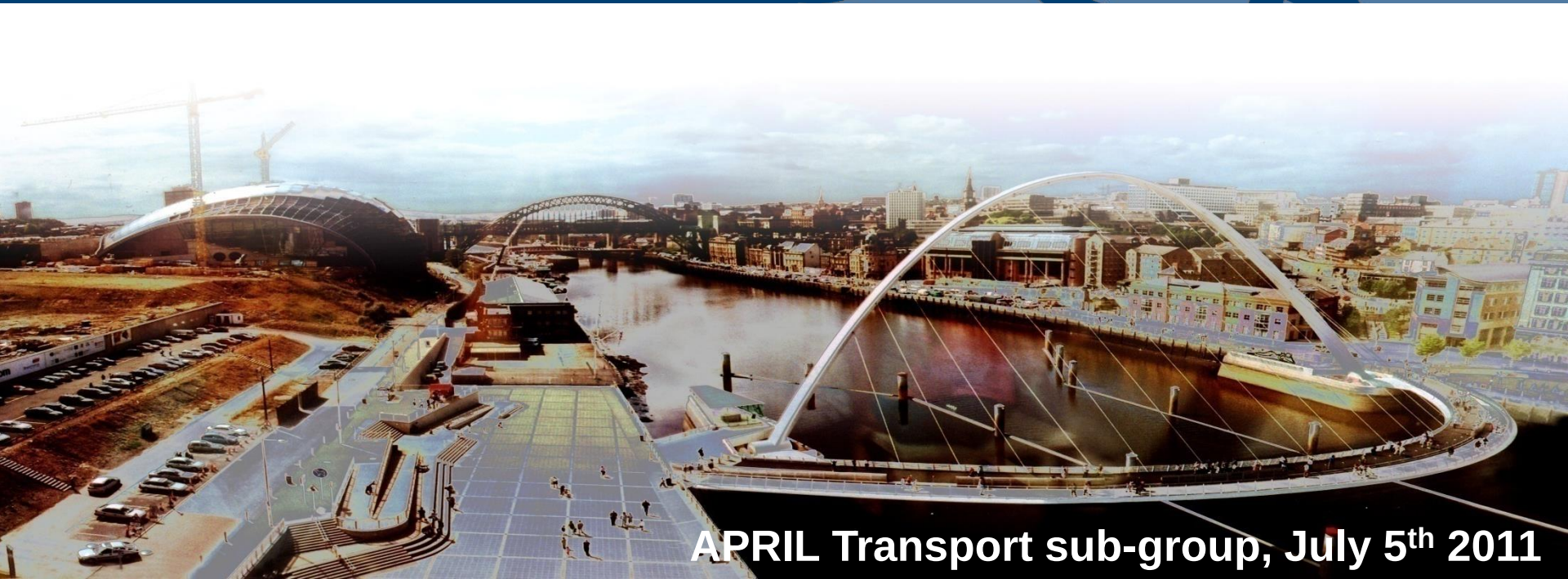
Quantifying pollutant emissions from the road vehicle fleet: Results from the 2008 remote sensing survey campaign in Ealing and Southwark

Glyn Rhys-Tyler
Transport Operations Research Group
Newcastle University



APRIL Transport sub-group, July 5th 2011

Research Motivation

Research motivation:

- There is surprisingly little hard data on ‘in-use’ emissions of the UK road vehicle fleet;
- Mainly because it is relatively difficult / expensive to collect;
- Vehicle emissions evolve with changes in technology, economy, behaviour, and law;
- Legal framework is not always consistent.

- Need evidence base for informed policy development

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Remote Sensing of Emissions

- Across road
  - CO, CO_2, HC, NO, Smoke (PM proxy)
  - NDIR, NDUV light absorption
  - Speed, Acceleration
  - Number Plate

Source: www.et.co.uk

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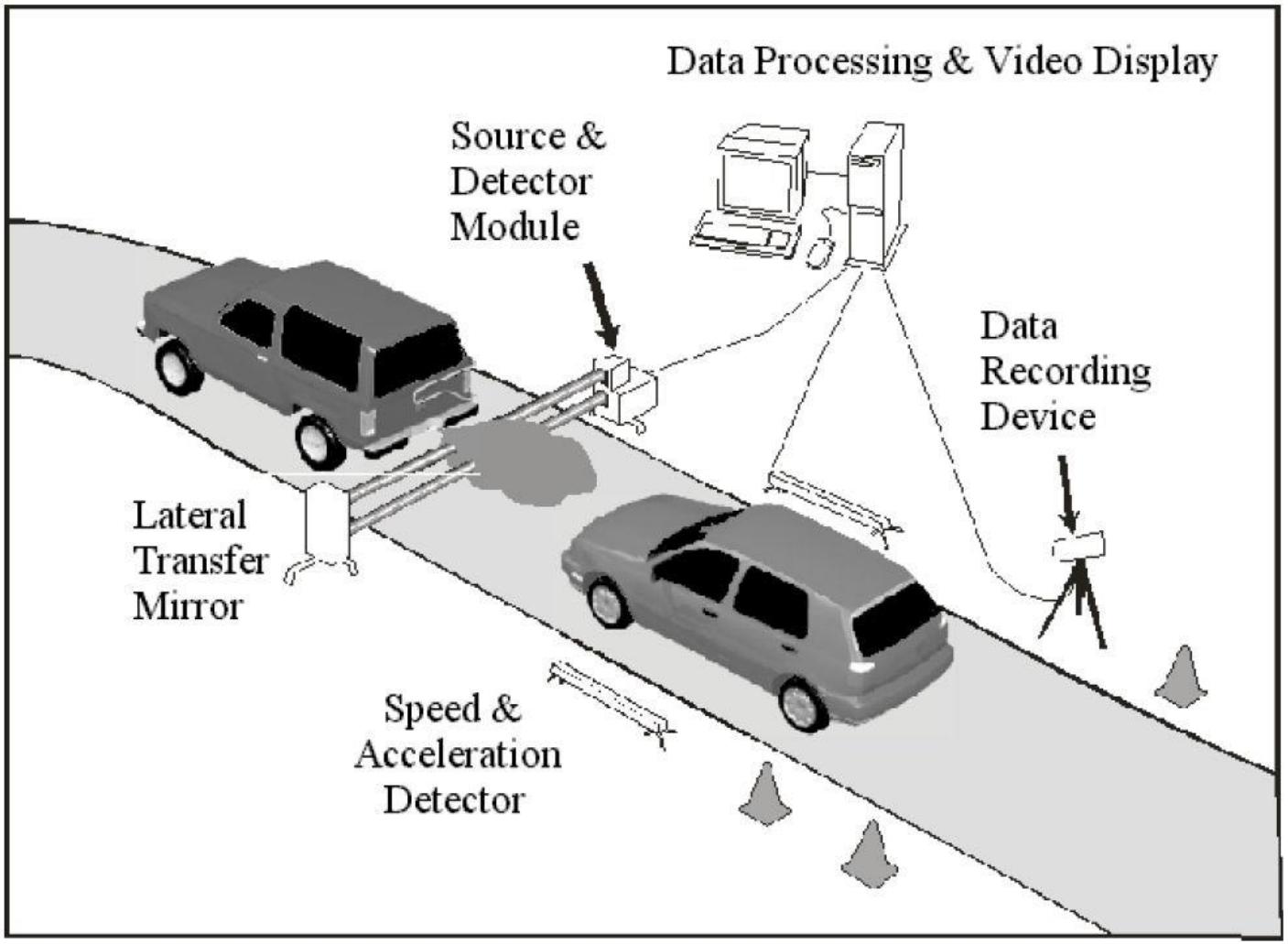
Remote Sensing of Emissions



Source: ESP / Southeast Michigan

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London Survey Summary

- 13 sites across Southwark and Ealing
- Ealing – March / April 2008
- Southwark – June, July, August 2008
- 29 usable survey days used in this analysis
- Circa 120,000 vehicle observations recorded
- Circa 55,000 measurements with successful gas (NO, CO, HC, Smoke) and ANPR measurements
- Mean speeds in the range 21kph – 37kph
- Mostly +ve gradients, mean accelerations all +ve
- Mean temperatures 5.8ºC – 27ºC

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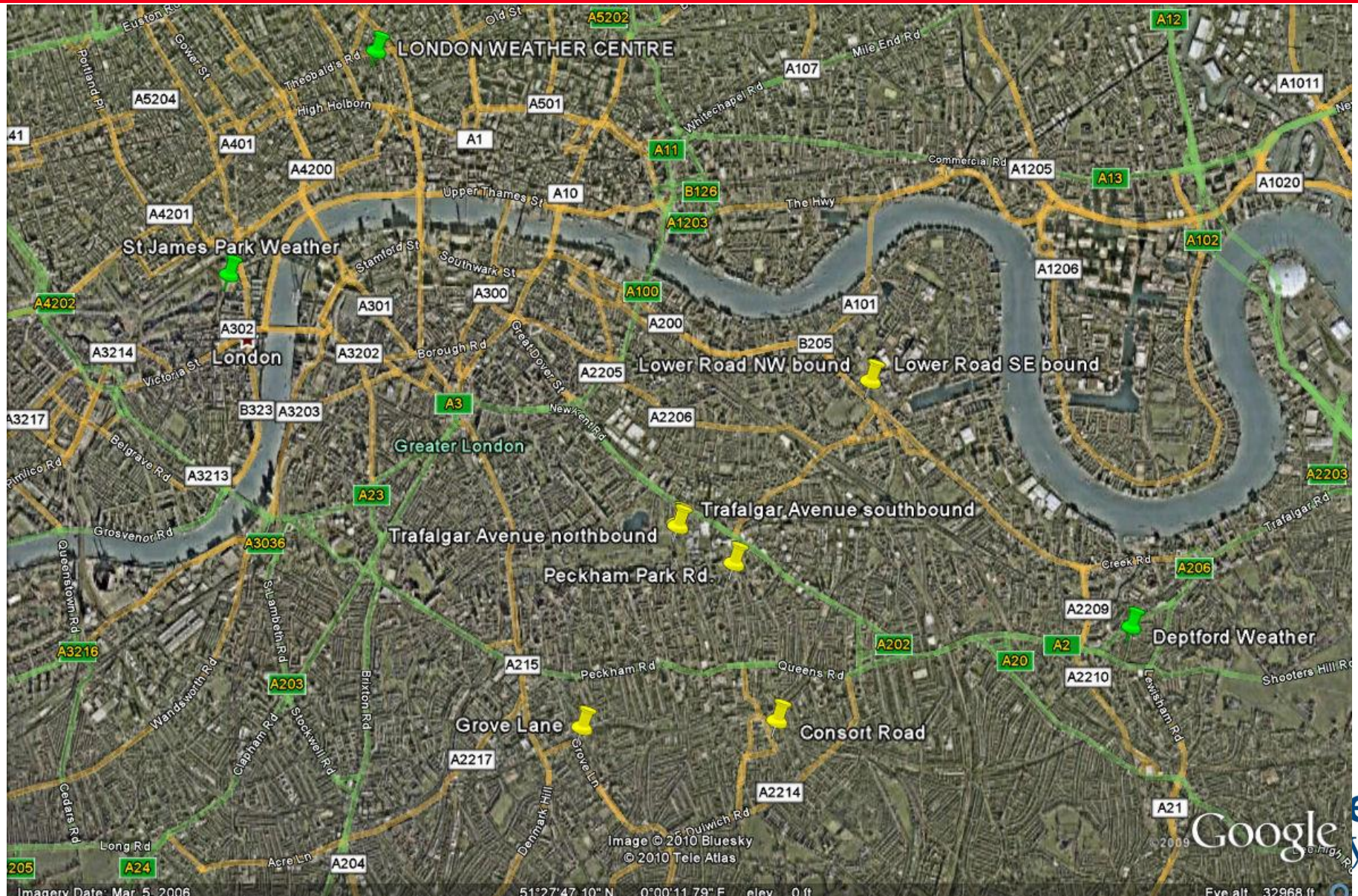
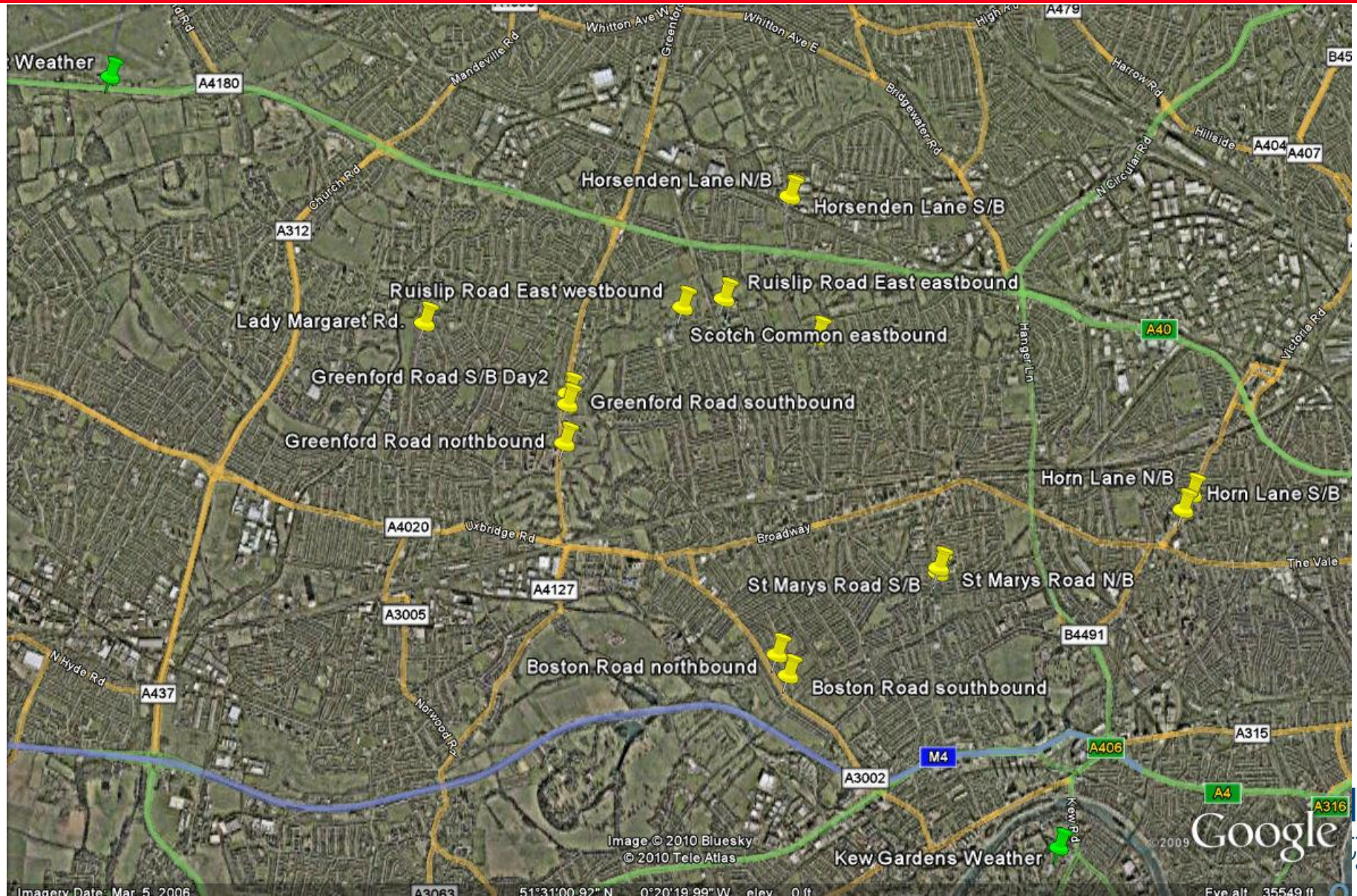
Remote Sensing in Southwark



Remote Sensing in Ealing



Oldest Vehicle Observed – 1930 Austin Seven

.....8.2 litre Dodge Viper

ANPR Limitations

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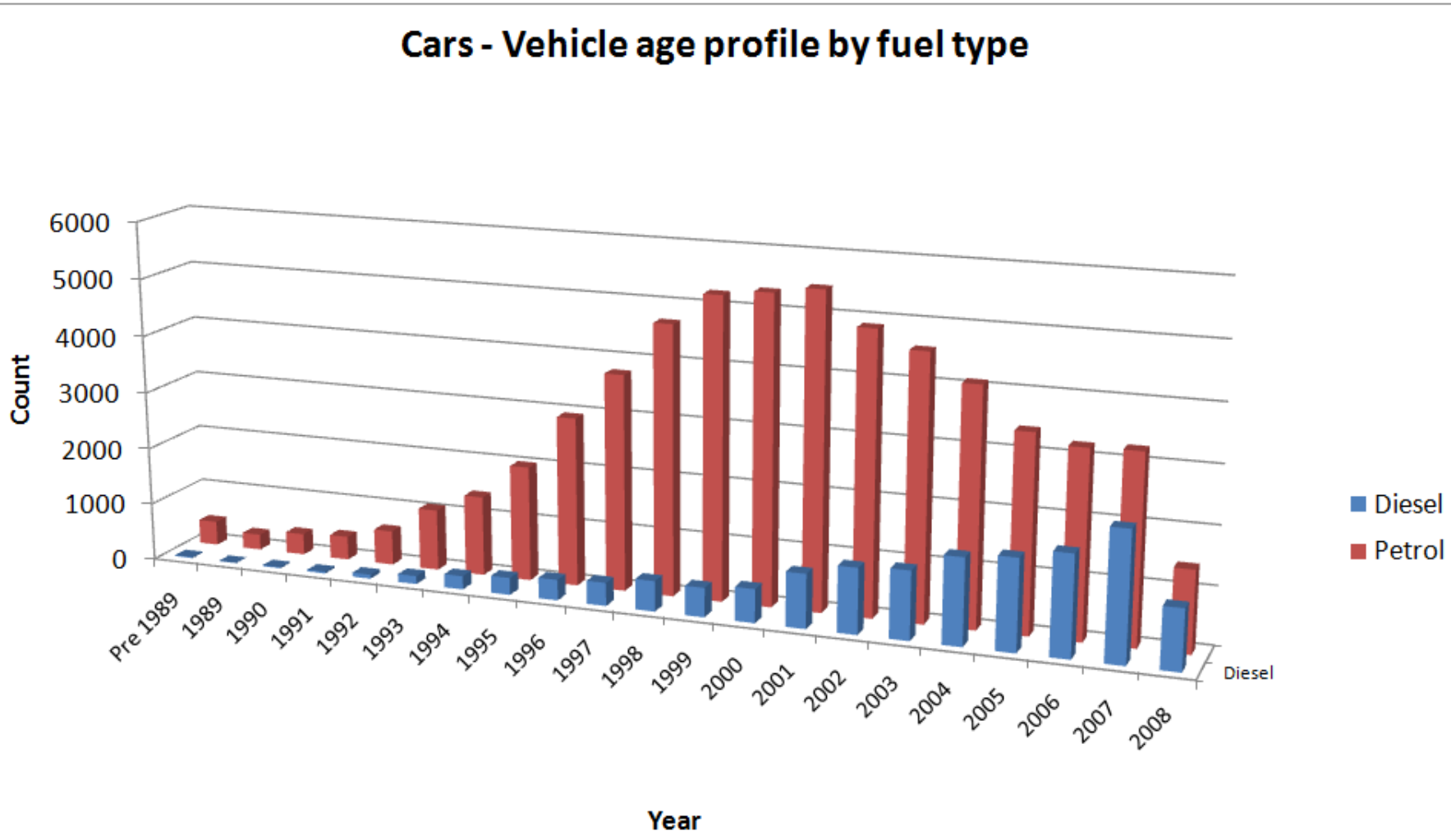
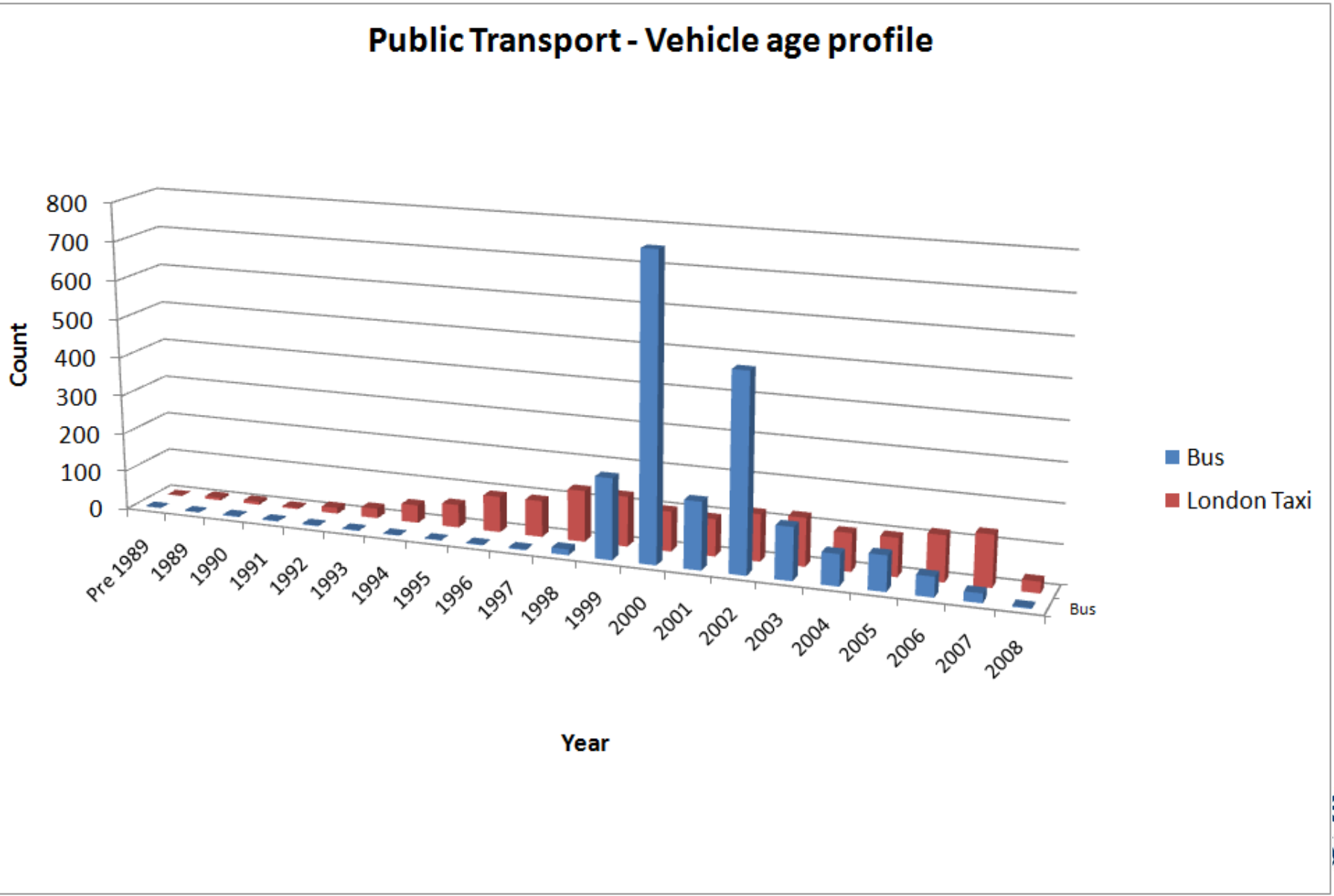
No licence plate visible, but.....

Dieselisation of the Car Fleet



Age Profile of the Public Transport Fleet



Average Age of Observed Fleet

Average age of observed vehicles

Vehicle Type	Age (years) Ealing	Southwark	UK average 2008[4]
Cars – Petrol (M1)	7.5	7.4	-
Cars – Diesel (M1)	5.0	4.7	-
Cars – Total (M1)	7.1	6.8	7.0
Light commercial – Petrol (N1)	8.2	6.0	-
Light commercial – Diesel (N1)	5.1	4.6	-
Light commercial – Total (N1)	5.3	4.6	6.8
Motorcycles (L1 and L3)	5.6	5.9	10.4
London taxis (Black cabs – M1)	7.7	7.0	-
Buses (M3)	7.2	6.6	9.0

[4]DoT, (2010)

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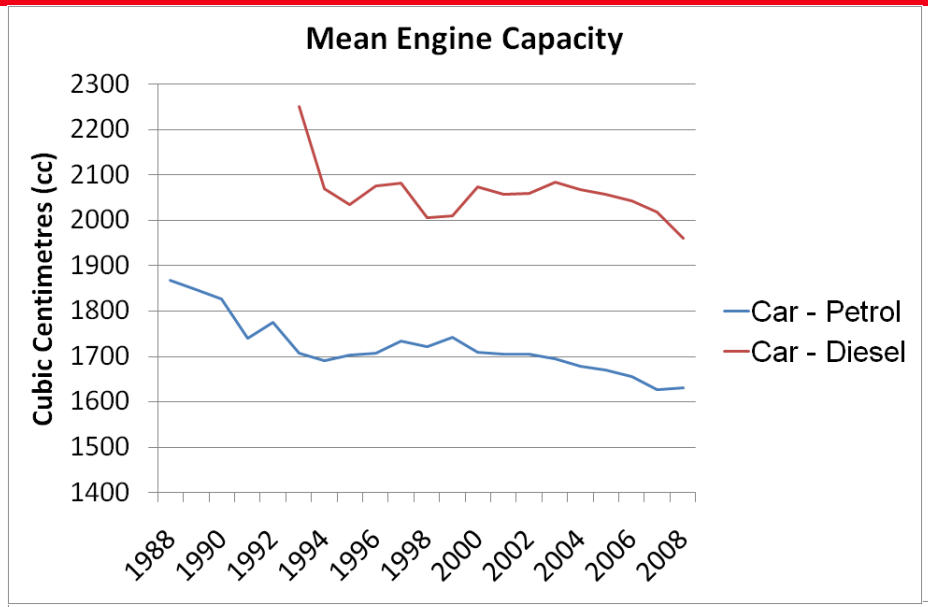
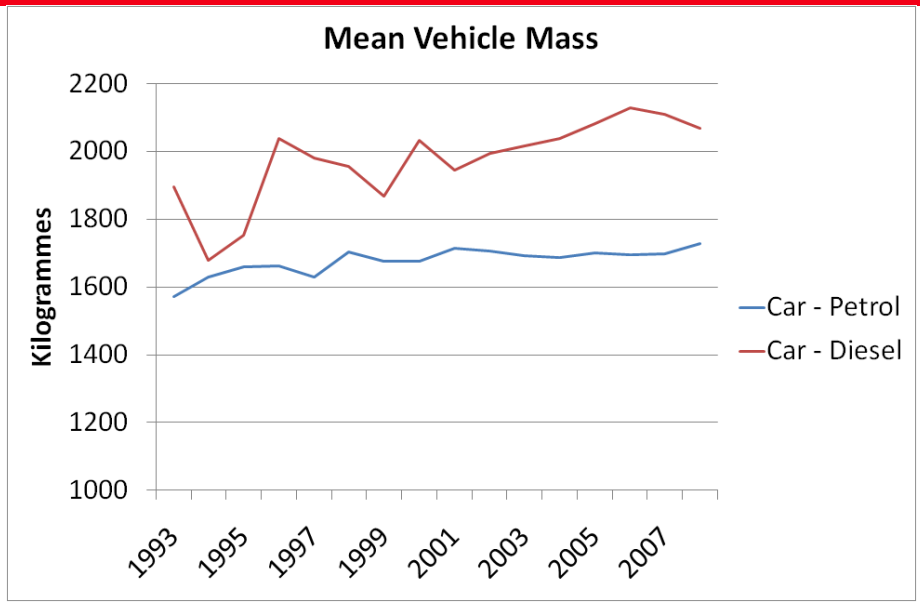
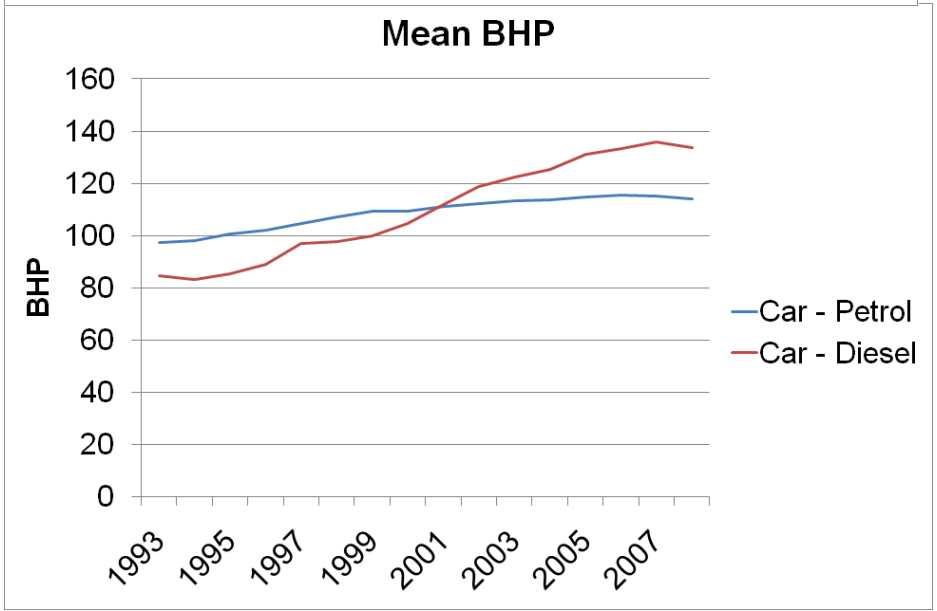
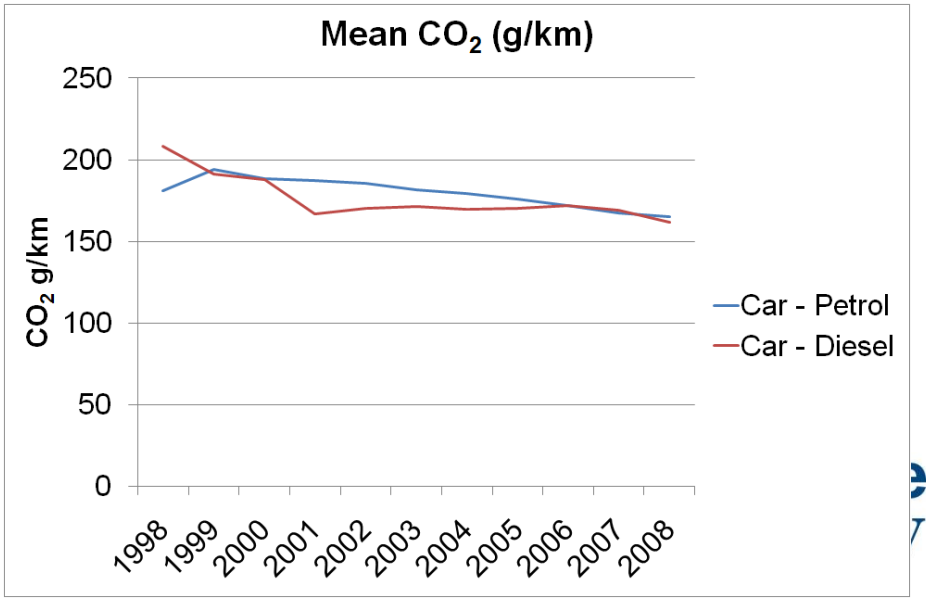
Car Technology Trends

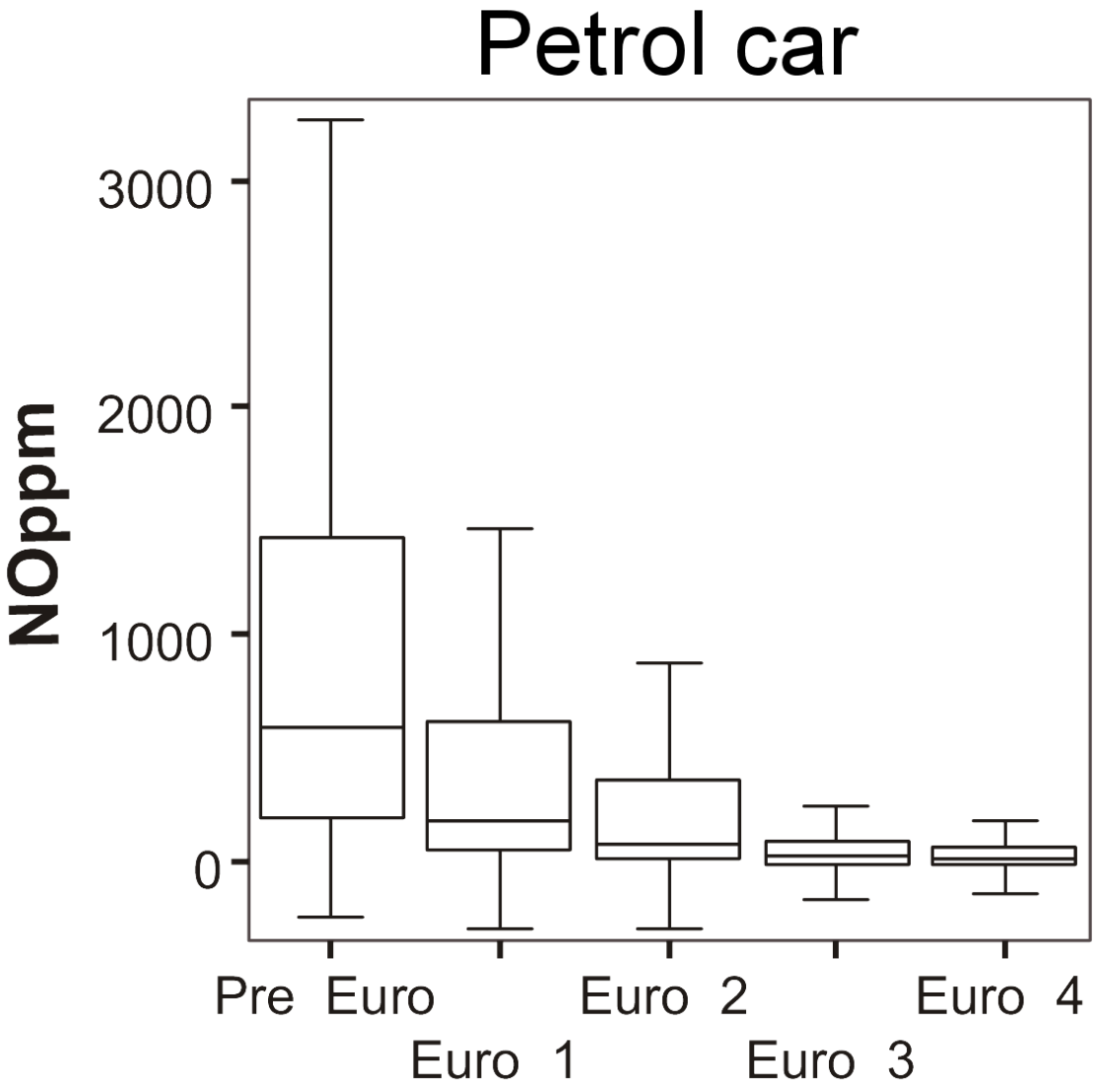








Petrol cars – Nitric oxide emissions



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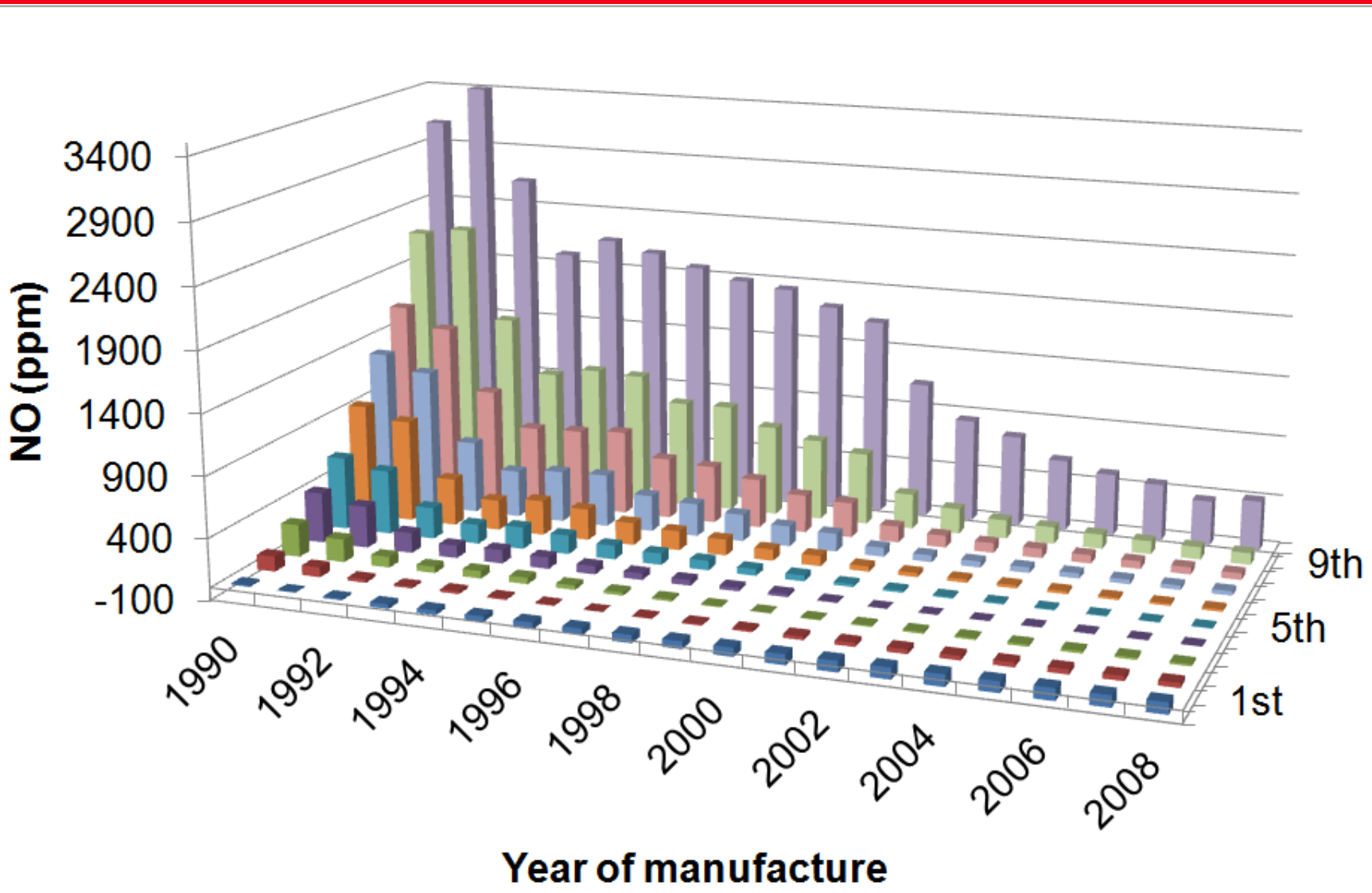
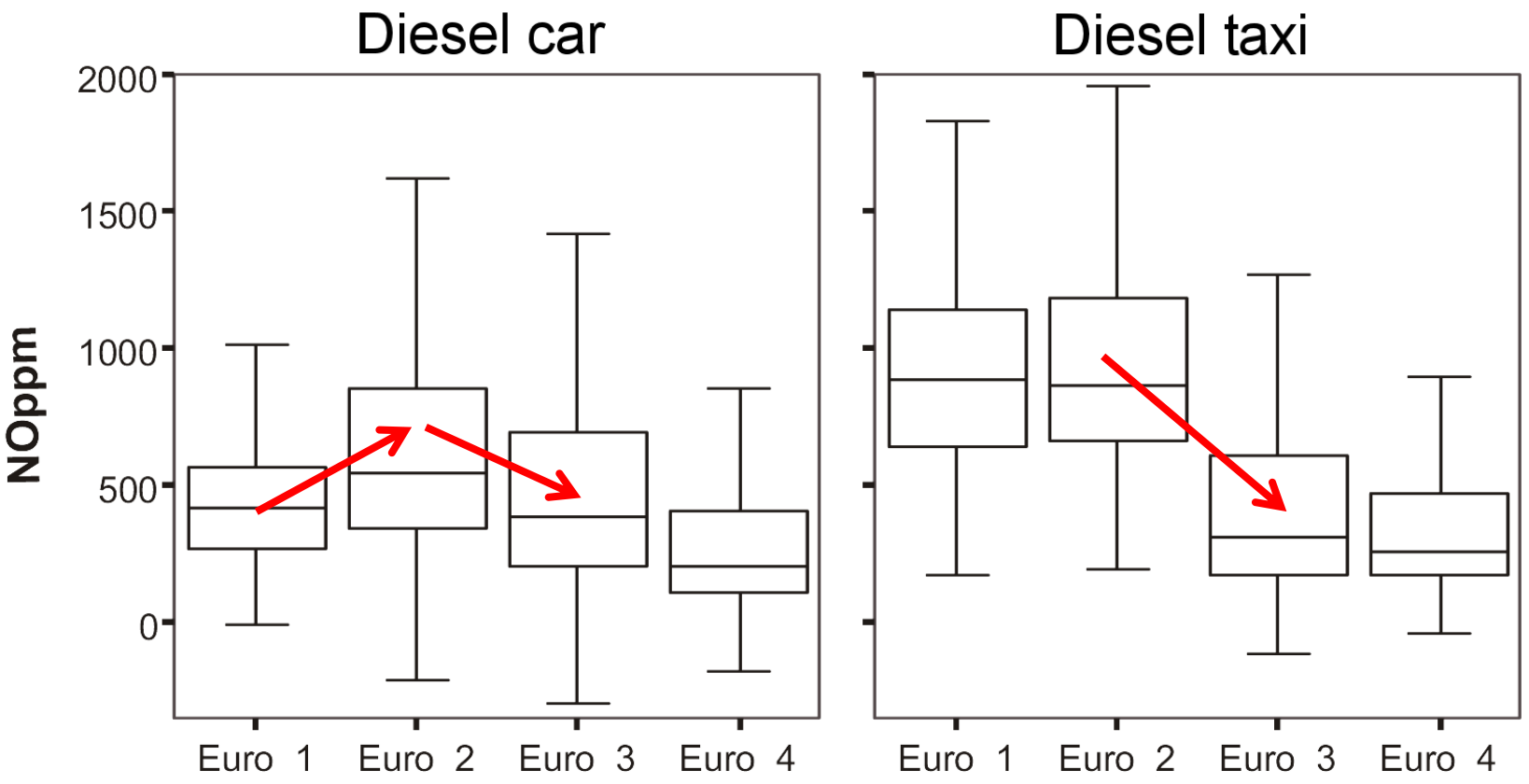
Petrol cars – Nitric oxide



Diesel cars vs London taxis – Nitric oxide emissions



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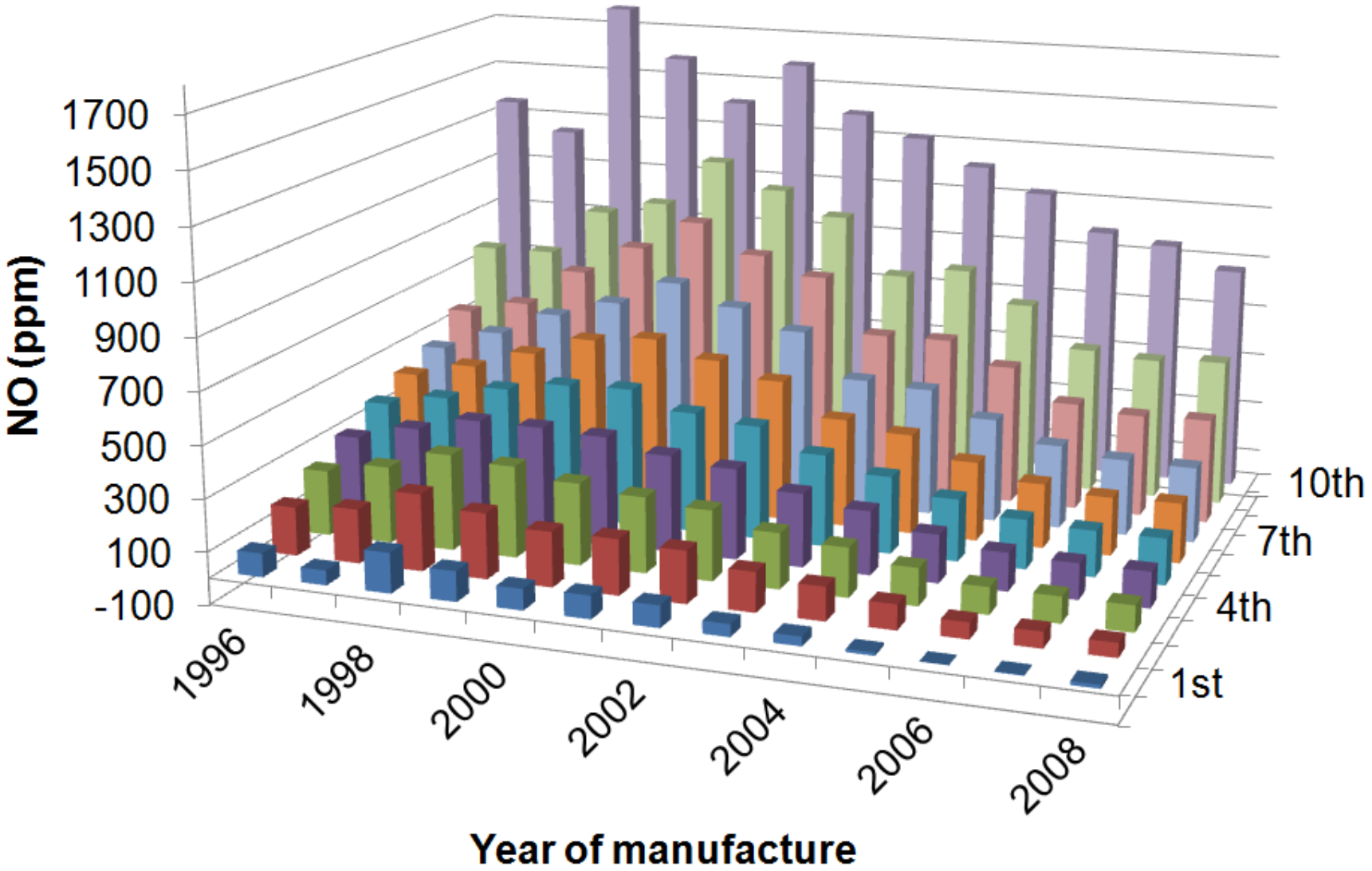
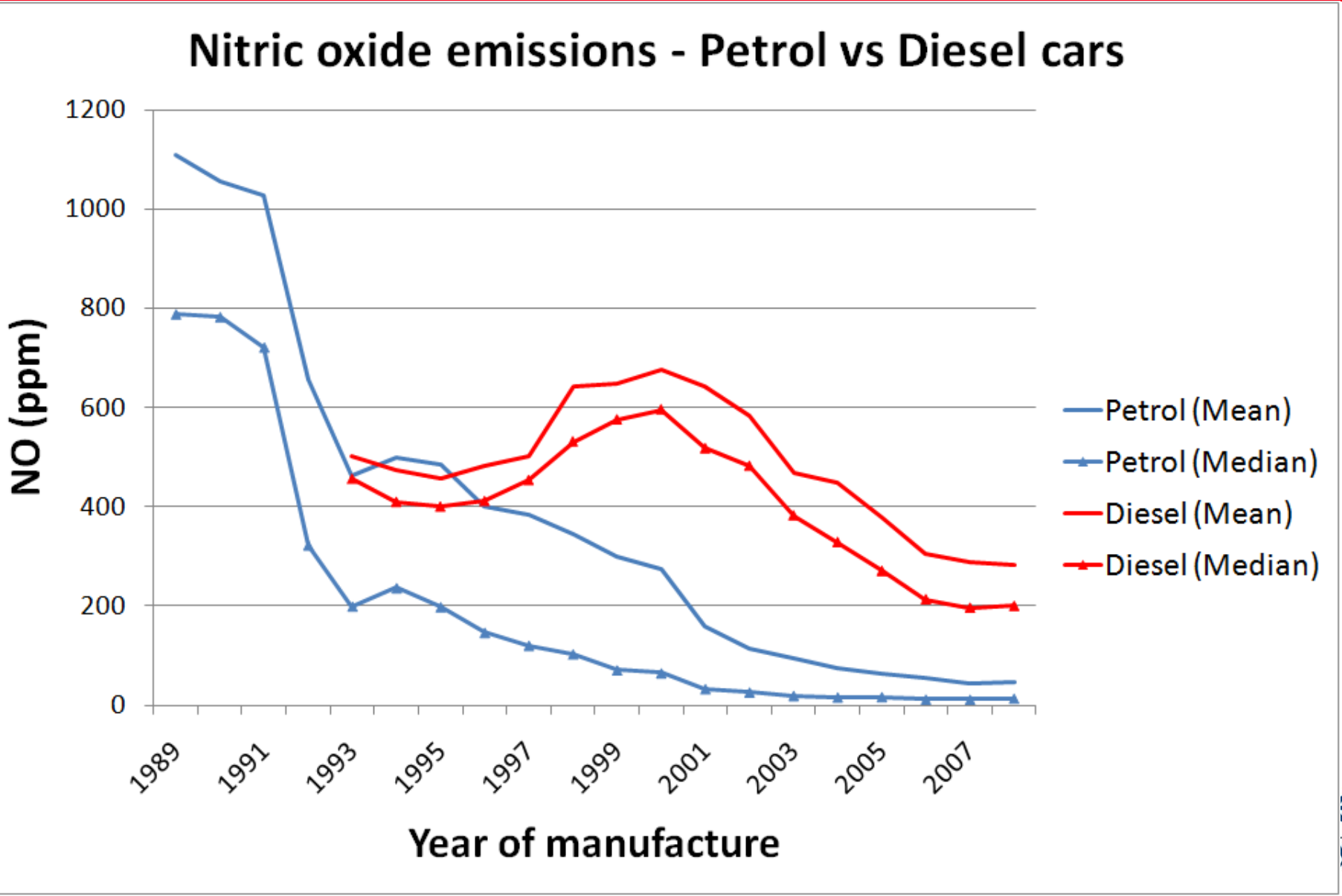
Diesel cars – Nitric oxide



NO by year – Petrol vs Diesel cars



Emissions standards for diesel cars

European type approval emissions standards for diesel cars (M1)

EU Directive	**Engine / fuel type***	**Limit values (g/km)**					**Implementation dates**	
		CO	HC	NO_x	$HC+NO_x$	PM	Type approval	In-use
Euro 1	D-IDI	2.72			1.0	0.14		
	D-DI	2.72			1.4	0.20	1/7/1992	31/12/1992
	D-DI	2.72			1.0	0.14	1/7/1994	31/12/1994
Euro 2	D-IDI	1.00			0.7	0.08		
	D-DI	1.00			0.9	0.10	1/1/1996	1/1/1997
	D-DI	1.00			0.7	0.08	1/10/1998	1/10/1999
Euro 3	D	0.64		0.50	0.56	0.05	1/1/2000	1/1/2001
Euro 4	D	0.50		0.25	0.30	0.025	1/1/2005	1/1/2006

Source: Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1, HA 207/07 Air Quality.

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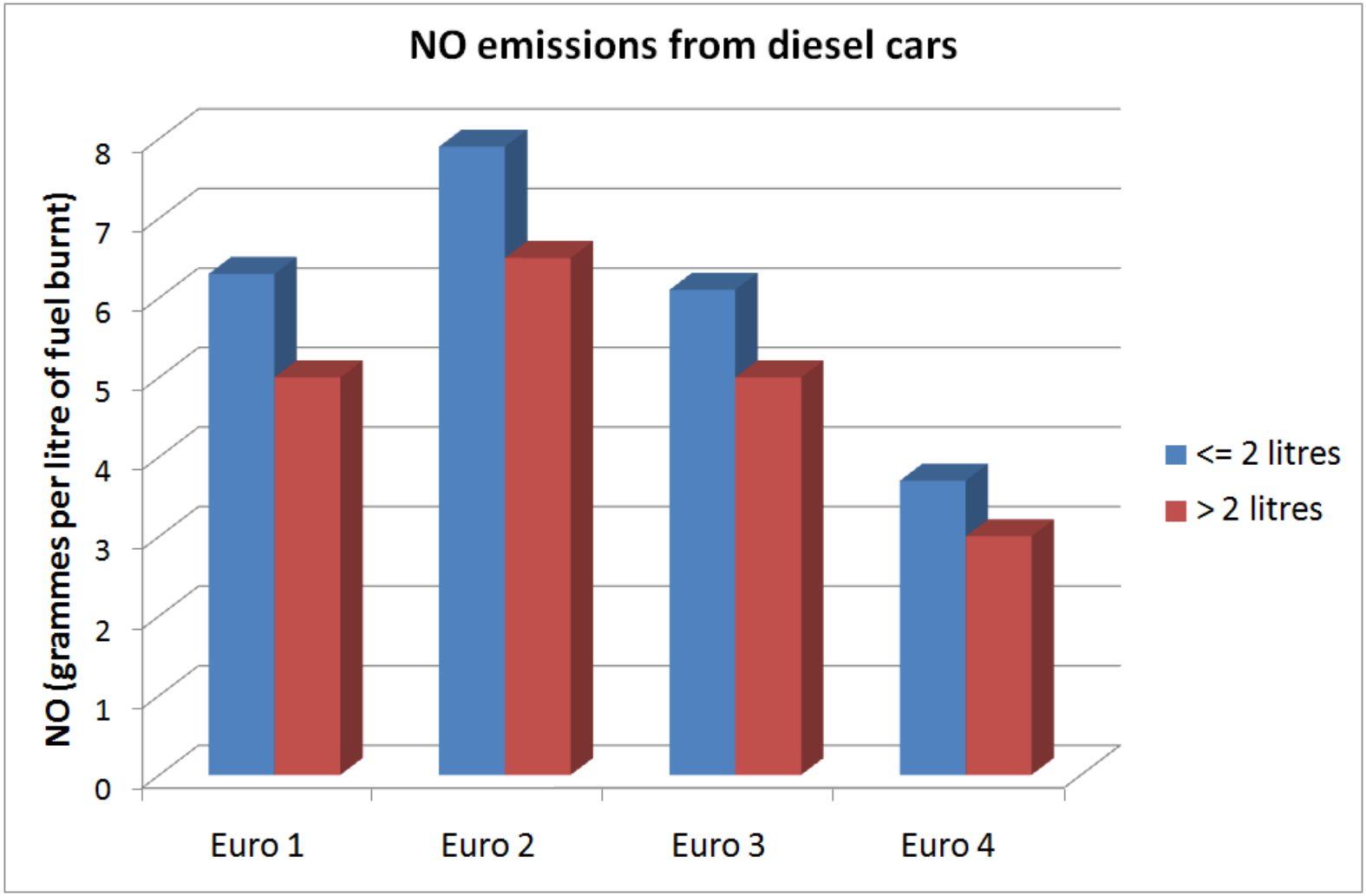
Diesel cars – Influence of engine size



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London Taxis (Black cabs)

London Taxis

Already required to be Euro 3 compliant for NO_x and particulates, either as built, or by retro-fitting of emissions control equipment

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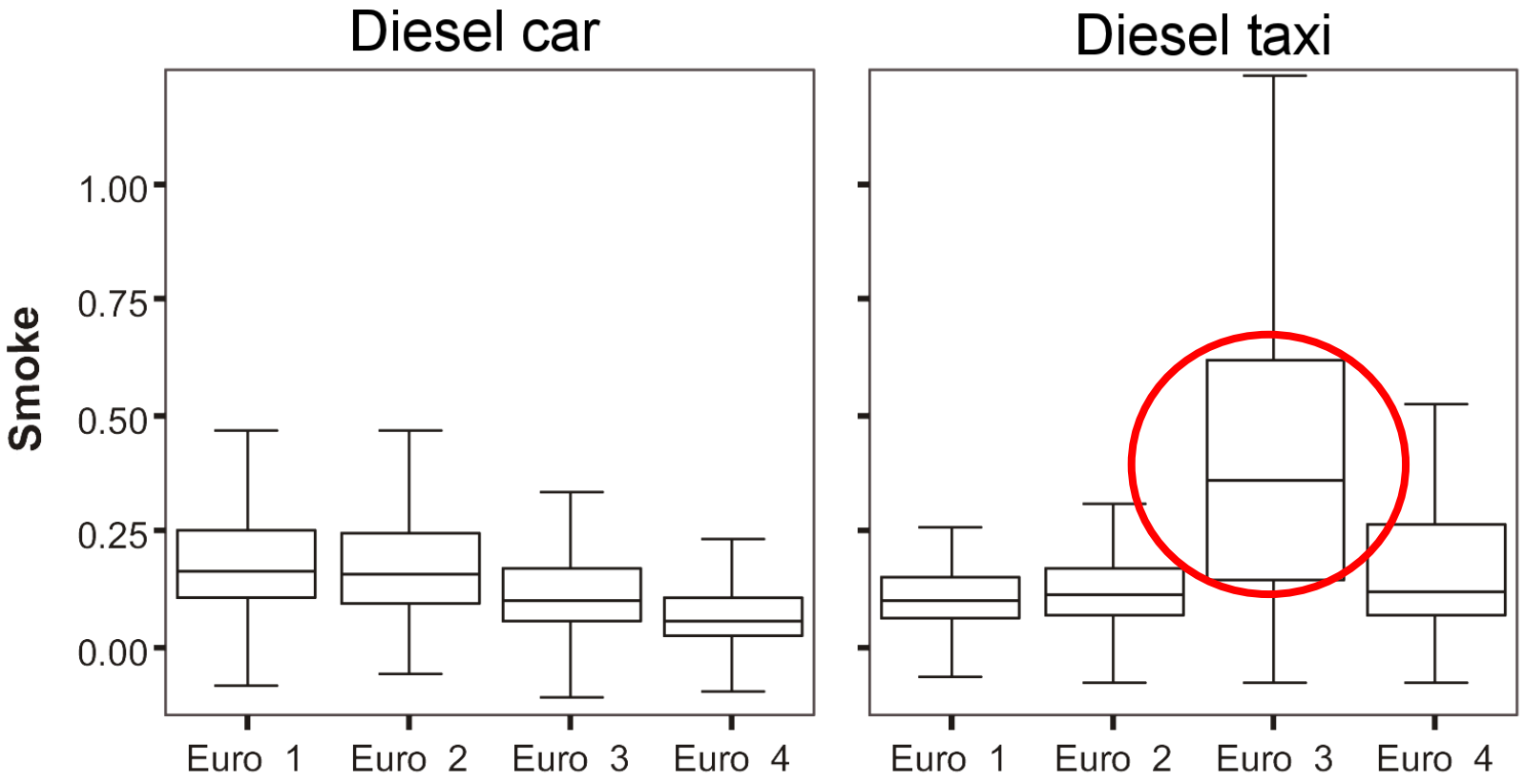
Diesel cars vs London taxis – Smoke (particulate) emissions



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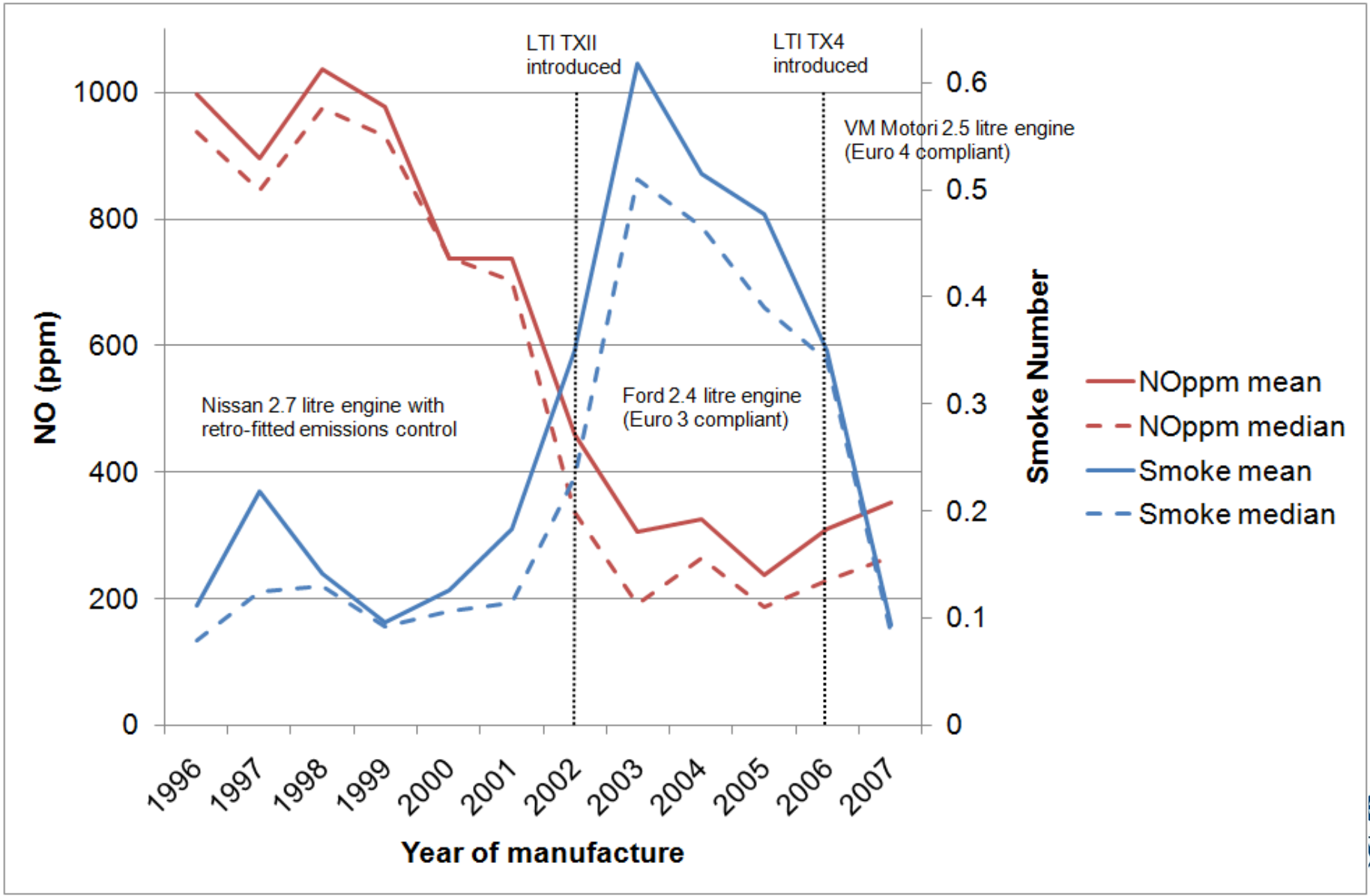
London Taxis (Black Cabs) – NO / Smoke



Abstract from TfL bus database

Bus type	Tailpipe NO_x (g km^{-1})	f-NO_2 tailpipe (%)	PM (g km^{-1})
Euro III buses fitted with DPF			
Volvo B7TL Double Deck	12.42	53.4	0.014
Scania Double Deck	10.58	39.3	0.008
Optare Solo Single Deck	5.43	24.3	0.014
Mercedes-Benz Citaro G Artic	12.98	35.0	0.024
Euro III buses fitted with DPF and SCR			
Dennis Dart single deck	5.33	46.0	0.007
Dennis Dart single deck	4.89	54.3	0.015
Euro IV buses without DPF			
Dennis Enviro 400 double deck	7.26	3.7	0.052
Dennis Dart single deck	8.6	7.7	0.029

Source: Trends in primary nitrogen dioxide in the UK, DEFRA 2007

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Observed London Buses 2008

Variability in observed bus nitric oxide emissions and smoke number

Make	Model	Year	Borough	Season	n	NOppm		Smoke number	
						Mean	Median	Mean	Median
Dennis	Single deck	1997-2000	Ealing	Spring	264	661	601	0.05	0.03
Dennis	Single deck	2001-2005	Ealing	Spring	56	812	641	0.05	0.04
Dennis	Double deck	1997-2000	Ealing	Spring	136	754	694	0.05	0.03
Dennis	Double deck	2001-2005	Ealing	Spring	169	1338	1194	0.28	0.08
Dennis	Double deck	1997-2000	Southwark	Summer	184	706	669	0.19	0.10
Dennis	Double deck	2001-2005	Southwark	Summer	140	1042	902	0.16	0.09
Volvo	Double deck	2001-2005	Ealing	Spring	54	913	874	0.08	0.05
Volvo	Double deck	1997-2000	Southwark	Summer	229	1137	1106	0.04	0.03
Volvo	Double deck	2001-2005	Southwark	Summer	430	903	839	0.06	0.04

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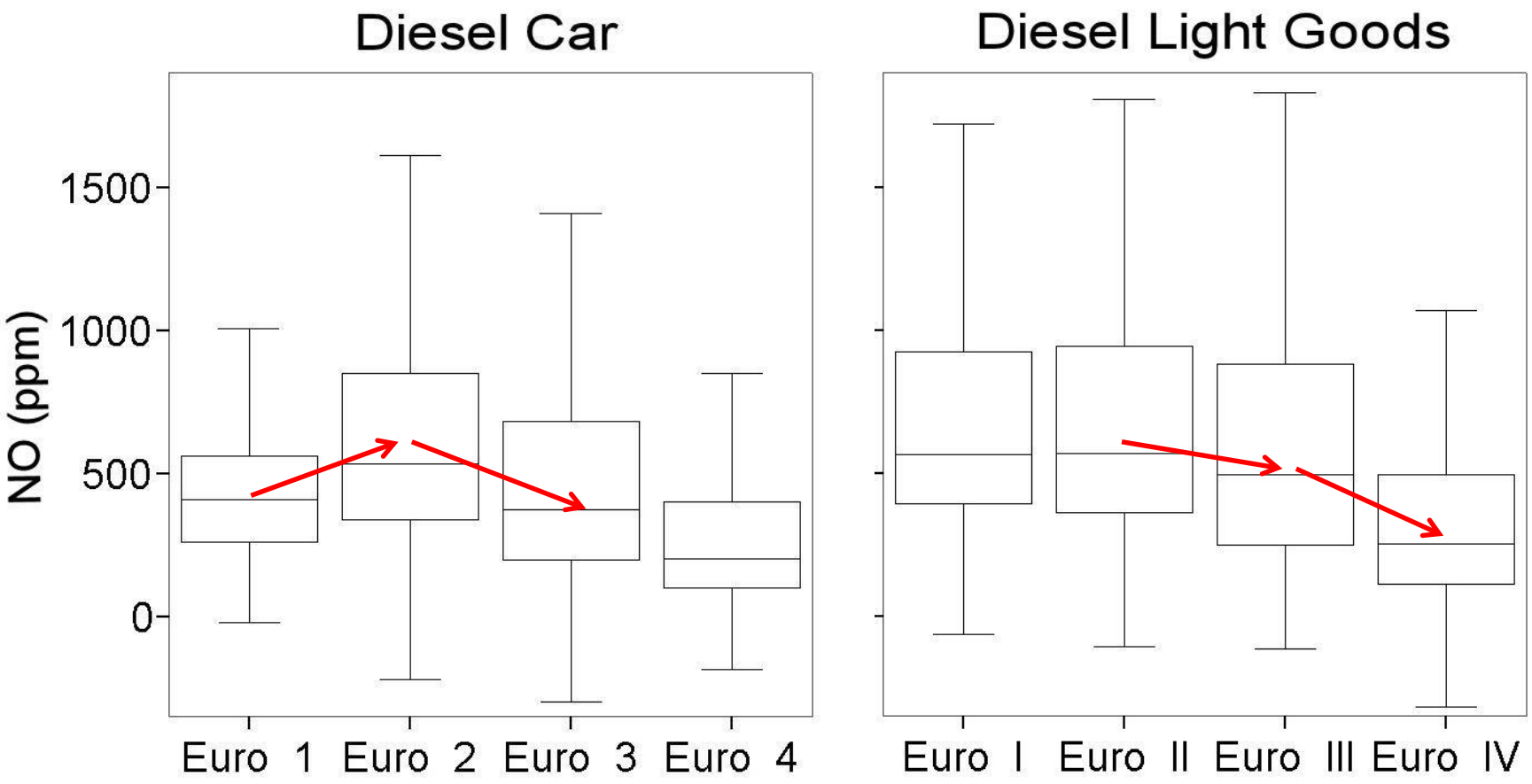
Light Goods Vehicles



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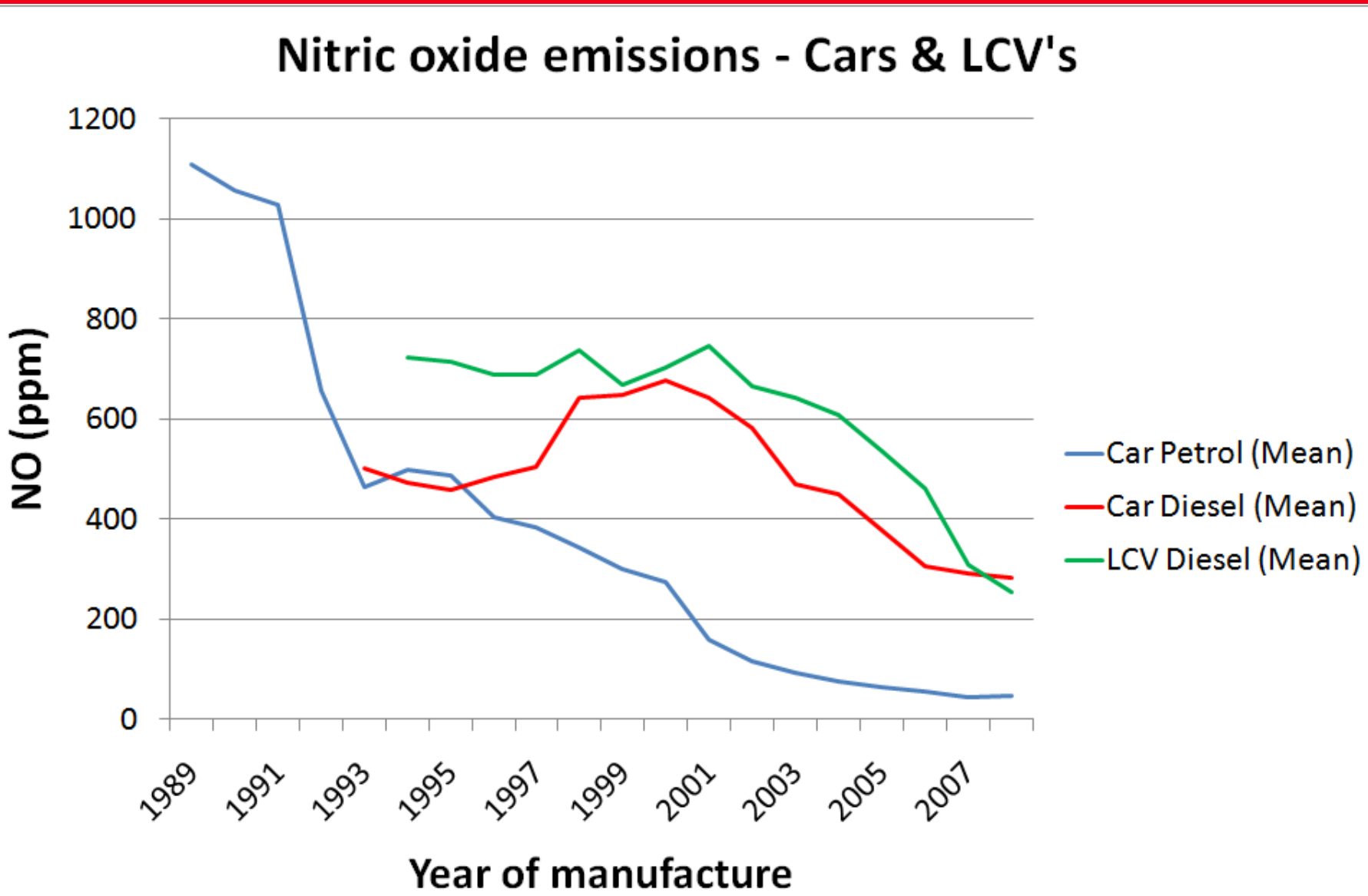
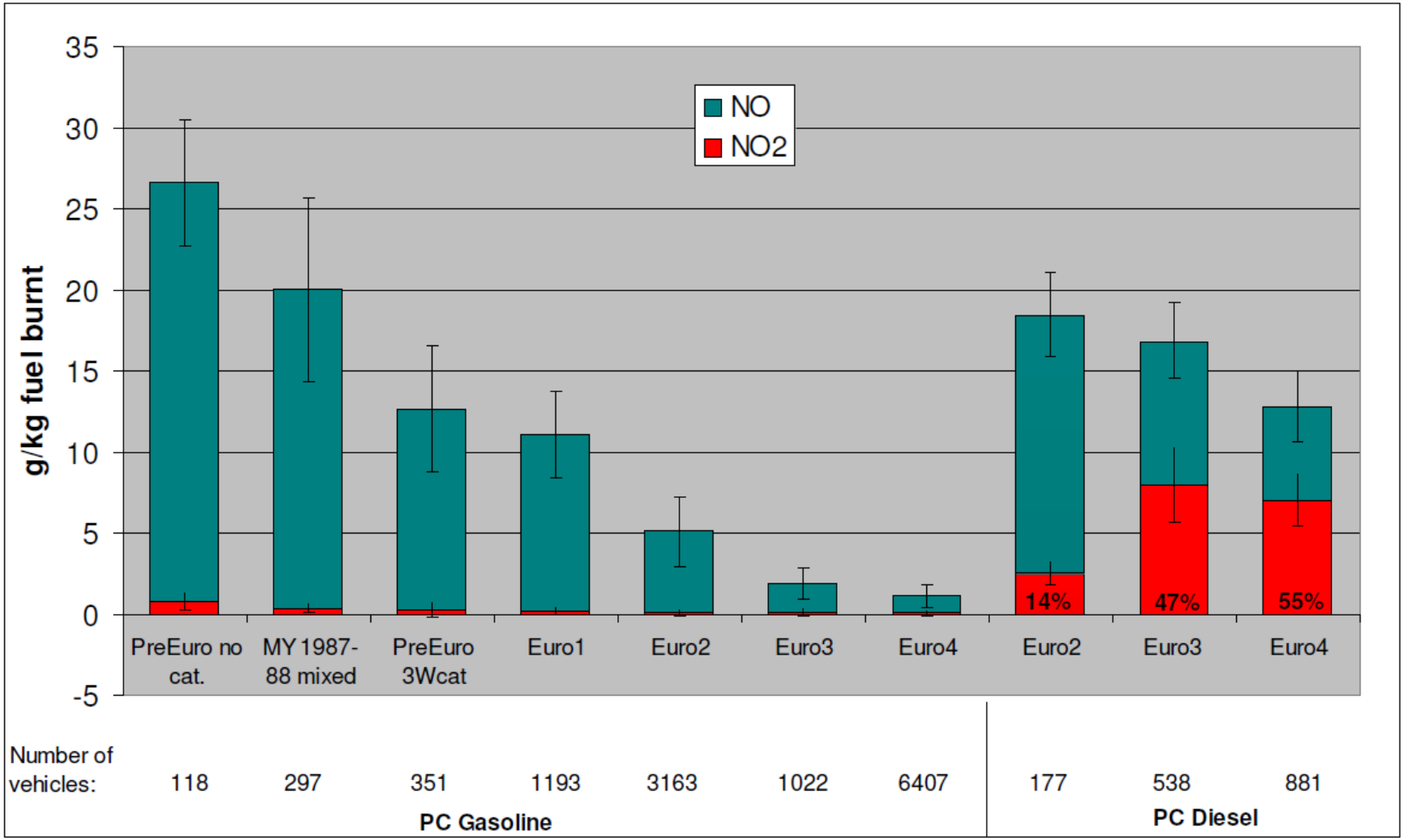
Light Goods Vehicles



Primary NO_2 problem



Source: Sjodin and Jerksjo 2008 (Gothenburg remote sensing 2007)

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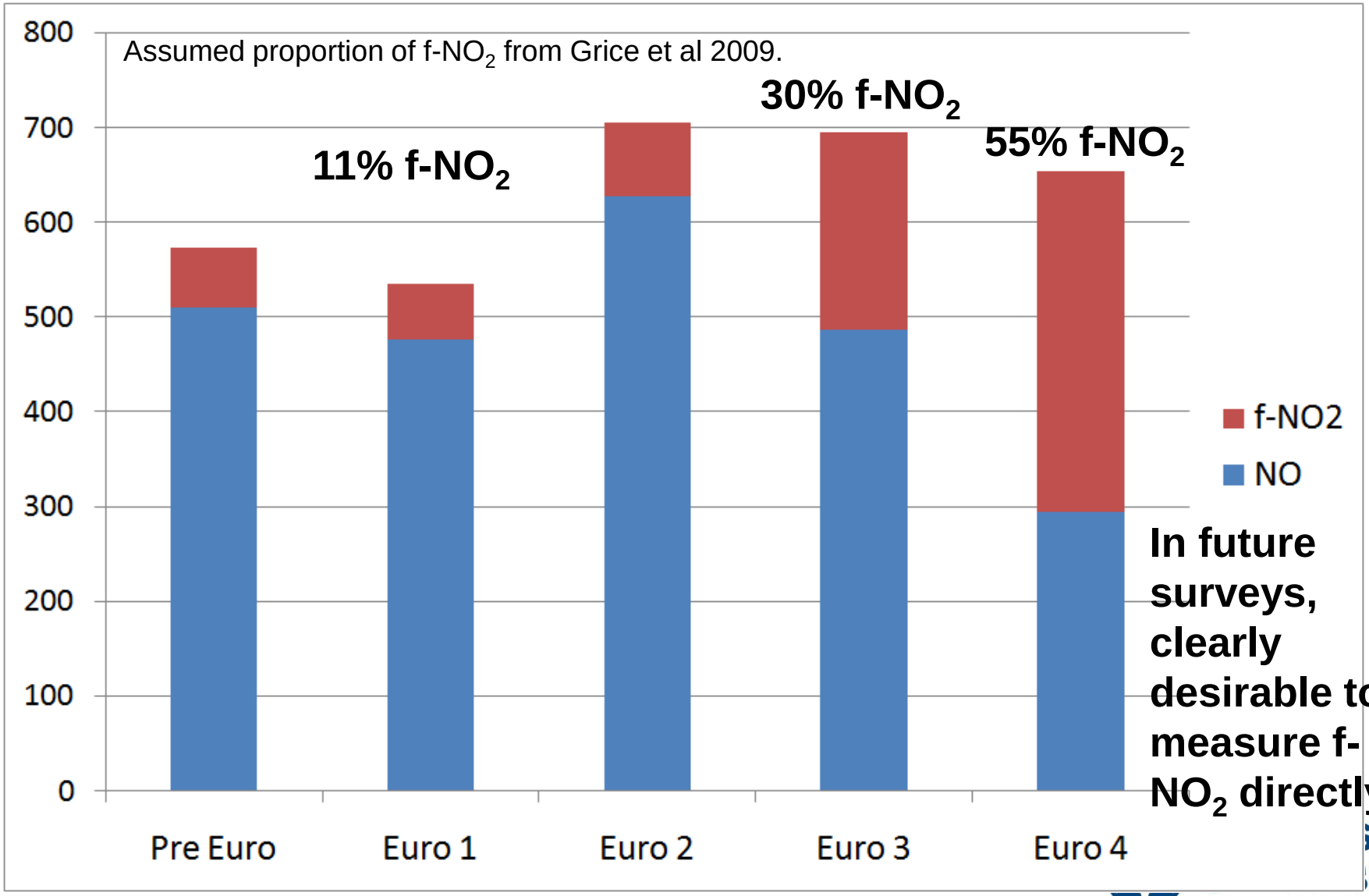
London 2008 diesel car NO data *plus* (assumed) f-NO_2



In future surveys, clearly desirable to measure f-NO_2 directly.

Informing air quality strategies

- **Policies of excluding certain vehicle types based simply on the age of the vehicle *may* not in all cases necessarily deliver the required air quality improvements (because some emissions do not decrease monotonically).**
- **Euro 3 London taxis (as built) were observed to emit higher levels of smoke (particulates) than Euro 1 or Euro 2 London taxis retro-fitted with emissions control equipment. Needs further research. How representative is the UV smoke measurement of particulates (compared to other traditional particulate measurement methods)?**
- **Euro 2 diesel cars were observed to emit higher levels of nitric oxide (Mann-Whitney $p<0.001$) than either Euro 1 or Euro 3 diesel cars.**
- **Mean NO emissions from Euro 4 diesel cars were observed to be 6 times higher than from Euro 4 petrol cars.**
- **(Some) Euro 3 buses were observed to emit higher levels of nitric oxide than Euro 2 buses.**
- **What about primary NO_2? Increasing problem in new diesels. Would be very useful to collect data on NO and NO_2 explicitly in future surveys (awaiting decision on London Borough of Ealing grant bid to DEFRA, submitted June 2011).**

Newcastle University

Discussion

Glyn Rhys-Tyler

Transport Operations Research Group (TORG)

School of Civil Engineering and Geosciences
Cassie Building
Newcastle University
Newcastle upon Tyne NE1 7RU

Email: glyn.rhys-tyler@ncl.ac.uk

Tel: 0191 222 5458

Newcastle University

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