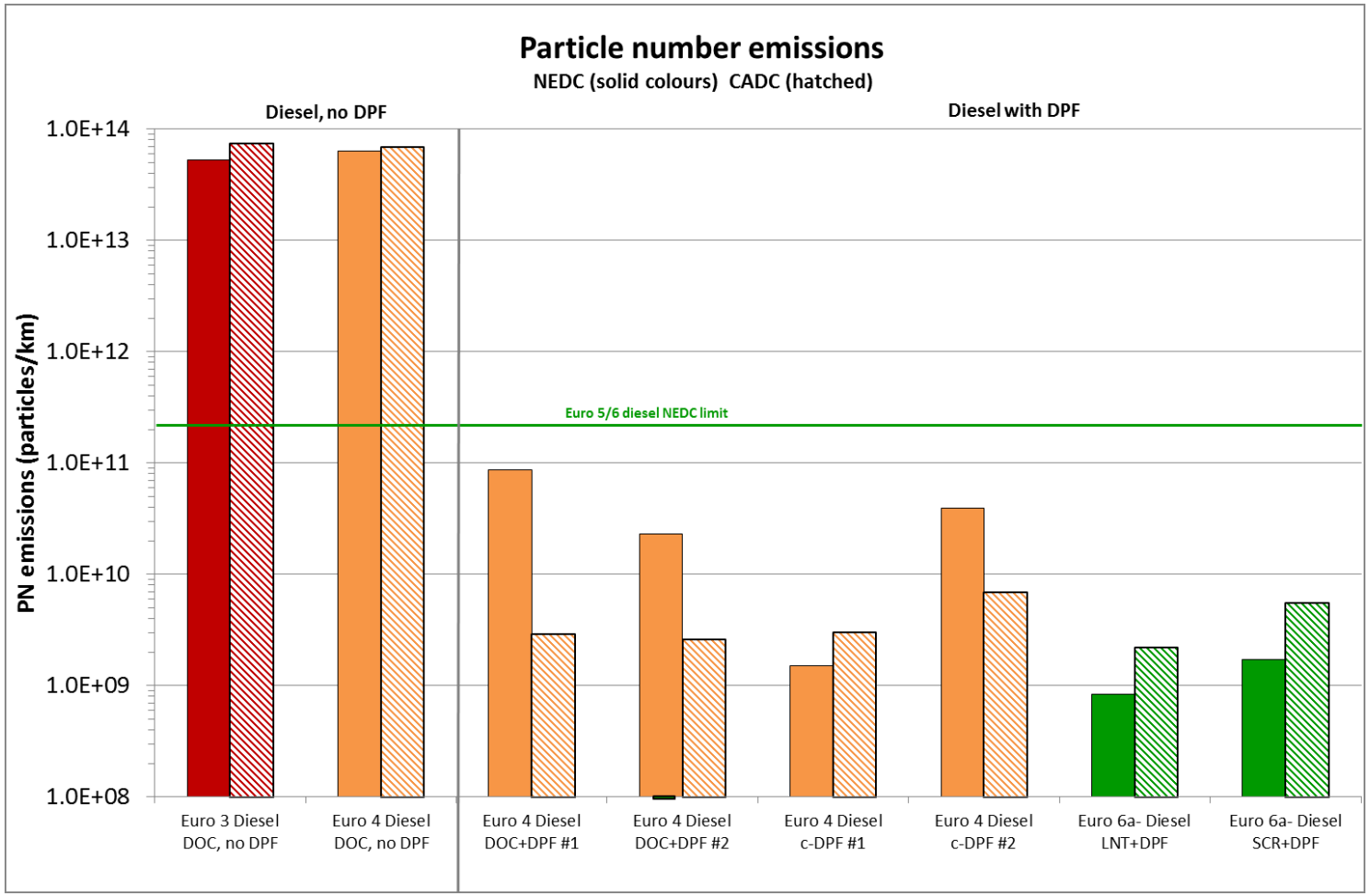
DOC Diesel Oxidation Catalyst
DPF Diesel Particulate Filter
c-DPF catalysed Diesel Particulate Filter
LNT Lean NOx Trap
SCR Selective Catalytic reduction

DI Direct Injection
M Manual Transmission
AT Automatic Transmission
following figure is the number of gears

Diesel Vehicles, Particulate Mass



Diesel Vehicles, Particle Number



- All DPF-equipped Diesels show Particle Numbers <6×1011/km.
- No clear trend for PN emissions on CADC compared to NEDC.

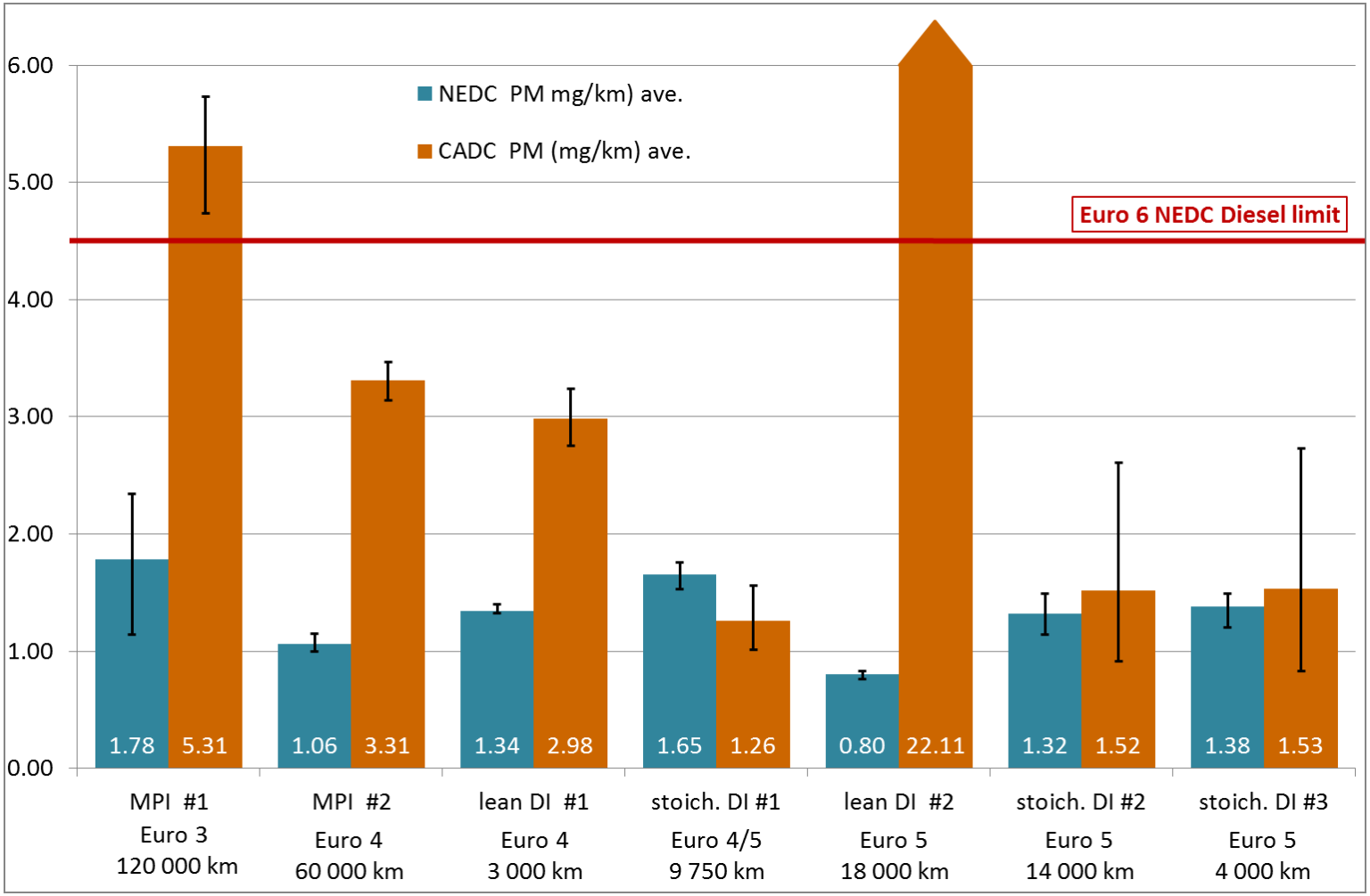
Petrol Vehicles

Working Principle	Engine Capacity	Power (kW)	Emission Approval	Registration year	Gearbox	Mileage (km)	Date of Test
MPI #1	2 litre	85	Euro 3	1999	M5	120000	April 2008
MPI #2	2 litre	85	Euro 4	2001	M5	60000	November 2008
lean DI #1	2 litre	105	Euro 4	2008	M6	3000	Aug. 2008
stoichiometric DI #1	1.4 litre	92	Euro 4 / 5	2008	M6	9750	Nov. 2008
lean DI #2	3.5 litre	215	Euro 5	2009	AT7	18000	Nov. 2010
stoichiometric DI #2	1.6 litre	115	Euro 5	2009	M6	14000	Dec. 2010
stoichiometric DI #3	1.2 litre	63	Euro 5	2010	M5	4000	Jan. 2011

MPI Multi-Point (indirect) Injection
DI Direct Injection

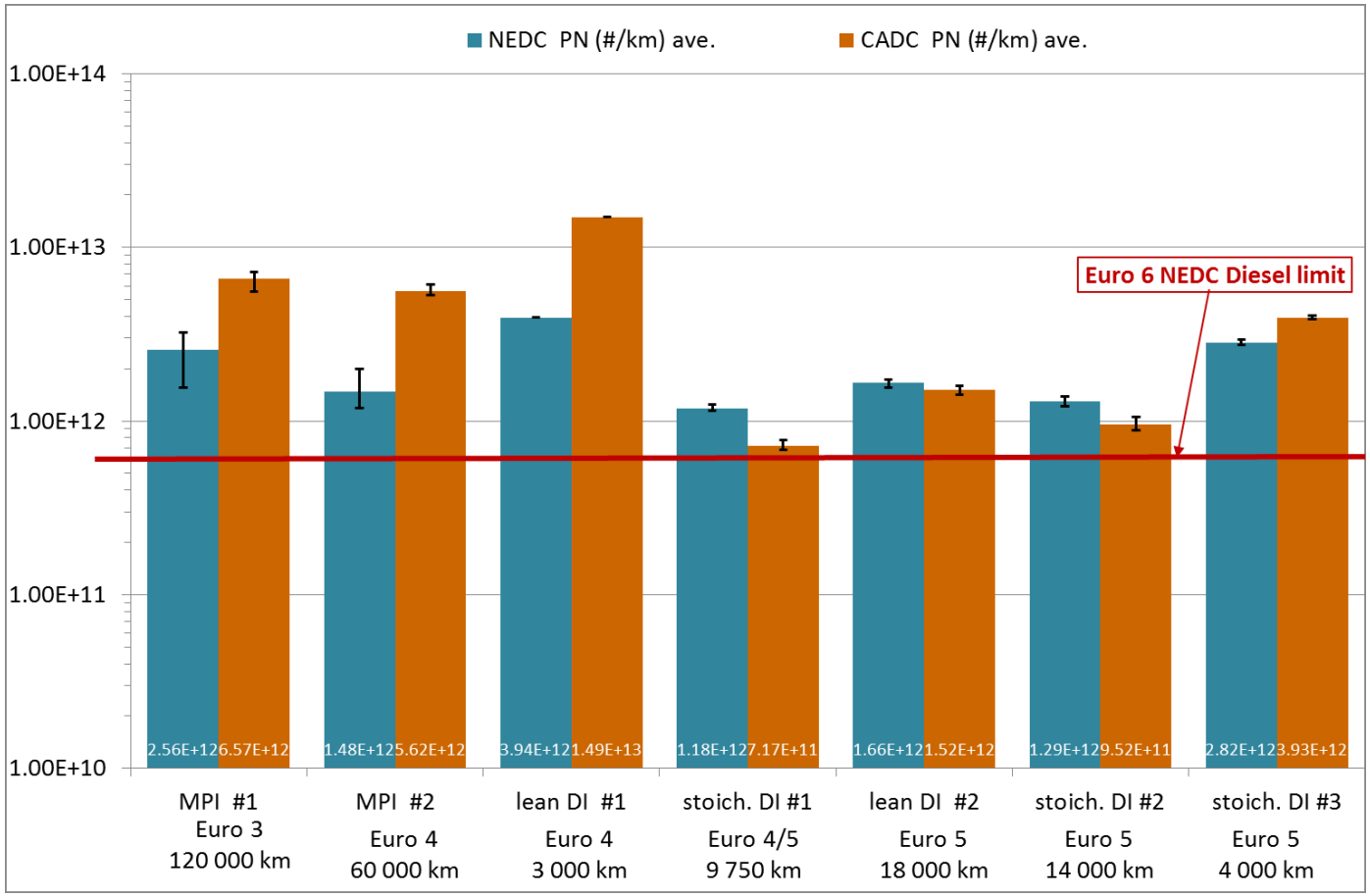
MPI and stoichiometric DI vehicles were equipped with 3-way catalysts (TWC)
Lean DI vehicles were equipped with lean NOx trap (LNT) + TWC

Particulate mass emissions NEDC & CADC



- For the majority of vehicles, emissions on the Artemis suite are higher than on the NEDC, but the extent of the difference varies.

Particle number emissions (NEDC & CADC)

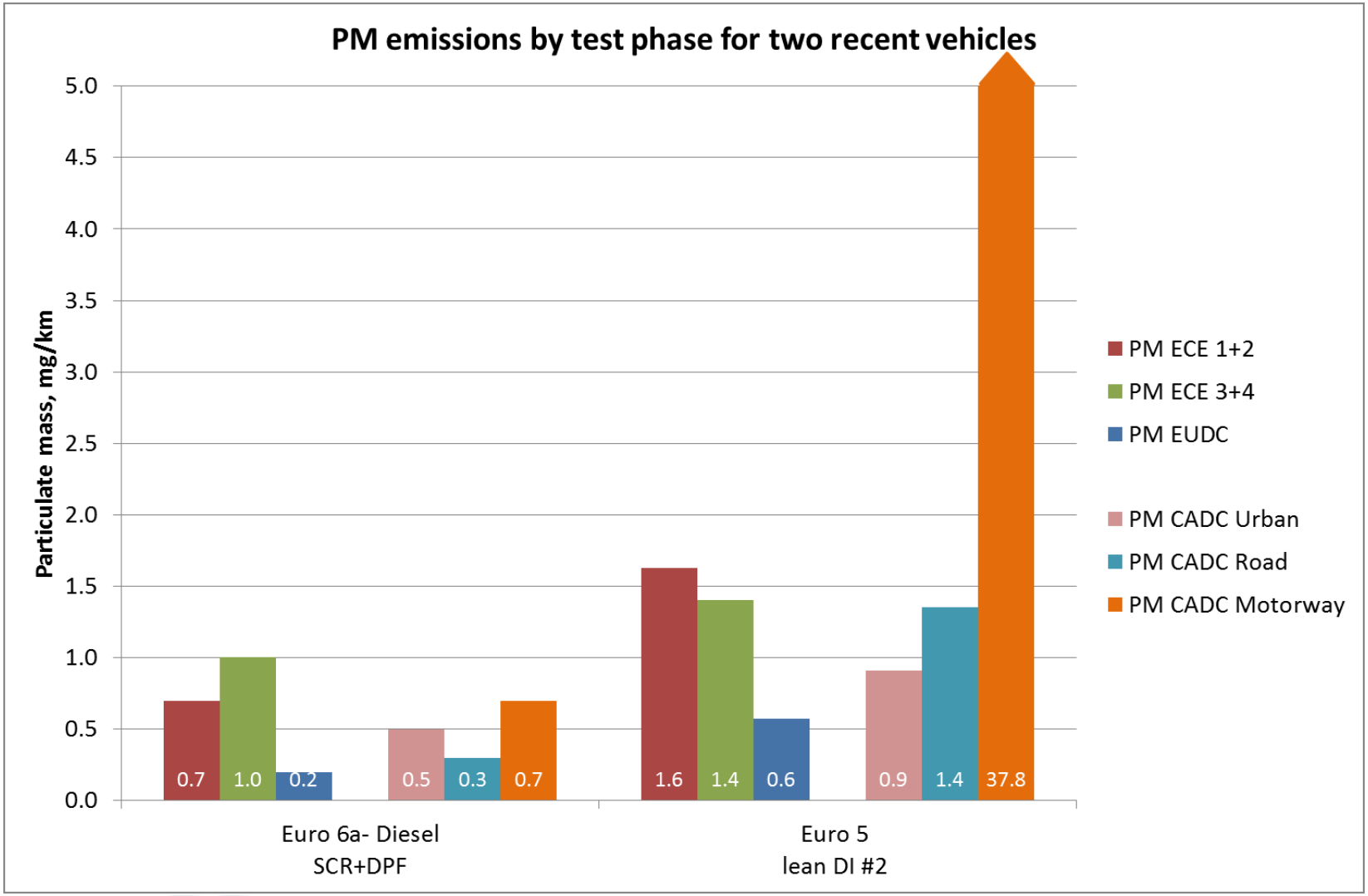


- The high particle numbers for the two MPI vehicles (which had similar engines) are believed to be related to engine characteristics rather than the high mileages.

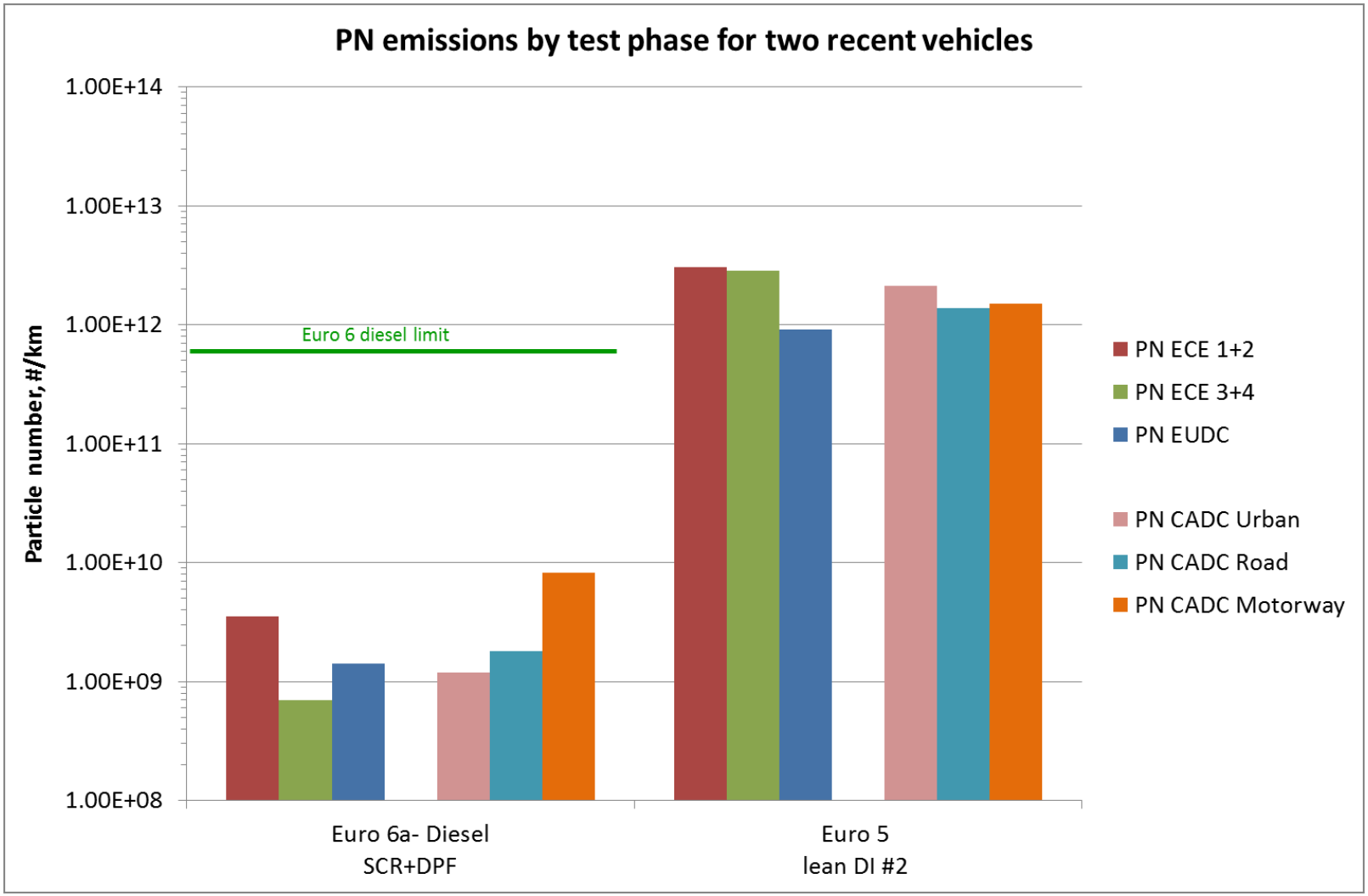
Test regime – additional data

- In addition to full cycle test results, data was collected for ECE 1+2, ECE 3+4, EUDC, and for the full CADC Urban, CADC Rural and CADC Motorway tests.
- CADC tests are hot start, but single cold-start tests (at normal test temperature) are available for vehicles tested towards the end of the programme.
- For the final 3 (DI petrol) vehicles particle size analysis (EEPS) was included.

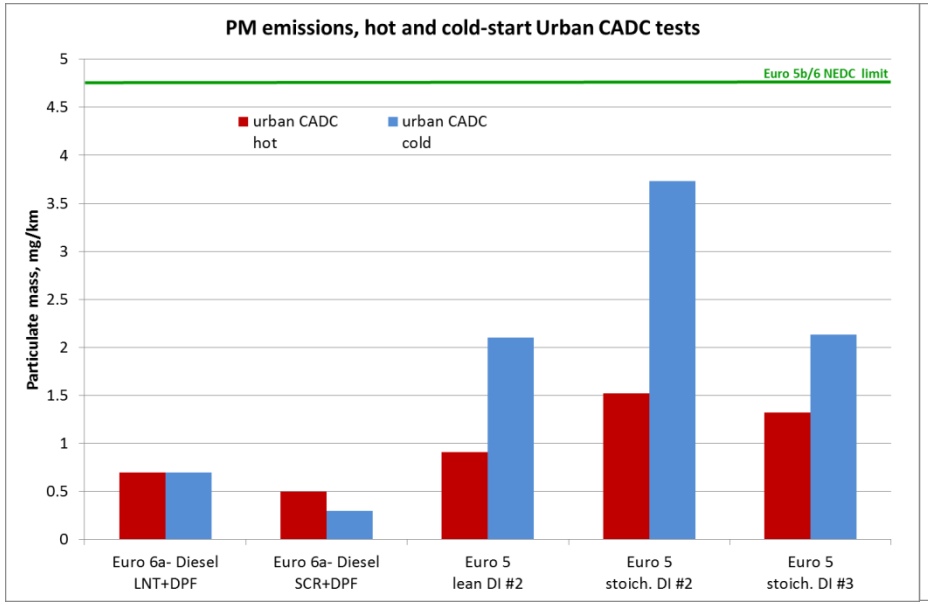
Example of PM emissions by test phase

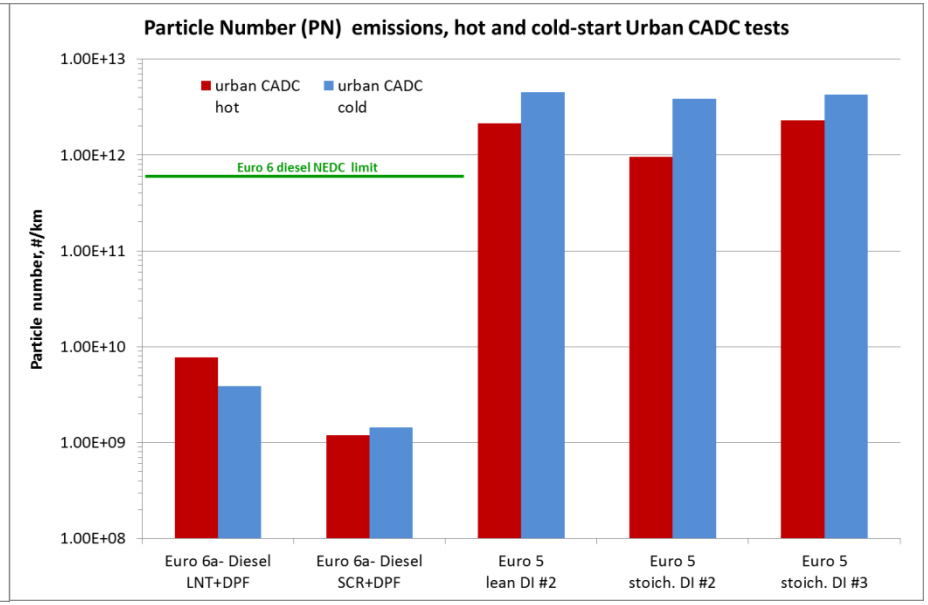


Example of PM emissions by test phase



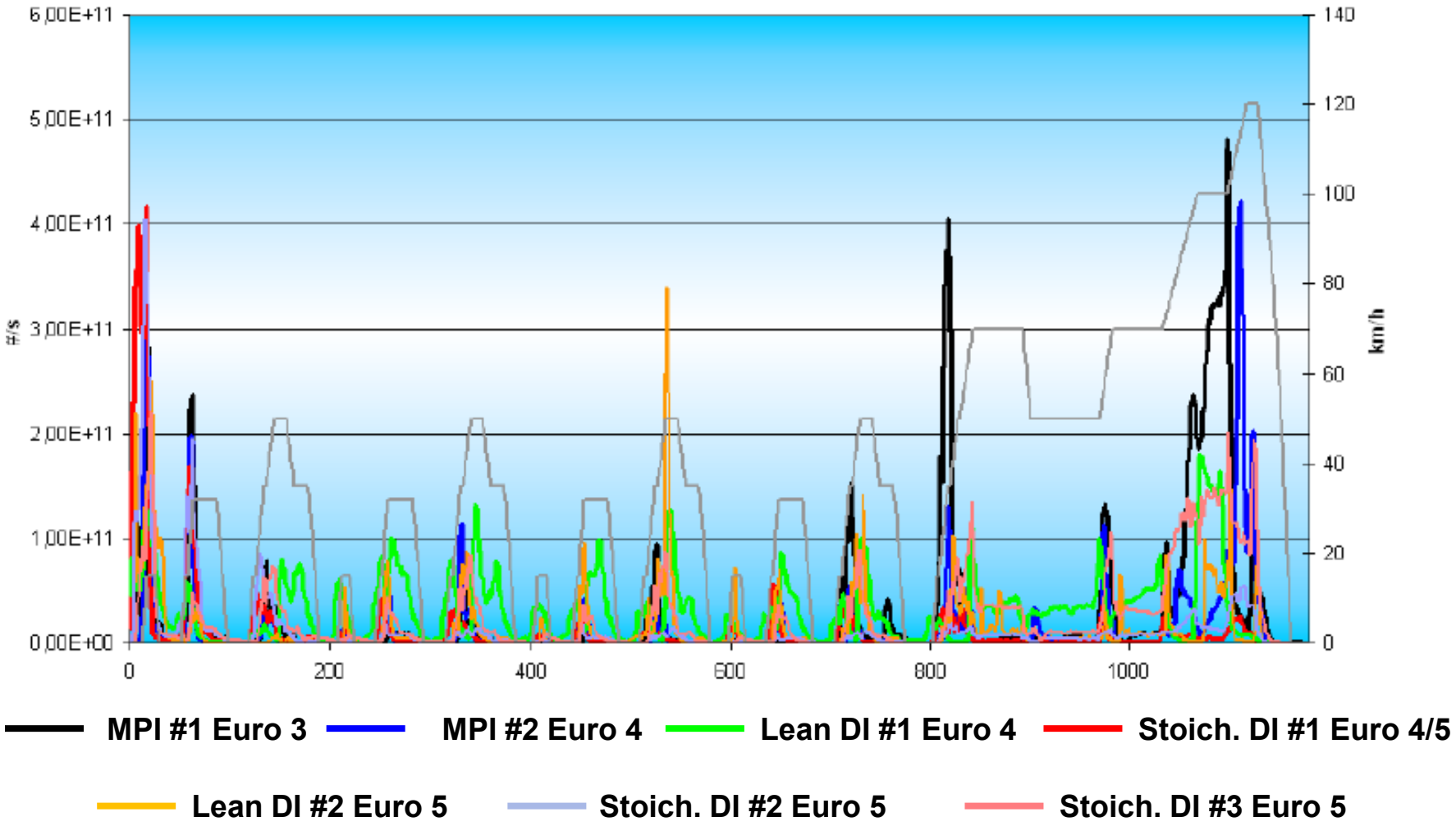
Effect of cold start on the CADC Urban test



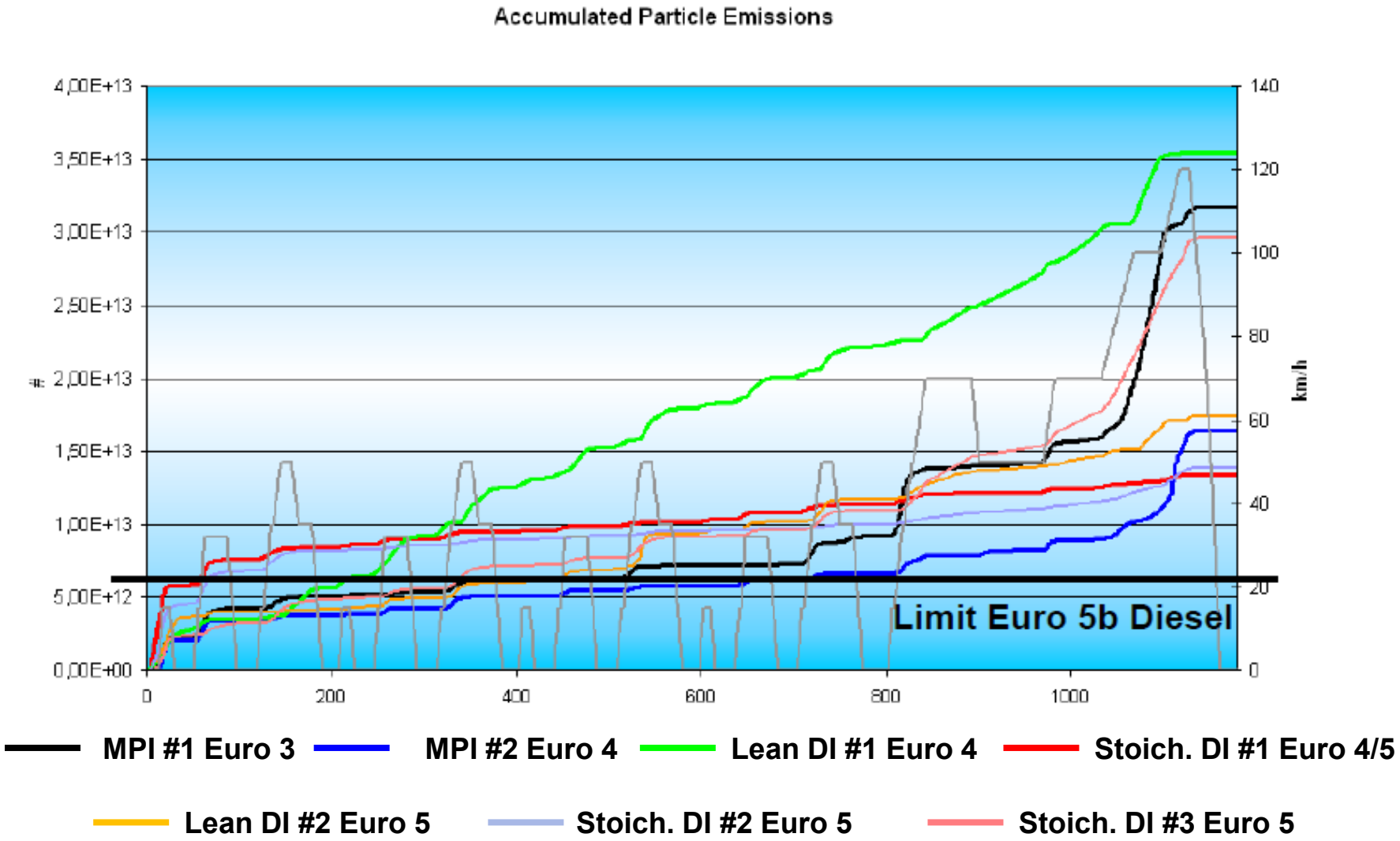


- Each of the vehicles met the NEDC PM limit of 4.5mg/km in both the cold-start and hot-start versions of the CADC Urban test.
- Both the diesel vehicles met the Euro 6 PN limit in both the cold-start and hot-start versions of the CADC Urban test.
- For the three DI petrol vehicles, PN emissions were somewhat higher for the cold-start tests than for the hot-start, but within less than 1 order of magnitude.

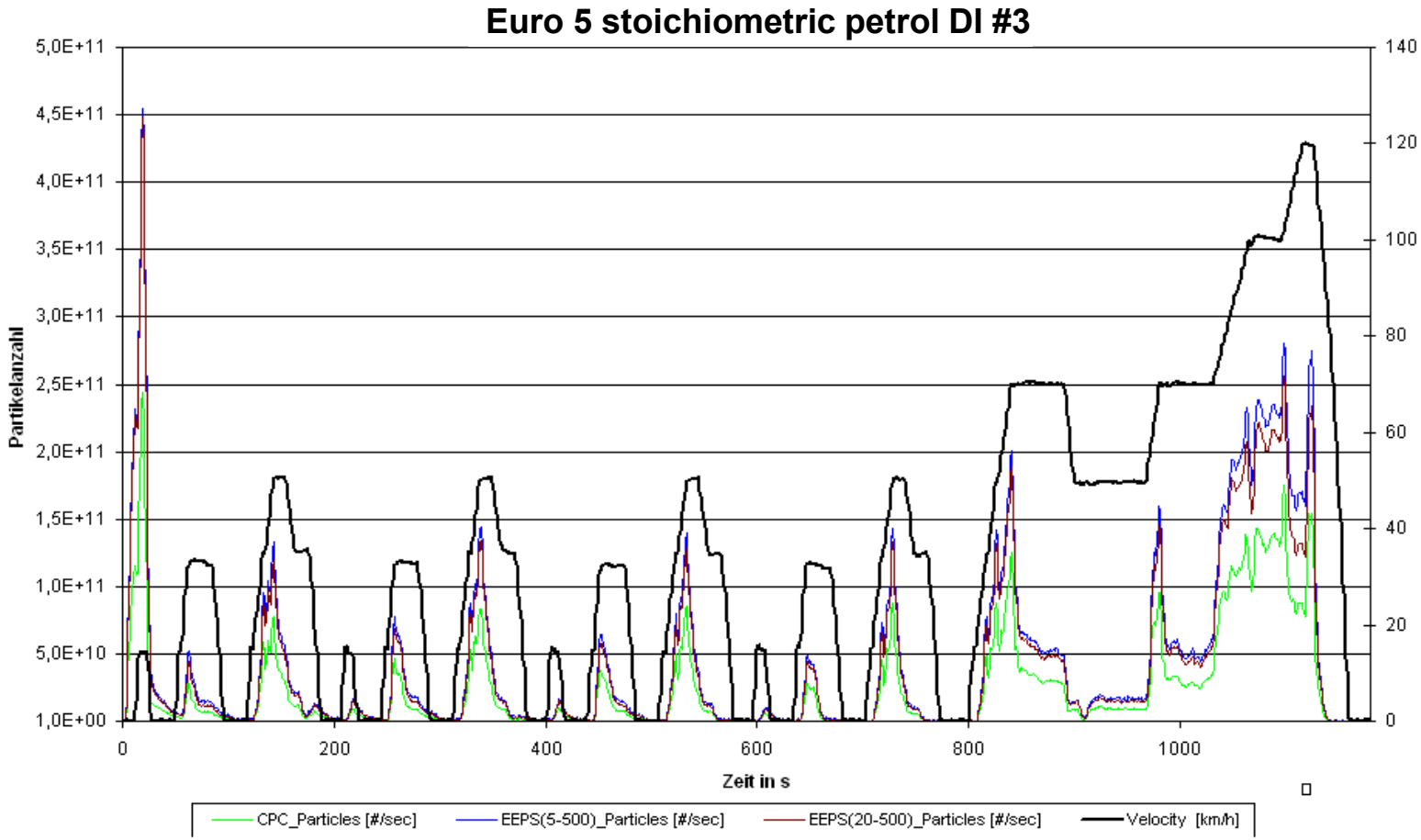
Particle number emissions for petrol vehicles NEDC continuous data



Cumulative particle number emissions for petrol vehicles (NEDC)

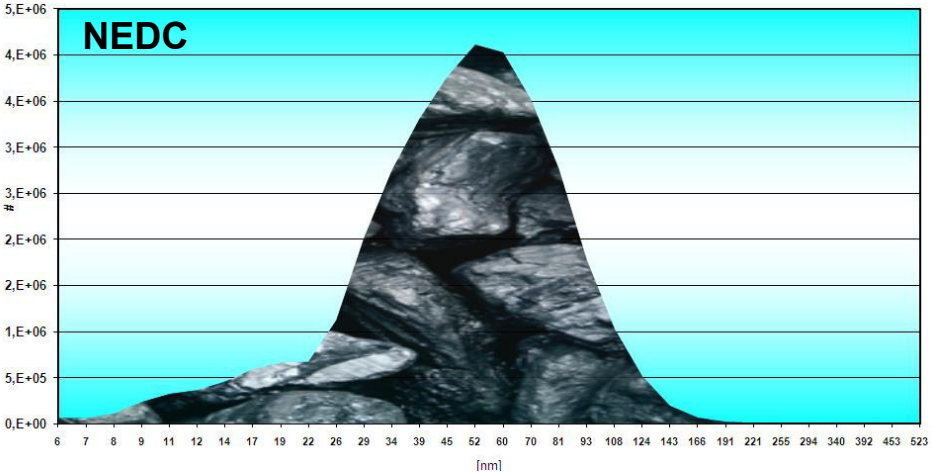


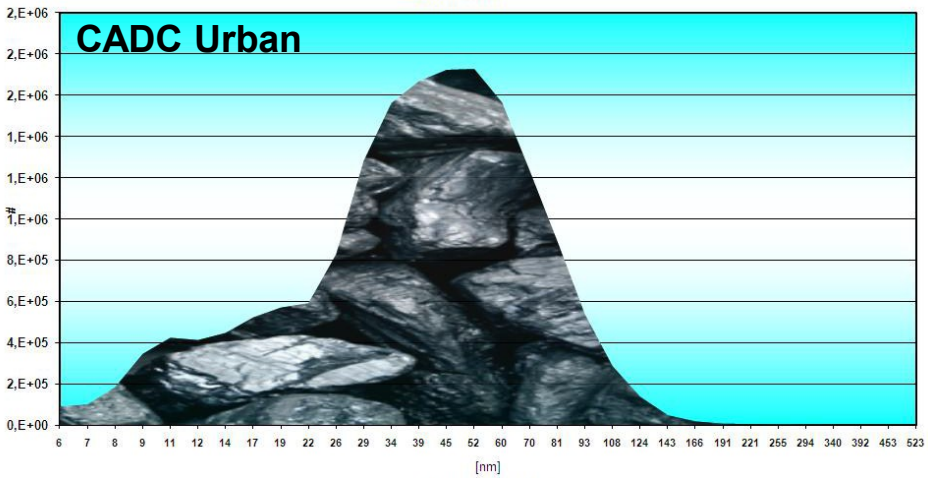
Comparison of PN by CPC and EEPS

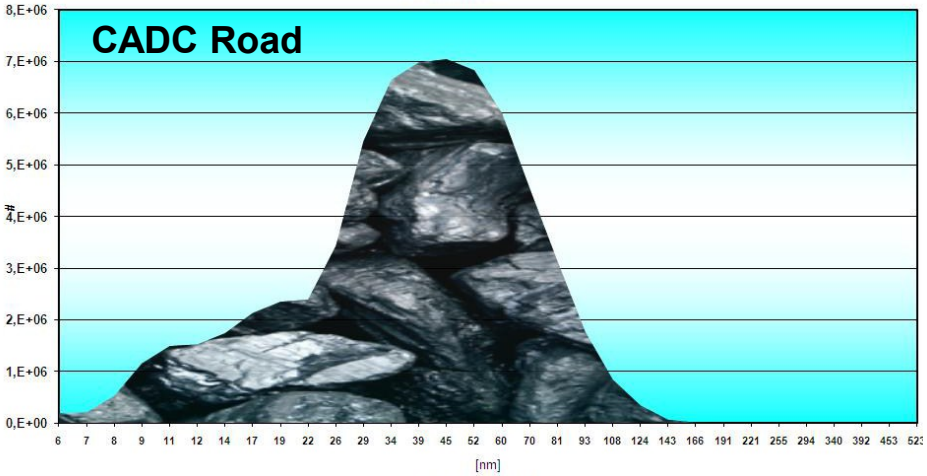


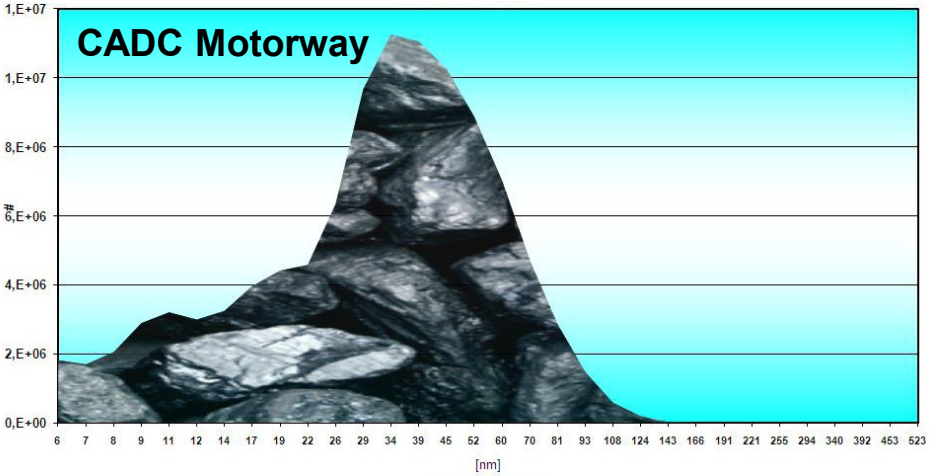
- Note EEPS measures total particles without volatile particle remover

Example of particle size distribution by EEPS





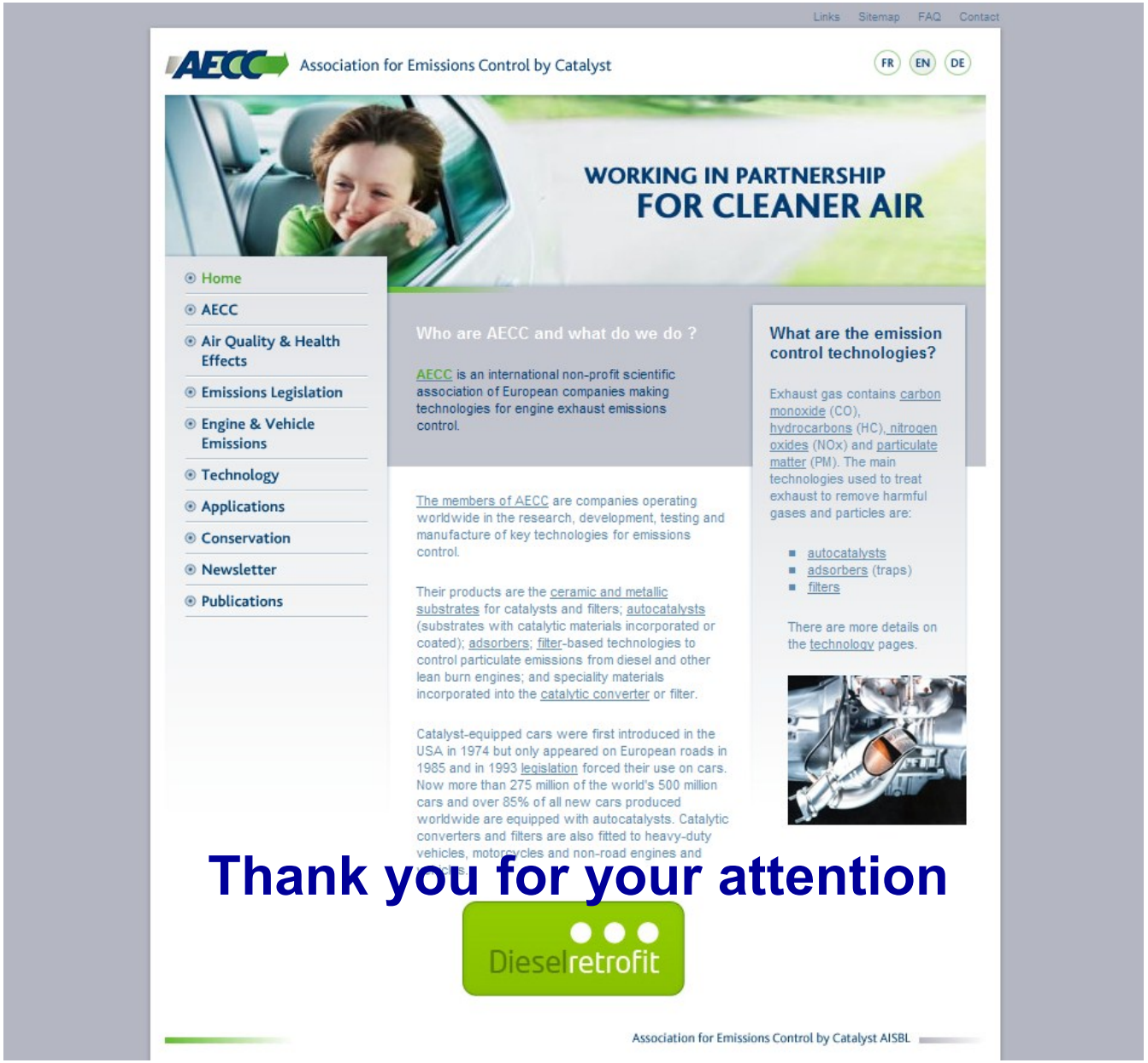




Euro 5 stoichiometric petrol DI #3

Summary

- AECC has conducted test programmes measuring PM and PN emissions over the NEDC and CADC (Artemis) test cycles from a range of petrol and diesel vehicles covering the Euro 3 to Euro 6 emissions standards
- Diesel vehicles with DPFs met the Euro 6 PM and PN emissions limits over all cycles.
- Data is available on the emissions by test phase, continuous and cumulative particle number emissions and particle size distribution.
- On the NEDC, PN emissions from stoichiometric and lean-burn petrol engines were in the range of 1×10^{12} to 4×10^{12}/km.
- For the same vehicles on the complete Artemis (CADC) suite, PN emissions ranged from 7×10^{11} to 1.5×10^{13}/km.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Who are AECC and what do we do ?
AECC is an international non-profit scientific association of European companies making technologies for engine exhaust emissions control.
The members of AECC are companies operating worldwide in the research, development, testing and manufacture of key technologies for emissions control.
Their products are the ceramic and metallic substrates for catalysts and filters; autocatalysts (substrates with catalytic materials incorporated or coated); adsorbers; filter-based technologies to control particulate emissions from diesel and other lean burn engines; and speciality materials incorporated into the catalytic converter or filter.
Catalyst-equipped cars were first introduced in the USA in 1974 but only appeared on European roads in 1985 and in 1993 legislation forced their use on cars. Now more than 275 million of the world's 500 million cars and over 85% of all new cars produced worldwide are equipped with autocatalysts. Catalytic converters and filters are also fitted to heavy-duty vehicles, motorcycles and non-road engines and
What are the emission control technologies?
Exhaust gas contains carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter (PM). The main technologies used to treat exhaust to remove harmful gases and particles are:
autocatalysts
adsorbers (traps)
filters
There are more details on the technology pages.
Thank you for your attention
Dieselretrofit
Association for Emissions Control by Catalyst AISBL