

Do diesel vehicles cause poor air quality?

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Inside the Engine: from Chemistry to Human Health
Royal Society of Chemistry
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Do diesel vehicles cause poor air quality?

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Key Pollutants

- **Nitrogen dioxide (NO₂)**
 - Emissions - nitric oxide (NO) + NO₂ = nitrogen oxides (NO_x)
 - NO_x from combustion processes
 - Mainly emitted as NO
 - Rapid oxidation to NO₂ in air
- **Particulate Matter**
 - Emitted directly into the air
 - Also formed in air from NO_x, SO₂, NH₃ and organic compounds
 - Heterogeneous
 - Emitted from many sources (e.g. dust, combustion processes)

Sources of air pollution

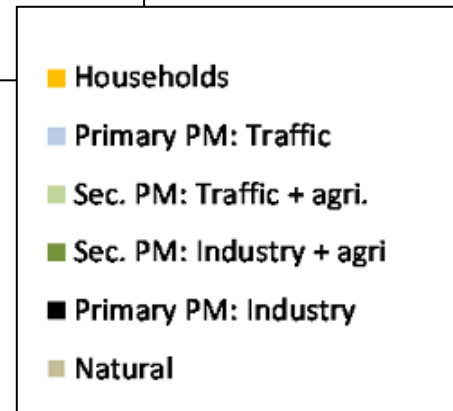
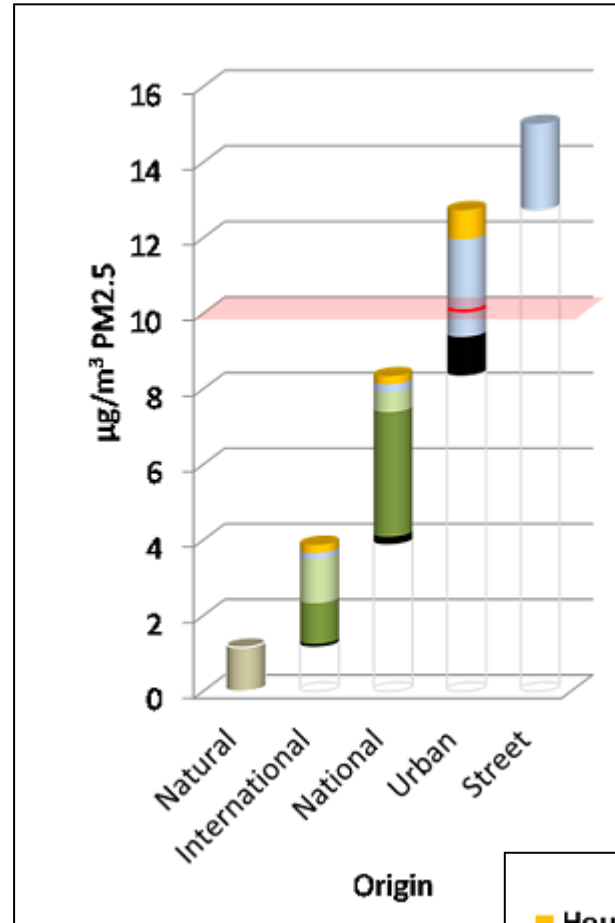
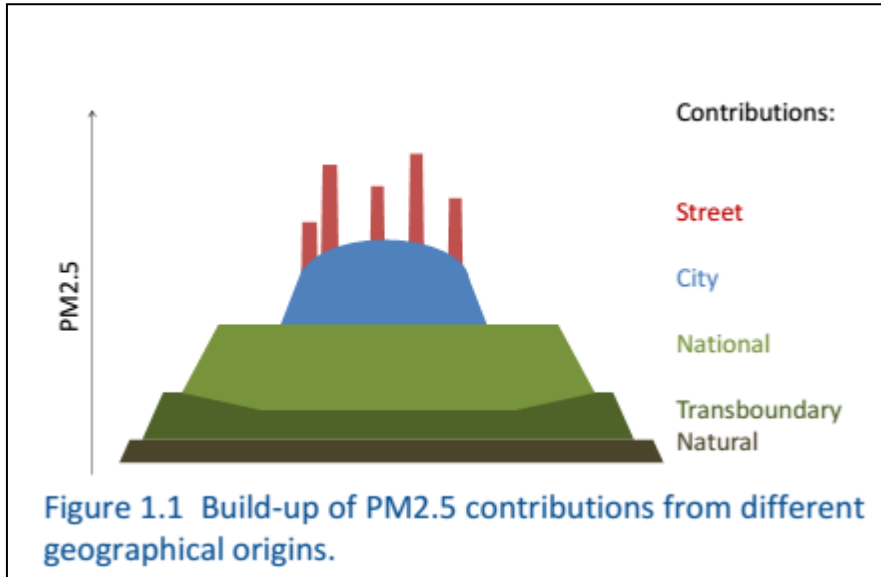
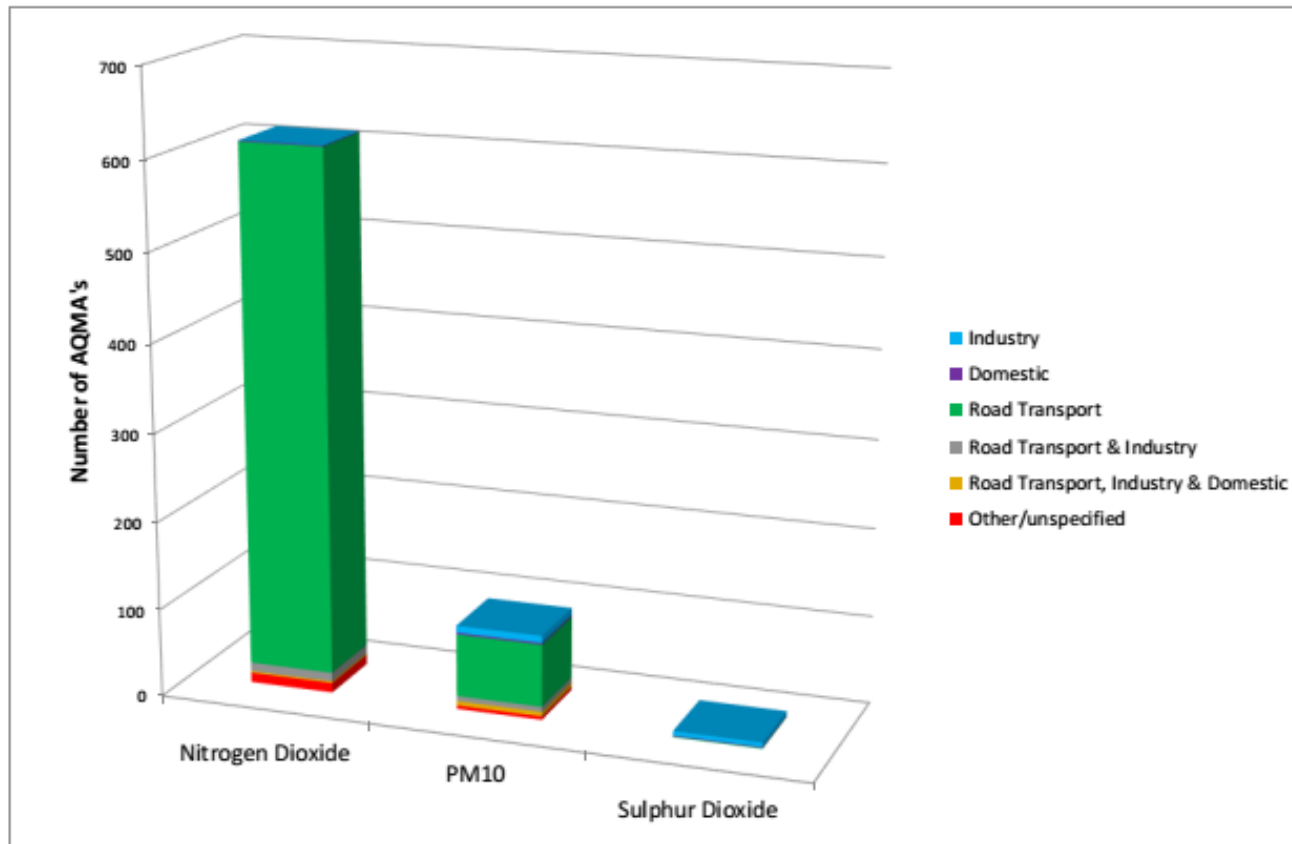


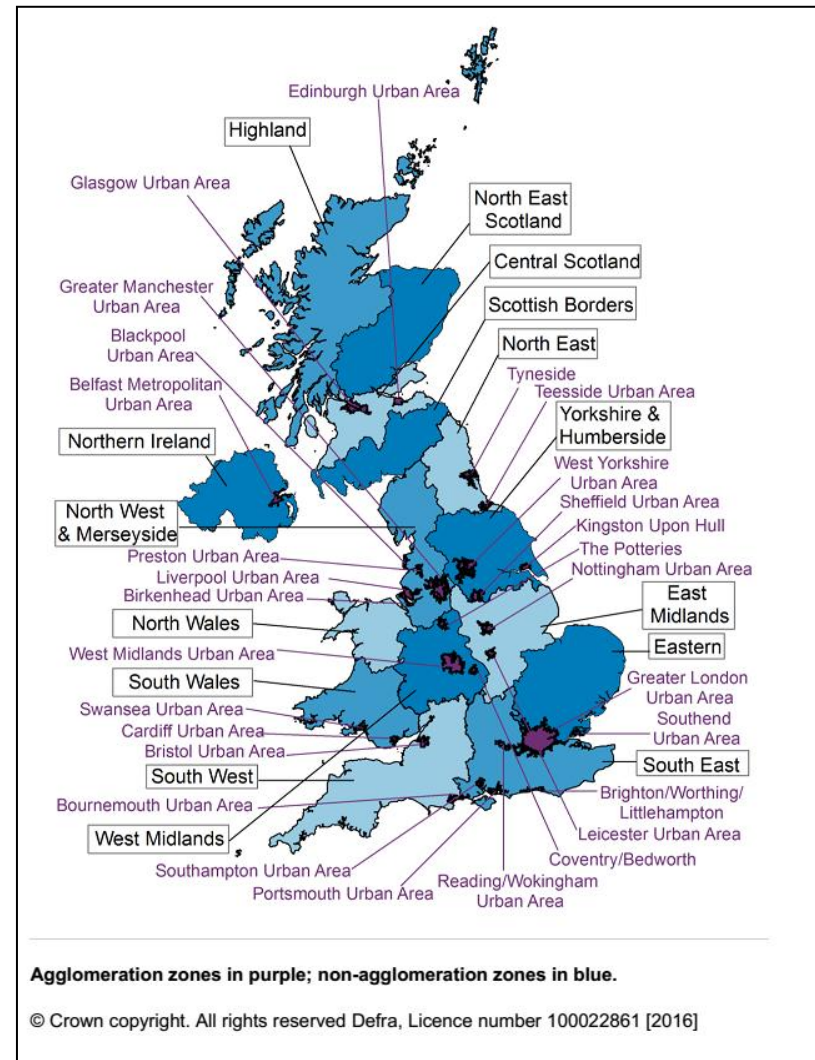
Figure 2-1 Number of Air Quality Management Areas Resulting from Various Sources



Source: Defra, 2016, Air Pollution in the UK 2015

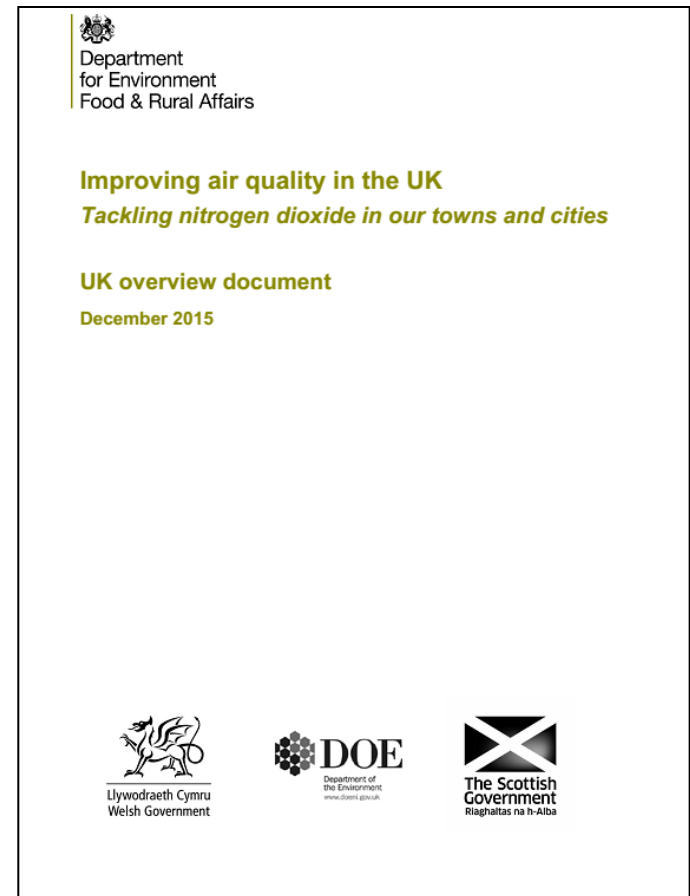
NO₂ – non-compliance with EU limit values in 2015

- 1-hour limit value:
 - Greater London
 - South Wales
- Annual mean limit value
 - 37 zones exceeded LV;
 - 6 achieved LV in 2015
 - Brighton/Worthing/Littlehampton,
 - Blackpool Urban Area,
 - Preston Urban Area
 - Highland Scottish Borders
 - Northern Ireland

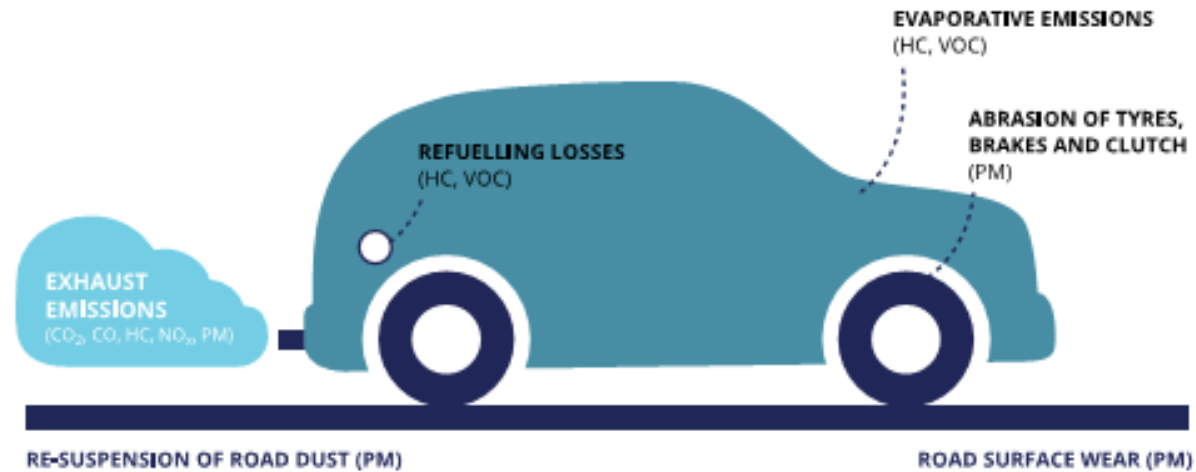


2015 UK Air Quality Plan

- In areas of concern:
 - Transport: 80% NO_x
 - The largest source - diesel vehicles
- Due to
 - the significant growth in diesel vehicle numbers
 - the emissions standards not delivering the expected emissions reductions.



Air emissions

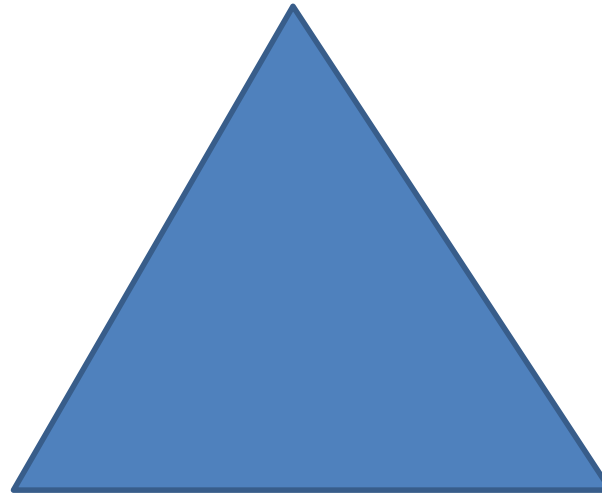


European Environment Agency, 2016. Explaining road transport emissions: A non-technical guide.

Engine emission trade-offs

Formed at high temperatures largely from atmospheric O_2 and N_2

NO_x



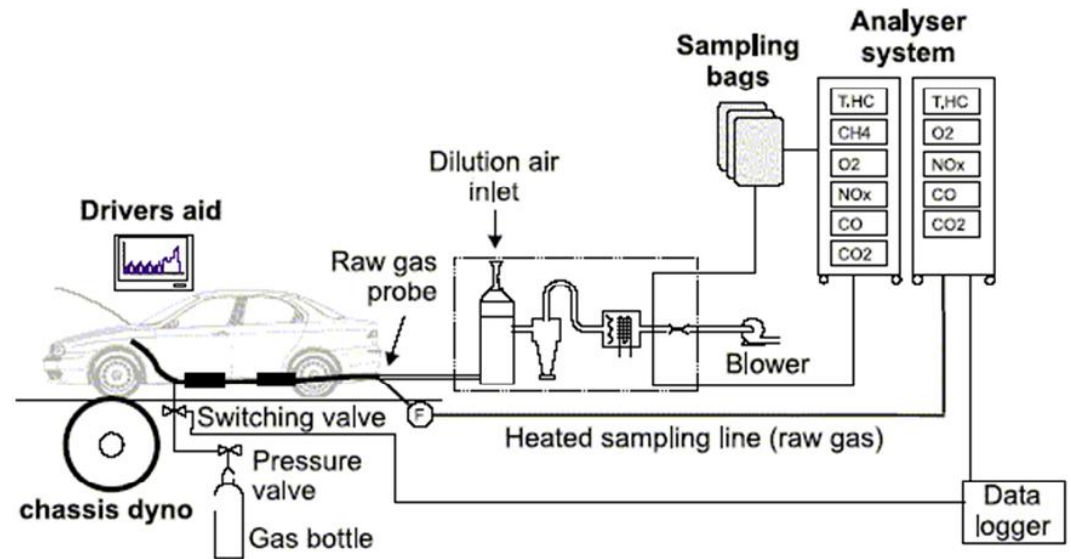
PM

Formed during incomplete combustion

CO₂

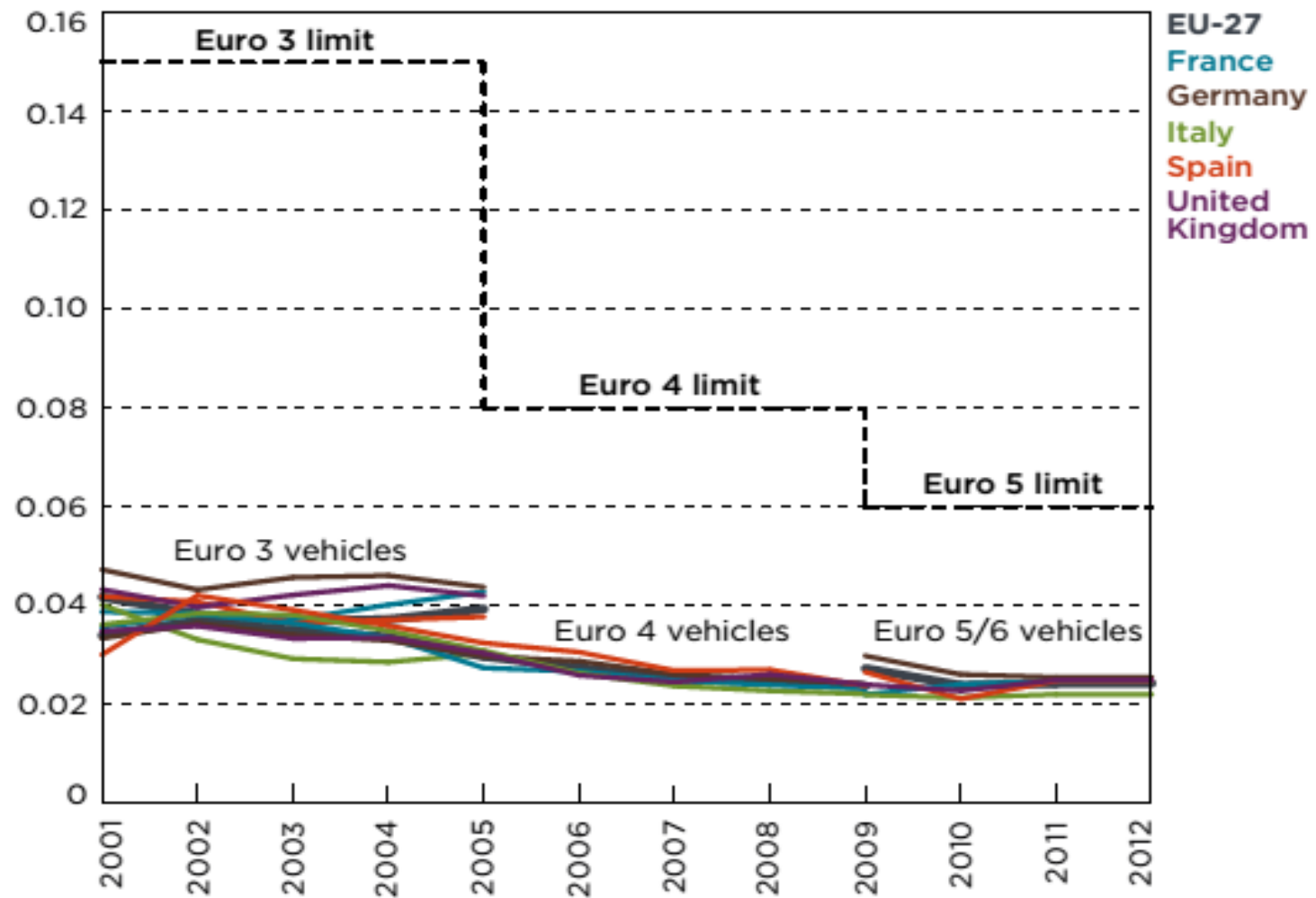
Product of complete combustion

EU Type approval test -chassis dynamometer for cars and vans



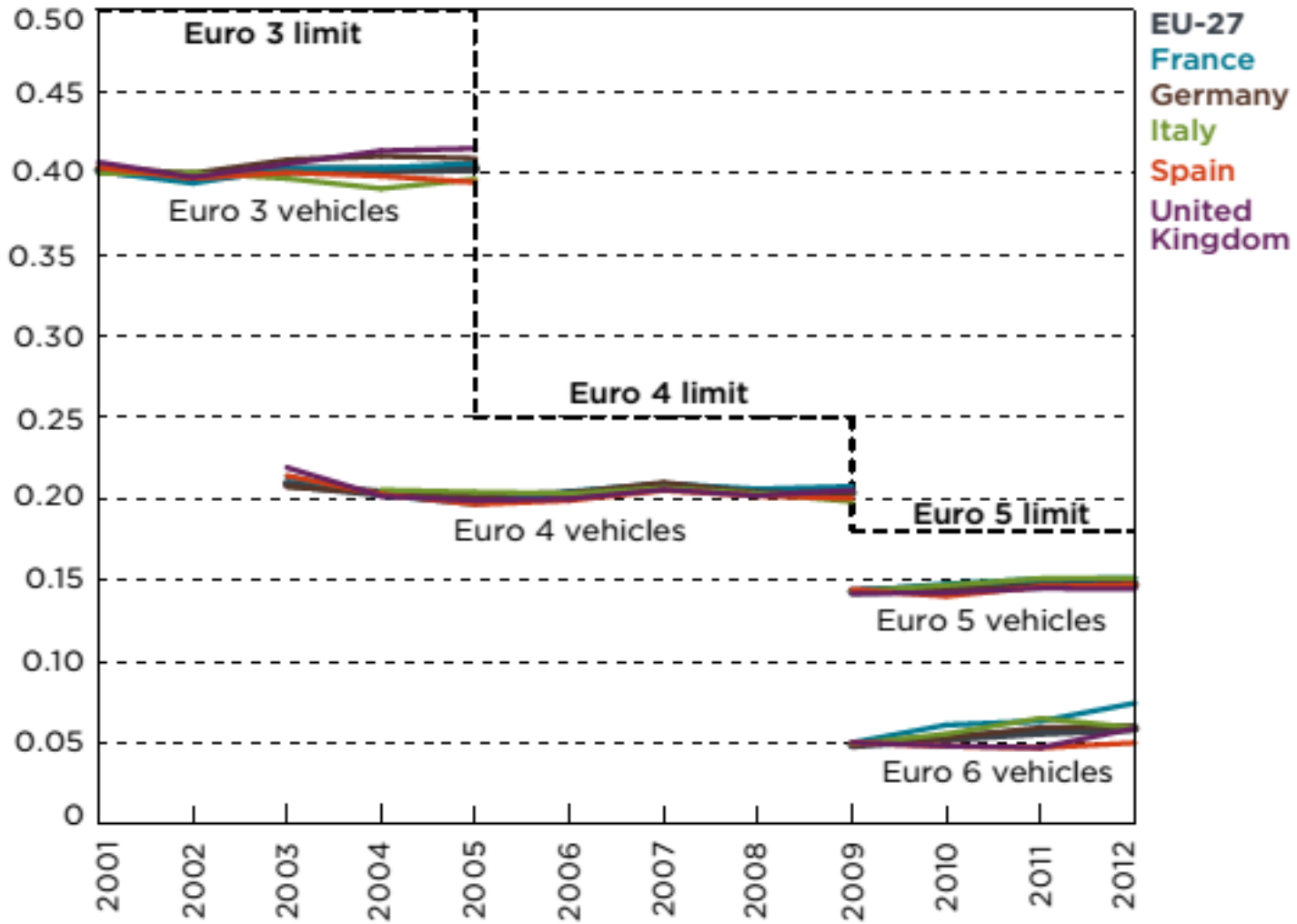
Source: Mikkeli University of Applied Sciences, Finland

NO_x emission levels, gasoline vehicles

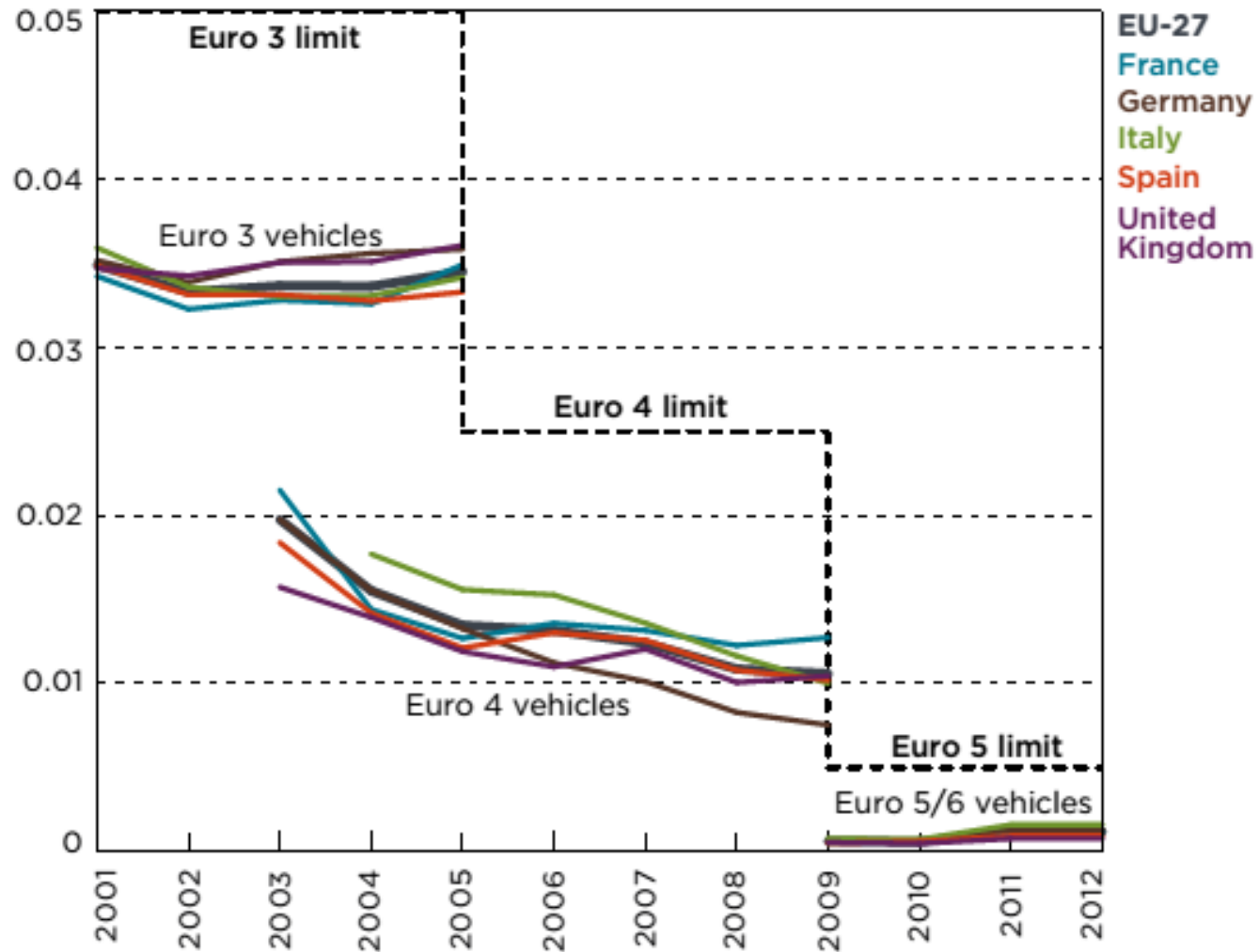


Vehicles with a previous emission standard registered in the years after a new standard is introduced were excluded from the analysis.

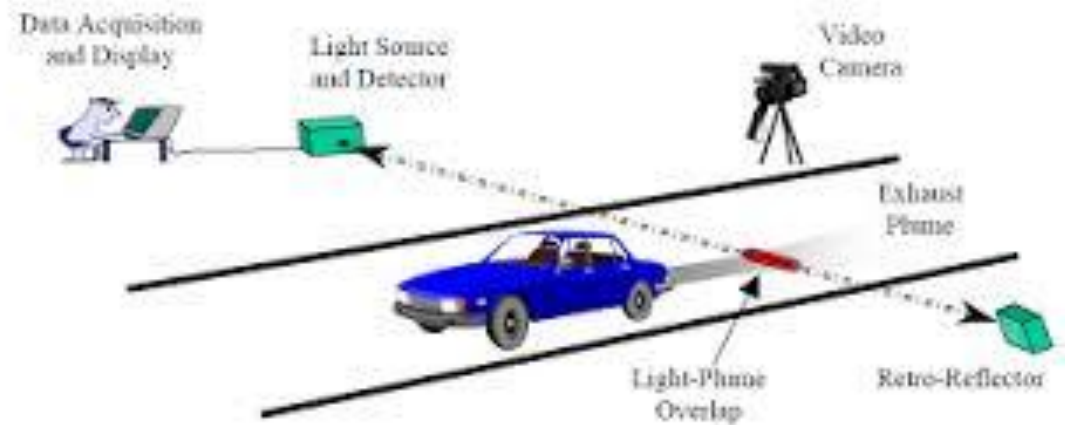
NO_x emission levels, diesel vehicles



PM emission levels, diesel vehicles (g/km)

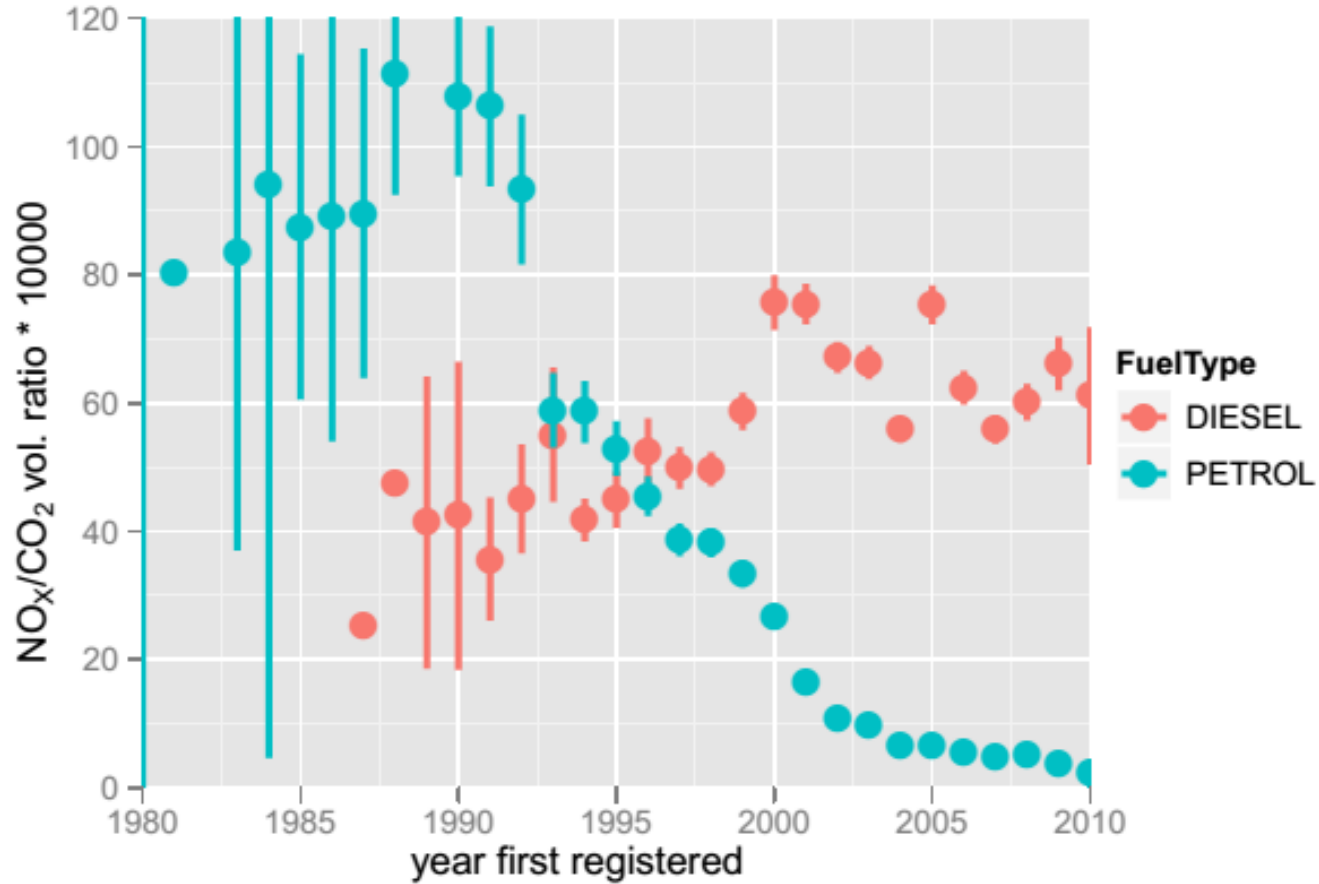


Remote Sensing of Vehicle Emissions



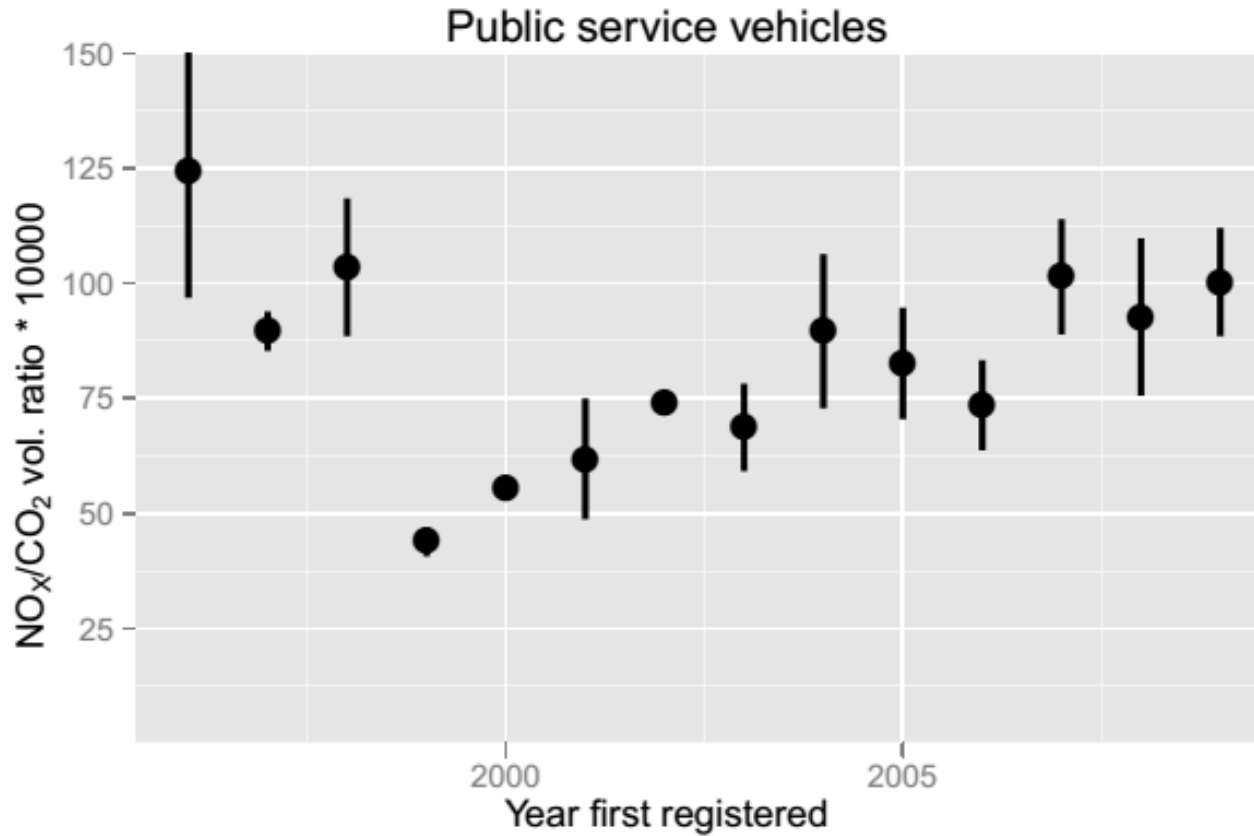
Setup for on-road remote sensing of automobile emissions

Real World Emissions



Source: Carslaw, D., Beevers, S. Westmoreland, E. Williams, M. Tate, J. Murrells, T. Stedman, J. Li, Y., Grice, S., Kent, A. and I. Tsagatakis (2011). Trends in NO_x and NO₂ emissions and ambient measurements in the UK. London: Defra

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Not a new problem!



Diesel Vehicle Emissions and Urban Air Quality

December 1993

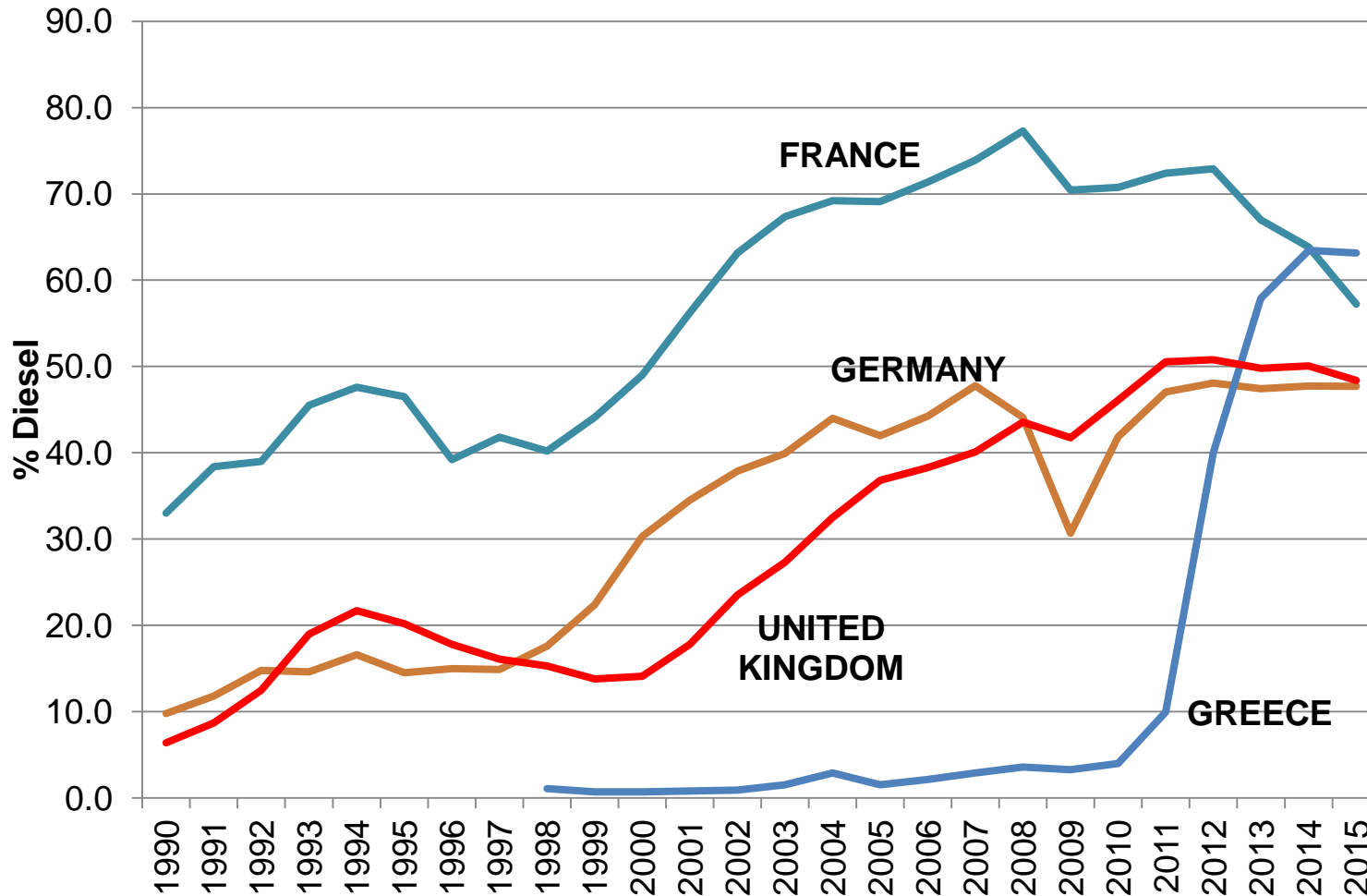
Second Report of the
Quality of Urban Air Review Group

Prepared at the request of the
Department of the Environment

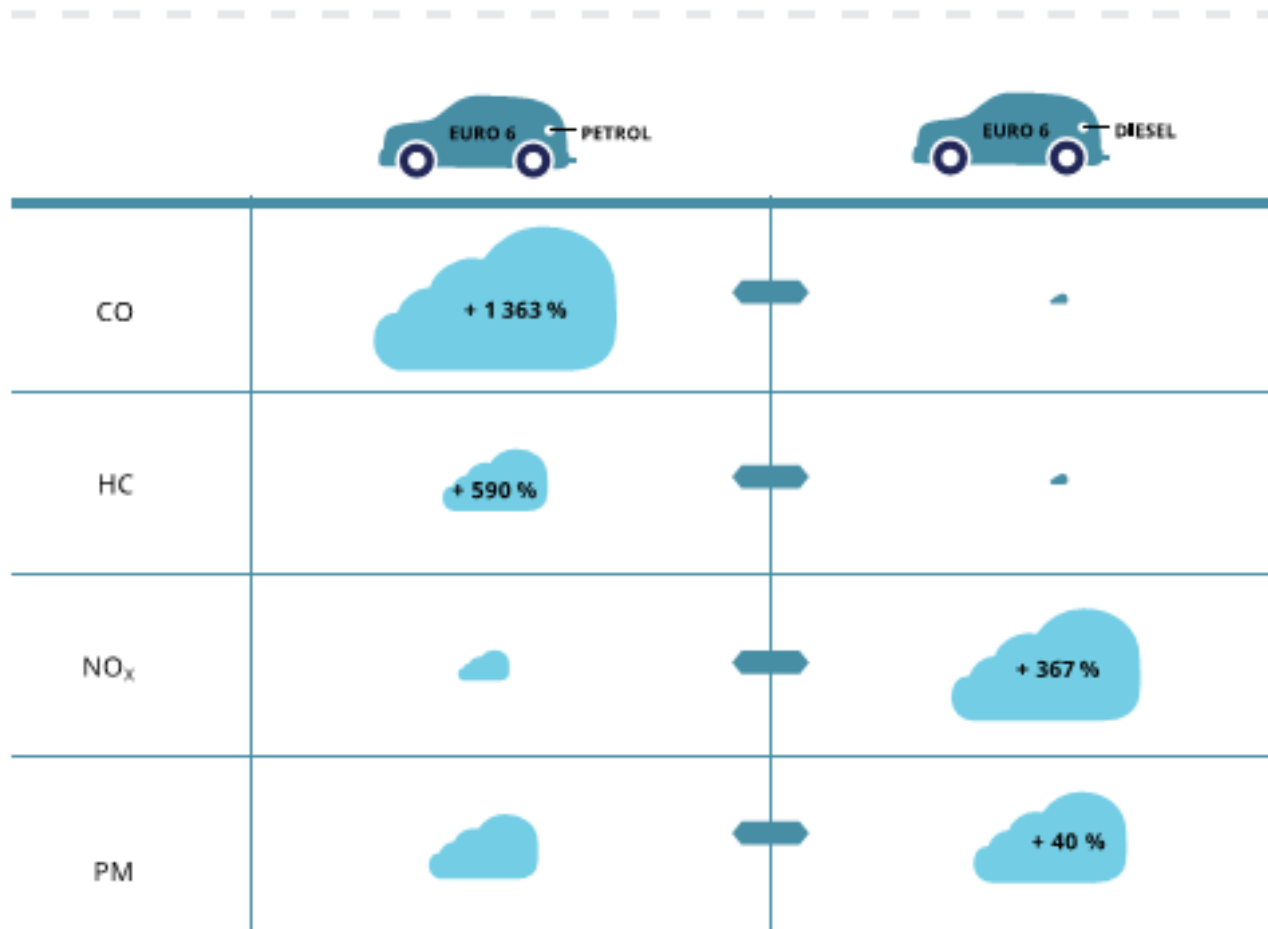
Quality of Urban Air Review Group, 1993

“...unless some improvements in the emissions from diesel vehicles can be achieved, there must be considerable concern over any increase in the proportion of diesel vehicles on our urban streets as their impact on urban air quality is undoubtedly quite serious.”

Diesel market share – new cars

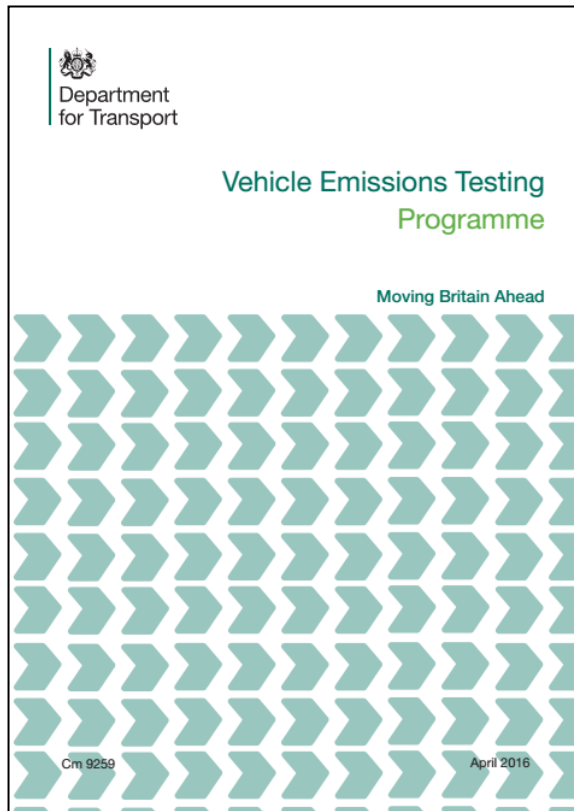


Real world emissions (Euro 6)



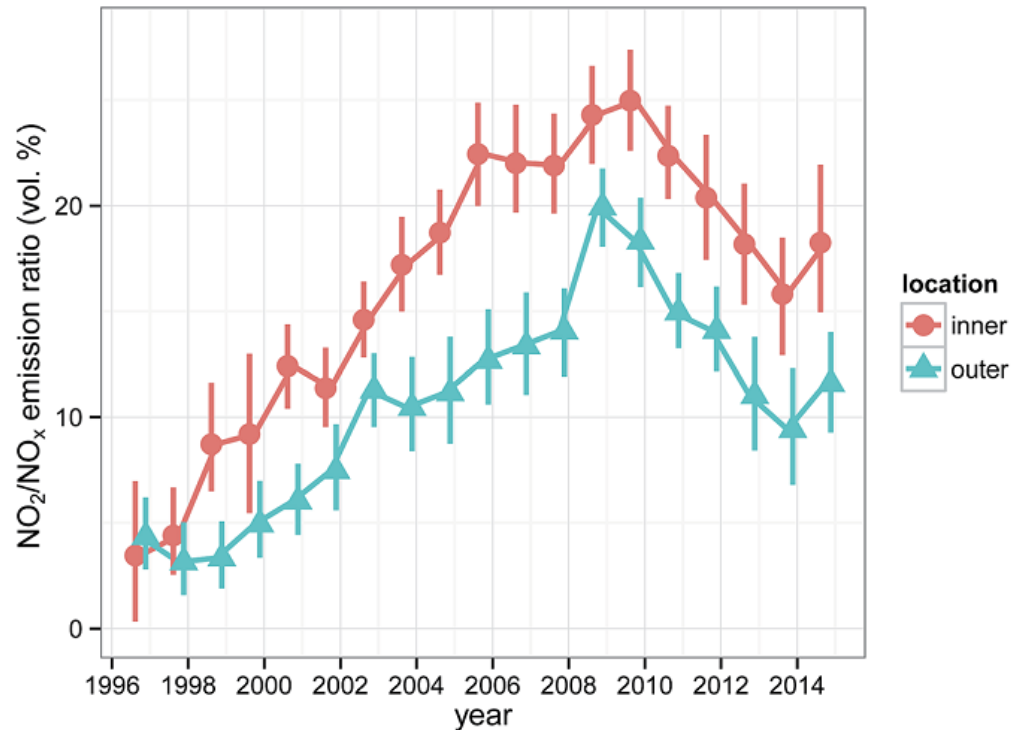
European Environment Agency, 2016. Explaining road transport emissions: A non-technical guide.

UK Vehicle Emissions Testing Programme



	LV (mg/km)	Average on-road (mg/km)
Euro 5	180	1135
Euro 6	80	500

Primary NO₂ emissions



Primary NO₂ emissions dominate source of of NO₂ concentrations at roadside locations

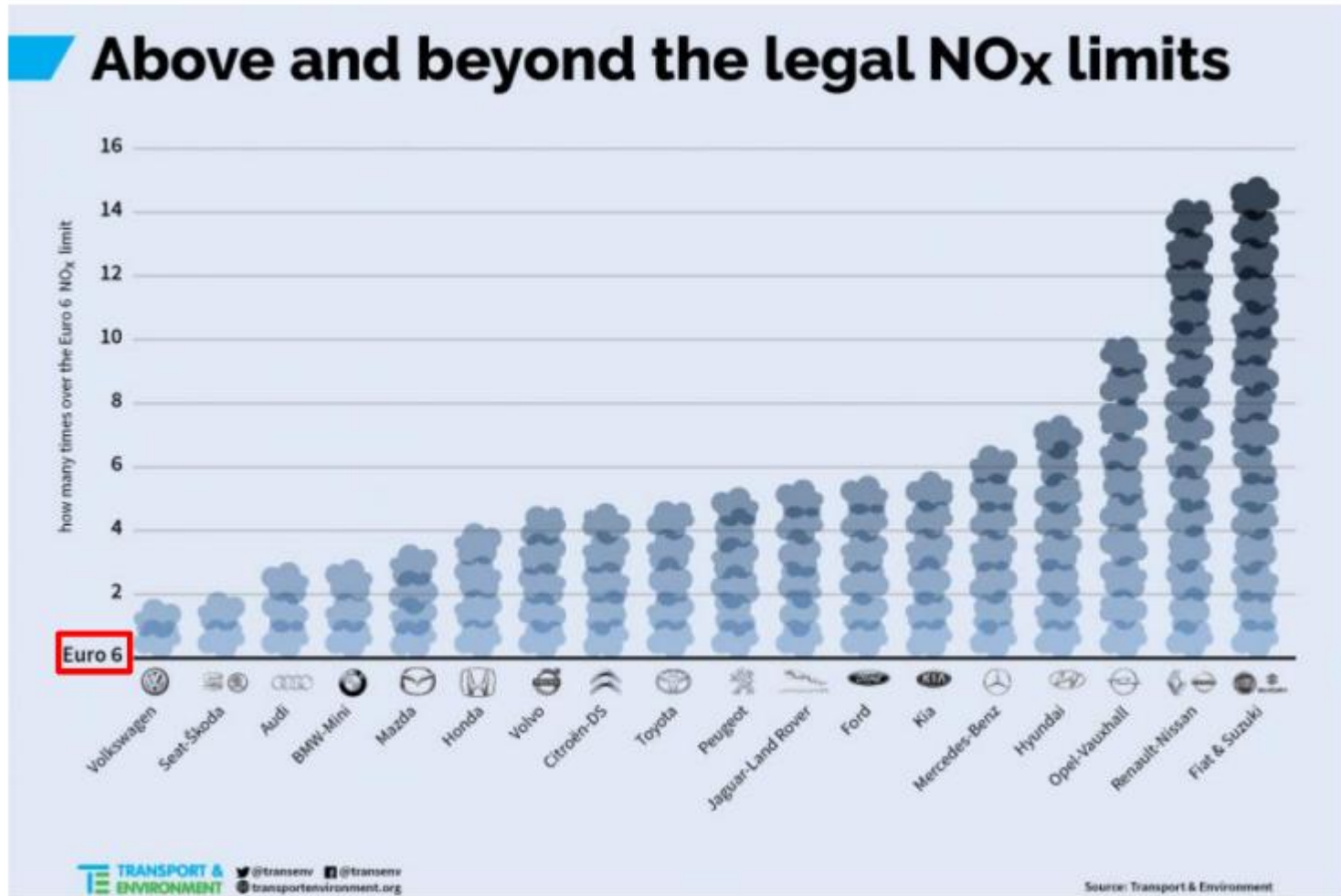
NO CO₂ NO NO_x
PERFECT!



SYNEIDER

ABGASTEST

Diesel car on-road NO_x emissions



Defeat devices

- VW – engine management system recognised the laboratory test cycle
- Fiat models switch off after 22 minutes. Emissions tests normally run for around 20 minutes.
- Other manufacturers switch the emission control system off when ambient temperature cold or very hot, or when the engine is under load.

When carmakers switch off pollution control

Average temperature in Europe:



Below 17°C



Opel (Vauxhall)

Below 17°C



Renault-Nissan

Below 10°C



Daimler

Below 5°C



Peugeot

High speeds
& full car



Ford

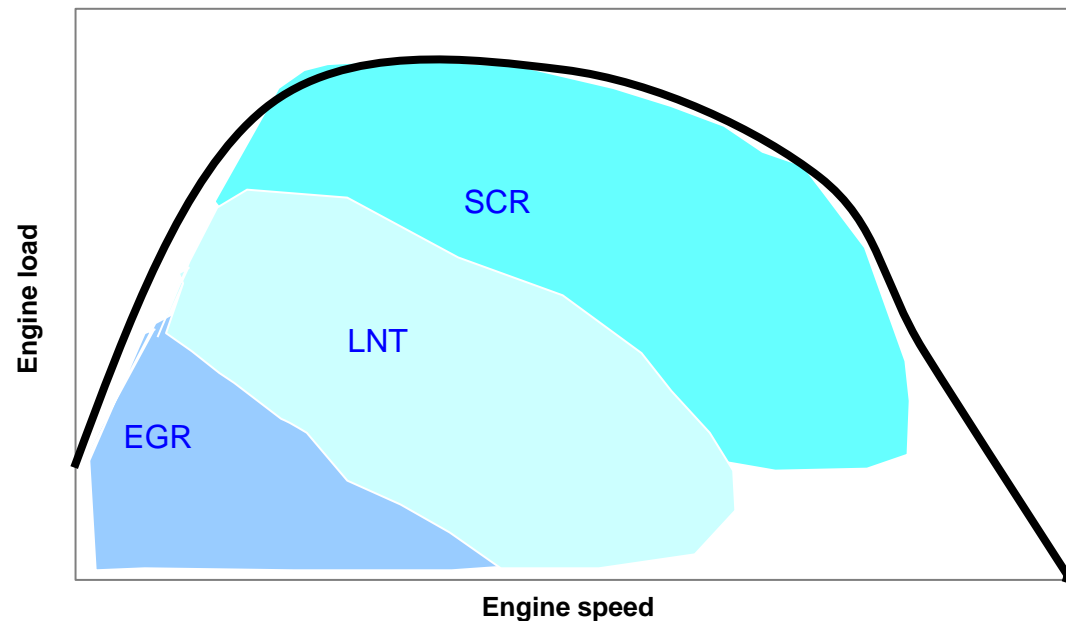
High speeds
& full car



Fiat

Abatement technology

- Exhaust gas recirculation (**EGR**) – used for many years
- Selective catalytic reduction (**SCR**) – requires reactant (NH_3 from urea solution - Adblue); required minimum exhaust temperature
- Lean NO_x trap (**LNT**) - stores NO_x emissions at low temperatures when the SCR system is less effective.



Future Regulation

- Real driving emissions (RDE) test:
 - from 2017 new models
 - 2019 all new vehicles: 2.1 times limit value;
 - from 220/201 1.5 times value.
- Will required larger Adblue storage/drivers' refilling and/or SCR+LN, or SCR+LNT+ERG.

Summary

- Main source of high NO₂ concentrations is diesel vehicles
- Petrol cars with TWC - low emissions of NO_x, CO and HCs.
- After-treatment for diesel vehicles - more recent
- Controlling NO_x from diesel engines under real world driving has proved difficult. The technology is improving.
- May need a combination of technologies to be effective under all driving conditions, but this will be expensive.
- DPFs are effective at reducing PM emissions. The new particle number standard has forced manufactures to adopt this technology.
- Legislation is the main driver for cleaner vehicles.
- Petrol and diesel likely to be the predominant fuels for many years.
- Vehicle emission control will continue to evolve (Euro 7/VII standards?)