Advanced Conventional Fuels and Vehicles

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Fuels quality and Emissions

ADVANCED CONVENTIONAL FUELS AND VEHICLES

- **Progress in EU fuel specifications**
- **Recent CONCAWE data on exhaust emissions with advanced vehicles and fuels**
  - **Gasoline**
  - **LD Diesel**
  - **HD Diesel**
- **Conclusions/Outlook**

MAJOR PROGRESS IN EU FUELS QUALITY

Year			1993	1995	1996	2000	2005	2009
Gasoline Unleaded 95/85			**EN228**					
Sulphur	ppm m/m	**max**	**1000**	**500**		**150**	**50/10**	**10**
Benzene	% v/v	**max**	**5**			**1**		
Aromatics	% v/v	**max**				**42**	**35**	
Olefins	% v/v	**max**				**18**		
Oxygen	% m/m	**max**	**2.5**[(1)]			**2.7**		
RVP (summer)	kPa	**max**	**up to 80**			**60**[(2)]		
E100	% v/v	**min**	**40(s)/43(w)**			**46**		
FBP	ºC	**max**	**215**			**210**		
Year			**1993**	**1995**	**1996**	**2000**	**2005**	**2009**
Diesel (standard grade)			**EN590**					
CI		**min**	**46**					
CN		**min**	**49**			**51**		
Sulphur	ppm m/m	**max**	**2000**		**500**	**350**	**50/10**	**10**[(3)]
Density	kg/m^3	**min**	**820**					
		max	**860**			**845**		
T95	deg C	**max**	**370**			**360**		
PAH	% m/m	**max**				**11**		
Lubricity	µm @ 60ºC	**max**			**460**			

(1) Up to 3.7% at Member State discretion. Individual limits apply to specific compounds

(2) 70 kPa max allowed in Member States with arctic or severe winter conditions

(3) End date for full introduction of 10 mg/kg S max diesel remains subject to further review

➢ **Enables introduction of wide range of advanced engine / after-treatment systems to achieve low emissions**

EU MOST ADVANCED ON FUELS QUALITY

CLE(1)			EU '09	US Fed '06	Japan '04	China	India	Brazil	RSA	NZ	WB '05 (4)
GASOLINE											
Sulphur	ppm m/m	max	10	30	50	1000	1000	1000	1000	500	400
Benzene	% v/v	max	1	1	1	2.5	5	1.5	_	5	2.5
Aromatics	% v/v	max	35	(5)	_	40		45	_	26-48	45
Olefins	% v/v	max	18	(5)	_	35		_	_	25	
Oxygen	% m/m	max	2.7	2<x<2.7	7 (2)	2.7	2.5	(3)		0.1	
DIESEL											
CI		min	46	40							
CN		min	51		50	45	48	42	45	49	
Sulphur	ppm m/m	max	10	15	50	10000	2500	2000	3000/500	3000	2000
Density	kg/m^3	min	820		_	_	820	820	800	820	
		max	845		_	_	870	870	_	860	
PAH	% m/m	max	11		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	

(1): CLE Current Legislation Enacted

(2): MTBE

(3): Gasohol specs

(4): World Bank recommendations

(5): US Fed: 'must meet requirements of complex model'

RECENT CONCAWE WORK ON EMISSIONS FROM ADVANCED ENGINES/VEHICLES

- Auto-Oil programmes were supported by EPEFE programme
  - Carried out 10 years ago on Euro 1-2 vehicles and engines

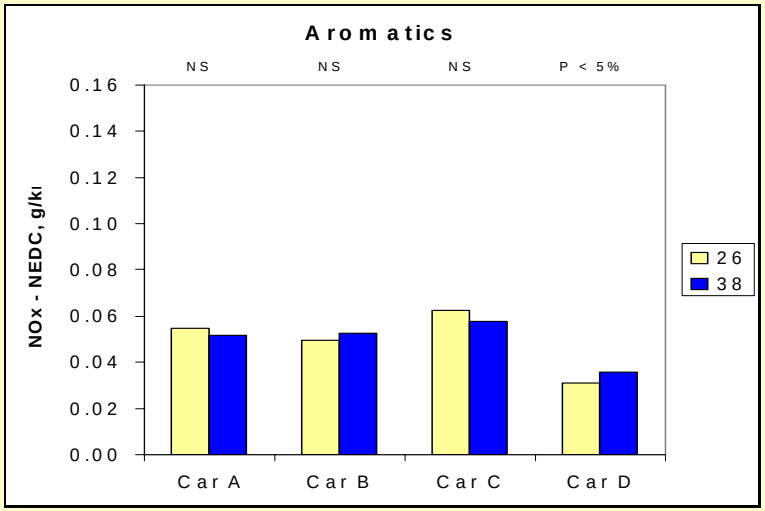
- To update knowledge, CONCAWE has continued to test new engines & vehicles as they enter/approach the market
  - Gasoline
  - LD Diesel
  - HD Diesel
  - Wide range of fuel qualities

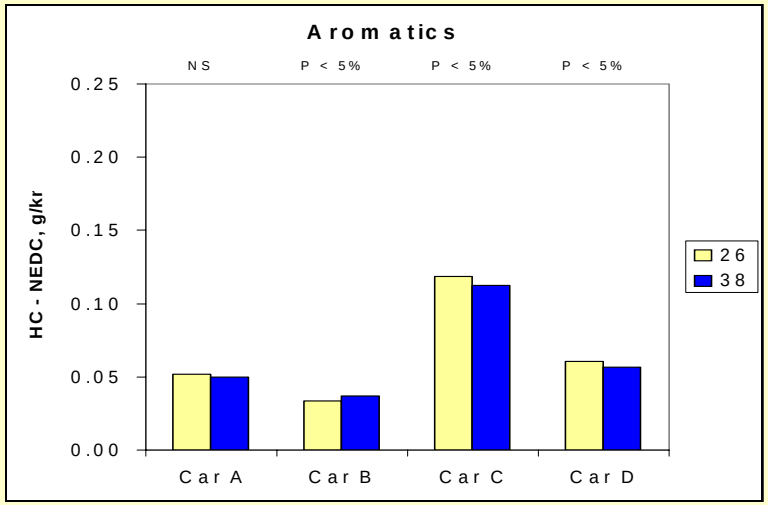
RECENT GASOLINE EMISSIONS WORK

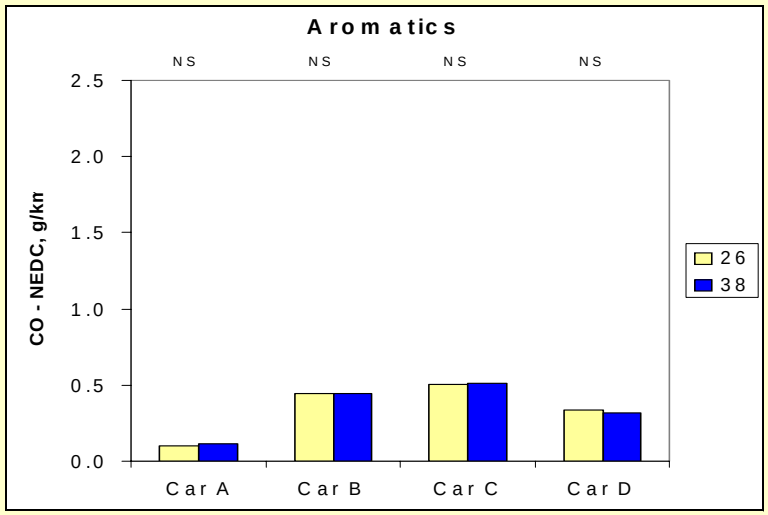
- Fuel effects on emissions evaluated with 4 advanced gasoline vehicles
  - 2 Euro-3 cars (A & C) and 2 Euro-4 cars (B & D)
    - Stoichiometric DI (Car A)
    - Advanced MPI (Car B)
    - 2 lean burn DIs (Cars C & D)
  - Fuel matrices : sulphur, aromatics, olefins, volatility and FBP
- Fuel effects were evaluated over a wide range of aromatics and olefins content, volatility and FBP, using a rigorous test protocol with multiple tests on each fuel/vehicle combination
- All 4 vehicles delivered very low NOx, HC and CO emissions
  - Only one Euro-3 car (C) exceeded Euro-4 limits on one emission (HC)

Reference: CONCAWE report 2/04

GASOLINE EFFECTS ON REGULATED EMISSIONS
EFFECT OF AROMATICS



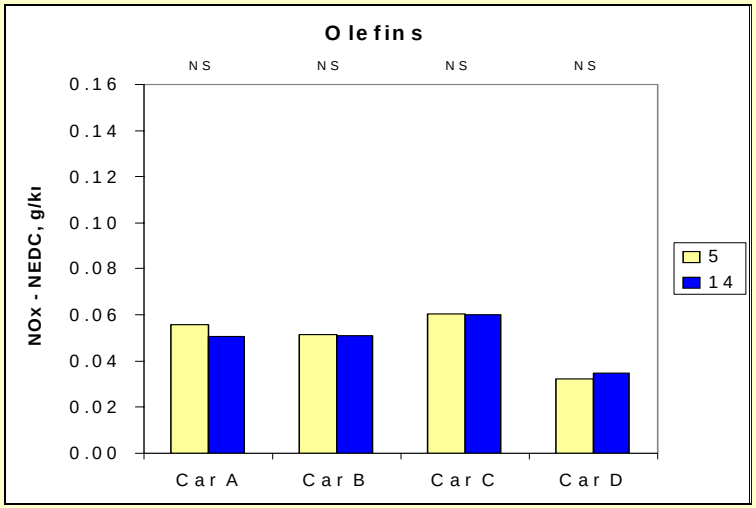


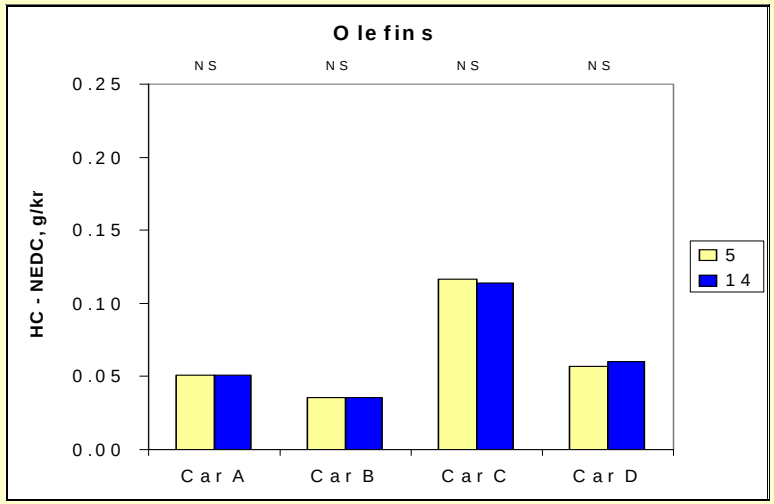


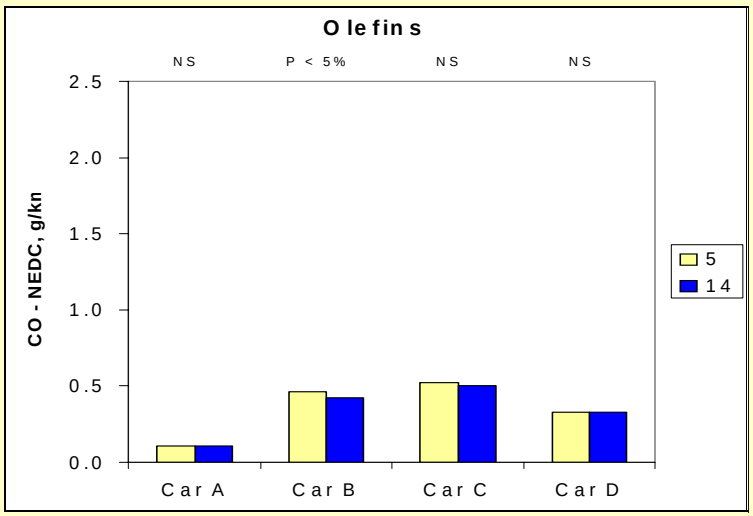
Euro-4 limits (g/km): CO 1.0, HC 0.10, NOx 0.08

- **Effects of reducing aromatics were small:**
  - Conflicting trends on NOx emissions
  - Increased HC emissions in the DI cars but decreased in the MPI car
  - No significant effects on CO

GASOLINE EFFECTS ON REGULATED EMISSIONS
EFFECT OF OLEFINS



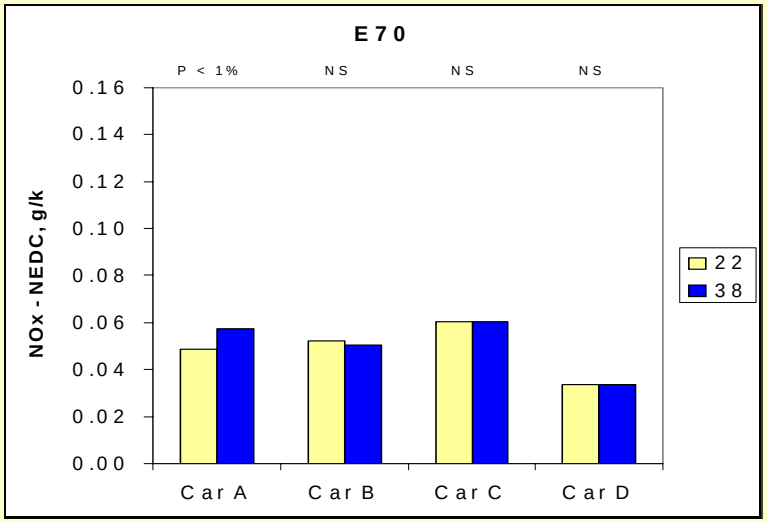


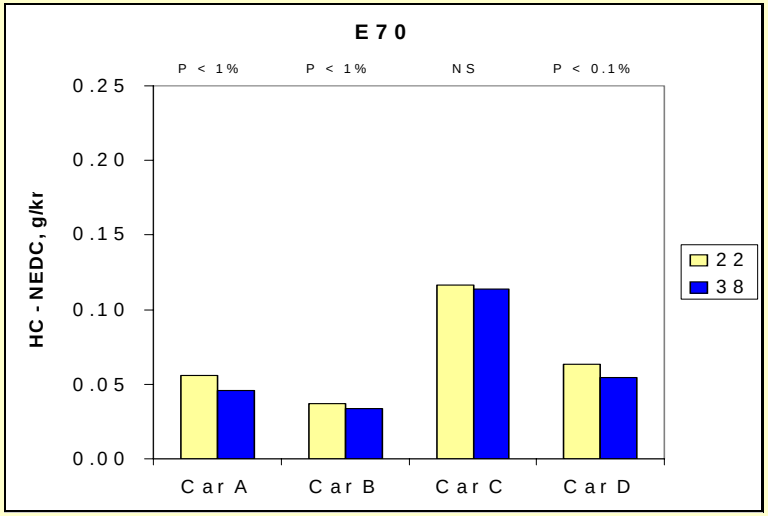


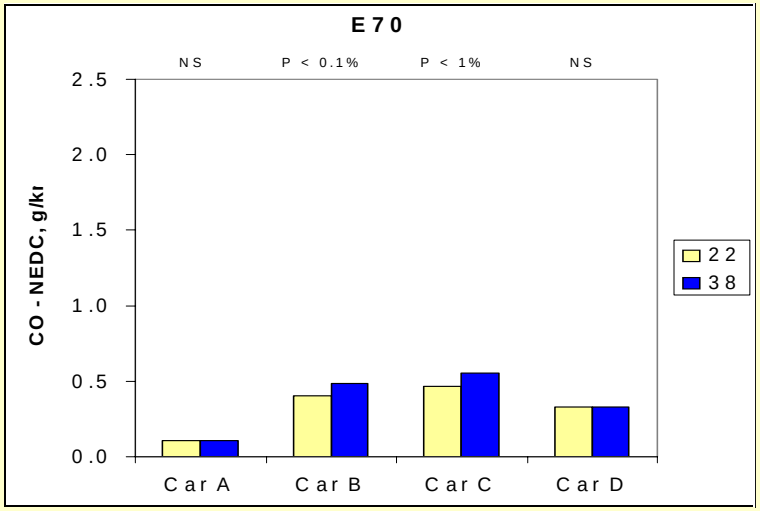
Euro-4 limits (g/km): CO 1.0, HC 0.10, NOx 0.08

- **Reducing olefins content gave no significant benefits on NOx, HC or CO emissions in any of the cars**

GASOLINE EFFECTS ON REGULATED EMISSIONS
EFFECT OF VOLATILITY (E70)



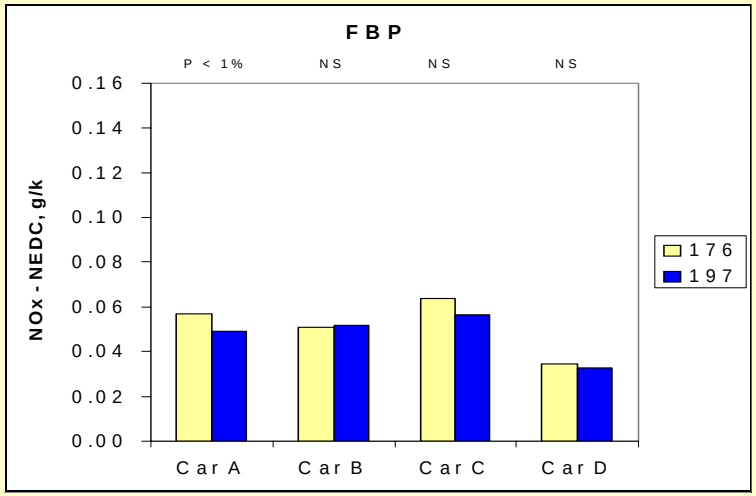


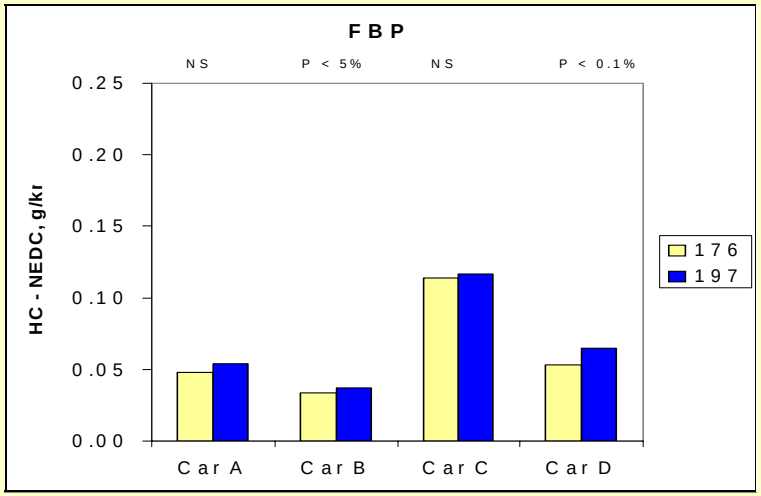


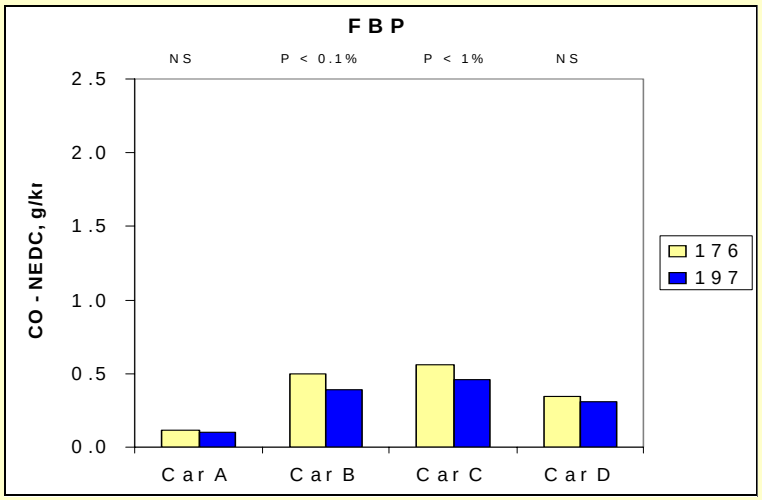
Euro-4 limits (g/km): CO 1.0, HC 0.10, NOx 0.08

- **Effects of reducing volatility were small:**
  - No consistent effect on NOx emissions
  - Increased HC emissions in all cars
  - Decreased CO emissions in 2 cars

GASOLINE EFFECTS ON REGULATED EMISSIONS
EFFECT OF FBP







Euro-4 limits (g/km): CO 1.0, HC 0.10, NOx 0.08

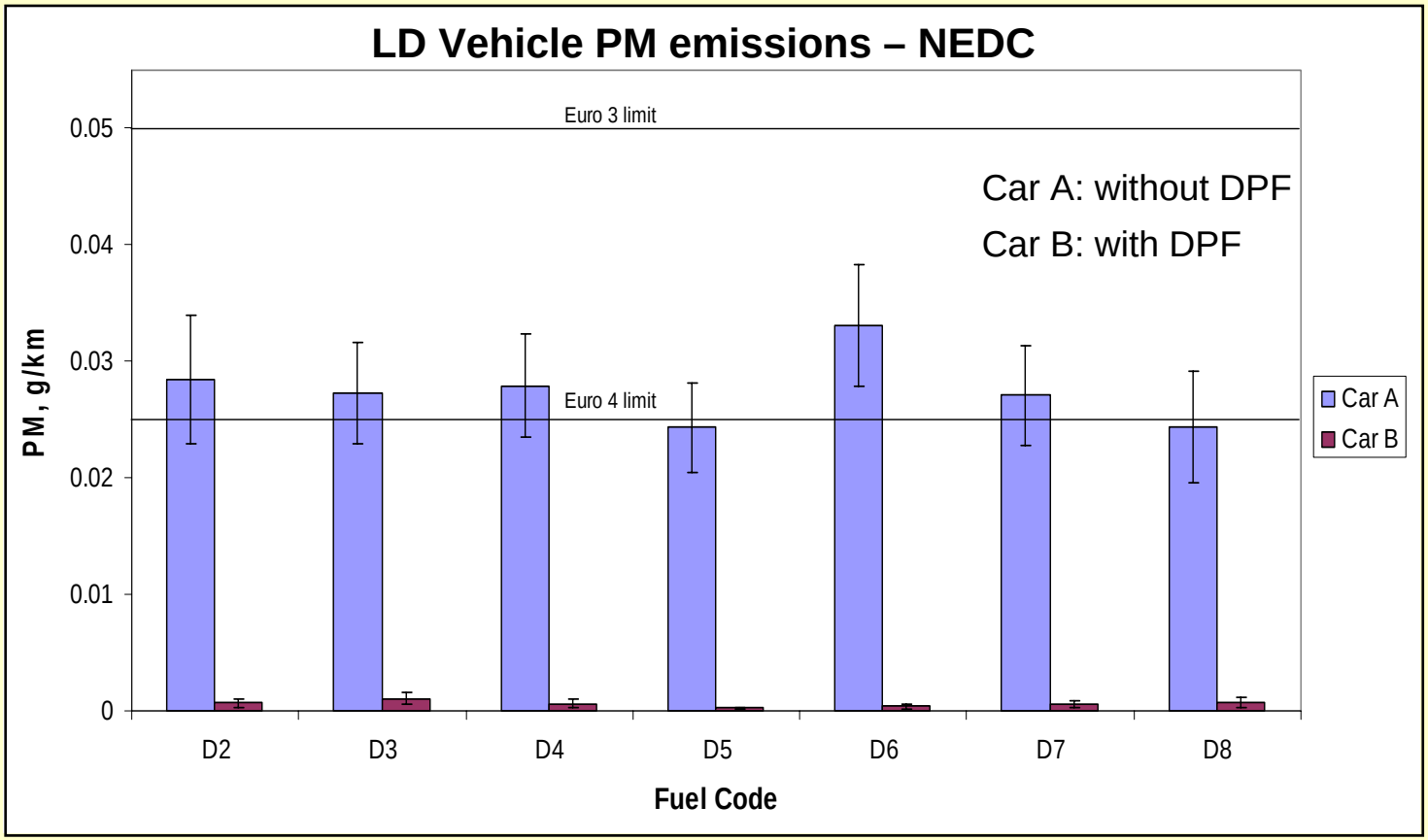
- **Effects of reducing FBP were small:**
  - Trend to decrease HC emissions but increase CO and NOx
  - Not all effects significant

DIESEL EMISSIONS

- Recent work included evaluation of a wide range of diesel fuel qualities in advanced LD vehicles and HD engines
  - In connection with the DG TREN Particulates Consortium
  - Advanced LD vehicles with and without DPF
  - Advanced HD engines: Euro-3, prototype Euro-4 and Euro-5

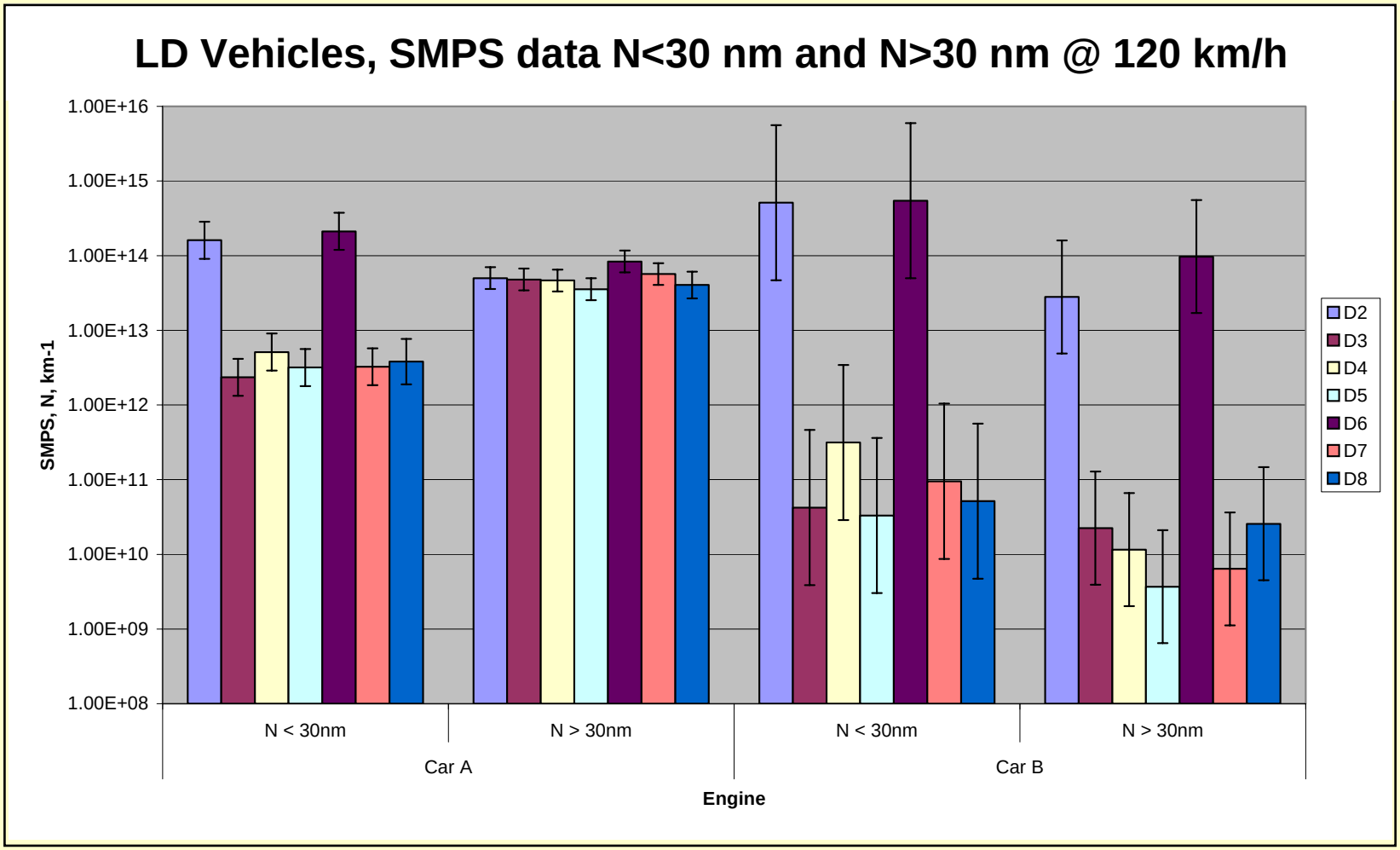
- Wide range of fuels
  - D2 EN 590 Diesel: 280 ppm S
  - D3 EN 590 Diesel: 38 ppm S
  - D4 EN 590 Diesel: 8 ppm S
  - D5 Swedish Class 1 Diesel
  - D6 Pre-2000 Diesel
  - D7 D4 + 5% RME
  - D8 Fischer-Tropsch Diesel

DIESEL PARTICULATE FILTERS: DRASTIC PM EMISSION REDUCTIONS



- DPFs with low sulphur fuels deliver very low PM emissions
  - No benefit from further changes to diesel fuel specifications

SULPHUR REDUCTION REDUCES NANO-PARTICLES



➢ **Low sulphur fuels with advanced after-treatment systems capable of delivering very low emissions**

CONCLUSIONS / OUTLOOK

- **Major efforts are underway to introduce sulphur-free fuels (10 mg/kg max S)**
- **EU 2005 specification sulphur-free fuels meet the needs of all advanced vehicle technologies that can be expected in the 2010 time-frame**
  - Advanced gasoline engines
    - Direct Injection, Variable Valve Actuation, Downsizing…
  - Improved diesel engines
    - Multiple high pressure injections, Exhaust gas recirculation…
  - Advanced after-treatment
    - Improved TWC, PM traps, lean NOx converters…
  - Hybrids
- **Very low emissions can be achieved by such advanced vehicle technologies in combination with sulphur-free fuels**
  - Changes to other fuel properties offer little or no additional Air Quality benefit, would increase CO_2 emissions and add to security of supply concerns, especially for diesel, where meeting the future demand is already a challenge
- **Novel combustion systems e.g. HCCI, CAI need more study**