Air Pollution

How Fresh is our Fresh Air

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Format of talk

What do we do?

Why is air pollution important?

What are the main sources of air pollution?

Air pollution and climate change – can we reduce both?

What can we do about it?

International perspective

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What do we do?

Atmospheric Dynamics, Air Quality and Climate

Air pollution, meteorology, climate interactions, impacts

Particle Instrumentation and diagnostics

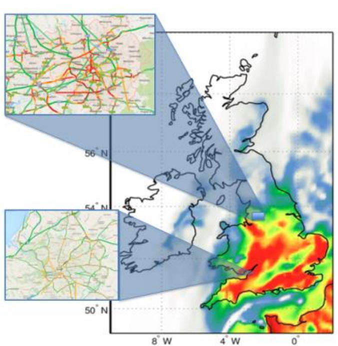
New sensors for airborne particles

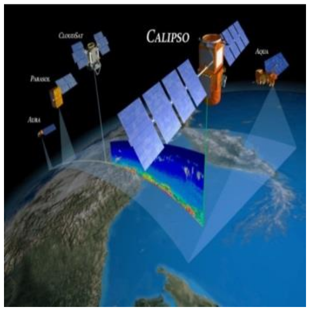
Laser Scattering and Radiation Processes

Understanding how particles affect radiation and clouds

Atmospheric Remote Sensing Laboratory

Detecting airborne particles with lasers, satellites



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Why is air pollution important?
Societal impact

Global challenge of Air pollution in towns and cities:

- Air pollution is ‘world’s largest single environmental health risk’ (WHO 2014)
- 7 million premature deaths worldwide due to air pollution exposure (one in eight of all global deaths)
- Air pollution is associated with a wide range of health impacts

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Why is air pollution important? Health effects

Increase in risk from exposure to air pollution:

Mortality
Strokes
Coronary heart disease
Acute lower respiratory disease,
Chronic obstructive pulmonary disease (COPD) and Lung cancer
And more…

Recent studies indicate that there is no threshold below which health effects do not occur

Pollutant	Health effects at very high levels
Nitrogen Dioxide (NO_2)	These gases irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases
Particles PM2.5, PM10	Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung diseases

PM2.5 ~ two thirds of PM10

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Why is air pollution important?

"Air pollution is estimated to reduce life expectancy of people in the UK by 6 months on average, imposing a cost of around £16 billion per year" (DEFRA 2013)

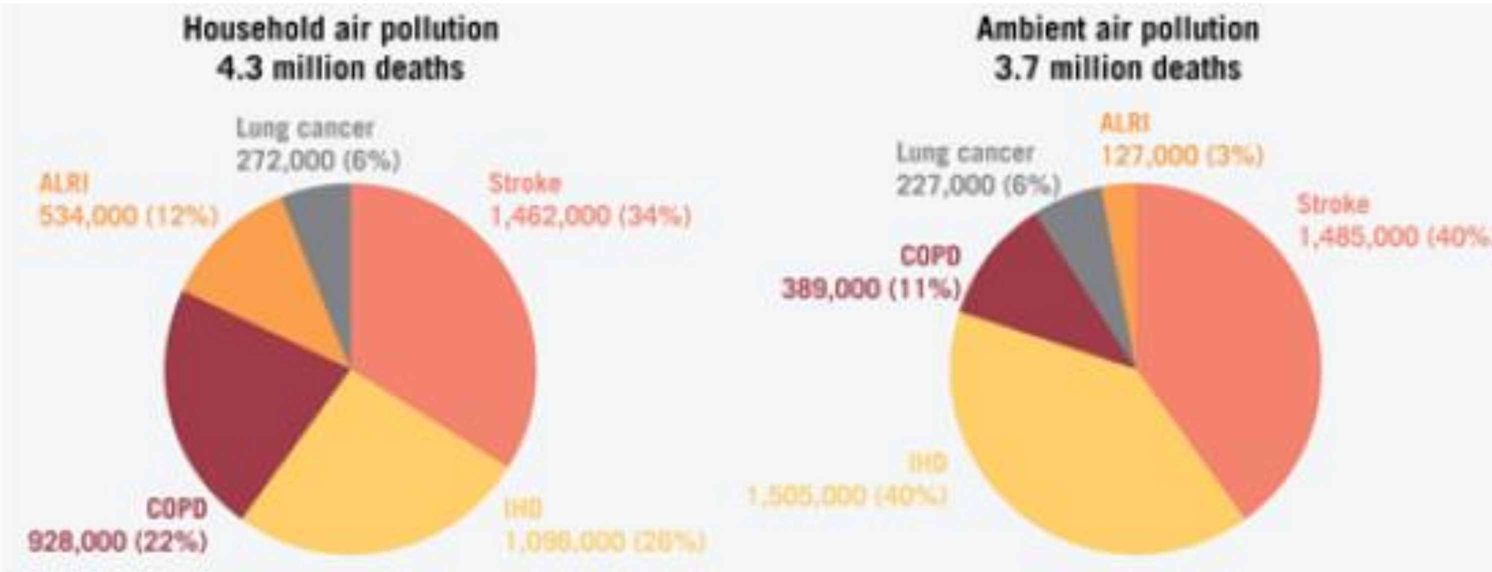
Department for Environment Food & Rural Affairs

www.gov.uk/defra

Abatement cost guidance for valuing changes in air quality

May 2013

World-wide health Impact of Air Pollution



Deaths attributed to household and ambient air pollution, 2012 (WHO 2014)
ALRI = Acute lower respiratory infections
IHD = Ischemic Heart Disease
COPD = Chronic Obstructive Pulmonary Disease

REDUCING GLOBAL HEALTH RISKS
Through mitigation of short-lived climate pollutants
Scoping report for policymakers (WHO 2015)

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Regulating air quality in Europe

Ambient Air Quality EU limit values and UK objectives

Pollutant	EU Limit Value	UK Objectives	Averaging period	Date to be achieved by UK
Fine particles ($PM_{2.5}$)	25 µg/m^3 **(WHO: 10)**	25µg/m^3	1 year	2020
Particulate matter PM_{10}	50 µg/m^3 not to be exceeded more than 35	50 µg/m^3 not to be exceeded more than 35 times a year	24 hours	31 December 2010
	40 µg/m^3 **(WHO: 20)**	40 µg/m^3	1 year mean	31 December 2004
Nitrogen dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times a year	200 µg/m^3 not to be exceeded more than 18 times a year	1 hour mean	31 December 2005
	40 µg/m^3	40 µg/m^3	1 year mean	31 December 2005
Ozone (O_3)	120 µg/m^3 25 days averaged over 3 years	100 µg/m^3 not to be exceeded more than 10 times a year	8 hour mean	31 December 2005

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Sources of air pollution

Primary emissions – air pollutants that are emitted directly into the atmosphere

Secondary sources– air pollutants that are formed in the atmosphere from chemical reactions between primary air pollutants and sunlight

Example:
Ozone (O_3) and Nitrogen dioxide (NO_2)

Vehicle traffic contributes significantly to ozone formation through emissions of NOx, VOCs and CO

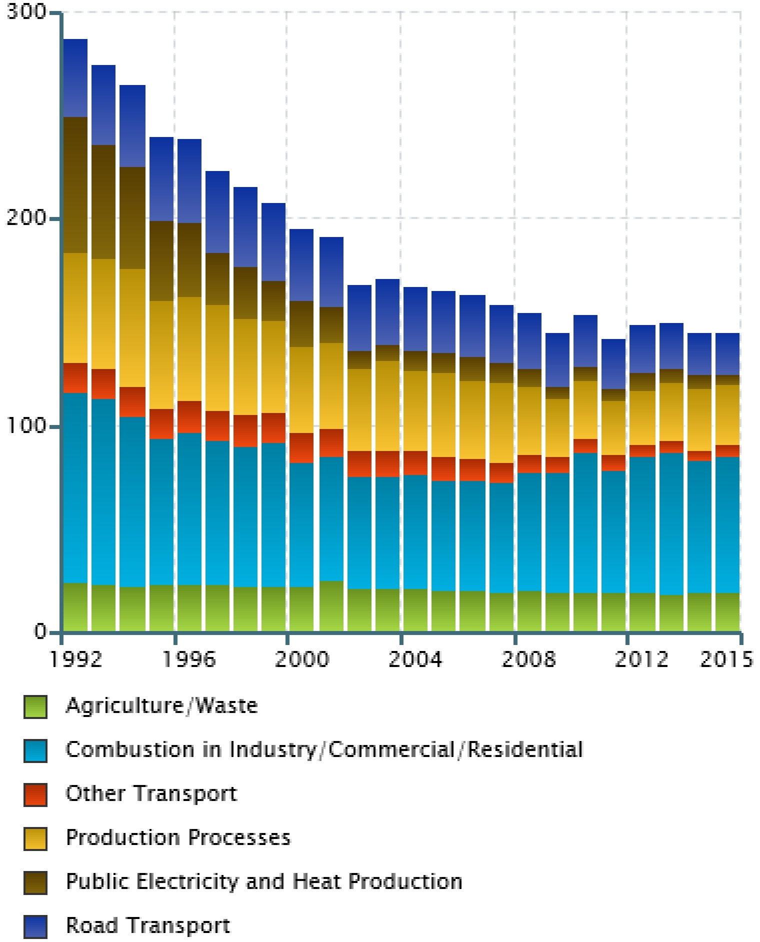
Airborne Particulate Matter

Pollutant	Source orientated response
PM10	Coarse e.g. road dust
PM2.5	Regional dominant, exhaust
EC	Combustion, exhaust
BaP	Wood burning
Particle Number	Combustion, exhaust

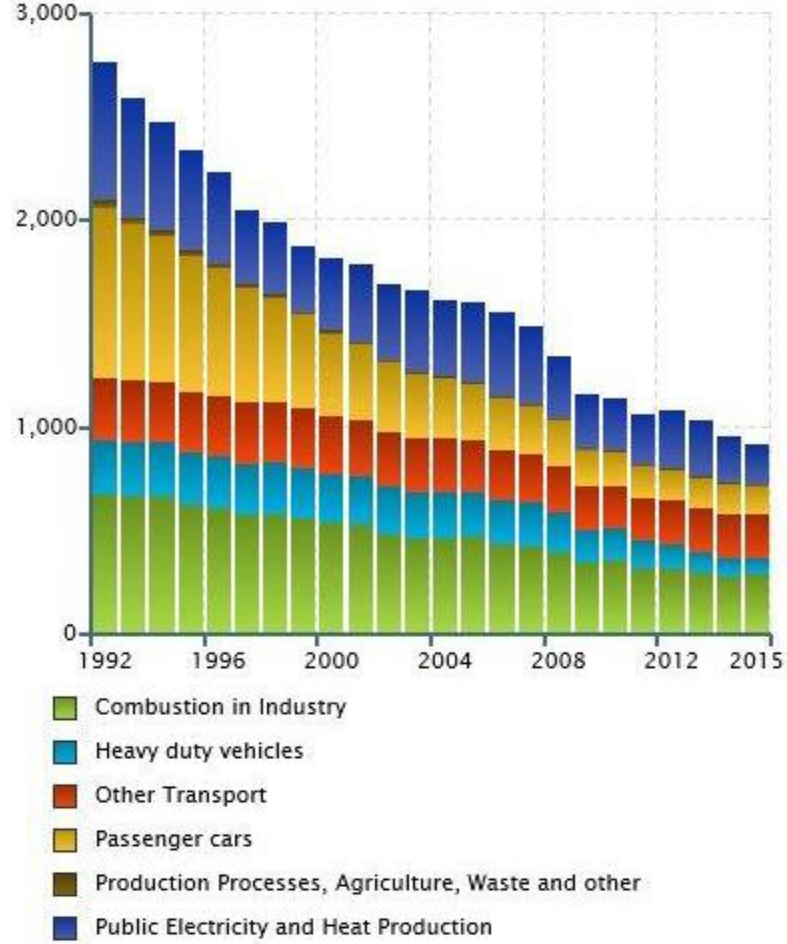
Sources of air pollution - UK

$NOx = NO + NO_2$

Particulate Mater (PM10) (ktonnes)



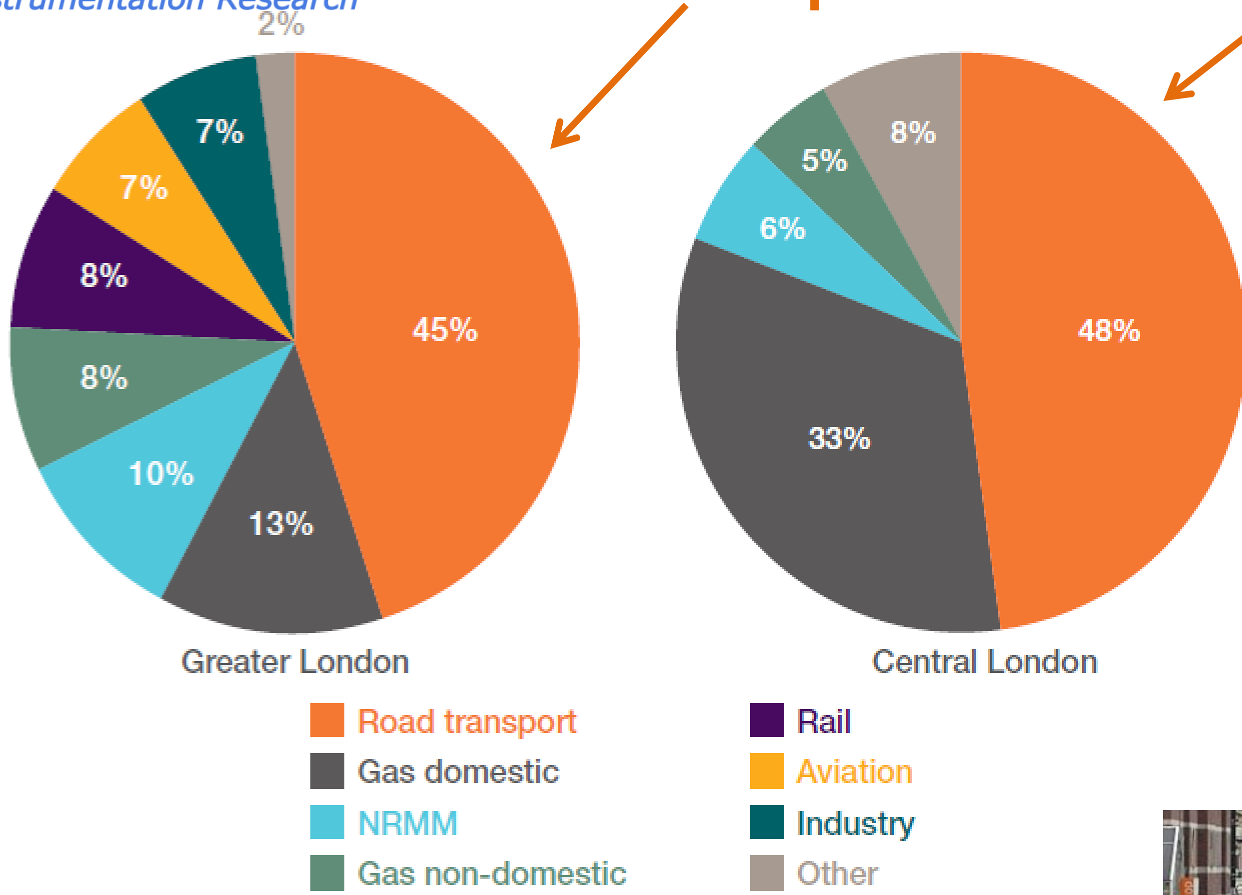
Nitrogen Oxides (NOx) (ktonnes)



Air pollution in the UK (2016)

Emissions of Nitrogen Oxides London

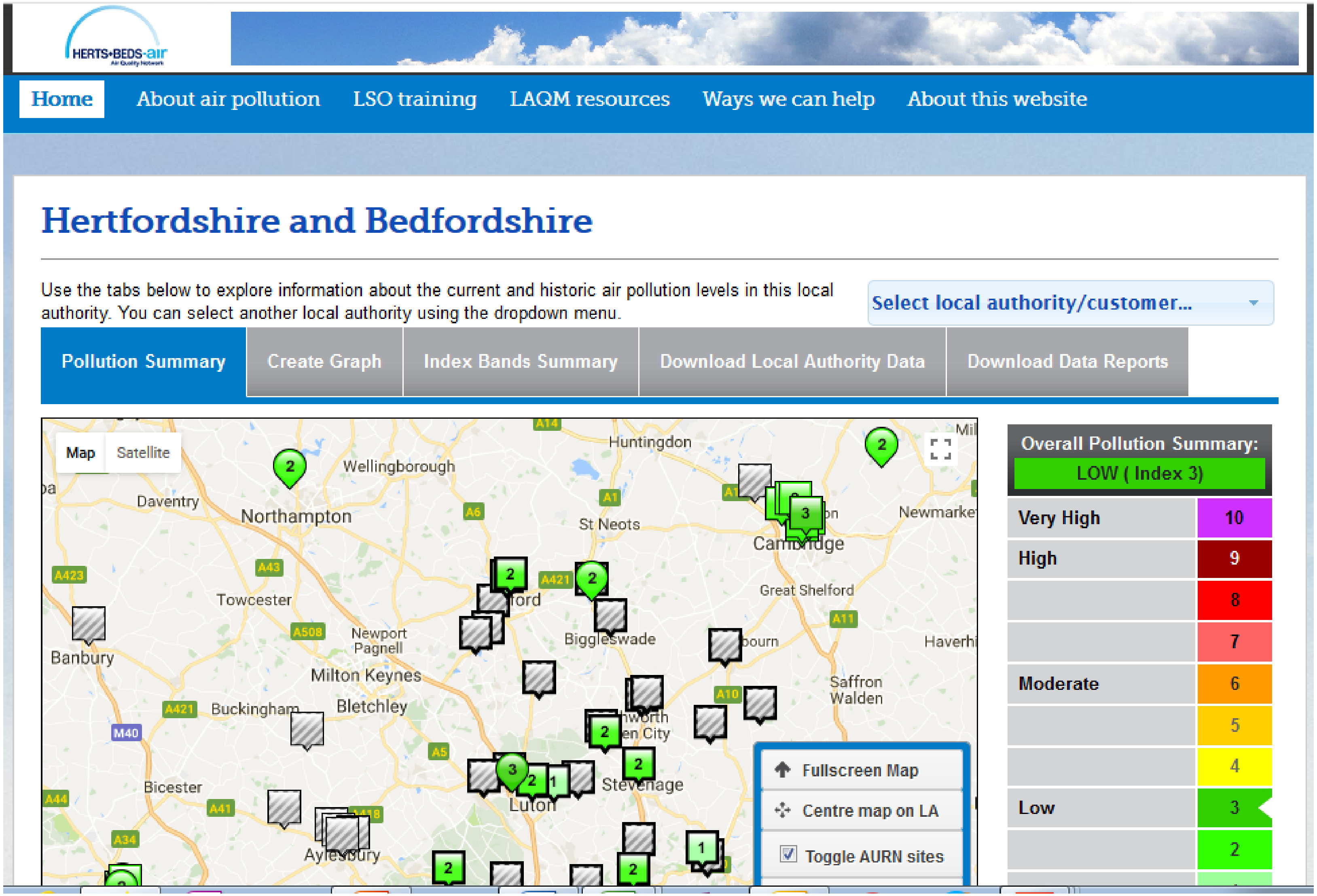
Road Transport contributions



Source: Interim update to GLA, 'London Atmospheric Emissions Inventory 2010' (GLA 2010)
*Note: 'NRMM' = 'non-road mobile machinery'.

Hertfordshire Air Quality

http://www.airqualityengland.co.uk/local-authority/
As of 7 February 2018



Air Quality Forecast by DEFRA

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https://uk-air.defra.gov.uk/forecasting/

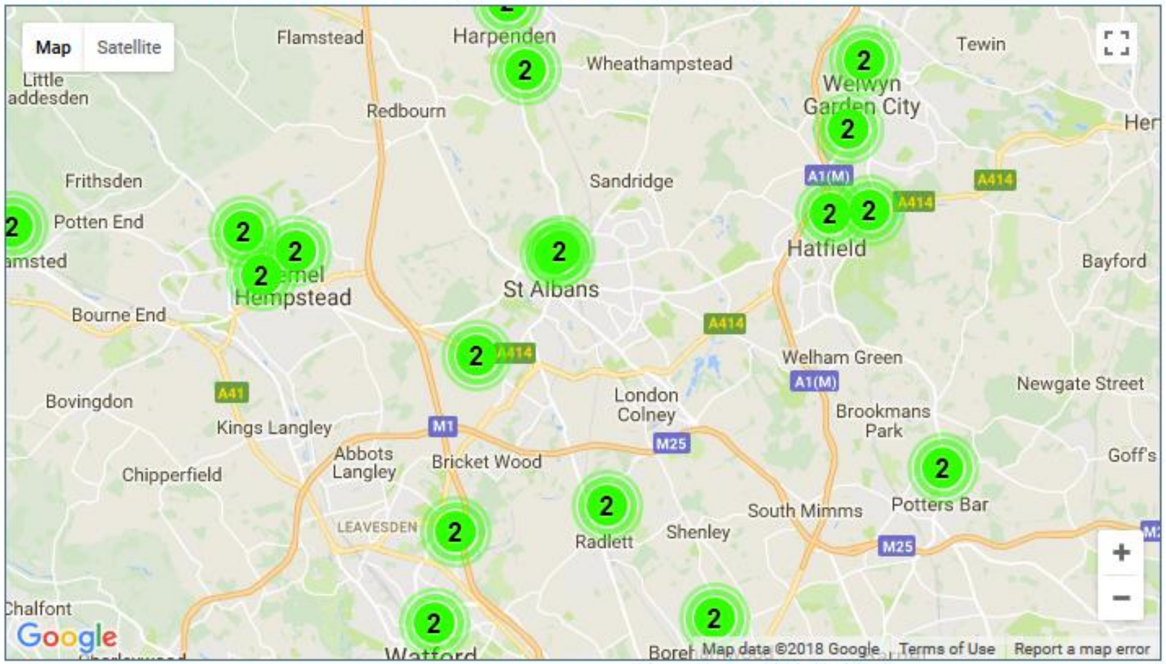
As of 7 February 2018

Enter your location or postcode:

e.g. Newcastle | Search

Today 7th Feb | Thu 8th Feb | Fri 9th Feb | Sat 10th Feb | Sun 11th Feb

Air pollution forecast for Today (7th February 2018) near Al1



Tweets by @DefraUKAir

The nearest locations to your postcode region are shown below and highlighted on the map.

Location	Today 7th Feb
St. albans Distance away: 0.92 miles	Low (Index 2)

Index Bands

1	2	3	4	5	6	7	8	9	10
Low			Moderate			High			Very High

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Smog alerts over London

27/09/2017

Sadiq Khan triggers alert for high air pollution in London

Capital is given emergency warning as polluted air from the continent combines with toxic air at home

▲ London's pollution alert has been issued seven times in the last 13 months. Photograph: Harriet

23/01/2017

London on pollution 'high alert' due to cold air, traffic, and wood burning

Camden, City of London, and Westminster hit 10 out of 10 on index, while pollution levels across UK also peaked

▲ Air pollution and traffic in Brompton Road, Knightsbridge, London, in January 2017. Photograph: Elizabeth Dalziel/Greenpeace

https://www.theguardian.com

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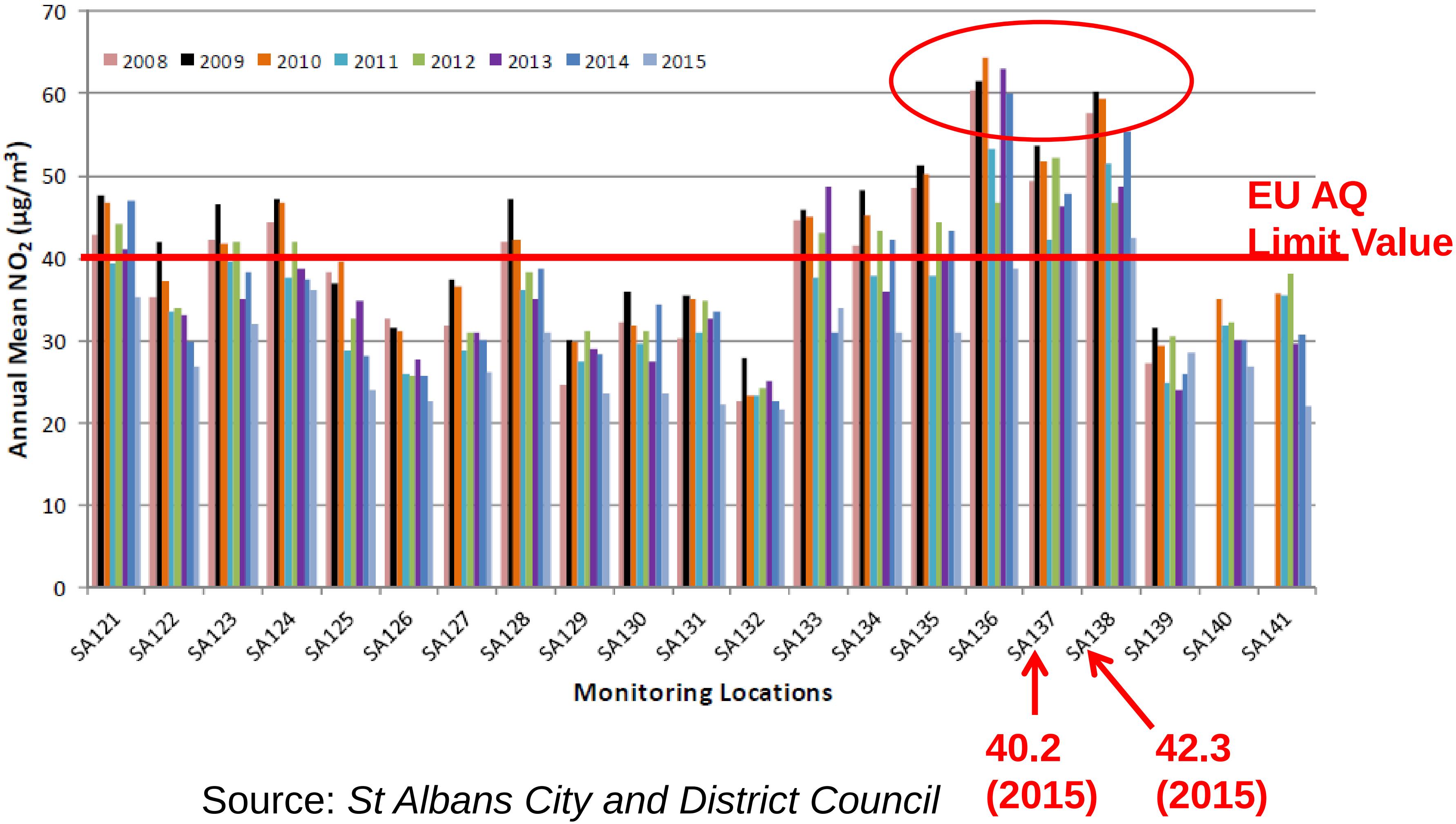
St Albans Trends in Annual Mean NO_2 Concentrations Measured 2008-2015



Source: *St Albans City and District Council Annual Status Report 2016*

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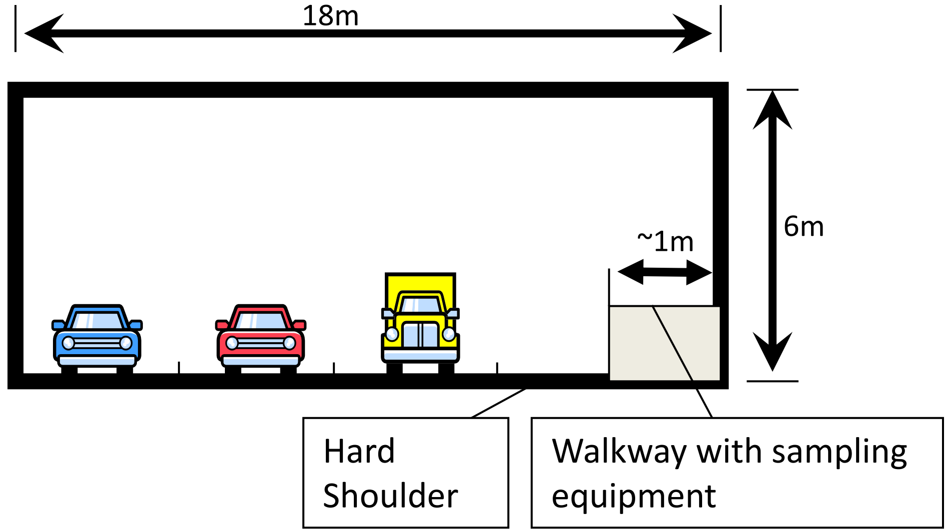
Hatfield Tunnel Laboratory



- Six week continuous campaigns
- 12 hour sampling period 7AM -7PM
- Entrance & Exit Sampling Sites
- High Volume Samplers

- Dichotomous Stacked Filter Units
- Partisol sampler
- Nomad meteorological sampler
- Golden River Marksman 660 for traffic monitoring

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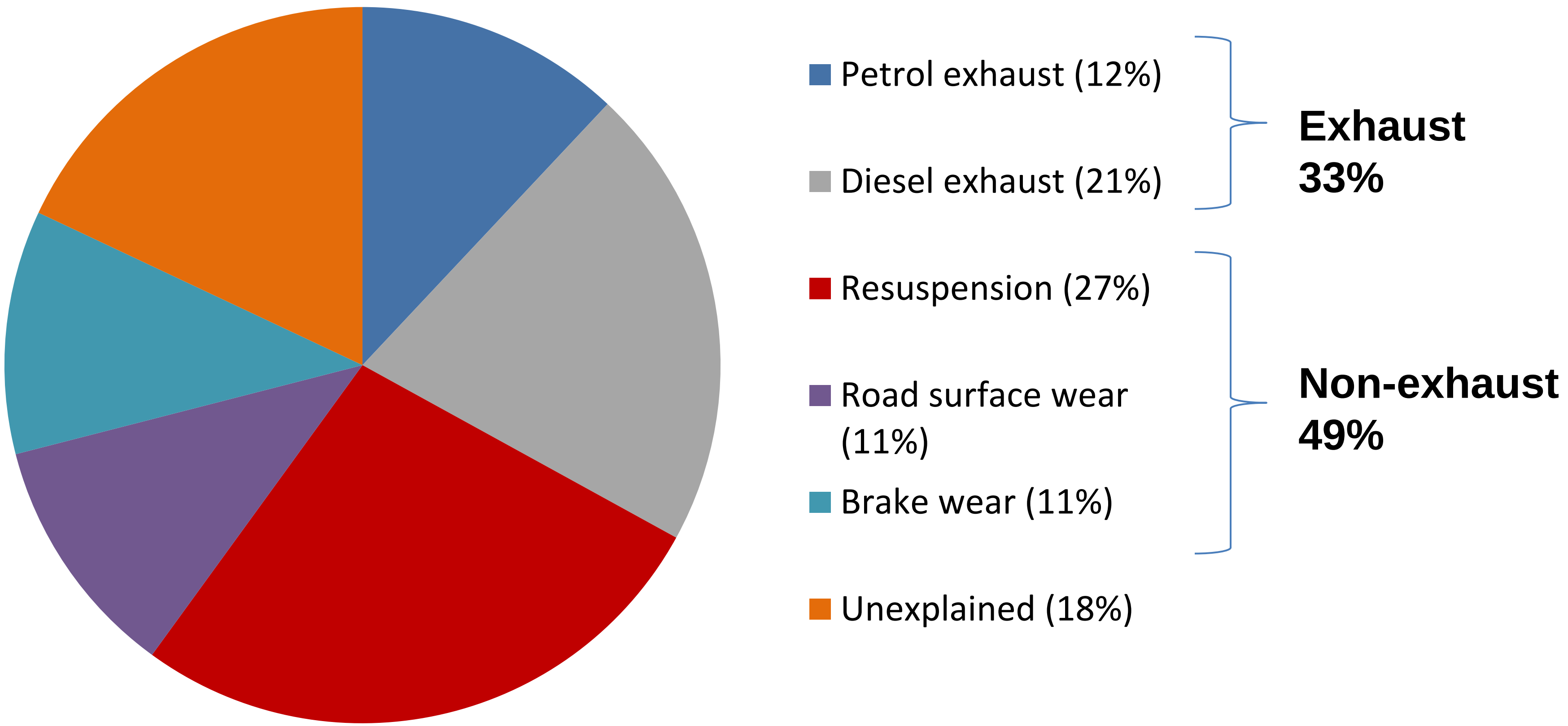
How much of PM10 comes from road traffic?

Hatfield Tunnel Study



Lawrence et al., Source apportionment of traffic emissions of particulate matter using tunnel measurements. Atmospheric Environment 77 (2013) 548-557

Why are non-exhaust emissions important?

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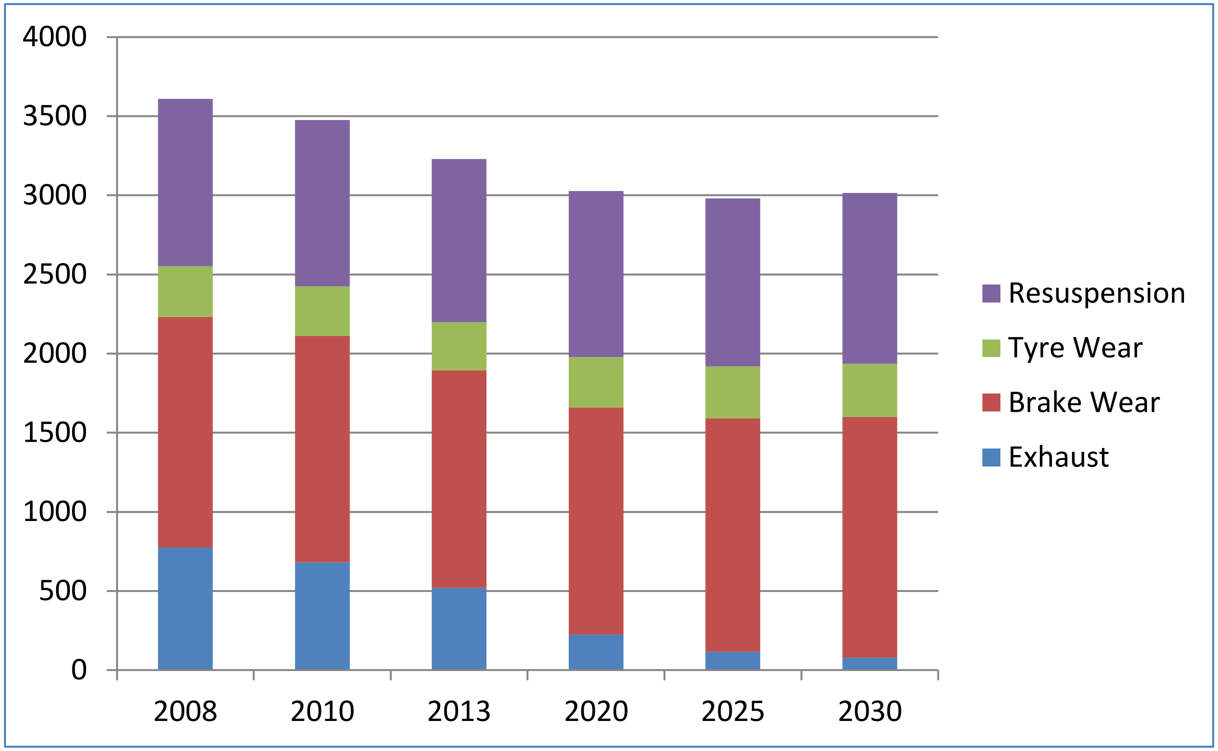
London



Exhaust emissions dropping BUT Non-exhaust becoming more important

Source: Based on LAEI 2013 (Brown 2016)

- As exhaust emissions decrease, the **unregulated** emissions from non-exhaust sources will become even more important
- Non-exhaust emissions can equal or surpass exhaust contributions
- Large uncertainties associated with non-exhaust emission factors and wear rates

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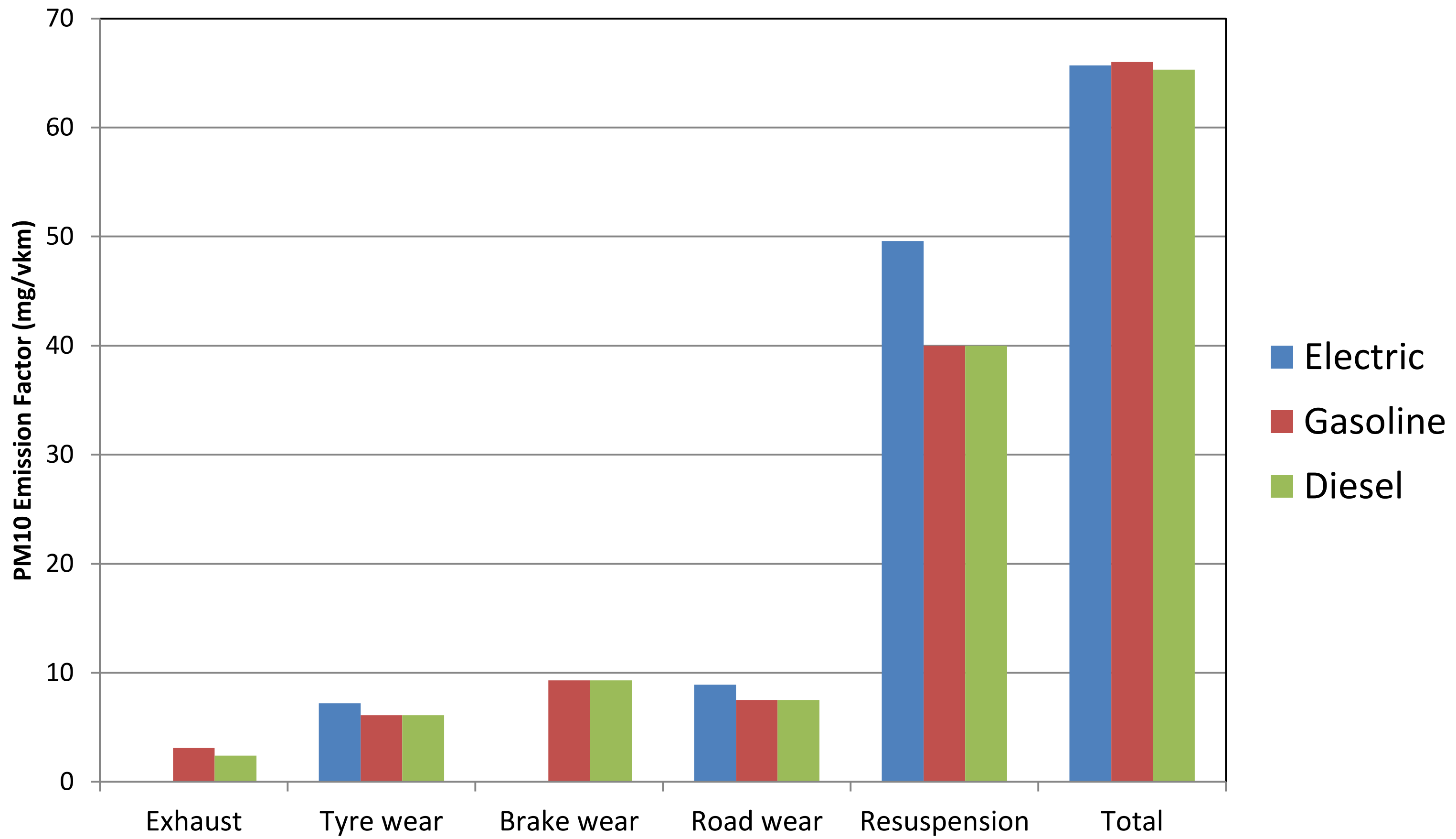
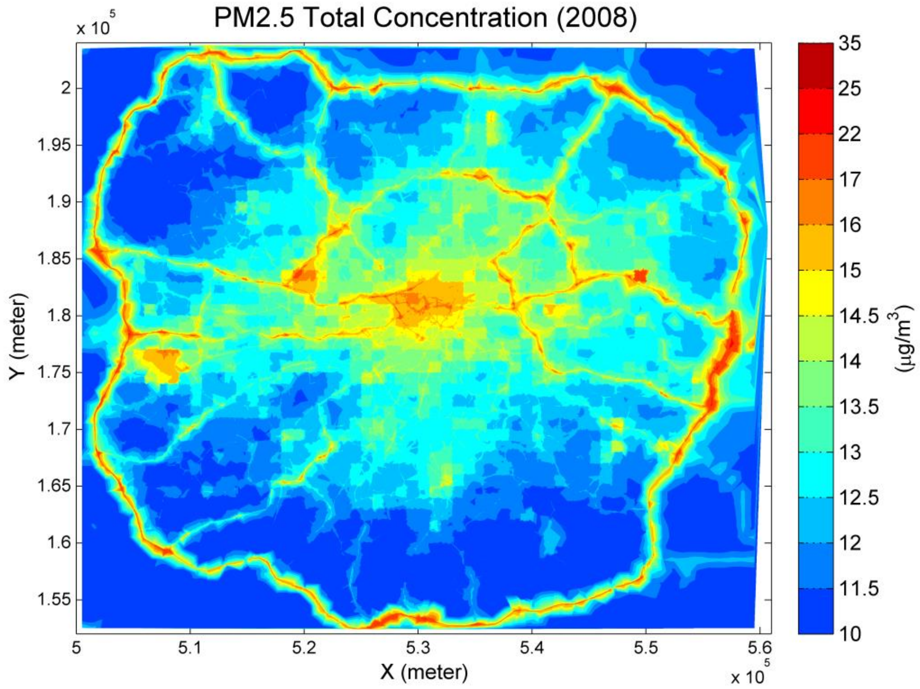
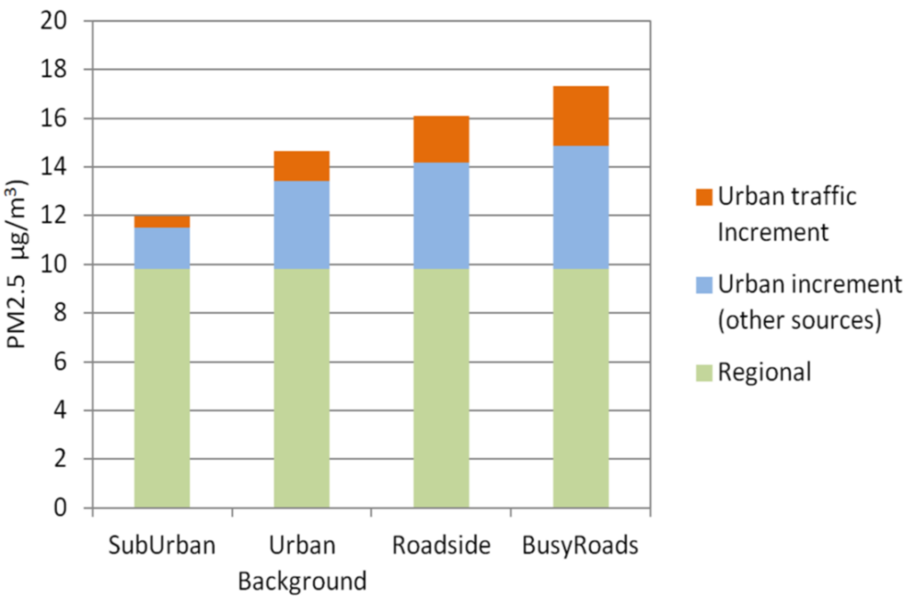
Electric cars – are they the answer?



Source: Timmers and Achten (2016) Non-exhaust PM emissions from electric vehicles, Atmospheric Environment 134 (2016) 10-17

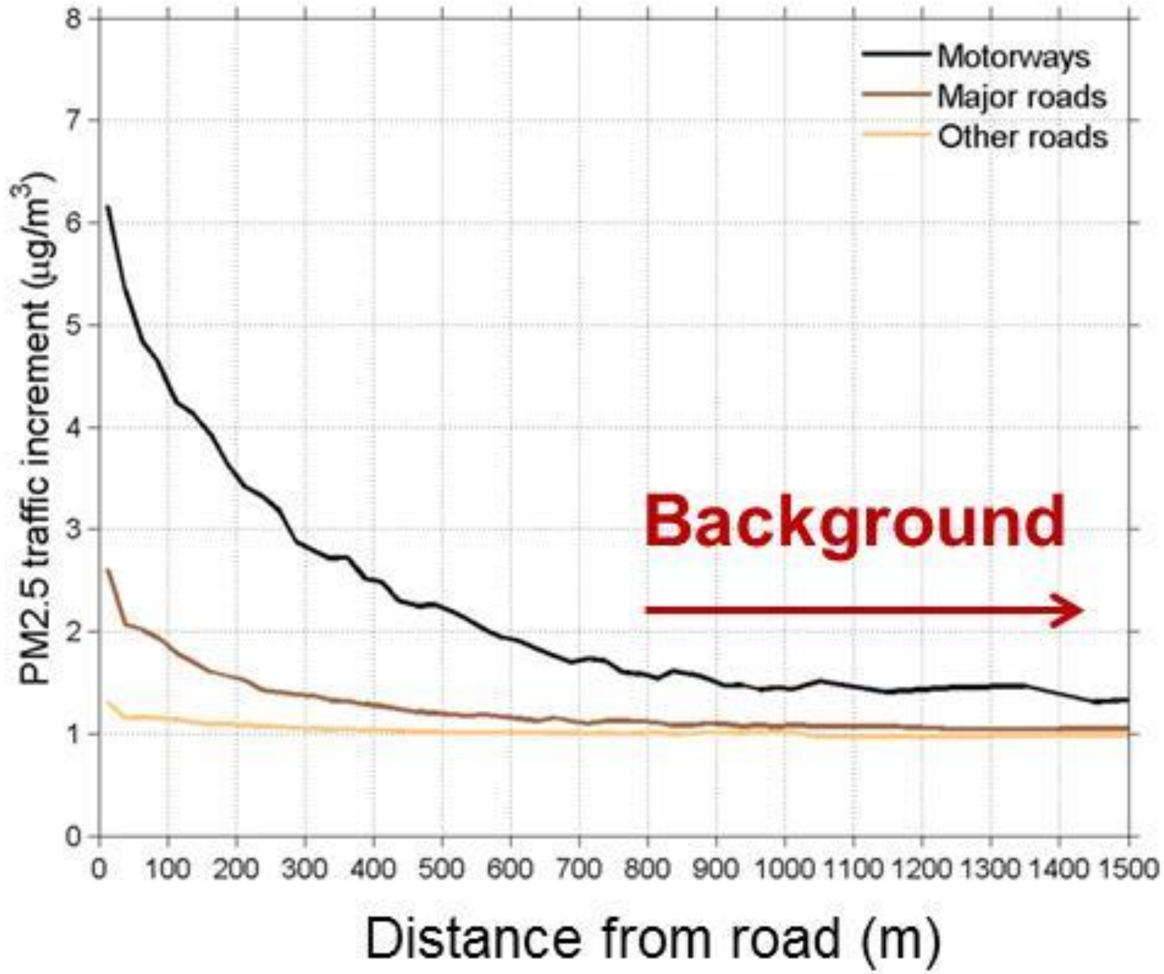
What air pollution comes into a city?





Source: Singh, V., Sokhi, R. S., & Kukkonen, J (2014) PM2. 5 concentrations in London for 2008 - A modelling analysis of contributions from road traffic. Journal of the Air & Waste Management Association 64 (2014) 509–518

Where should I live?



Source: Singh e t a., (2014)

Air pollutants that you don't hear much about?

Short Lived Climate Pollutants (SLCP)

Examples – Black carbon (BC), Methane (CH_4), Nitrogen Oxides (NOx), Ozone (O_3)

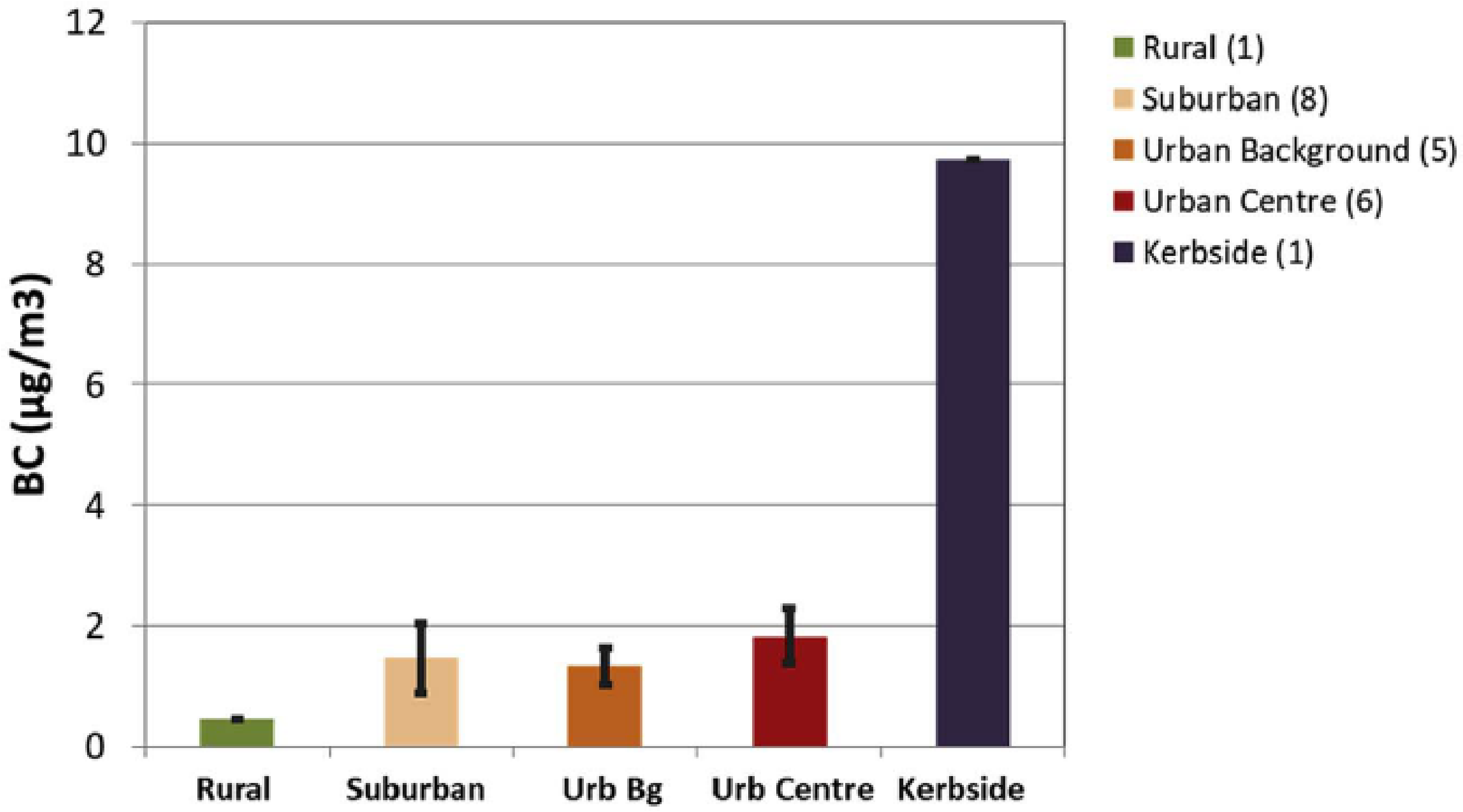
Table 12. Characteristics of ozone and its four main precursors

Name	Effect	Primary or secondary	Main anthropogenic emission source(s)	Atmospheric lifetime	Removal mechanisms	GWP_{20}[1]	Radiative forcing[2] ($W\ m^{-2}$)
Ozone	Warming	Secondary	N/A	Weeks	Chemical, deposition	N/A[3]	0.40 (0.20, 0.60)[4]
Methane	Warming	Primary	Agriculture, fossil fuel industry, waste	~12 years	Chemical, soil uptake, migration to stratosphere	84	0.48 (0.43, 0.53)
CO	Warming	Primary	Transport, residen-tial / commercial combustion	Months	Chemical	18.6 ± 8.3	0.23 (0.18, 0.29)
NOx	Uncer-tain (cooling likely)	Both	Transport, large-scale combustion	Hours to days	Chemical, solar radiation	-560 ± 279	-0.15 (-0.34, 0.02)
nmVOCs	Warming	Primary	Various	Variable (hours – years)	Chemical	14	0.10 (0.06, 0.14)

GWP = Global Warming Potential. [1] Based on a 20-year time horizon. Reflects estimates from the literature reported by the IPCC (18). [2] Estimates for precursors include impacts from ozone as well as other pathways and is from reference (28) and refers to the change in emission between 1750 and 2010. [3] GWP is not estimated for ozone, as it is a secondary pollutant. [4] Tropospheric only (does not include stratospheric).

WHO (2015)

Black Carbon (BC) - an important climate and air quality pollutant



Singh et al (2018) Atmospheric Environment 178 (2018) 148–157

Co-benefits of reducing air pollutants

Reducing emissions of SLCPs can indirectly improve health in many ways.

Black carbon and ozone in the atmosphere reduce agricultural productivity, thereby threatening food security and nutrition.

SLCP emissions can influence local and regional climates, which can affect air temperature and exposure to natural hazards

Contribute to global climate change, which entails numerous additional health risks

Reduction of SLCPs will reduce impact of climate change and improve AQ

WHO (2015)

What can we do to improve air quality?

Government's response for tackling high levels of Nitrogen Dioxide

£1bn – to improve the infrastructure for ultra-low emission vehicles
£290m – to reduce transport emissions as part of the National Productivity Investment Fund
£11m – awarded to local authorities in the Air Quality Grant
£89m – for a Green bus fund
£27m – for the Clean Bus Technology Fund and Clean Vehicle Technology Fund
£1.2bn – for a Cycling and Walking Investment Strategy
£100m – for air quality as part of the Road Investment Strategy

The UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations' July 2017

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What can we do?

Table 1. Four SLCP mitigation actions with potential to produce major climate and health benefits.

Sector and mitigation action	Certainty of major SLCP-related climate benefit	Aggregate level of potential health benefit	Potential level of CO_2 reduction co-benefit
Support active travel (aided by rapid mass transit)	High	High	High
Promoting healthy diets low in red meat and processed meats and rich in plant-based foods	High	High	Medium-high
Low-emission stoves and/or fuel switching to reduce solid fuel use	Medium-high	High	Medium
Stricter vehicle emissions/ efficiency standards	High	Medium-high	High

WHO (2015)

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How do we improve air quality?

Technological improvements
Engine characteristics, reducing aerodynamic drag, and retrofitting diesel particle filters

Reducing use of diesel fuel

Fuel types: Liquefied natural gas can lead to reductions in PM and possibly GHG emissions

Liquid biofuels – mixed evidence of benefit e.g. competition with land use leading to deforestation (hence limited impact on greenhouse gases)

Electric vehicles - if the electricity is provided by fossil fuel combustion, emissions will occur at the source.

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How do we improve air quality?

Prioritise low-emission modes of transport
Urban rapid transit as well as active travel (walking/cycling) for shorter trips

Cycling and walking increases physical activity – additional health benefits

Journey avoidance and optimization
Avoiding journeys and/or reducing travel distances

Electronic information technology e.g. internet shopping is increasing

International Challenges

Brick Kilns

Cooking stoves

Increasing road traffic

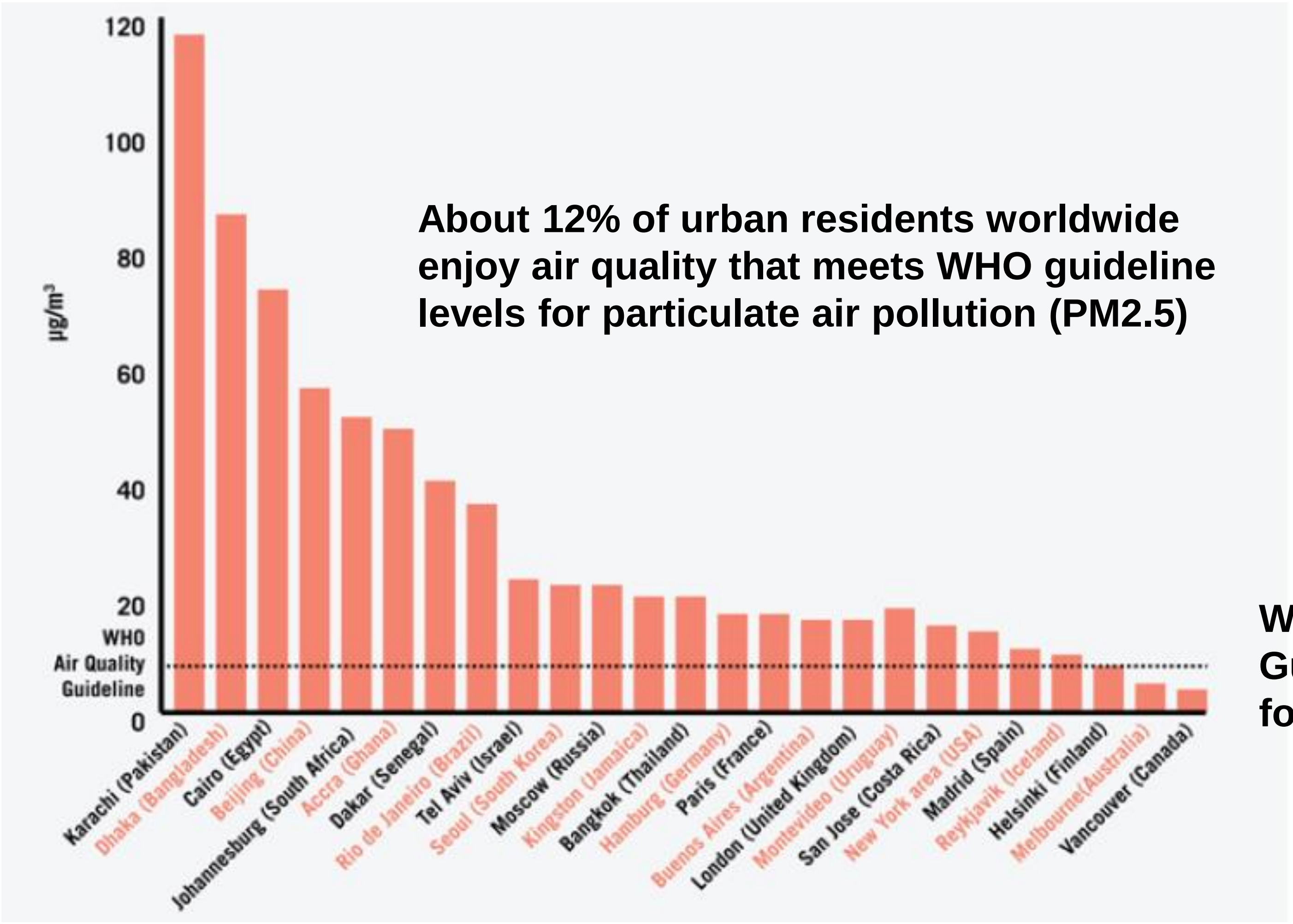
Industrial air pollution

More than 50% of the world's population now resides in urban areas

Every day the urban population grows by an estimated 200 000 people

International perspective

Annual average concentration of PM2.5 for selected cities, 2008-2013



About 12% of urban residents worldwide enjoy air quality that meets WHO guideline levels for particulate air pollution (PM2.5)

WHO Guideline for PM2.5

Source: WHO Ambient Air Pollution database, 2014

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Thank you for your time and patience

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