Real Driving Emissions

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UnICEG meeting

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Association for Emissions Control by Catalyst (AECC) AISBL

AECC members: European Emissions Control companies

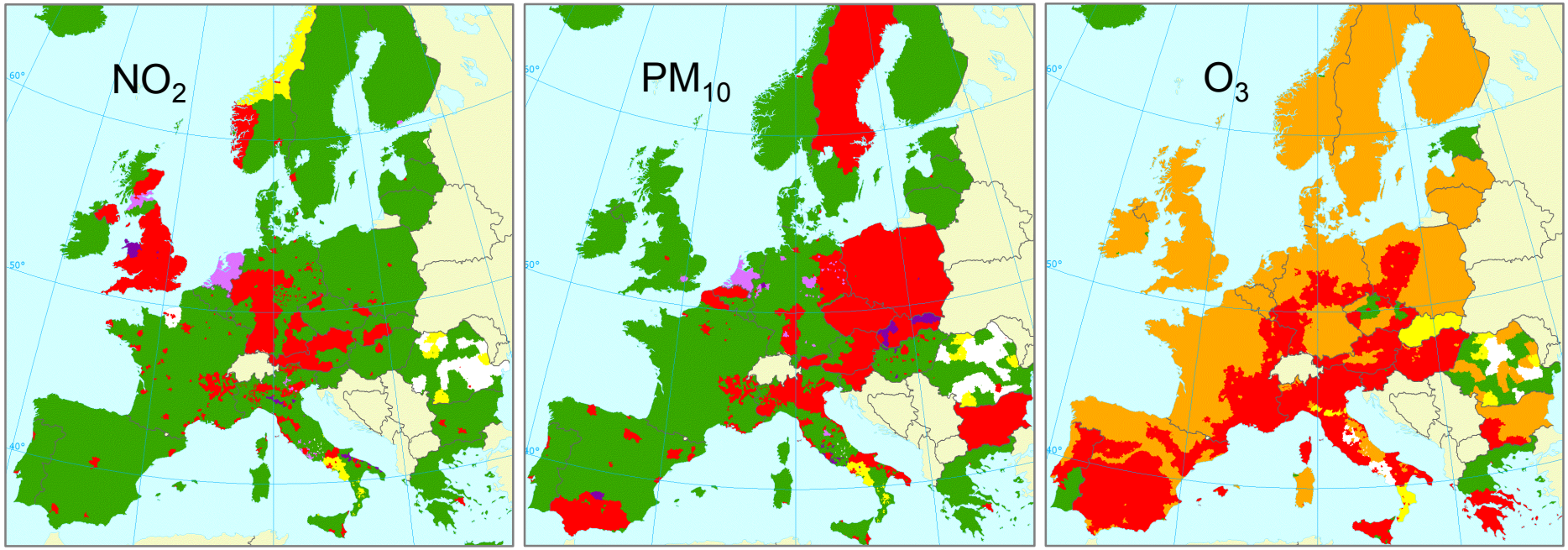
Exhaust emissions control technologies for original equipment, retrofit and aftermarket for all new cars, commercial vehicles, motorcycles and non-road mobile machinery.

Contents

- Background to Real Driving proposal.
- RDE and PEMS.
- Some test results.
- Current status.
- Summary.

Air quality issue in Europe

Source: European Environment Agency 2014 (2011 data)



- Growing traffic volumes give difficulties meeting air quality targets.
- Threat of fines on EU Member States for Air Quality infringements.

Real Driving Emissions: background

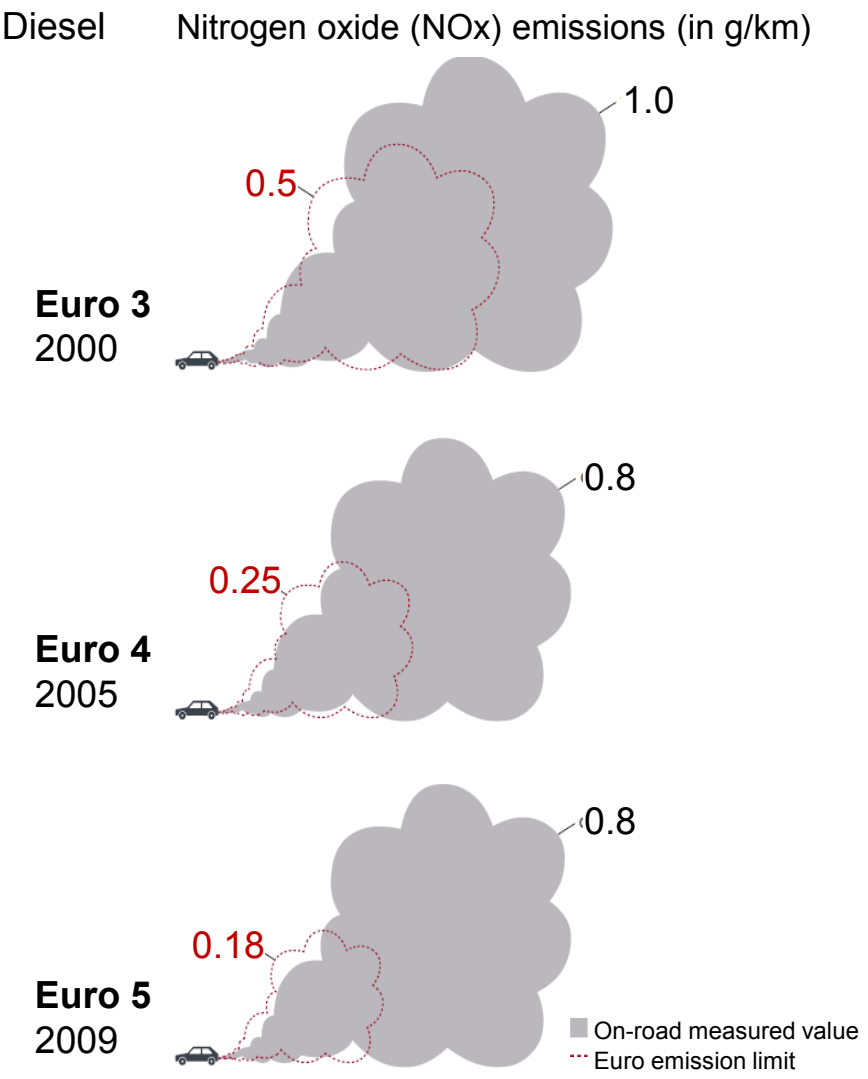
- The 2007 light-duty emissions Regulation (EC 715/2007) requires emissions to be effectively limited throughout the normal life of the vehicles under normal conditions of use.
- Real-world emissions ≠ test cycle Type Approval data
  - NOx (especially diesel) and PN are main concerns.
  - Need to match if Air Quality targets are to be met.

  ► European Commission proposals for an additional 'Real Driving Emissions' (RDE) test.

- Introduction of Worldwide harmonised Light vehicles Test Procedure (WLTP) and cycle (WLTC) in same timeframe.

The Diesel NOx RDE issue

- Euro 5 has reduced particle number emissions from Diesel vehicles fitted with DPFs.
- But Euro 3 to 5 standards have been insufficient to control Diesel NOx emissions in real-world.
- Diesel NOx aftertreatment is now introduced with Euro 6.
- NOx emissions can be controlled in real-world provided the standard requires technology to be used to its full potential.

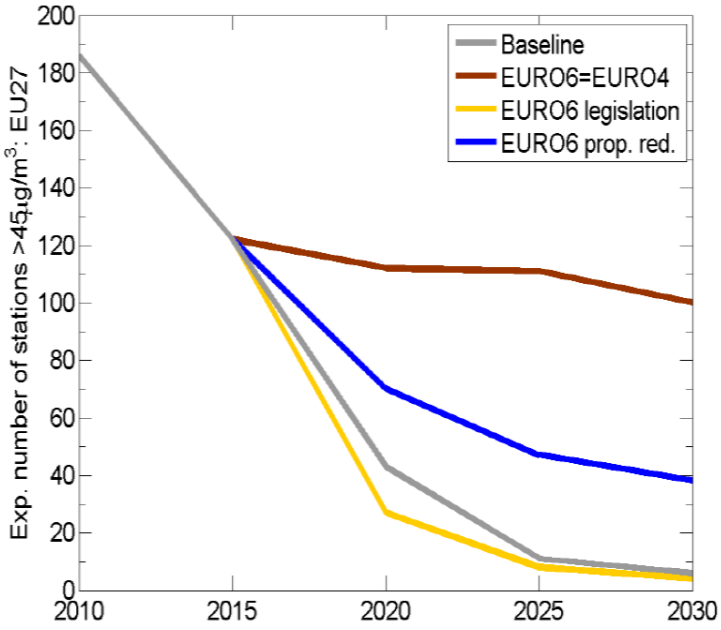


Source: ICCT pocketbook, 2012

Effect of NOx conformity on air quality

- 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 if CF is high (CF~10)
  - Euro 6 NOx RDE reduces proportionally if CF=4
  - CF=1, Euro 6 limits met in real-world
- With CF~4, NO_2 non-compliance in 2020 is 3 times higher than in the baseline (CF=1.5) scenario

Figure 8: Baseline projected compliance with NO2 standards in case Euro 6 would not correct the real world emission problems



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

RDE & PEMS

- The proposed RDE procedures require Portable Emissions Measurement Systems for NOx, CO, CO_2 and [PN] .
- Exhaust mass flow has to be measured.
- 90 to 120 min. trip including urban, rural, motorway driving.
- Has to be conducted on working days.
- Test includes cold start but data excluded from evaluation until coolant temperature reaches 70°C (or max. 5 minutes).
- Ambient conditions:
  - ≤ 700 m altitude (up to 1300 m for 'extended' conditions).
  - 0°C to +30°C temperature (-7°C to +35°C for 'extended' conditions). (But +3°C instead of 0°C and -2°C instead of -7°C initially)

(Details remain subject to change)

PEMS route requirements

Note: details of the RDE Regulation remain subject to change.

	Urban	Rural	Motorway
Definition	Up to 60 km/h	60 – 90 km/h	>90 km/h
Proportion of trip	Approx. 34% Min. 29%	Approx. 33%	Approx. 33%
Speed constraints	Ave. 15-30 km/h including stops.		Max. 145 km/h (up to 160 OK for up to 3% of motorway duration) At least 5 mins >100.
Stop periods	At least 10% of urban duration; Several stops of 10s or longer.		
Min. distance	16 km	16 km	16 km
v*a proposed by ACEA as measure of driving severity Cumulative altitude gain parameter also discussed			

AECC tests

- Tests conducted at two independent laboratories
  1. a gasoline vehicle and an early Euro 6 diesel, then
  2. 2 Euro 6 diesels - different NOx control technologies.

- All vehicles were tested using
  - PEMS in real driving,
  - NEDC (current Type Approval test),
  - CADC (Artemis; used in modelling),
  - WLTC, and
  - 3 different Random Cycles.

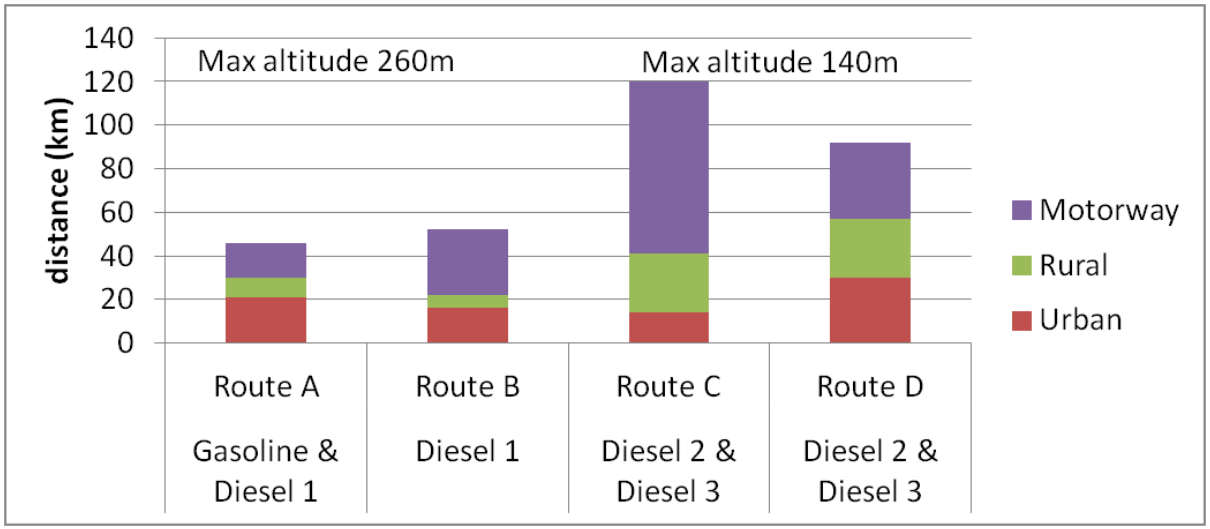
Test vehicles

- Normal production vehicles taken from the EU market.
- Tested ‘as received’ after checks for no faults / OBD flags.

Vehicle	Engine size (litres)	Power (kw)	Euro standard	Engine technology	Emissions control technology	Transmission	Mileage at start of testing (km)
Gasoline	1.8	125	Euro 5b	Gasoline PFI+DI	Three-way catalyst (TWC)	6-speed manual	4 000
Diesel 1	3.0	180	Euro 6b	Turbocharged DI Diesel	DOC + DPF + LNT + urea-SCR	8-speed automatic	22 900
Diesel 2	2.0	103	Euro 6b	Turbocharged DI Diesel	DOC + DPF + urea-SCR	6-speed manual	13 500
Diesel 3	2.1	125	Euro 6b	Turbocharged DI Diesel	High pressure EGR + DOC + DPF + Low pressure EGR	7-speed semi-auto	11 000

Test cycles/routes

- Chassis dyno cycles
  - All tests were run in triplicate.
  - WLTC tests used the 4-phase test for Class 3b vehicles (power to mass ratio >34 W/kg and v_{max} >120km/h)
  - CADC test were sampled and measured over the full cycle
- RDE – PEMS Routes



  - U/R/M shares based on RDE discussions at time of testing.

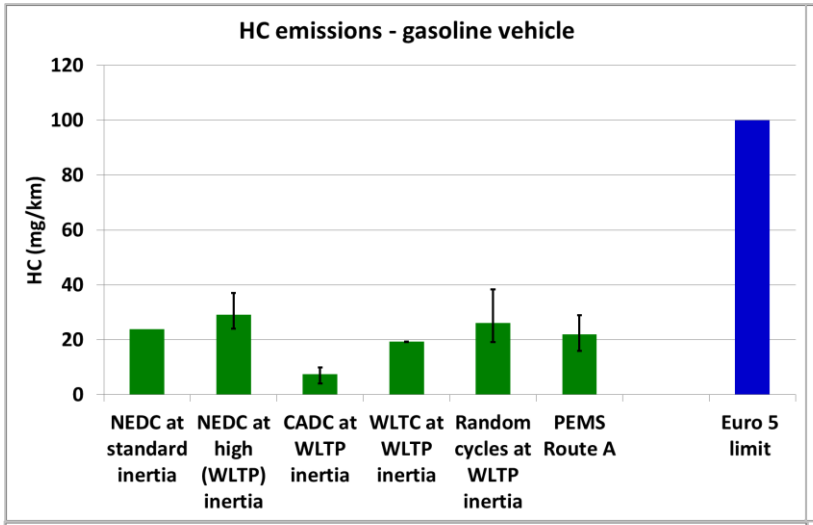
Chassis dyno inertia masses

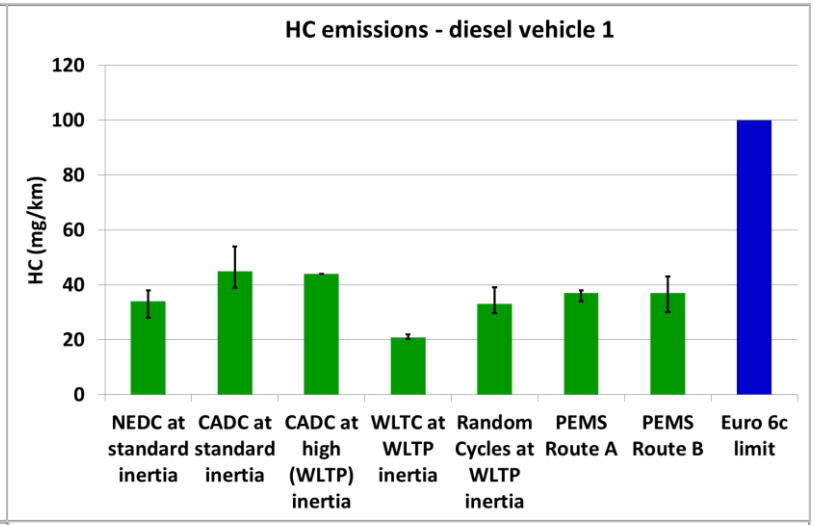
- WLTP introduces new requirements for road load determination and inertia setting, resulting in settings that differ from those for NEDC.
- For the first vehicle, all tests were run at the new (WLTP) inertia. In the light of experience this was modified for subsequent tests, as shown below.

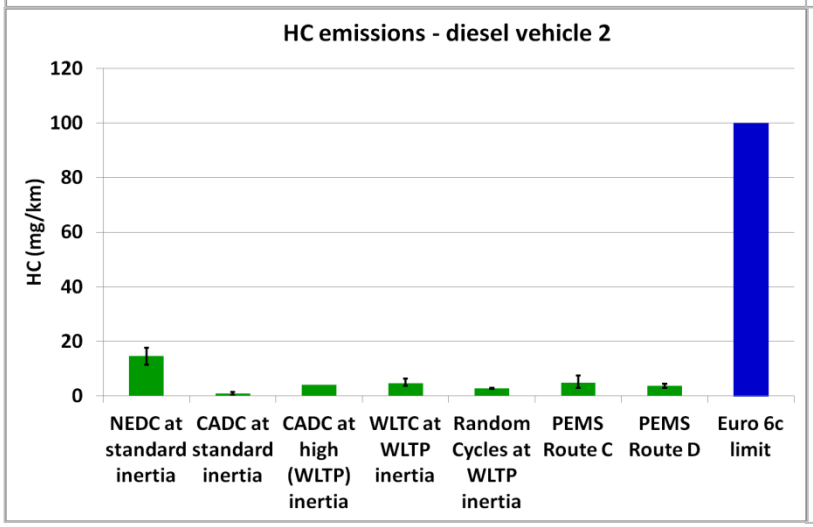
	NEDC inertia (kg)	WLTP inertia (kg)	Inertia used for tests				
			NEDC tests	CADC tests	WLTC tests	Random Cycles	Other
Gasoline vehicle	1590	1930	WLTP	WLTP	WLTP	WLTP	Extra NEDC at NEDC inertia
Diesel vehicle 1	2150	2460	NEDC	NEDC	WLTP	WLTP	Extra CADC at WLTP inertia
Diesel vehicle 2	1700	1810					
Diesel vehicle 3	1470	1590					

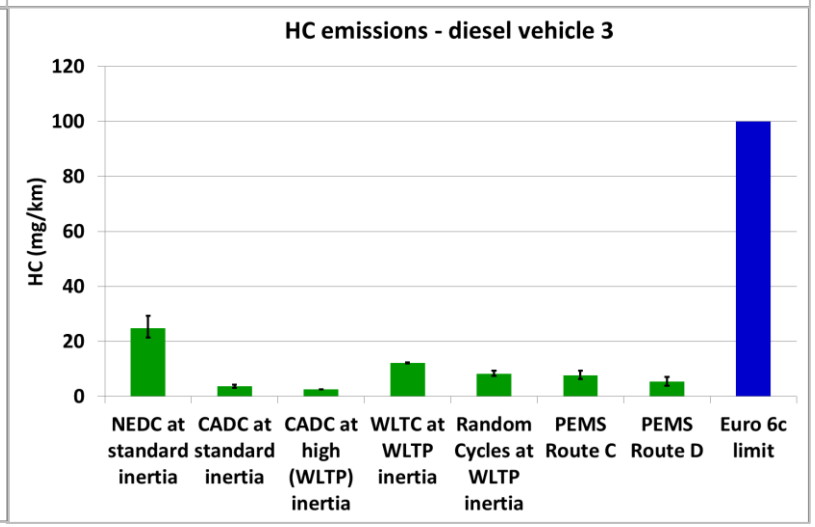
HC emissions

- HC emissions all well within the legislative limits



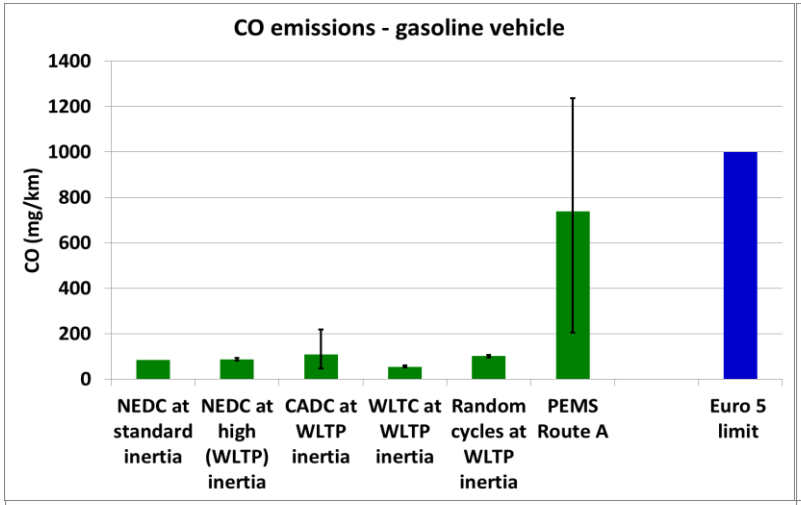


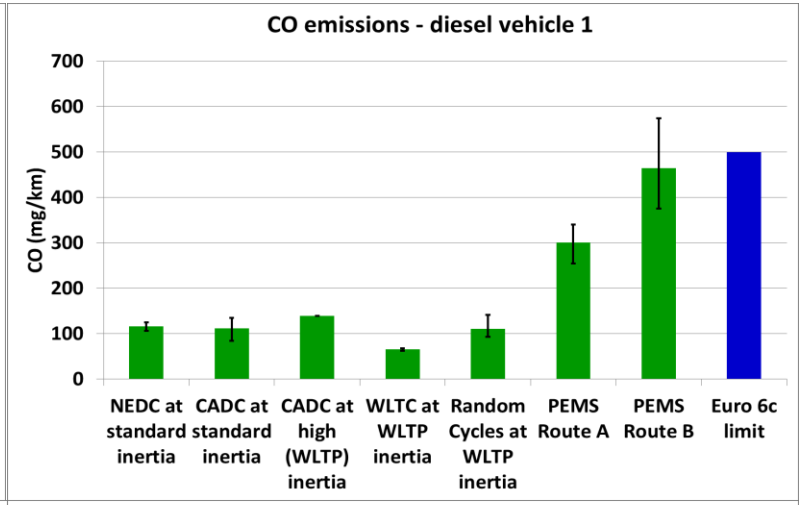


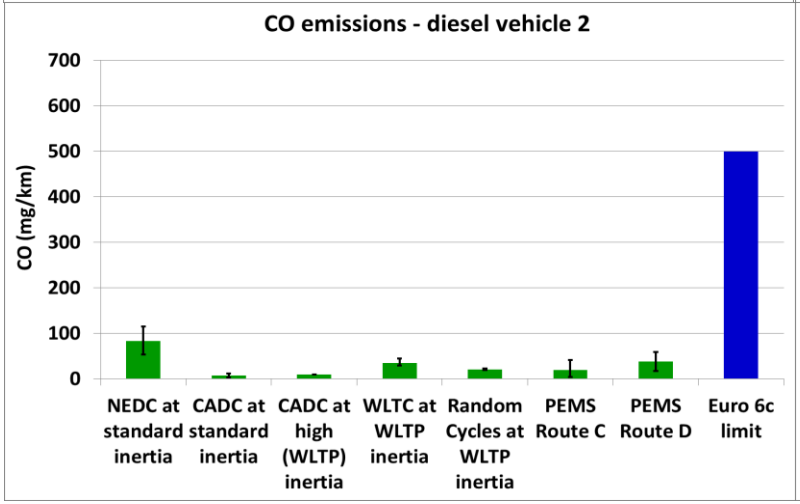


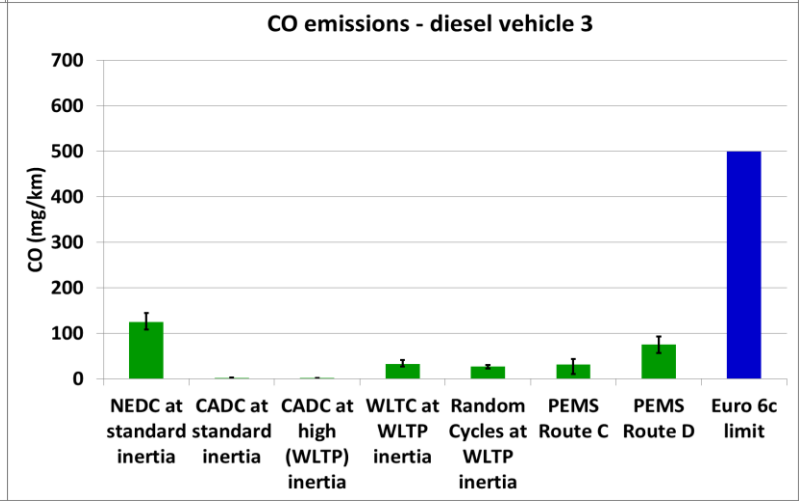
CO emissions

- Average CO emissions all within legislative limits
- PEMS CO emissions varied considerably for the gasoline car.







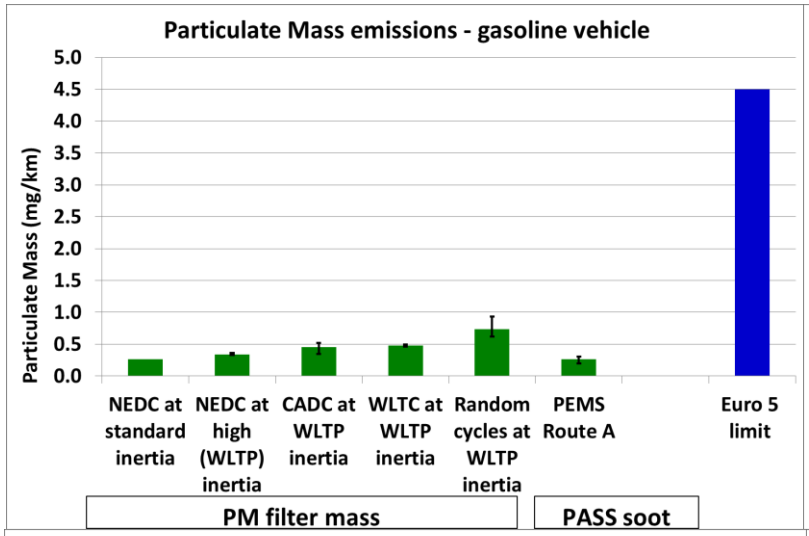


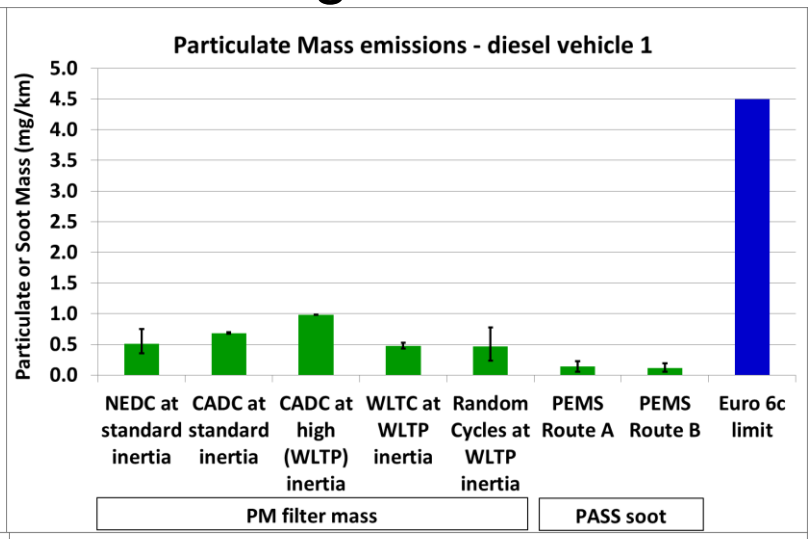
PEMS PM and PN measurements

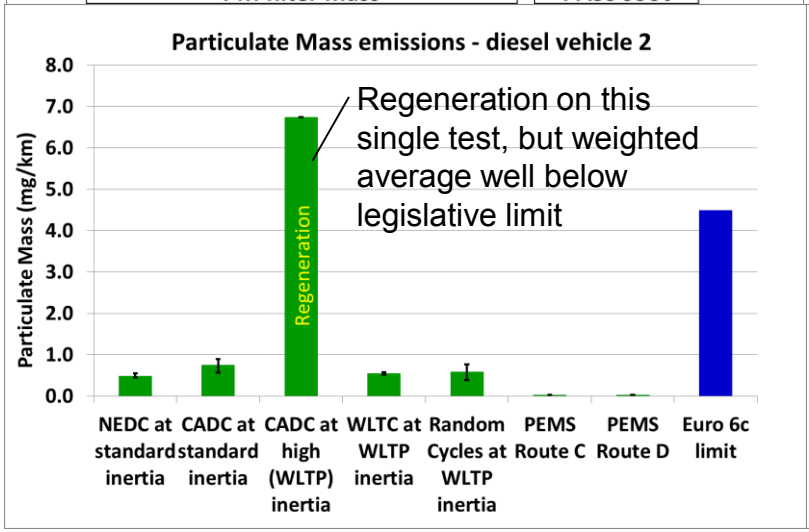
- Gasoline vehicle and Diesel 1:
  - Photoacoustic PEMS PM sensor
    - measures the soot content of PM, so lower mass than filter .
  - No PEMS PN equipment available at this time.
- Diesels 2 & 3:
  - Filter-based PM system.
    - collection and removal of volatiles over long RDE test leads to low g/km figure (collected mass on filter stabilises).
  - Particle mobility-based PN system, 23 nm cut-off.
    - Lack of Volatile Particle Remover (VPR) can result in slightly higher results than PMP esp. during regenerations.

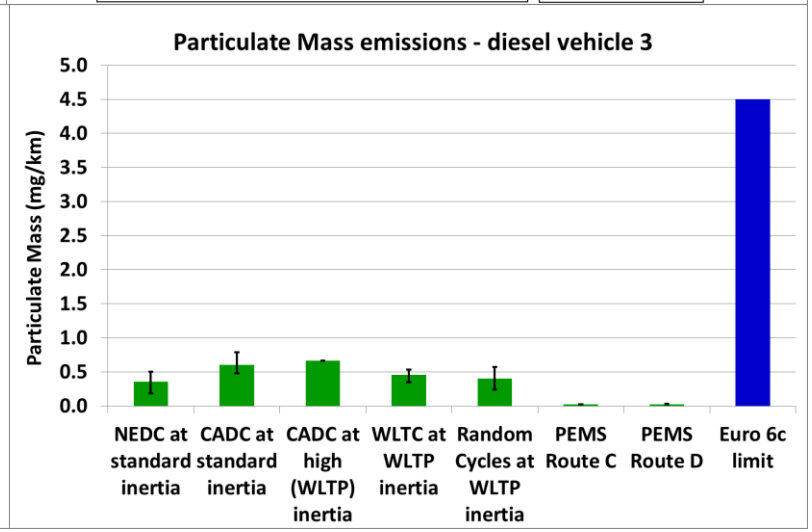
Particulate Mass (PM) emissions

- PM emissions all well within the legislative limits

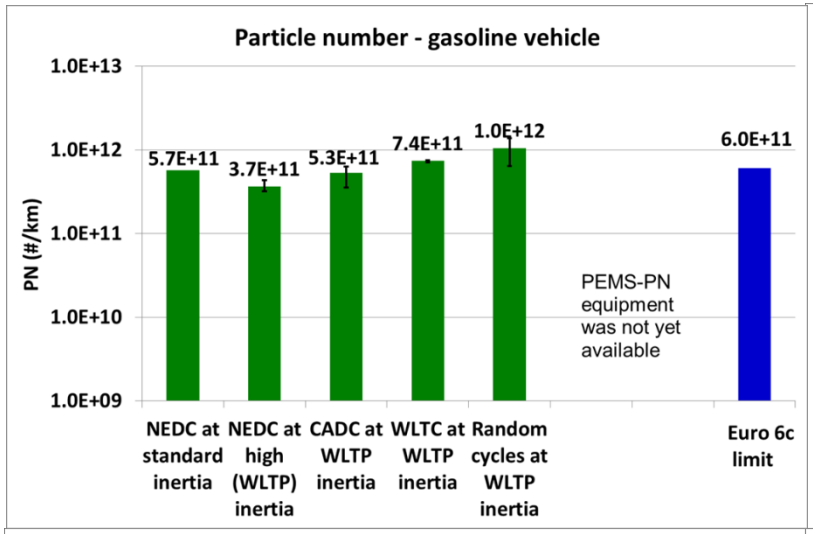


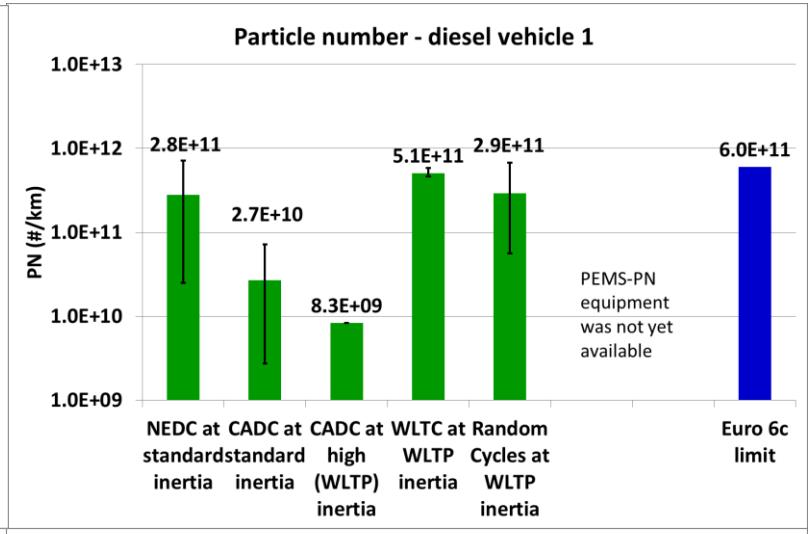


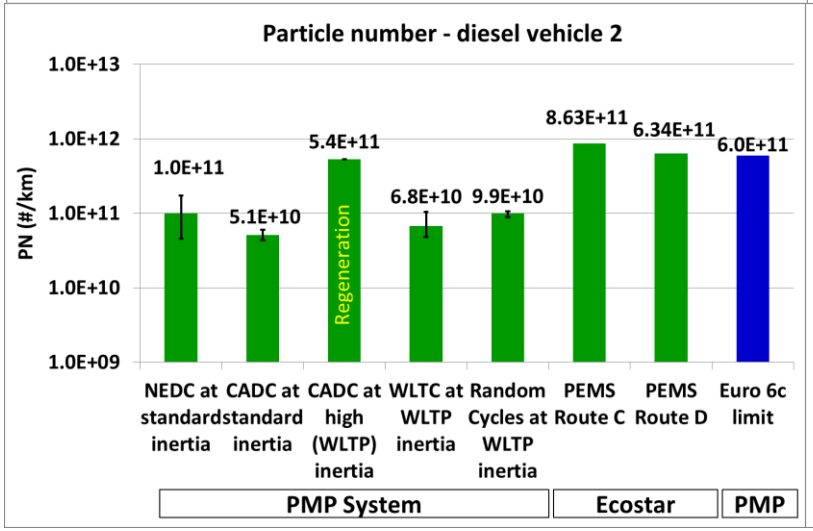


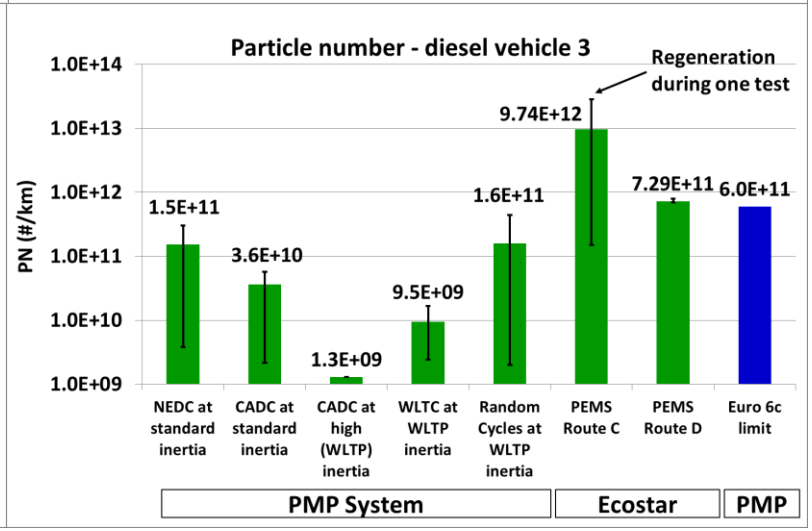


Particle Number (PN) emissions

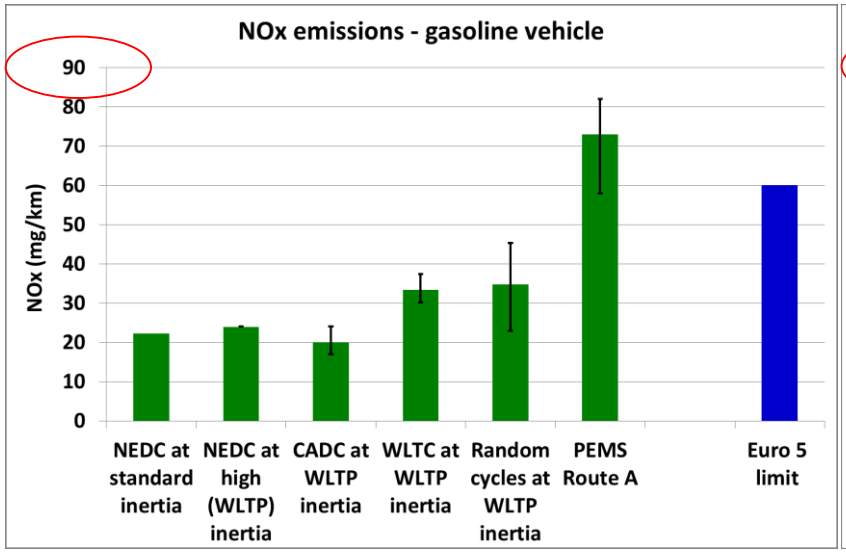


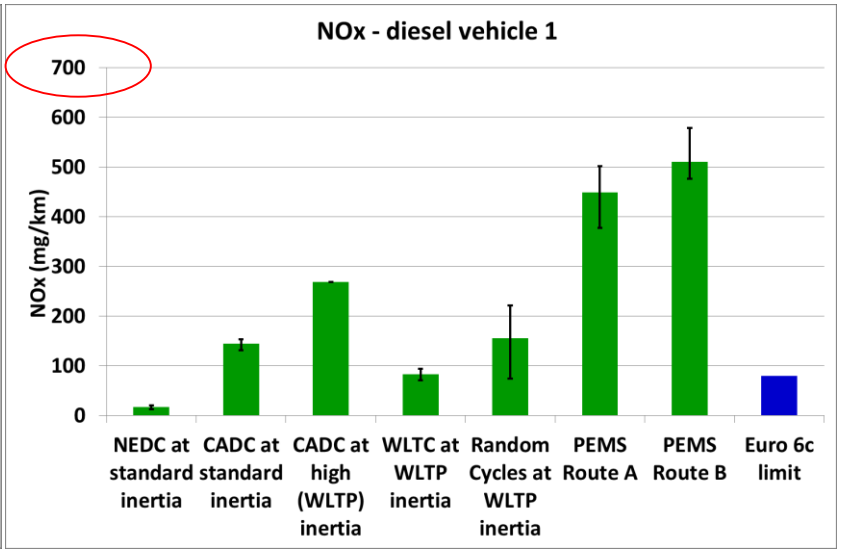


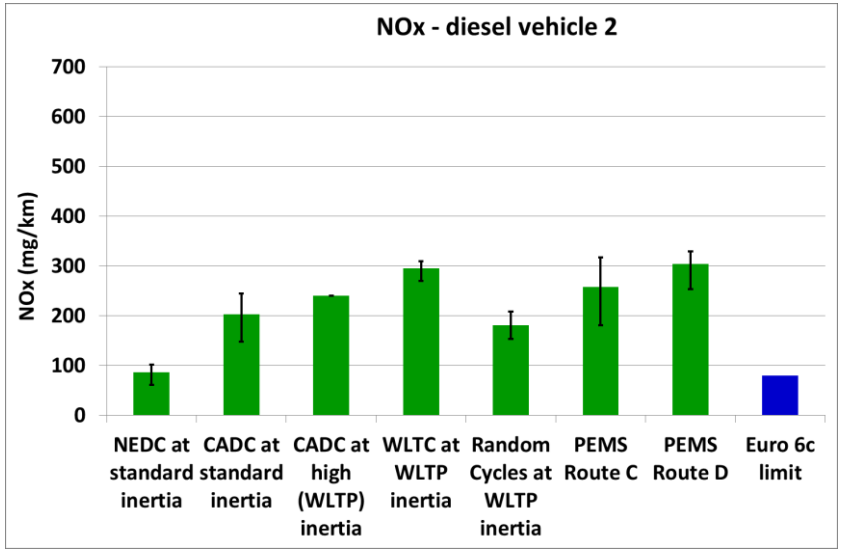


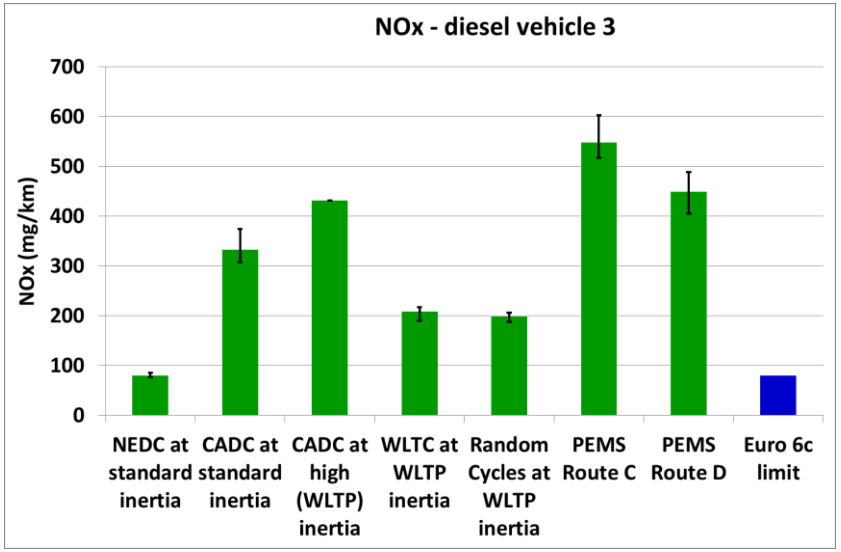


NOx emissions



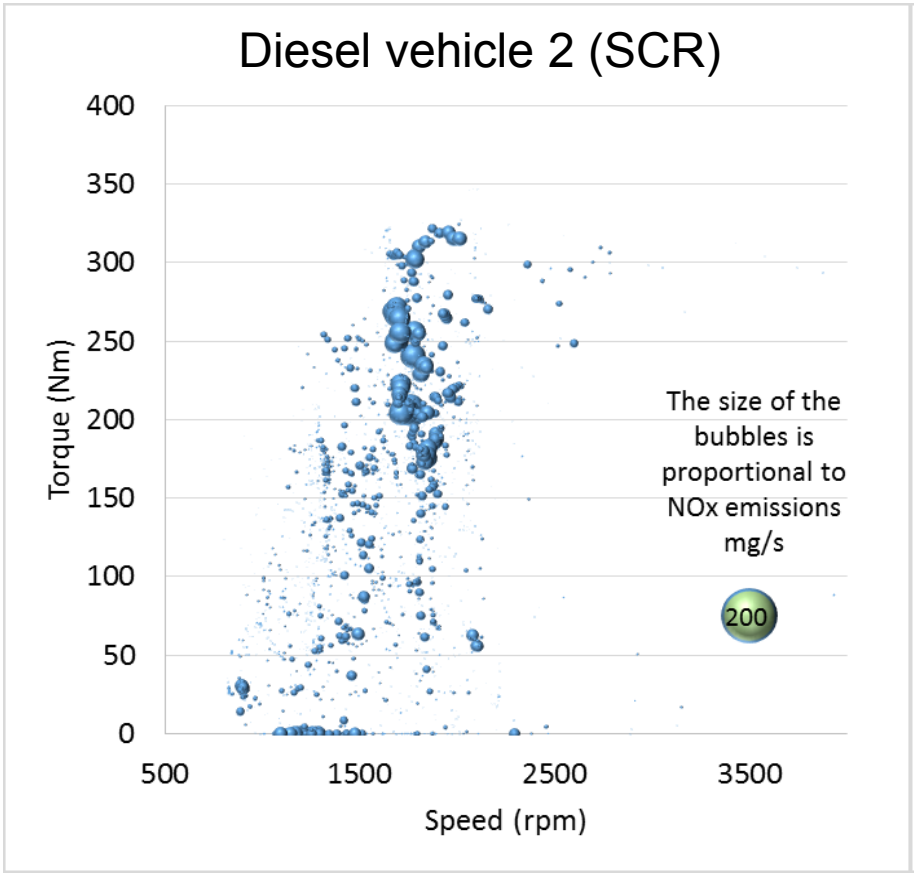


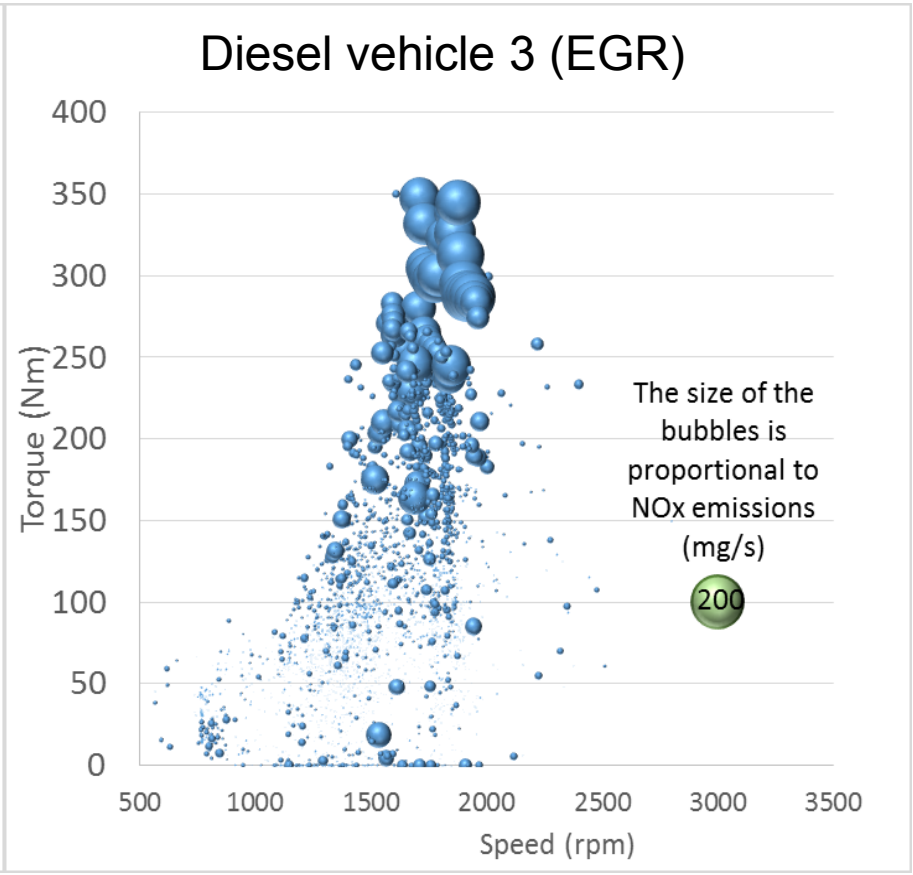




PEMS NOx evaluation

- Data available on instantaneous & total mass, g/km etc.
- Simple ‘bubble charts show max. NOx at high loads.



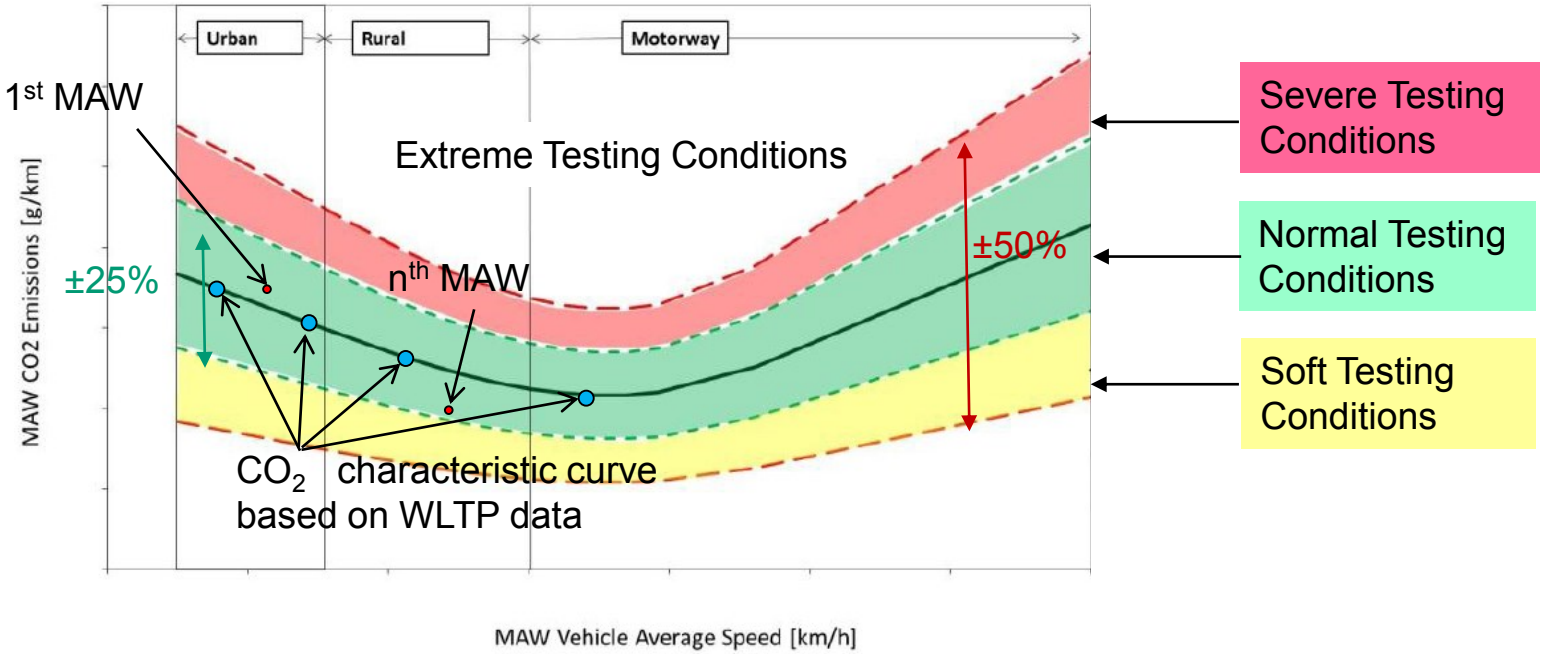


PEMS data analysis methods

- Legislative process aims to limit extremes and focus on ‘typical’ driving.
- Draft Regulation has 2 alternative methods for legislative PEMS data analysis:
  - EMROAD developed by DG-JRC.
    - CO_2-based Moving Average Windows (MAW).
  - CLEAR developed by TU Graz.
    - ‘power binning’ (frequency distribution).

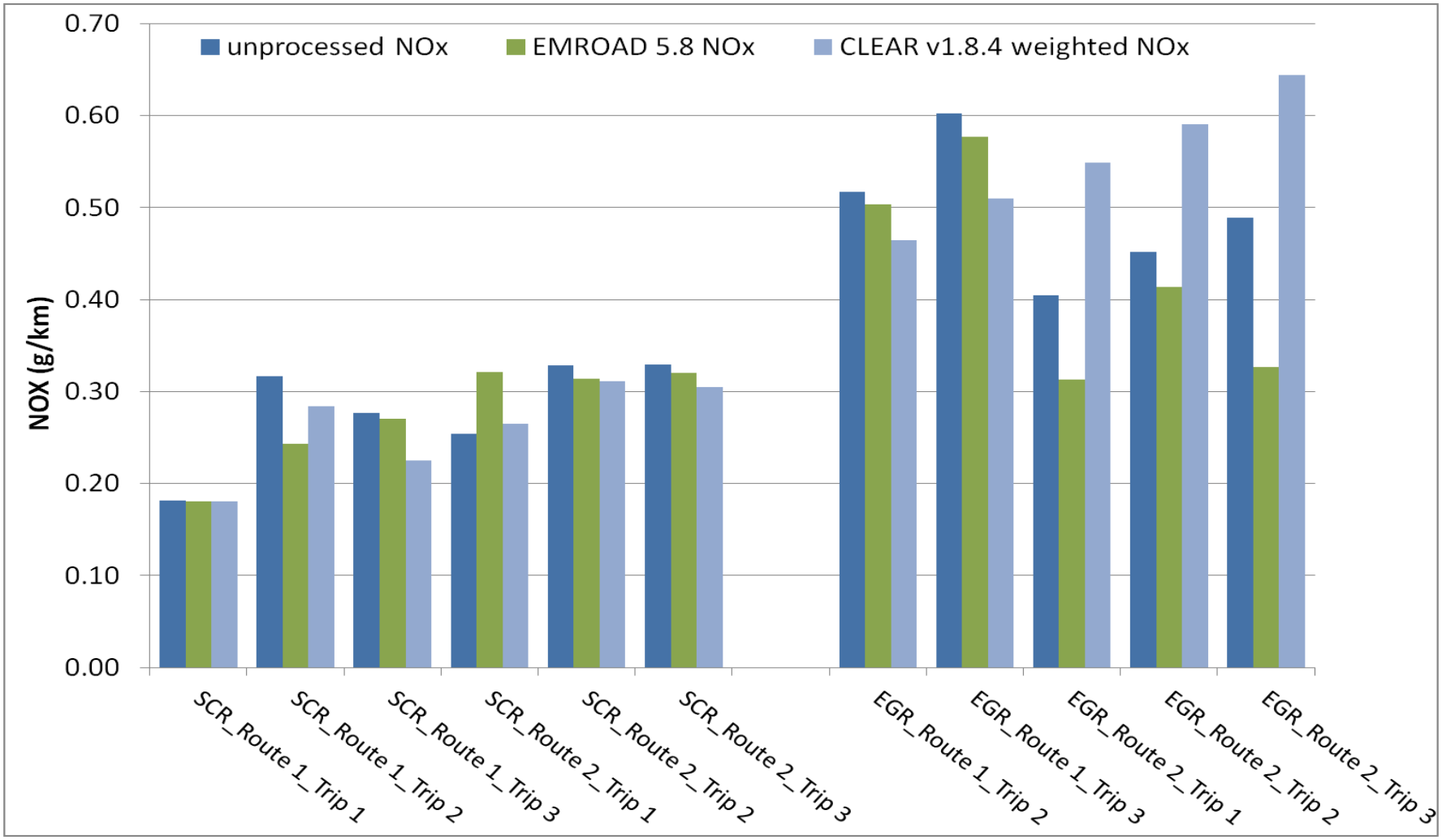
EMROAD analysis of PEMS data

- Each MAW is classified as ‘normal’, ‘severe’, ‘soft’ or ‘extreme’ driving by comparison with characteristic curve based on WLTP CO_2 data.
- Also classified by speed as urban, rural or motorway driving.



- Min. 50% of Urban, Rural, Motorway windows must be in normal band.
- Must be >15% of windows for each section out of the total.
- Uses all windows in ±25% band + weighted windows in 25-50% bands.

Comparison of evaluations



Diesel vehicle 2 **Diesel vehicle 3**

Association for Emissions Control by Catalyst AISBL

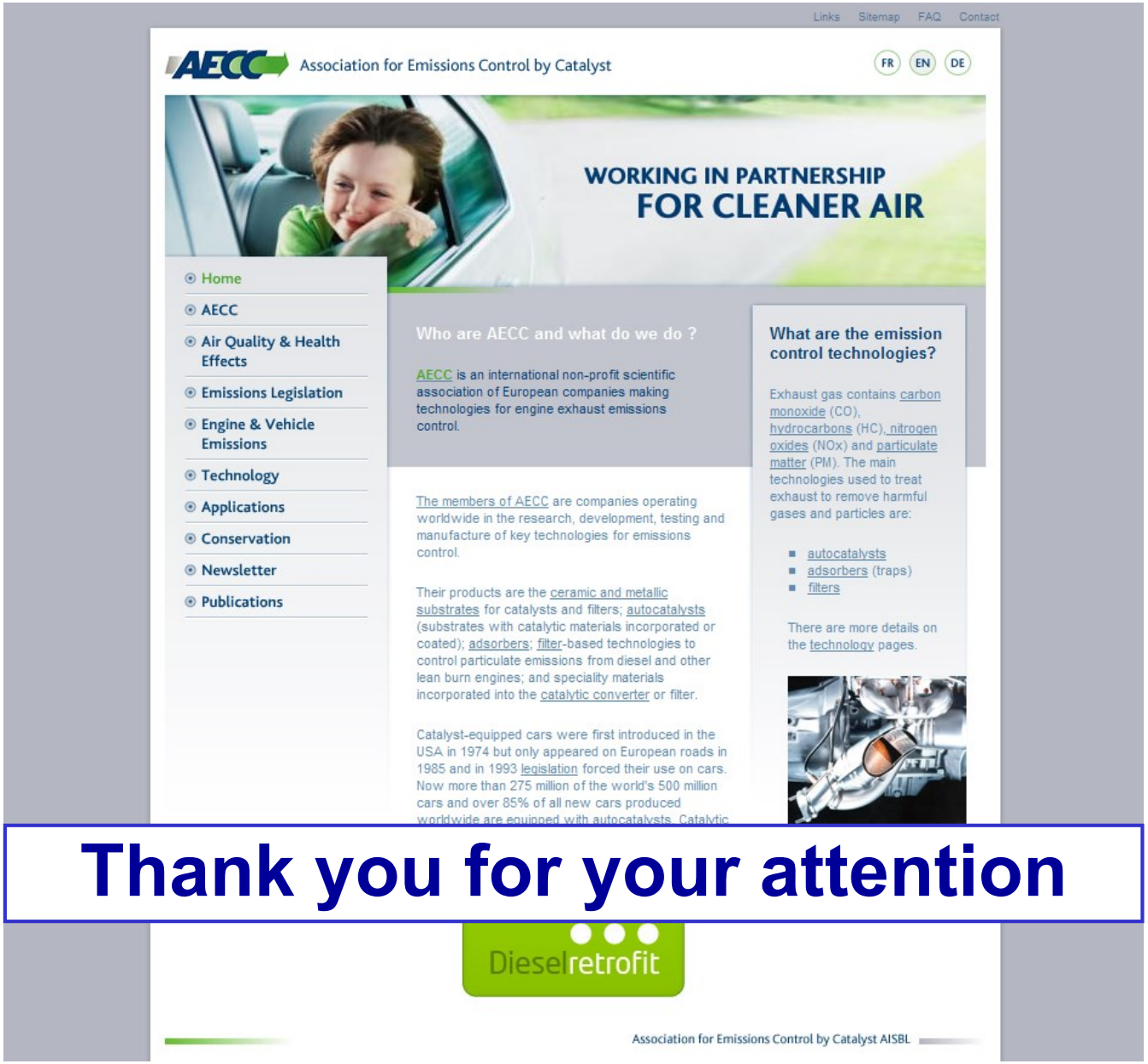
RDE Introduction

Note: details of the RDE Regulation remain subject to change.

- First adoption: RDE test procedure for CO, NOx, CO_2
  - Vote in TCMV expected in next months
  - RDE monitoring required from date of adoption.
- Package 2: Adoption of NOx & PN Conformity Factors
  - Probably 2nd half of 2015
  - Applicable from September 2017 (new types) / 2018 (all) [TBC]
  - 2 steps of Conformity Factors
- 3rd package: PN procedure
  - expected to be adopted by end 2015
- 4th package: RDE In-Service Conformity Provisions
  - Early 2017.
  - Also WLTP expected to be introduced in 2017, but with period of overlap with NEDC for Type Approval.

Summary

- ‘Real world’ emissions need to be well controlled to allow EU Member States to meet air quality legislation.
- Tests of recent vehicles show that ‘real driving’ emissions can be significantly higher than in Type Approval tests.
- The EC is proposing a new ‘Real Driving Emissions’ (RDE) test using Portable Emissions Measurement Systems.
- The two proposed RDE data evaluation methods can give significantly different results. A single method is preferred.
- Meeting the expected RDE requirements will need more comprehensive calibration and system strategies.



Thank you for your attention