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Road Transport and Air Quality

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Transport Planning Society 21st Jan 2015

The Issue

"There are still major challenges to human health from poor air quality. We are still far from our objective to achieve levels of air quality that do not give rise to significant negative impacts on human health and the environment."

Janez Potočnik, European Commissioner for the Environment
(Potočnik, 2013)

Overview of Air Quality Legislation

- European Air Quality Directive and health based air quality standards
  - Compliance assessed at the national level
  - No direct exposure relationship

- National Emission Ceiling Directive
  - Ceiling on national emissions
  - Assessed at the national level

- Local Air Quality Management (LAQM)
  - Same health based standards
  - Link to exposure – no exposure, no problem
  - Assessed locally
  - Air Quality Management Areas (AQMA)
  - Air Quality Action Plans (AQAP)

The air quality limit values

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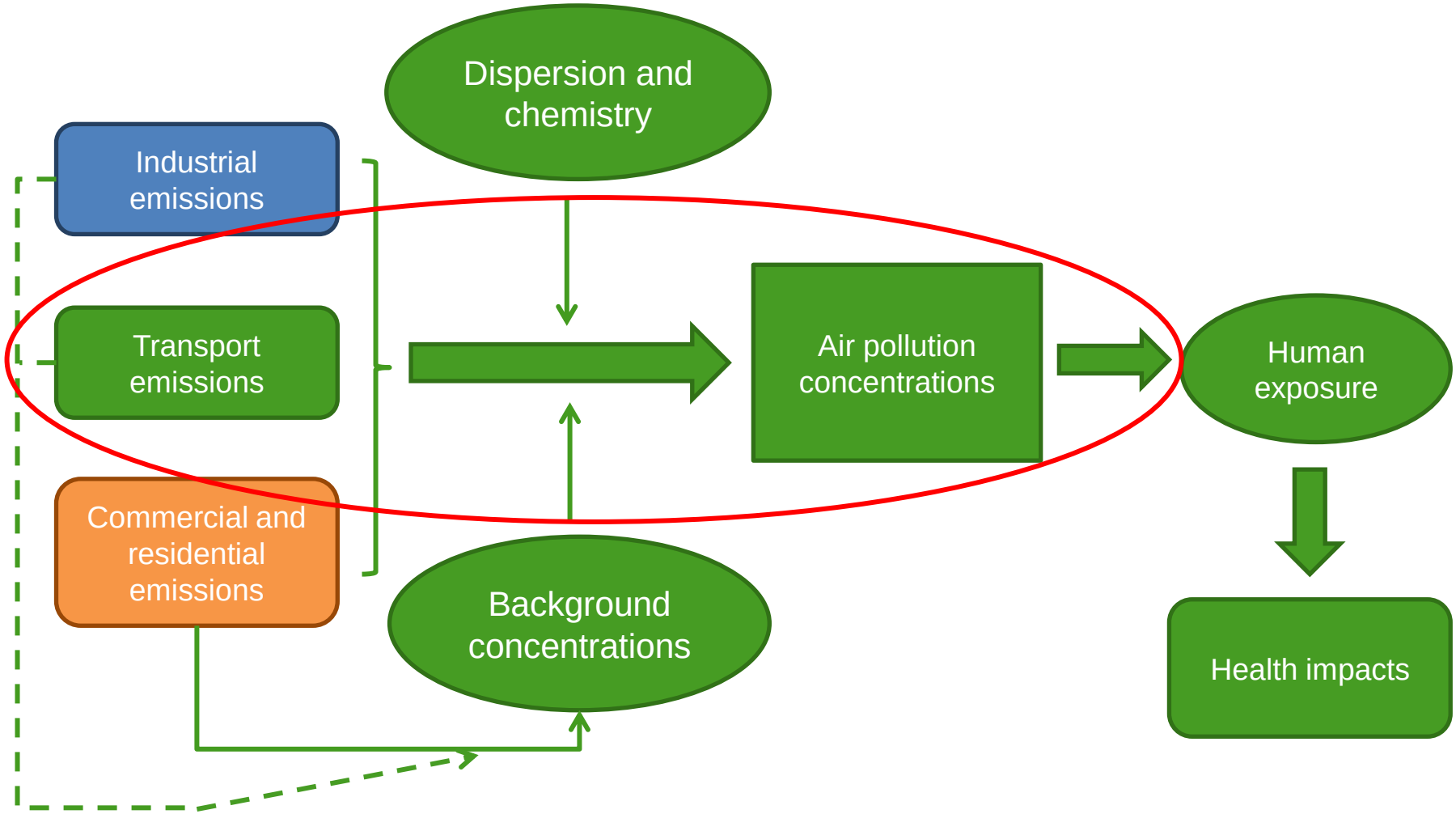
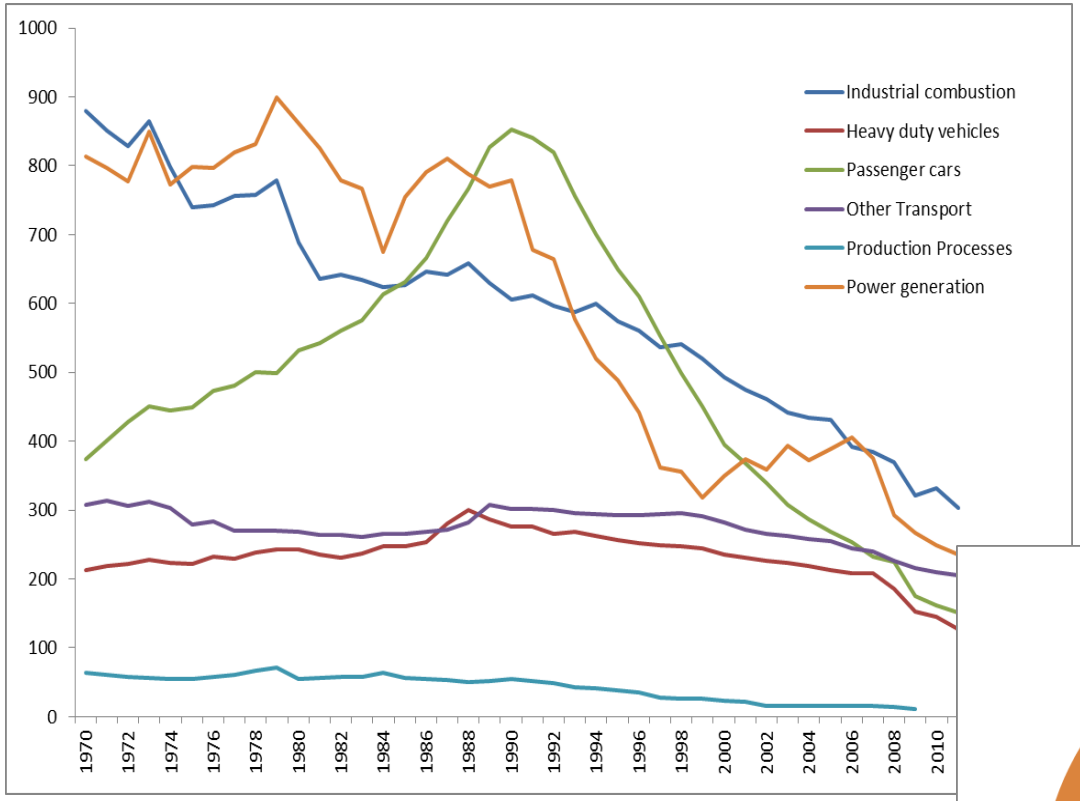
Pollutant	Averaging period	Concentration	
		EU limit	WHO guidelines*
PM_{10}	24-hour mean	50 µg/m^3	50 µg/m^3
	Annual mean	*40 µg/m^3*	*20 µg/m^3*
$PM_{2.5}$	*Annual mean*	*25 µg/m^3 ***	*10 µg/m^3*
Ozone	Daily 8-hour mean	120 µg/m^3	100 µg/m^3
Nitrogen dioxide (NO_2)	Hourly mean	200 µg/m^3	200 µg/m^3
	Annual mean	*40 µg/m^3*	*40 µg/m^3*

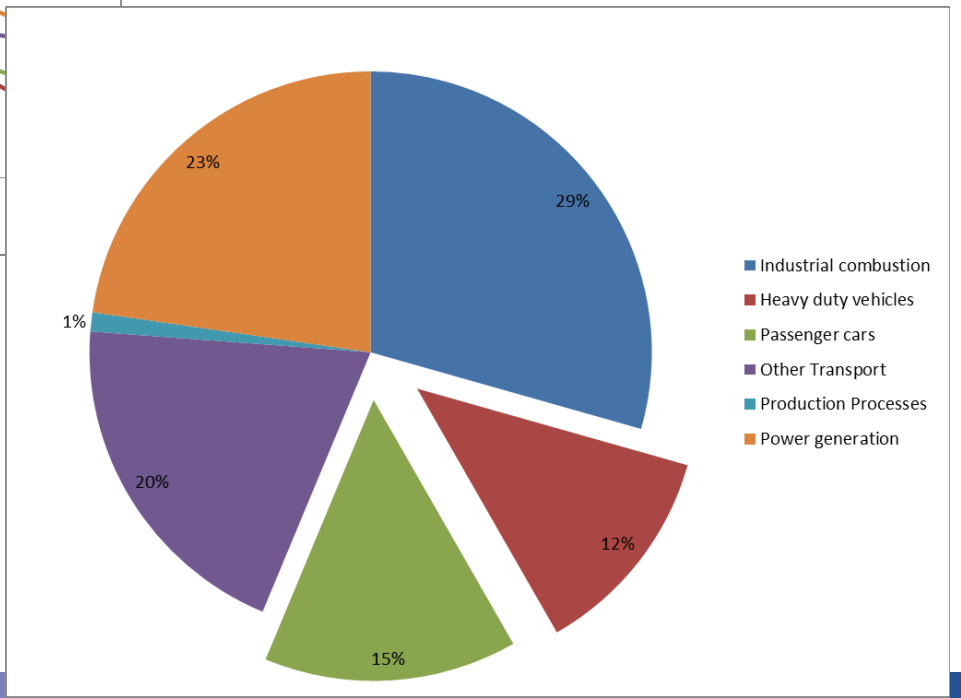
Emissions, Concentrations and Health impacts



National emissions of NOx

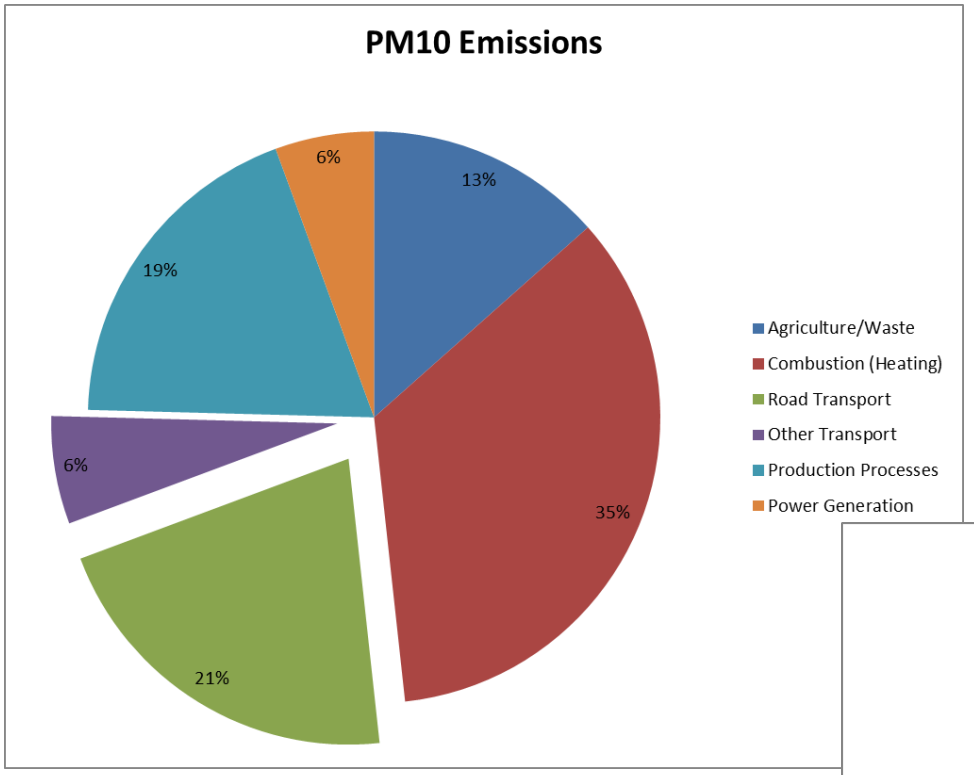


Road transport accounts for about 1/3 of national NOx emissions

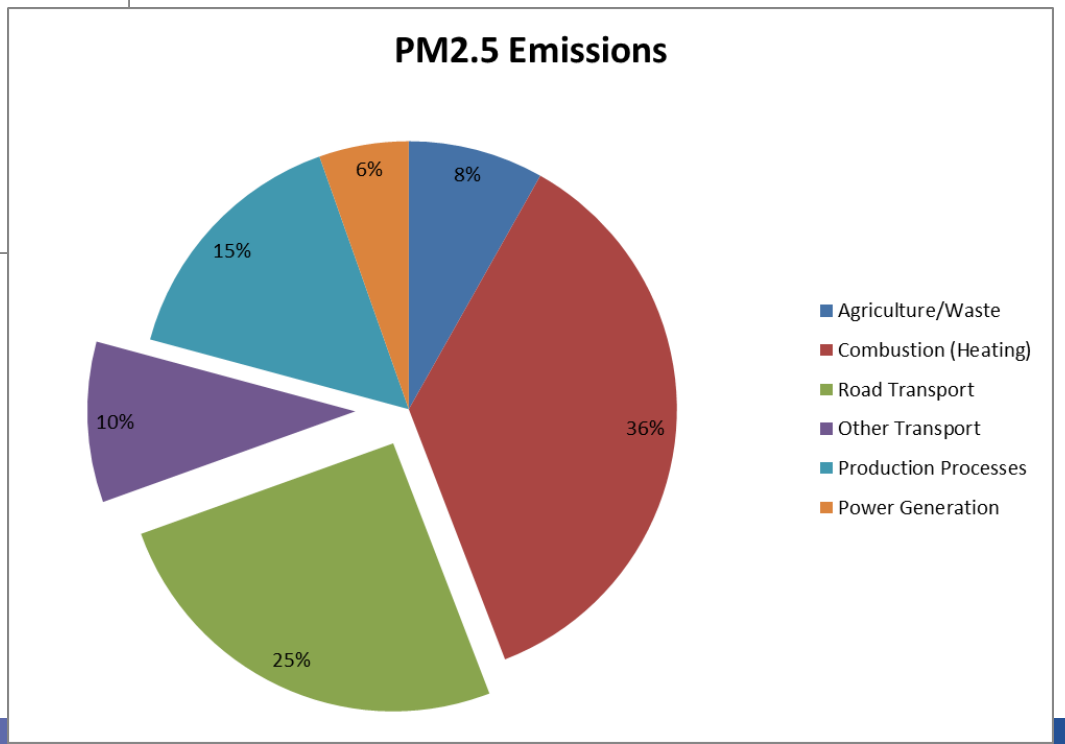


Source NAEI, 2012

National particulate emissions



Road transport accounts for 25% of PM_{10} emissions and 35% of $PM_{2.5}$ emissions



Source NAEI, 2012

Trends in Modelled Transport Emissions

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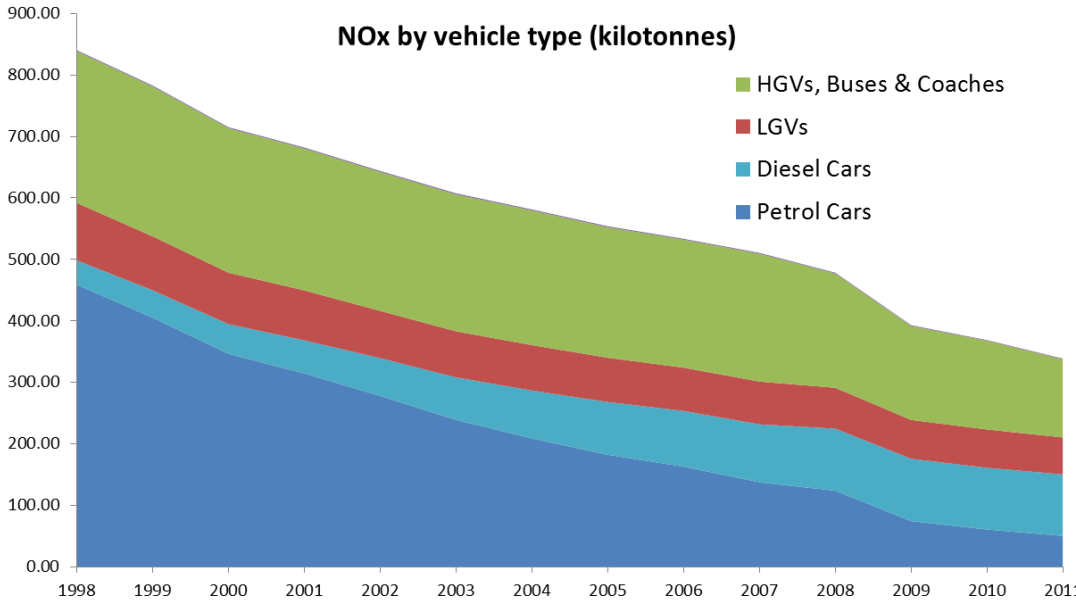
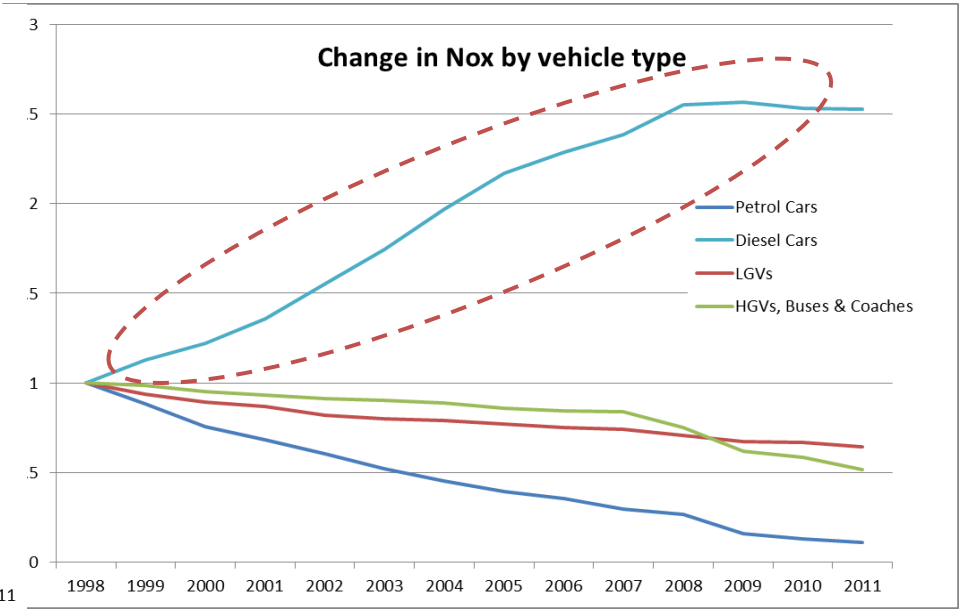
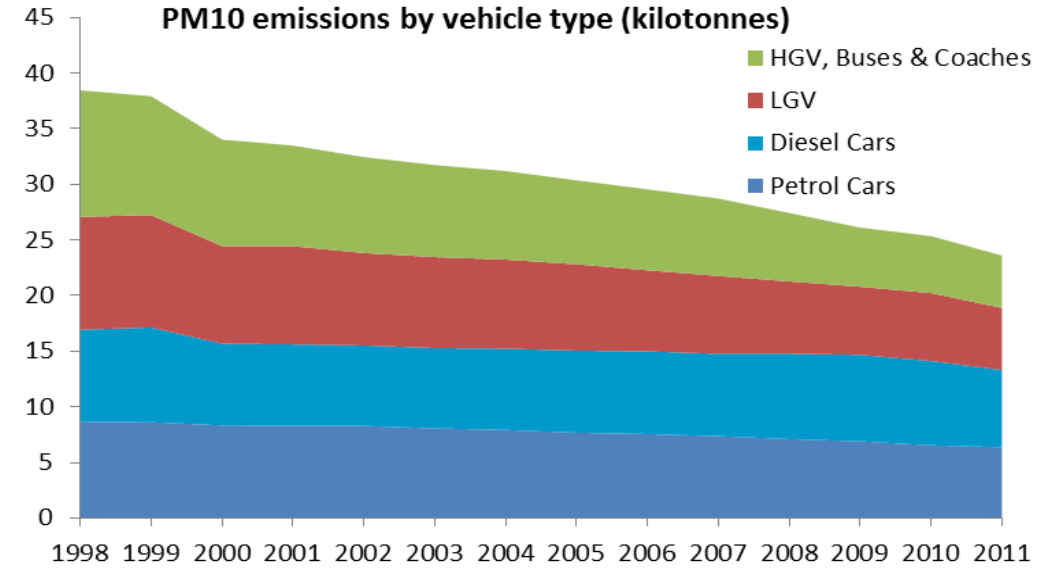
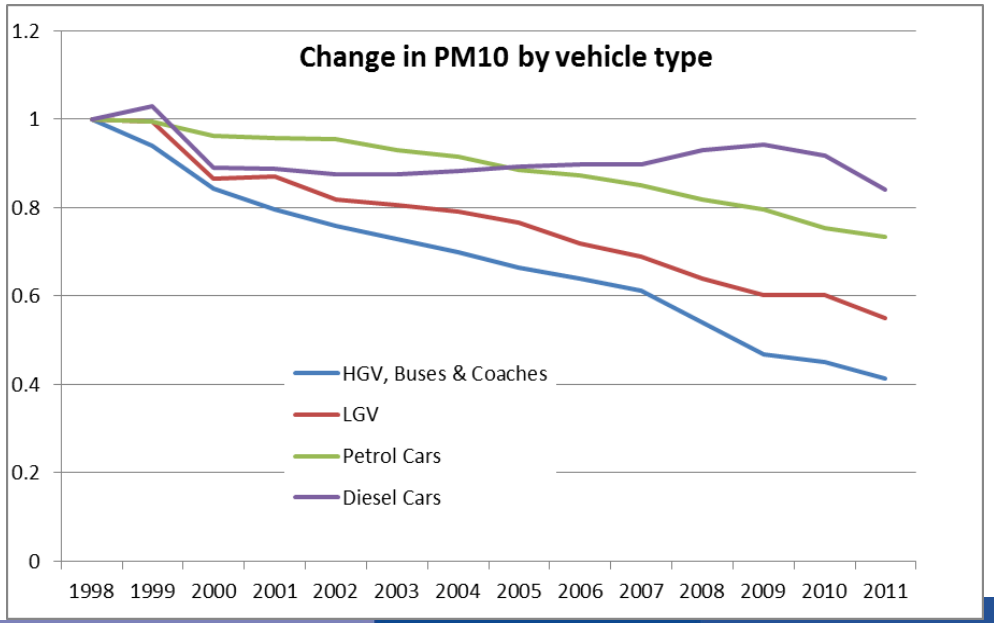
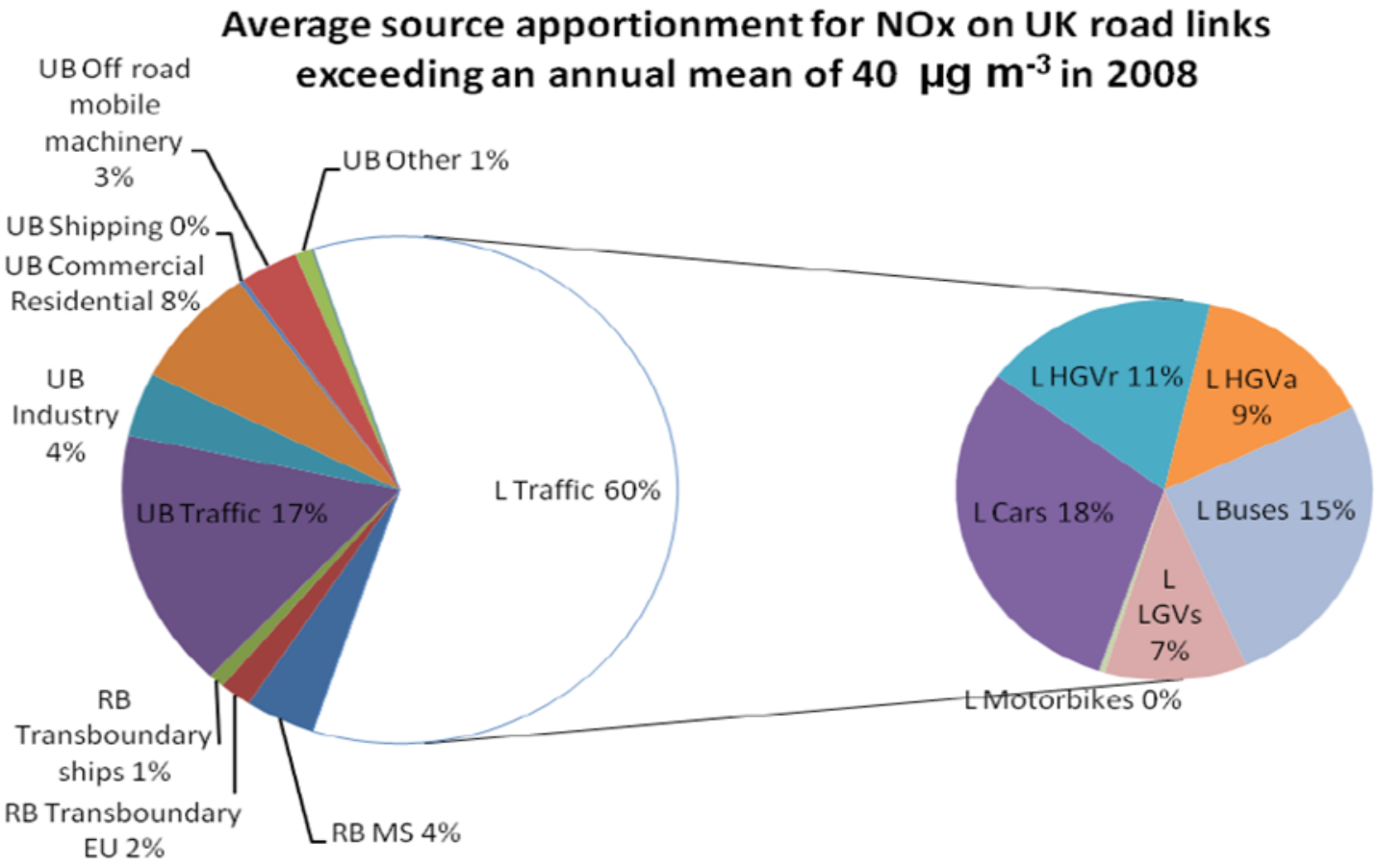








NO_2 concentrations at roadside



Source: 'Air Quality Plans for the achievement of EU air quality limit values for nitrogen oxide (NO2) in the UK', DEFRA, 2011.

Transport is the main cause of AQMA's

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Pollutant	Objective Declared	England	Wales	Scotland	N. Ireland	London	Total
Nitrogen dioxide NO2	1-Hour and Annual Mean	13	6	3	1	7	30
Nitrogen dioxide NO2	1-Hour Mean	1					1
Nitrogen dioxide NO2	Annual Mean	453	27	19	21	26	546
Nitrogen dioxide NO2	Interval Not Defined	1					1
Particulate Matter PM10	24-Hour Mean	37	1	1	1	24	64
Particulate Matter PM10	Annual and 24-Hour Mean	4		1	5	5	15
Particulate Matter PM10	Annual Mean	1		8	1		10
Particulate Matter PM10	Scotland Annual and 24-Hour Mean			4			4
Particulate Matter PM10	Scotland Annual Mean			7			7
Sulphur dioxide SO2	15-Minute and 1-Hour and 24-Hour Mean	2					2
Sulphur dioxide SO2	15-Minute Mean	5		1			6
Total		517	34	44	29	62	686

NO_2 is the main pollutant of concern and transport is the main source

Source	England	Wales	Scotland	N. Ireland	London	Total
Road transport unspecified	175	12	21	22	26	256
County or Unitary Authority Road	158	16	5		1	180
Mixture of road types	79	4	3		2	88
Highways Agency Road	43	1				44
Transport and Industrial Source	10		1		4	15
Transport, Industrial and domestic sources	8					8
Industrial Source	10	1	1			12
Domestic Heating	2		1	5		8
Not Defined	4			2		6
Total	489	34	32	29	33	617
Total with a transport element						**591**
% of total						**95.8%**

Local air quality problems

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Pollutant	Objective Declared	England	Wales	Scotland	N. Ireland	London	Total
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Total with a transport element						**591**
% of total						**95.8%**

More than 600 AQMA's

85% relate to NO_2 breaches

95% attributed to transport

A locally specific problem – Leicester example

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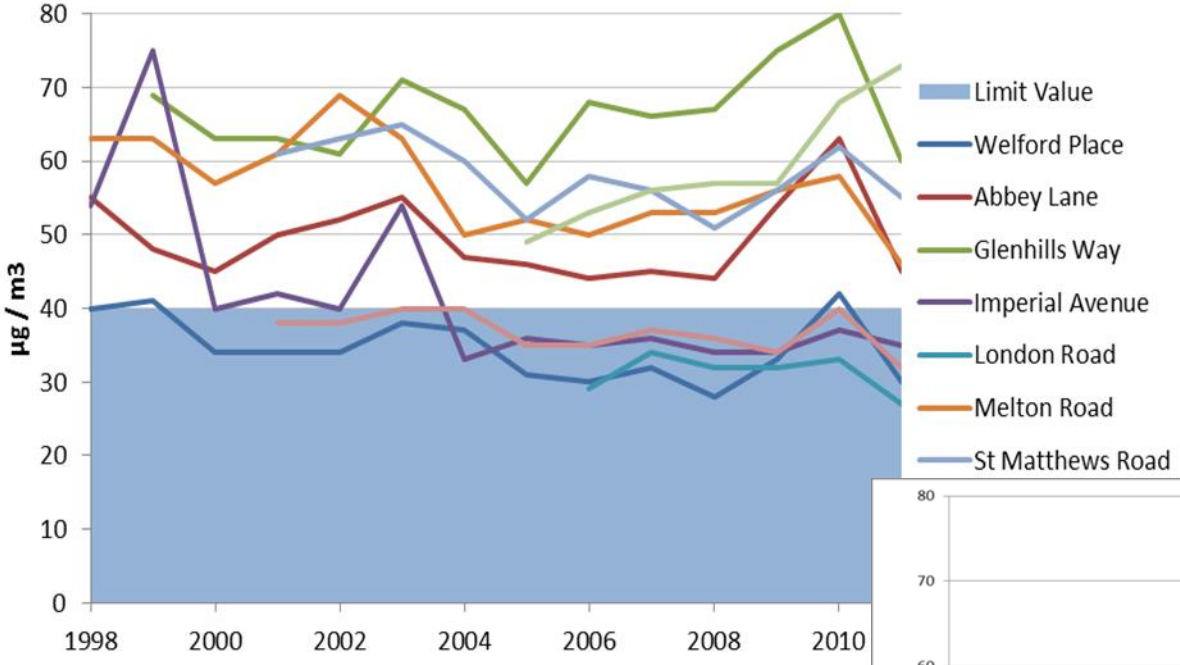
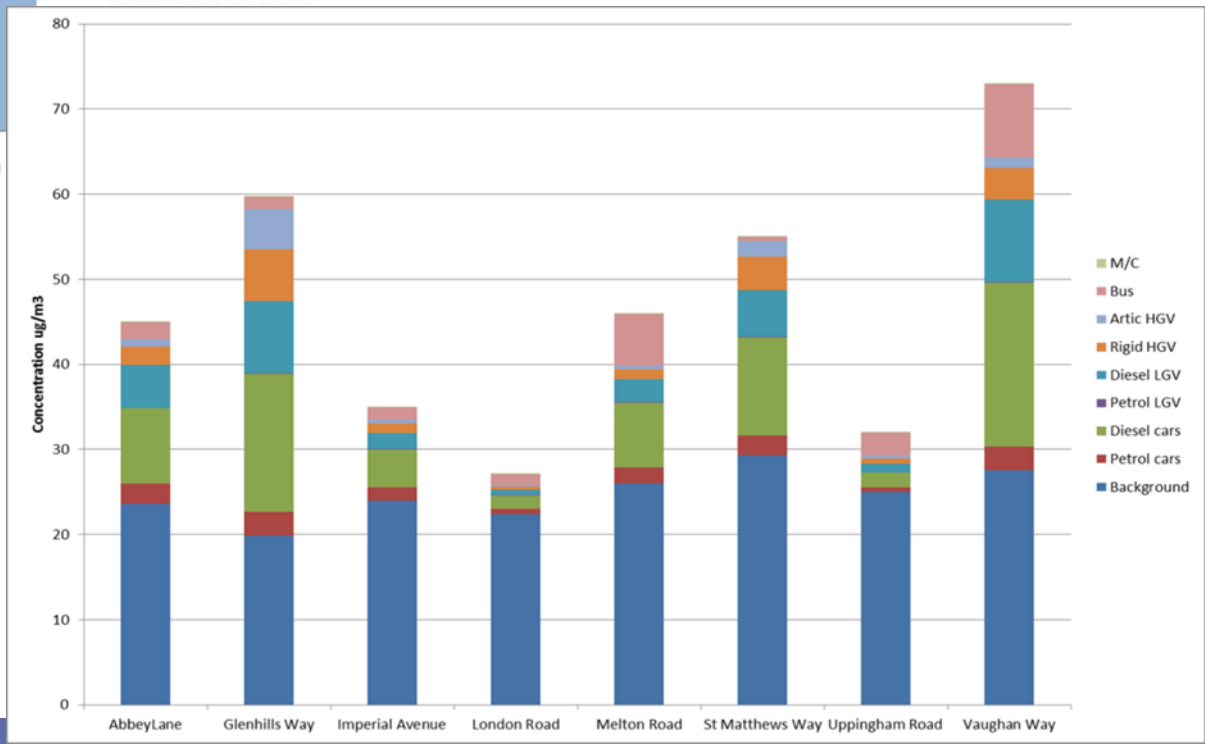
Monitored NO_2



Little clear evidence of reduction in NO_2 levels

Source apportionment



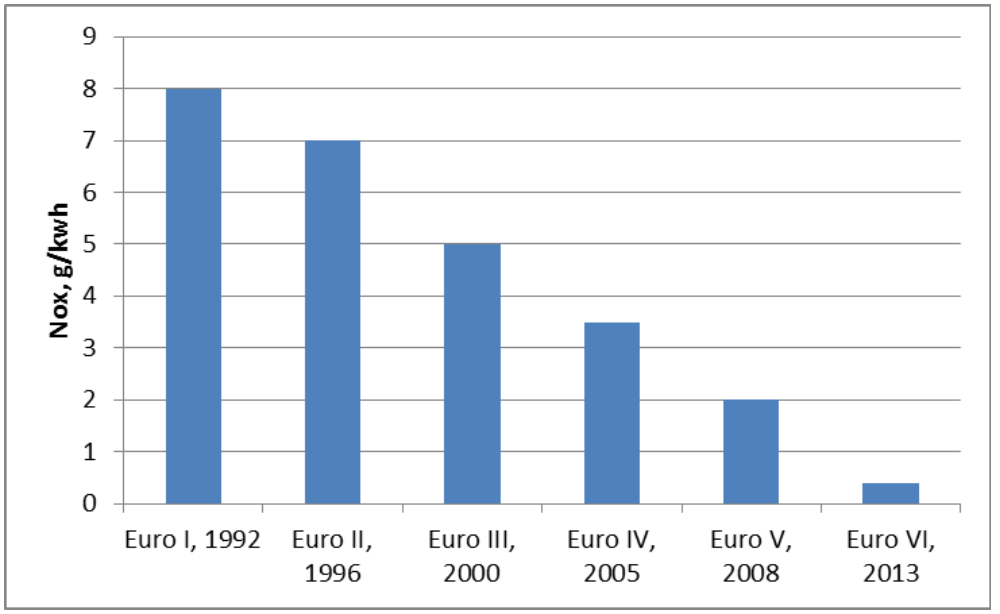
Background: 20-30 µ/m3

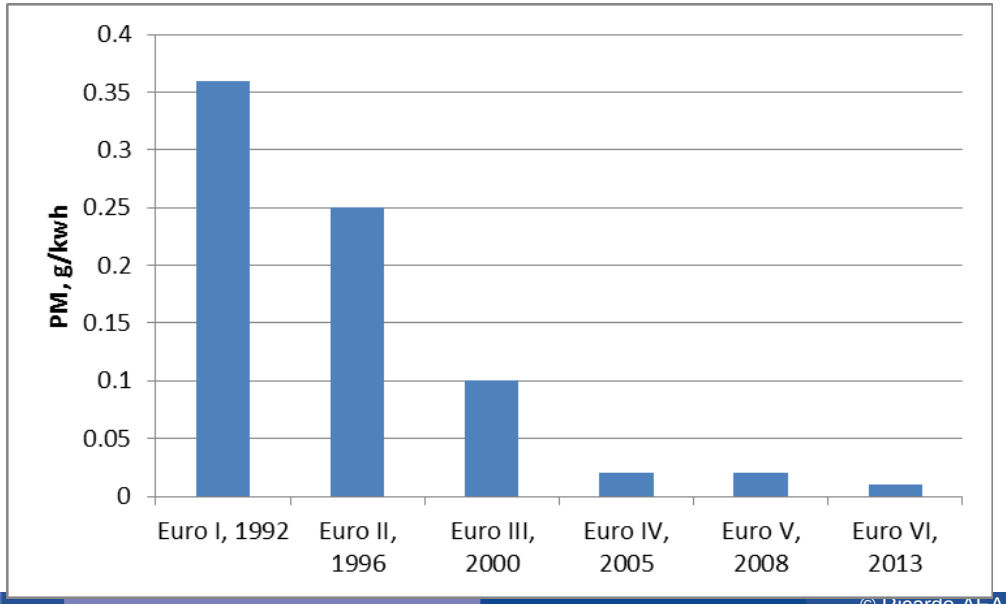
Transport: 10-50 µ/m3

Diesel vehicles a key component

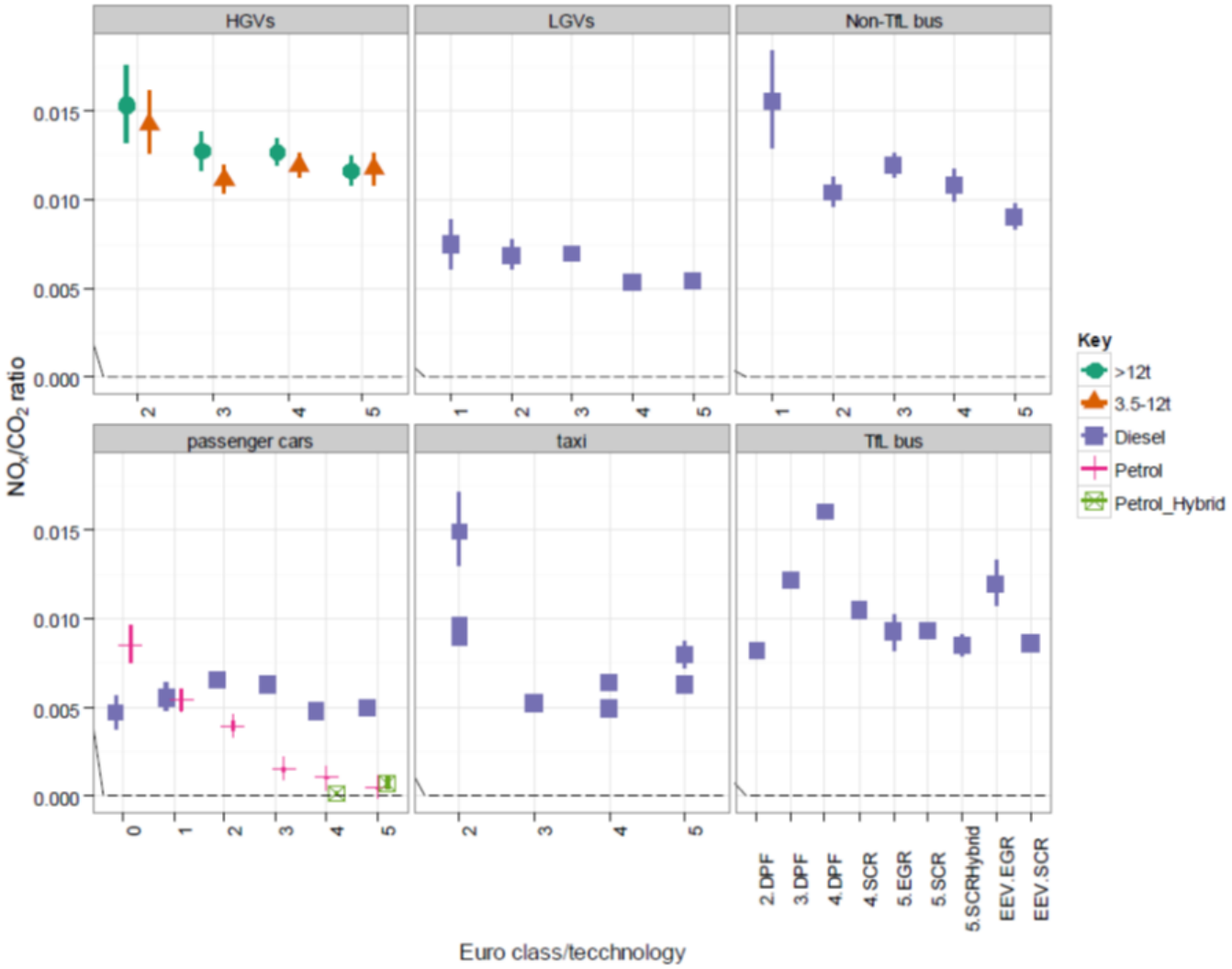
European Emission standards

- Emission durability tests
  - Catalyst performance
- On-board diagnostics
  - Better maintenance
- In service compliance
  - PEMS testing





But are they performing in real-world?



Petrol ✓

Diesel PM ✓

Diesel NOx ✘

Technology and emission standards

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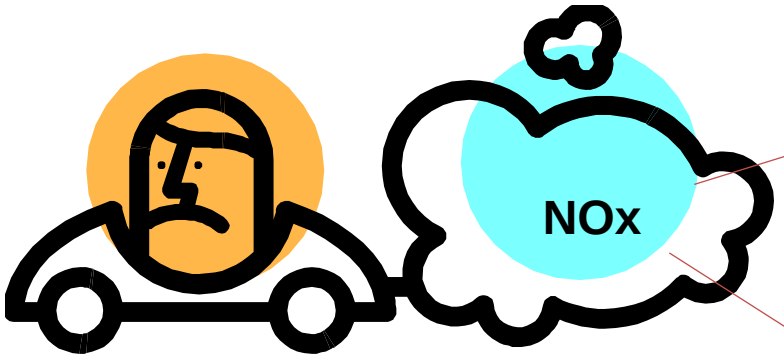
Standard*	Light-duty diesel car and van	Heavy-duty bus and truck
Euro 1/I	Engine and fuel system design (IDI* engines only) – some EGR	Engine and fuel system design (DI only on heavy-duty)
Euro 2/II	Engine and fuel system design (now fully electronic), mechanical "on/off" EGR + DOC (mix of IDI and DI** engines)	Engine and fuel system design
Euro 3/III	Engine and fuel system design, electronic (fine) control EGR + DOC (DI engines only from now on generally on sale)	Engine and fuel system design (now fully electronic)
Euro 4/IV	Engine and fuel system design, electronic (fine) control EGR + DOC + DPF (on heavier vehicles)	Engine and fuel system design + SCR (no DPF) or EGR with partial DPF
Euro 5/V	Engine and fuel system design, electronic (fine) control EGR + DOC + DPF	Engine and fuel system design + SCR (no DPF) or EGR with partial DPF
Euro 6/VI	Engine and fuel system design, electronic (fine) control EGR and/or SCR + DOC + DPF	Engine and fuel system design + SCR and/or EGR both with DPF

Technology definitions	
IDI, DI	Indirect injection and direct injection. IDI is less efficient but cheaper
DOC	Diesel oxidation catalyst – reduces CO and HC, but can increase NO_2
EGR	Exhaust gas recirculation – decreases NOx by 30-50%, but can increase fuel use
DPF	Diesel particulate filter – reduces PM by 80-90%, passive systems use NO_2 to regenerate
SCR	Selective catalytic reduction – reduces NOx by 80-90%

NOx emissions and NO_2



Direct

NO oxidation

Roadside concentration

NO_2

NO_2

($F\ NO_2$)

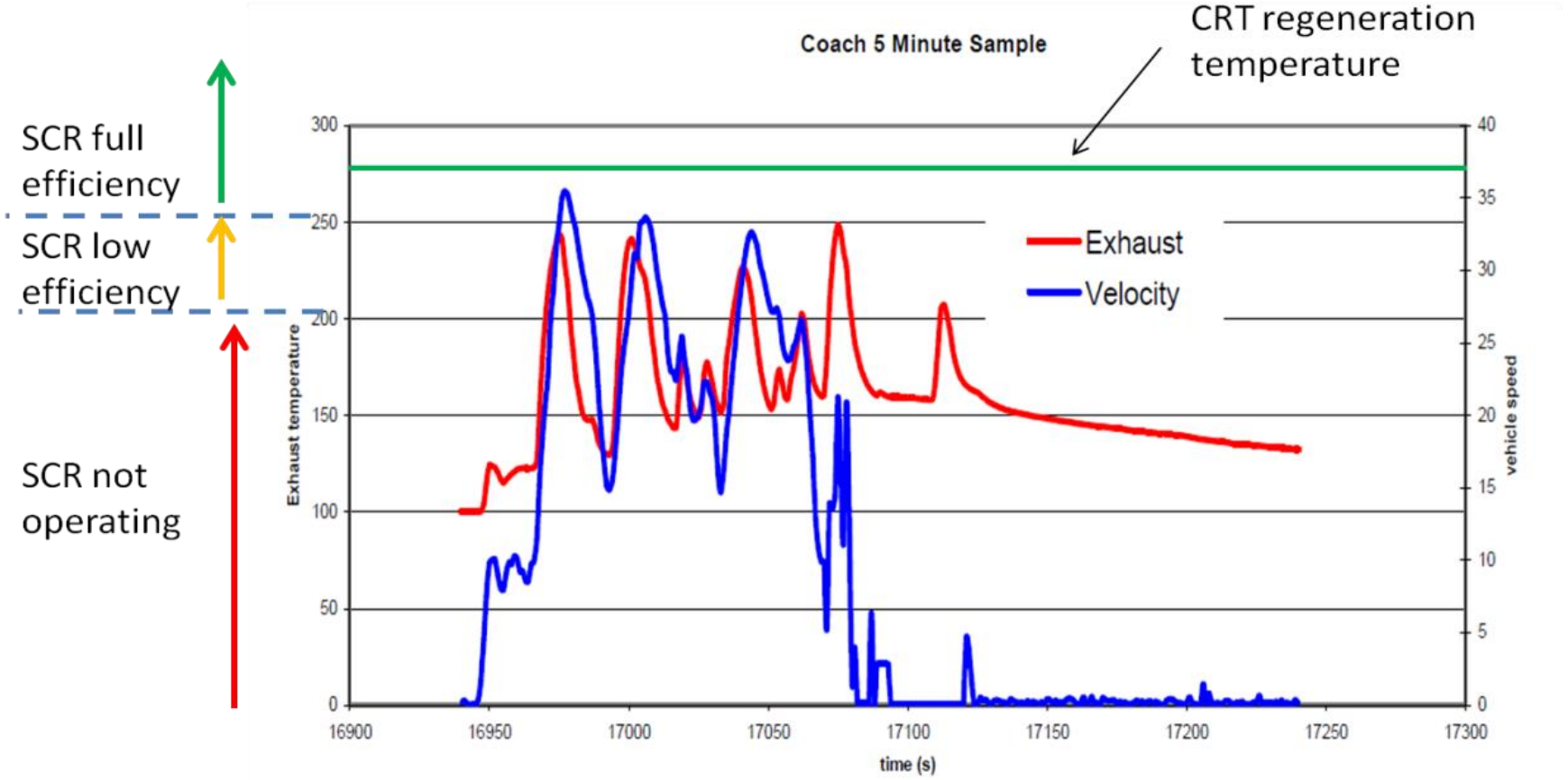
$F\ NO_2$	LDV	HDV
Pre-Euro 1	0.11	0.11
Euro 1	0.11	0.11
Euro 2	0.11	0.11
Euro 3	0.25	0.14
Euro 3 with DPF	0.35	
Euro 4	0.55	0.14
Euro 4 with DPF	0.55	
Euro 5	0.4	0.1
Euro 6	0.3	0.1

DOC and DPF

SCR

So NOx may be reducing but not direct NO_2 …

Impact of real world driving



SCR has limited effect and CRT doesn't regenerate

Source: STS analysis for Heathrow, 2011

Health impacts of pollutants

Pollutants	Quantified health effects	Unquantified health effects	Other possible effects
Particulate matter / TSP / sulphates	Mortality Chronic and acute bronchitis Minor RAD Chest illness Days of work loss Moderate or worse asthma status	Changes in pulmonary function	Chronic respiratory diseases other than chronic bronchitis Inflammation of the lung
Ozone	Mortality Respiratory RAD Minor RAD Hospital admissions Asthma attacks Changes in pulmonary function Chronic sinusitis and hay fever	Increased airway responsiveness to stimuli Centroacinar fibrosis Inflammation in the lung	Immunologic changes Chronic respiratory diseases Extrapulmonary effects (changes in the structure or function of the organs)
Nitrogen oxides	Respiratory illness	Increased airway responsiveness	Decreased pulmonary function Inflammation of the lung Immunological changes

Valuing health impacts

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	Central Estimate (1)	Sensitivities	
		Low Central Range (2)	High Central Range (2)
NOX	£955	£744	£1,085
SOX	£1,633	£1,320	£1,856
Ammonia	£1,972	£1,538	£2,241
PM domestic	£28,140	£22,033	£31,978
PM agriculture	£9,703	£7,598	£11,027
PM waste	£20,862	£16,335	£23,708
PM industry	£25,229	£19,753	£28,669
PM ESI	£2,426	£1,900	£2,757
PM transport average	£48,517	£37,987	£55,133
PM transport urban large	£70,351	£55,081	£79,944
PM rural	£15,041	£11,776	£17,091

Source: IGCB/Defra, 2011

Costs of air quality in context

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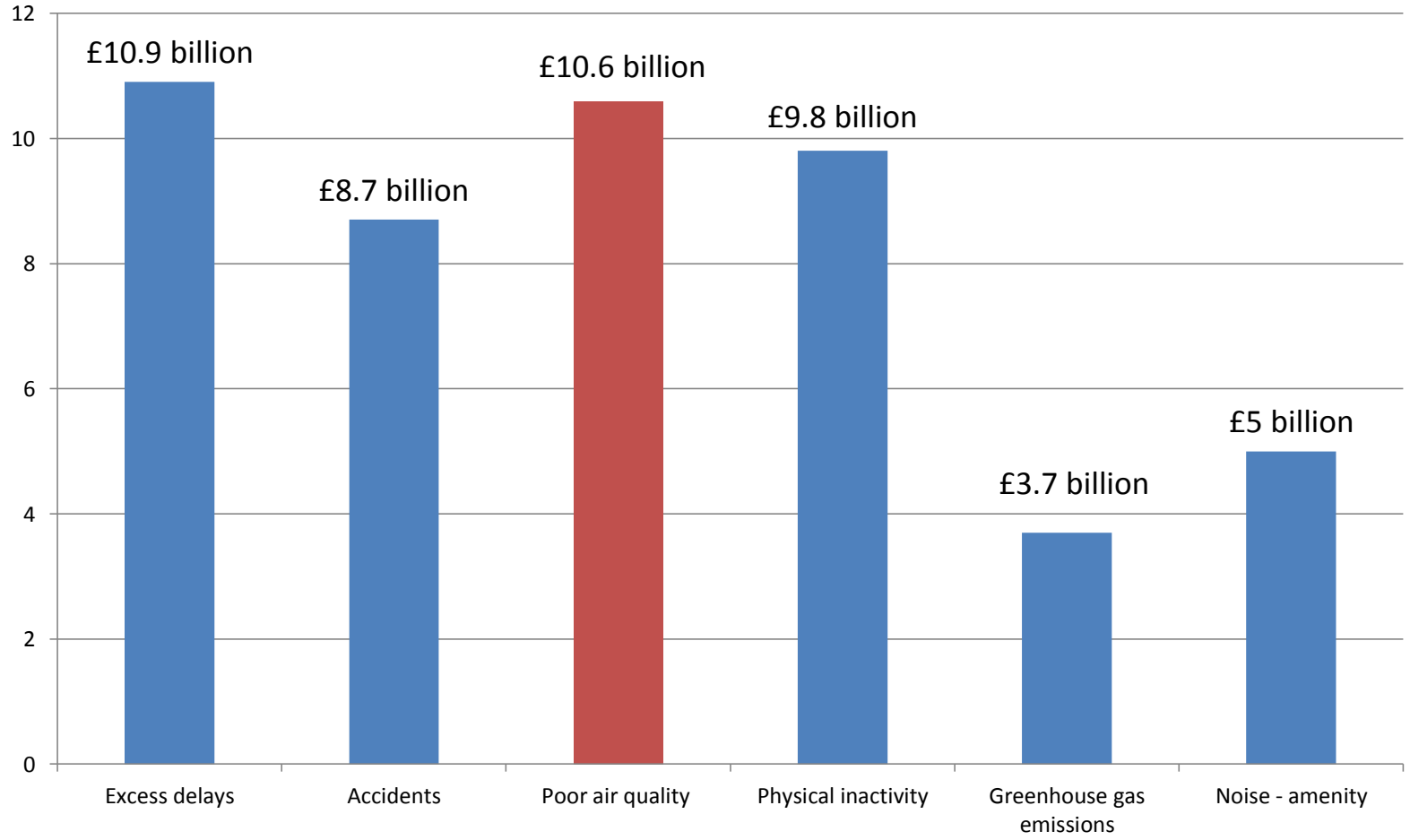
Comparing costs of transport (congestion) in urban areas in England with other issues



Source: The Cabinet Office, 2009

Public health and air quality

- Health and Social Care Act 2012
  - Public health responsibilities pass back to local authorities (Tier 1)
  - Directors of Public Health
  - Health and wellbeing boards

- Public Health Outcomes Framework (PHOF)
  - Fraction of mortality attributable to particulate air pollution (proportion, %)
  - Calculated by DoH, based on modelled $PM_{2.5}$ concentrations
  - Ranges from 4% in rural areas to 8% in urban areas

Conclusions

- Air pollution remains a key public health issue
- Transport, especially diesel vehicles, is a major cause of this pollution
- Air pollution levels have remained stubbornly high despite tightening regulations
- A key cause is the failure Euro standards for diesel vehicles to perform in urban driving conditions
- This is linked with an increasing ‘dieselisation’ of the car fleet driven by fuel efficiency and the climate change agenda
- There is also a potential conflict in air quality and public health policy
  - LAQM driven by NO_2 compliance
  - Public health driven by $PM_{2.5}$ exposure
- However
  - Regulations are reducing PM emissions
  - There are also strong synergies between air quality solutions and other public health issues in the form of ‘active’ travel

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