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College of Science and Engineering

$PM_{2.5}$ – What's the small deal?

Prof. Paul S. Monks

BIRMINGHAM

WORKING TOWARDS A HEALTHY CITY, HEALTHY PLACE

Birmingham City Council

Public Health, August 2016
Not to be used without permission.
Numbers have been rounded

EFFECTS OF AIR POLLUTION

IN 2010/11

891

DEATHS

linked to man-made air pollution

LINKED TO

* Cancer * Diabetes * Asthma * Obesity * Stroke * Dementia * Heart Disease *

Deaths

due to air pollution worldwide per year

affects the **vulnerable** and **deprived** areas most

LINKED TO

* Low birth weight * premature deaths * still births* infant deaths * organ damage*

CHILDREN in HIGH POLLUTION AREAS are 4x more likely to have reduced lung function when they become adults

exposed to 21% higher levels of pollution

33.9 % travel to work by car

BUS & TAXI DRIVERS are exposed to **3x more** pollution than anyone else

Data sourced from: Public Health Outcomes Framework (PHE), "Every Breath We Take - the lifelong impact of air pollution" (2015 RCP & RCPCH), Marmot Cold Homes. Active Travel Survey 2015

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POLLUTANTS THAT AFFECT AIR QUALITY

Primary Particulate Matter ($PM_{2.5}$)

SOURCES

- Domestic wood & coal burning — 38%*
- Industrial combustion — 16%*
- Road transport — 12%*
- Use of solvents & industrial processes — 13%*

*percentage of total $PM_{2.5}$ emissions (2016)

IMPACTS

These tiny particles from smoke, soot and dust can get into the...

lungs and blood

PM can be transported around the body

and get embedded in organs

More likely to be affected are:

- those already suffering from lung and heart conditions
- the elderly
- and very young

LIFESPAN

$PM_{2.5}$ can **shorten** lifespans

Original design by Defra Digital Comms

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Leicester Air

23/5/2013-5/6/2013

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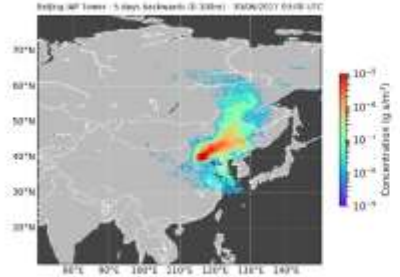

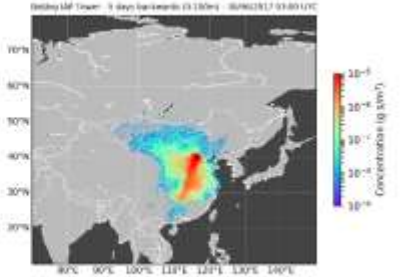

APHH Beijing (2017)

Sommariva and Panagi

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University of Leicester

$PM_{2.5}$ & Mortality

ROLL CALL OF DEATH

Area	Population Age 25+	Deaths Age 25+	$PM_{2.5}$ (mean anthropogenic)	Attributable Fraction (%)	Attributable deaths	Associated life years lost
UK	42,788,600	557,828	9.4 µg/m³	5.3%	28,969	306,835
England	35,878,000	458,743	9.9 µg/m³	5.6%	25,002	264,749
Scotland	3,660,533	53,800	6.8 µg/m³	3.9%	2,094	22,474
Wales	2,075,433	31,041	7.5 µg/m³	4.3%	1,320	13,549
Northern Ireland	1,174,633	14,243	6.6 µg/m³	3.8%	553	6,063
Some highs and lows among selected local authorities. Beware of conclusions that a lot of people die in big authorities!:						
Allerdale	68,800	1,073	6.0 µg/m³	3.4%	37	359
Manchester CC	298,100	3,708	10.4 µg/m³	5.9%	219	2,508
Liverpool	289,300	4,388	9.6 µg/m³	5.4%	239	2,440
Leicester	189,500	2,448	11.7 µg/m³	6.6%	162	1,736
Sandwell	194,800	2,663	12.2 µg/m³	6.9%	198	2,073
Thurrock	105,500	1,131	11.5 µg/m³	6.5%	73	821
Westminster	182,500	1,061	14.9 µg/m³	8.3%	88	1,403
Kens'tn & Chelsea	128,000	824	14.9 µg/m³	8.3%	68	1,164
Isle of Wight	103,300	1,689	8.1 µg/m³	4.6%	78	764
Slough	84,700	744	12.1 µg/m³	6.8%	51	714
Spelthorne	66,500	793	11.1 µg/m³	6.3%	50	538
Cornwall	387,800	5,802	6.7 µg/m³	3.8%	221	2,181
Gwynedd	81,200	1,347	5.5 µg/m³	3.1%	42	408
Cardiff	212,600	2,653	9.5 µg/m³	5.4%	143	1,543
Highland	160,200	2,296	4.3 µg/m³	2.5%	57	641
Edinburgh	339,500	4,169	8.6 µg/m³	4.9%	205	2,269
Outer Hebrides	19,400	349	4.2 µg/m³	2.4%	8	85
Fermanagh	41,900	497	4.3 µg/m³	2.5%	12	126
Belfast	172,700	2,693	9.2 µg/m³	5.2%	141	1,494

$PM_{2.5}$ mean anthropogenic
The man-made portion of total $PM_{2.5}$ (eg with sea salt etc subtracted).

Attributable fraction:
the proportion of deaths estimated due to long-term exposure to anthropogenic $PM_{2.5}$.

Attributable deaths:
Long-term exposure to anthropogenic $PM_{2.5}$ is estimated to have an effect on mortality risks equivalent to the number of attributable deaths.

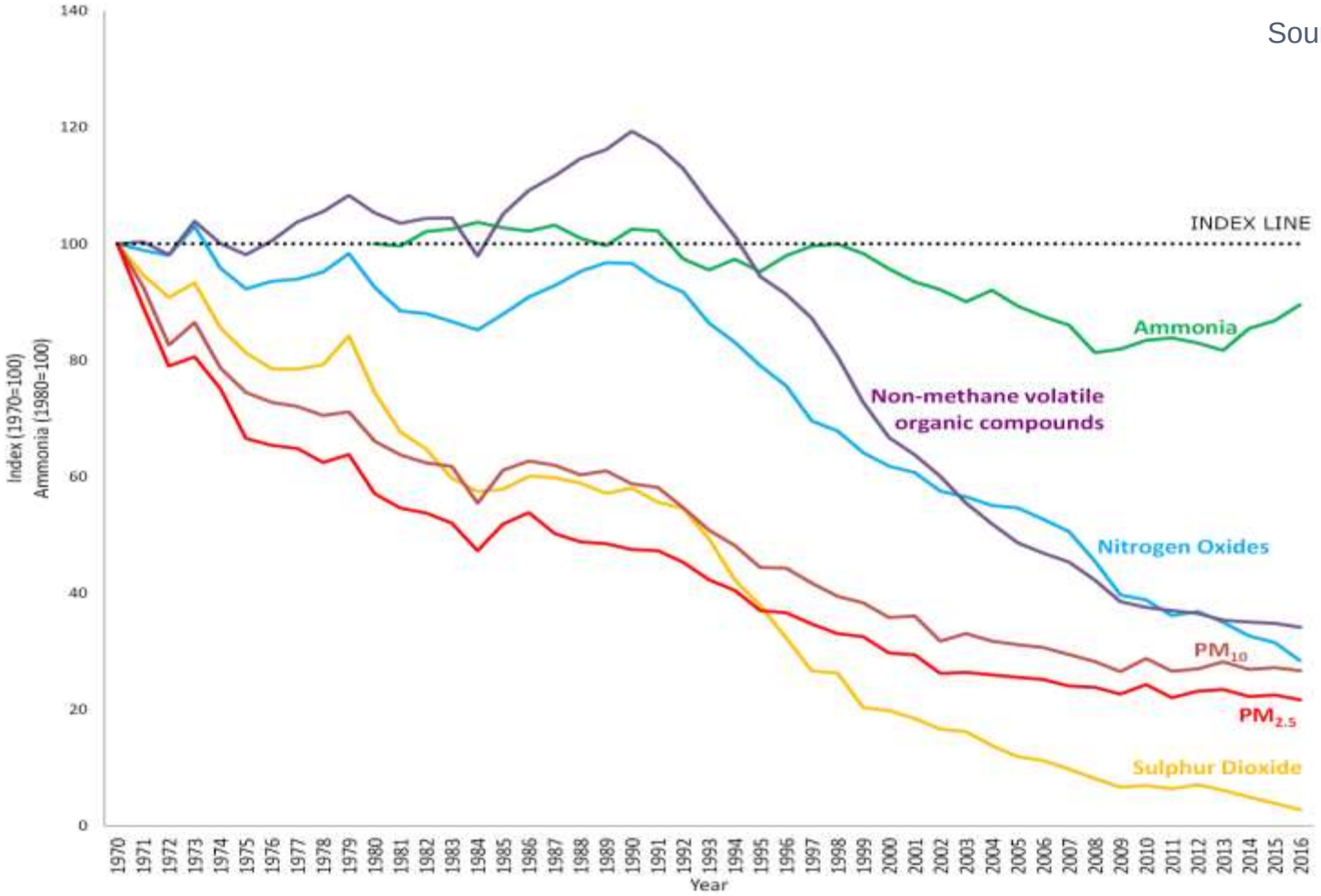
Air pollution is likely to contribute a small amount to the deaths of a larger number of exposed individuals rather than being solely responsible for the number of deaths equivalent to the calculated figure of attributable deaths.

Associated life-years lost:
The years of life lost to the population due to increased mortality risk attributable to long-term exposure to particulate air pollution.

Table from Air Quality Bulletin (May 2014)

Data from Public Health England Report

Source: Defra (Feb 2018)



The index line is a comparator that shows the level of emissions if they had remained constant from the beginning of the time series.

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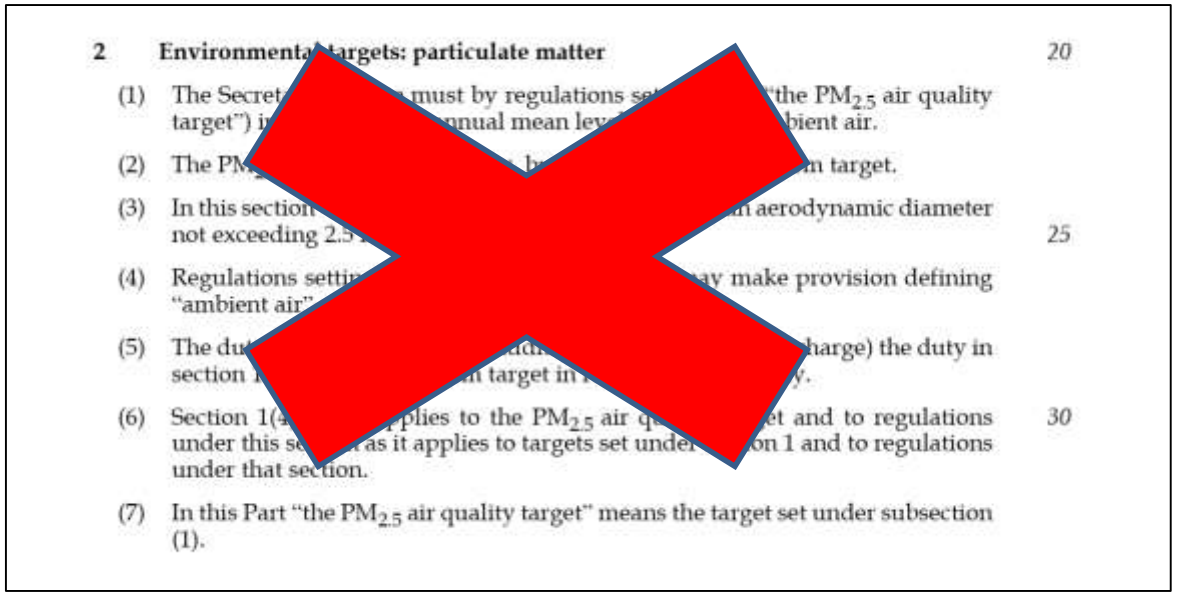
Clean Air Strategy

We will progressively cut public exposure to particulate matter pollution as suggested by the World Health Organization. We will set a new, ambitious, long-term target to reduce people's exposure to $PM_{2.5}$ and will publish evidence early in 2019 to examine what action would be needed to meet the WHO annual mean guideline limit of 10 $\mu g/m^3$.

Environment Bill 2019

1st Reading in HoC – 15 October

2nd Reading in HoC – 28 October



2 **Environmental targets: particulate matter**

(1) The Secret… must by regulations set… "the $PM_{2.5}$ air quality target") i… …nual mean lev… …bient air.

(2) The PM… …n target.

(3) In this section… …n aerodynamic diameter not exceeding 2.5…

(4) Regulations setti… …ay make provision defining "ambient air".

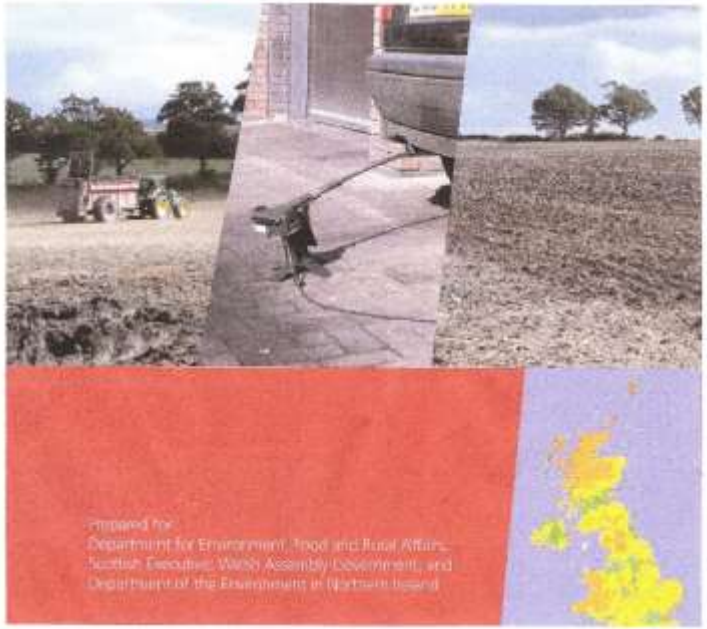
(5) The du… …harge) the duty in section … …n target in … …y.

(6) Section 1(… …pplies to the $PM_{2.5}$ air q… …et and to regulations under this se… …as it applies to targets set under… …on 1 and to regulations under that section.

(7) In this Part "the $PM_{2.5}$ air quality target" means the target set under subsection (1).

AIR QUALITY EXPERT GROUP

Fine Particulate Matter ($PM_{2.5}$) in the United Kingdom



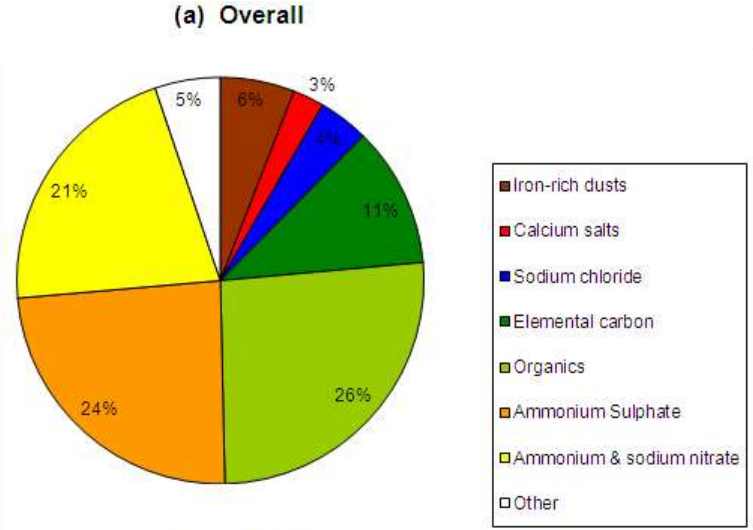
Prepared for:
Department for Environment, Food and Rural Affairs;
Scottish Executive; Welsh Assembly Government; and
Department of the Environment in Northern Ireland

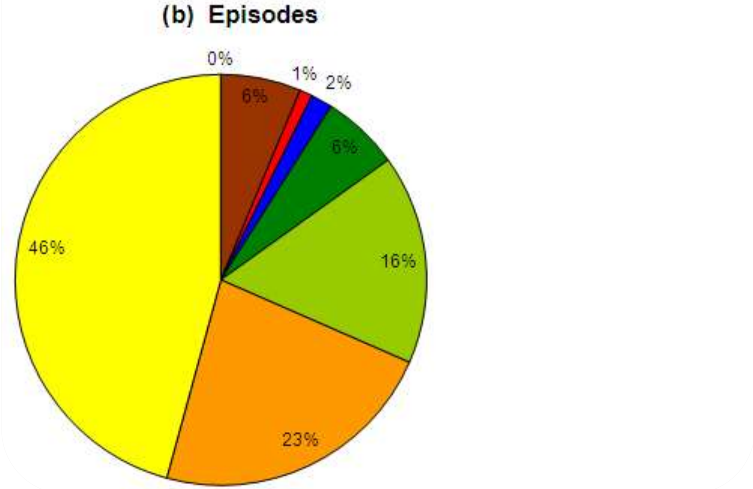
http://uk-air.defra.gov.uk/library/reports?report_id=727

Urban PM2.5

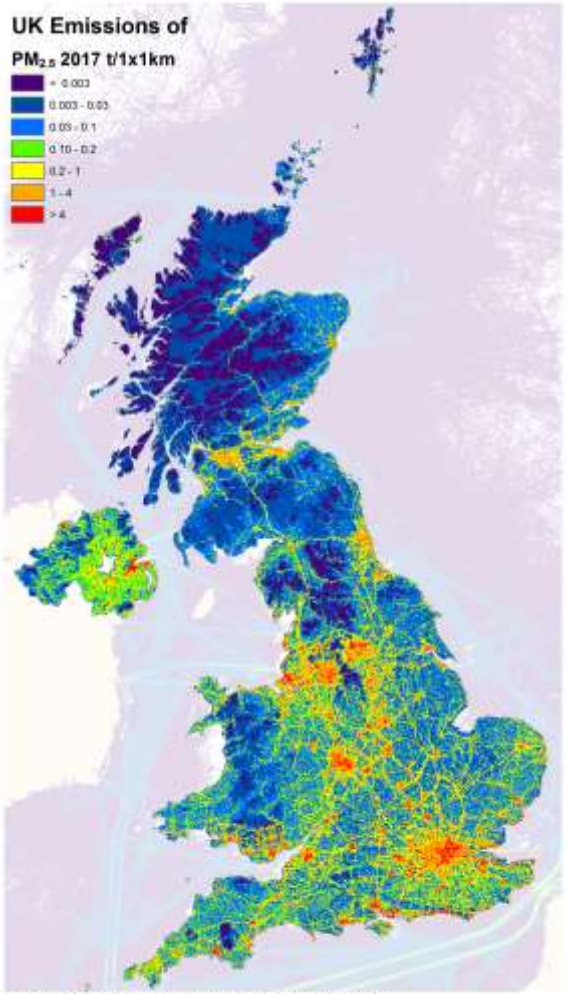
- Overall

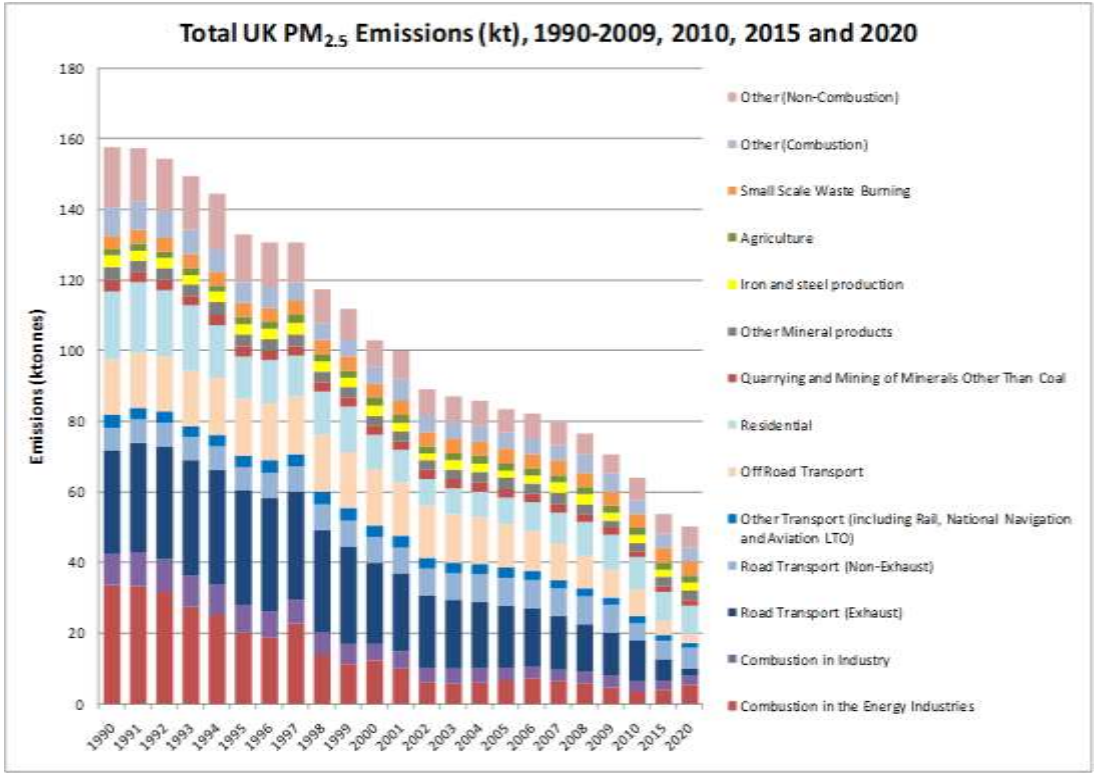
- Episodes > 50μg m^{-3}





(Yin and Harrison, 2008)





Mostly Combustion Sources

NAEI – PM2.5

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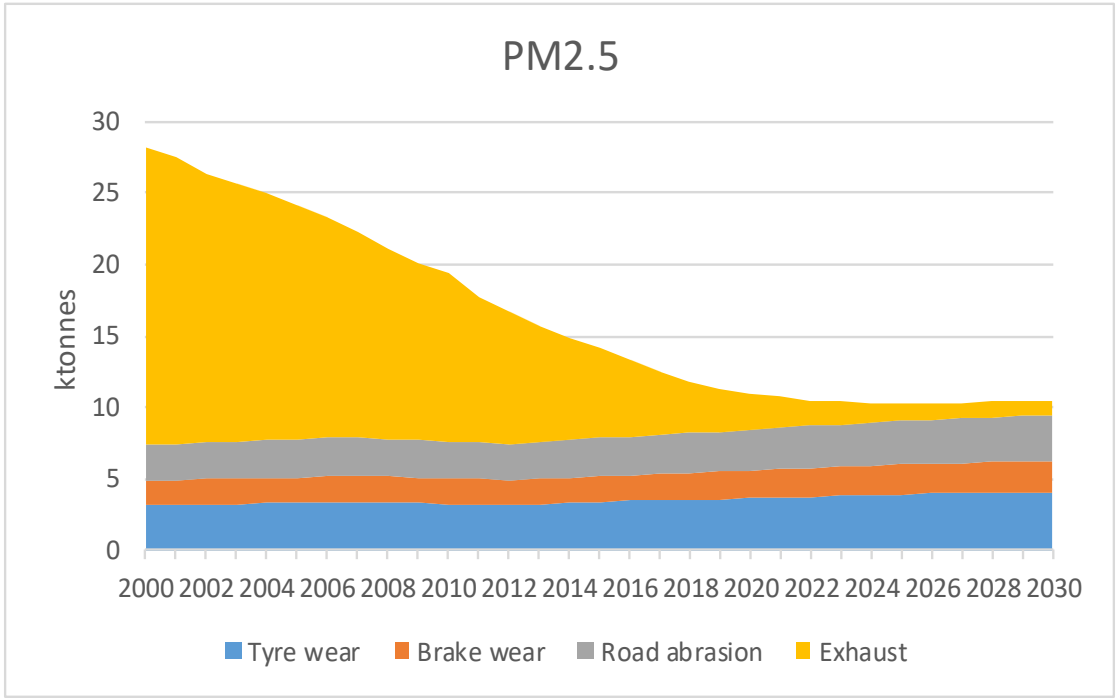

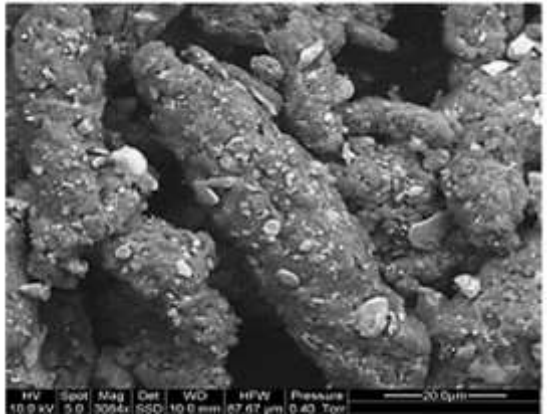

UK National Atmospheric Emissions Inventory (NAEI) indicates that particles from brake wear, tyre wear and road surface wear currently constitute 60% of primary $PM_{2.5}$ emissions from road transport and ca. 7.4% of total.

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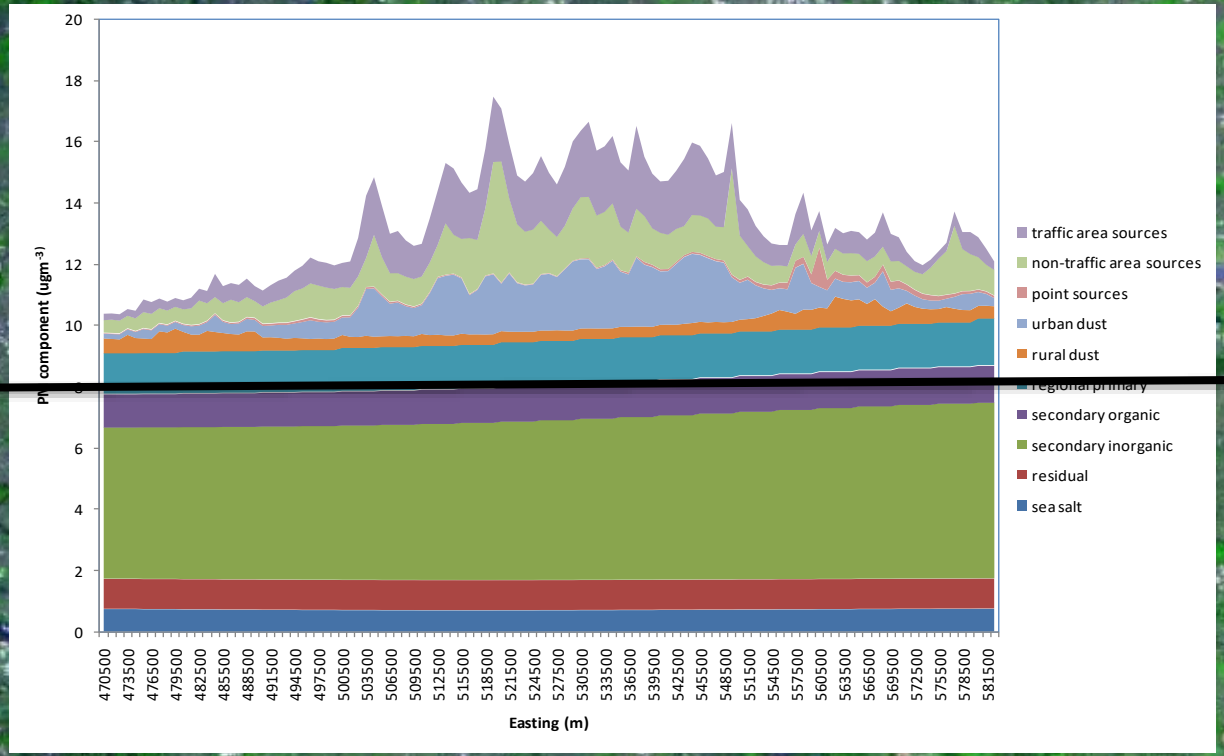
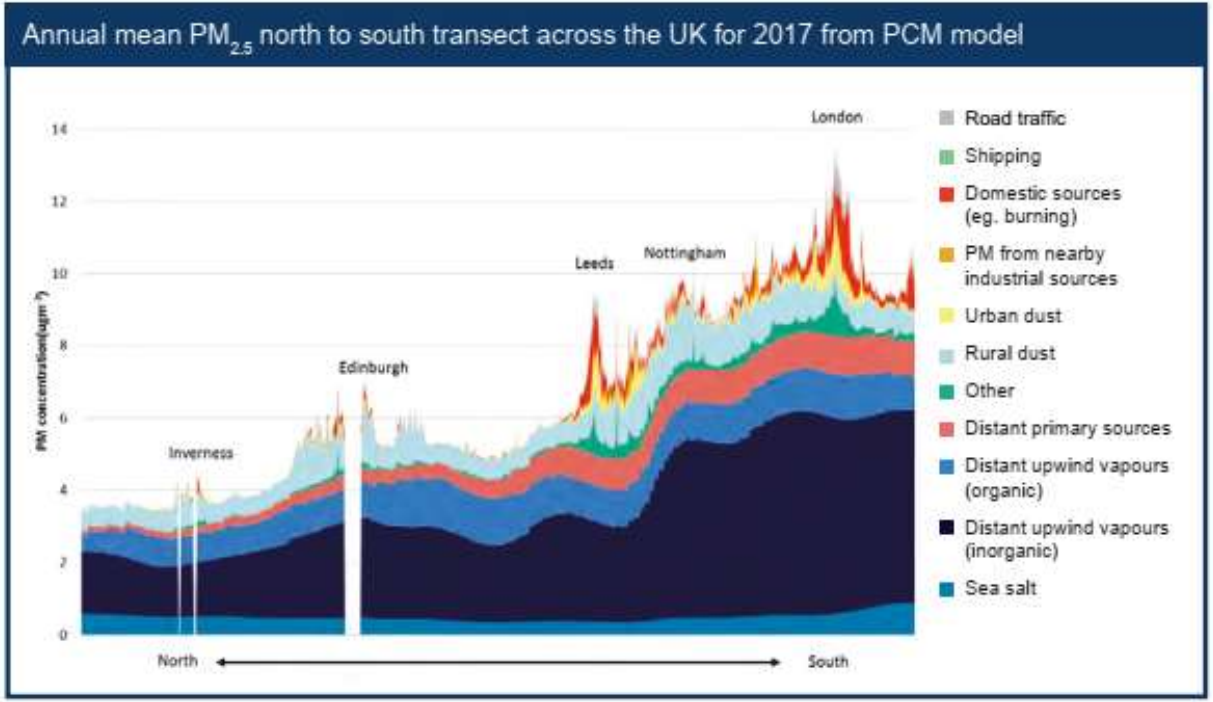
A transect ...

Henley upon Thames

Southend upon sea

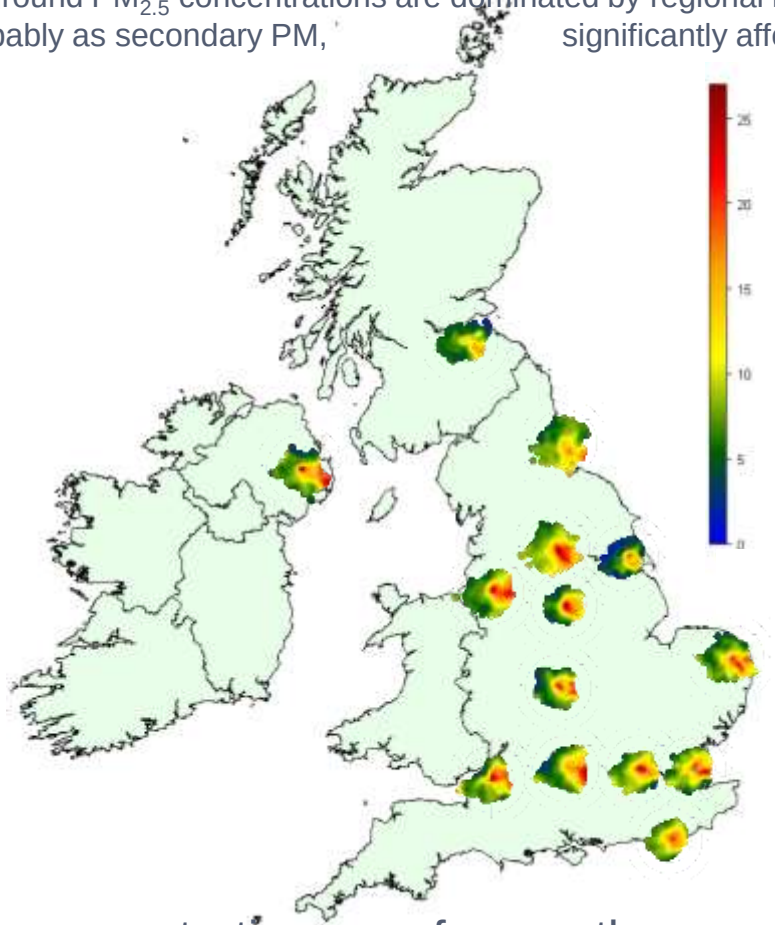


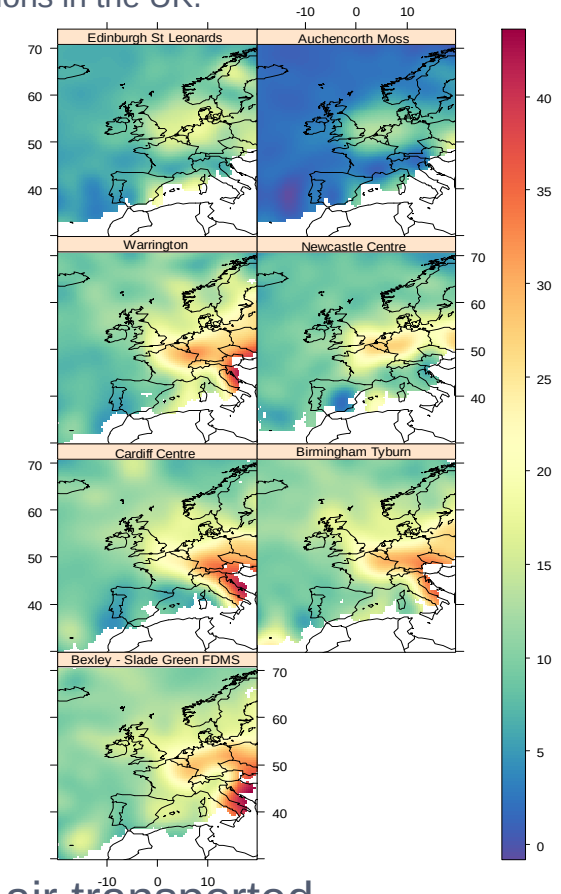
Annual Mean $PM_{2.5}$



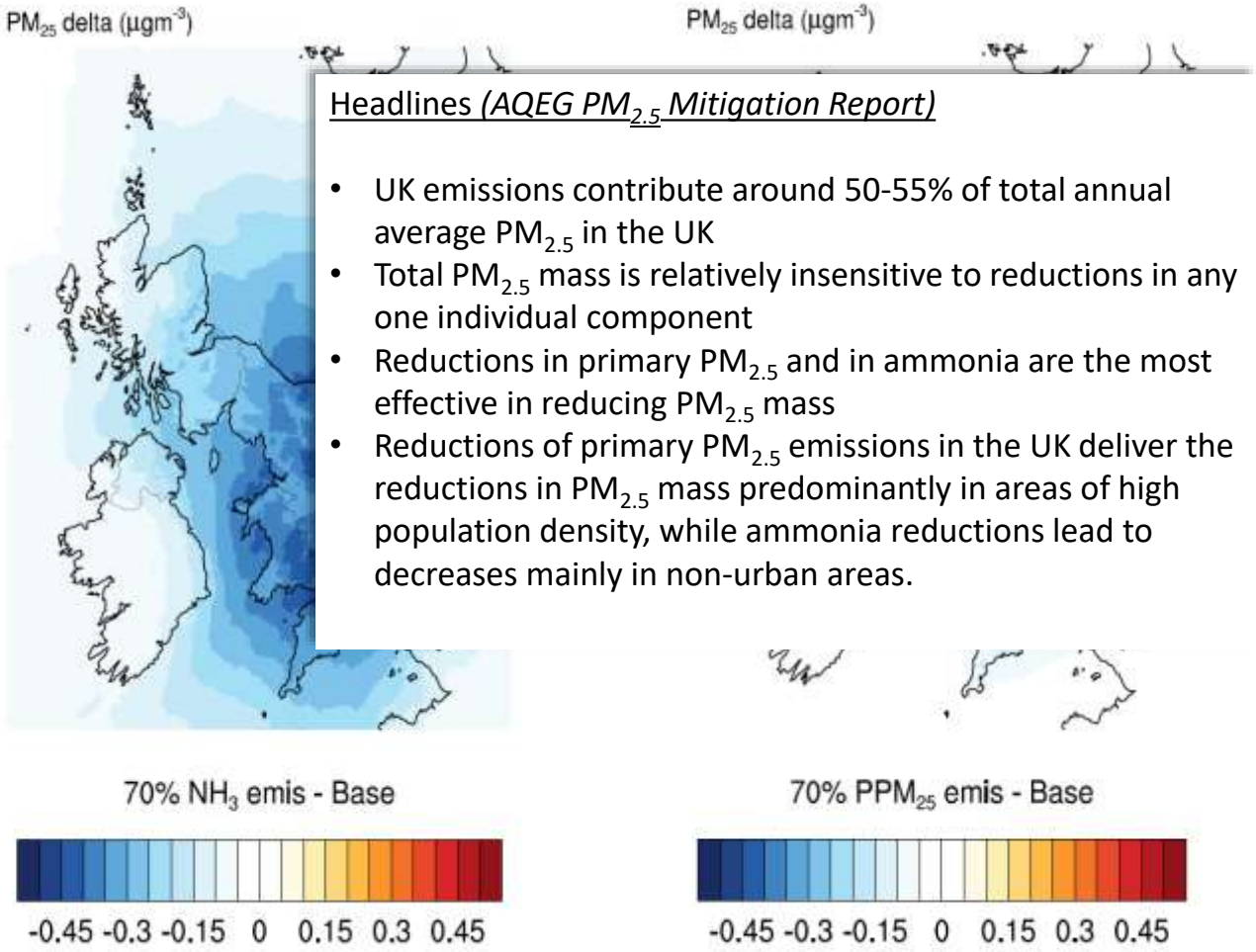
Source: Clean Air Strategy, 2019

Urban background $PM_{2.5}$ concentrations are dominated by regional rather than local sources, PM from sources in continental Europe, probably as secondary PM, significantly affects concentrations in the UK.



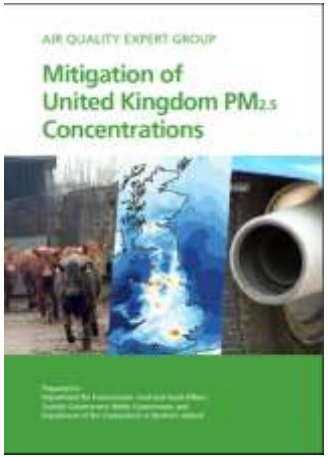


High $PM_{2.5}$ concentrations are frequently associated with air transported into the UK from continental Europe.



Headlines *(AQEG $PM_{2.5}$ Mitigation Report)*

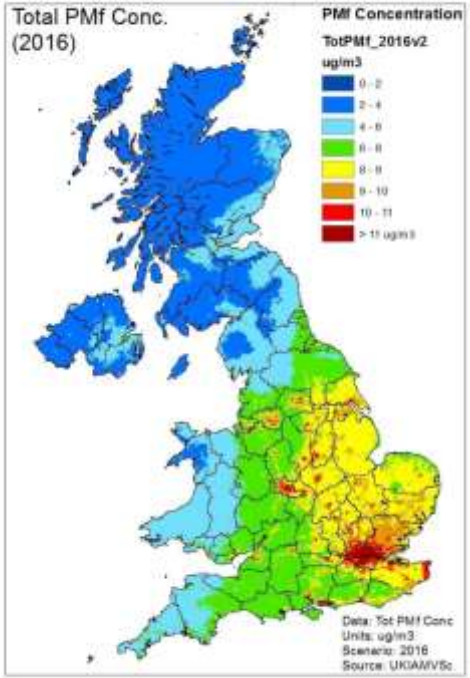
- UK emissions contribute around 50-55% of total annual average $PM_{2.5}$ in the UK
- Total $PM_{2.5}$ mass is relatively insensitive to reductions in any one individual component
- Reductions in primary $PM_{2.5}$ and in ammonia are the most effective in reducing $PM_{2.5}$ mass
- Reductions of primary $PM_{2.5}$ emissions in the UK deliver the reductions in $PM_{2.5}$ mass predominantly in areas of high population density, while ammonia reductions lead to decreases mainly in non-urban areas.



Courtesy of Massimo Vieno, Eiko Nemitz, CEH Edinburgh, UK

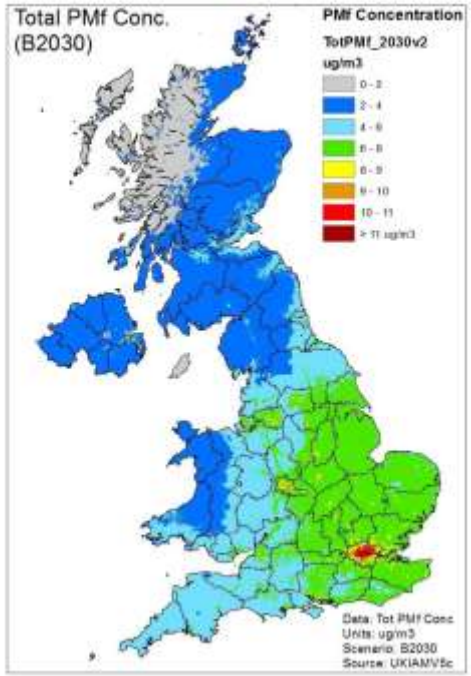
Can 10 µg/m^3 be achieved by 2030?

Figure 3.1 $PM_{2.5}$ concentrations in 2016 across the UK



Red 10-11 µg/m^3
Brown > 11 µg/m^3

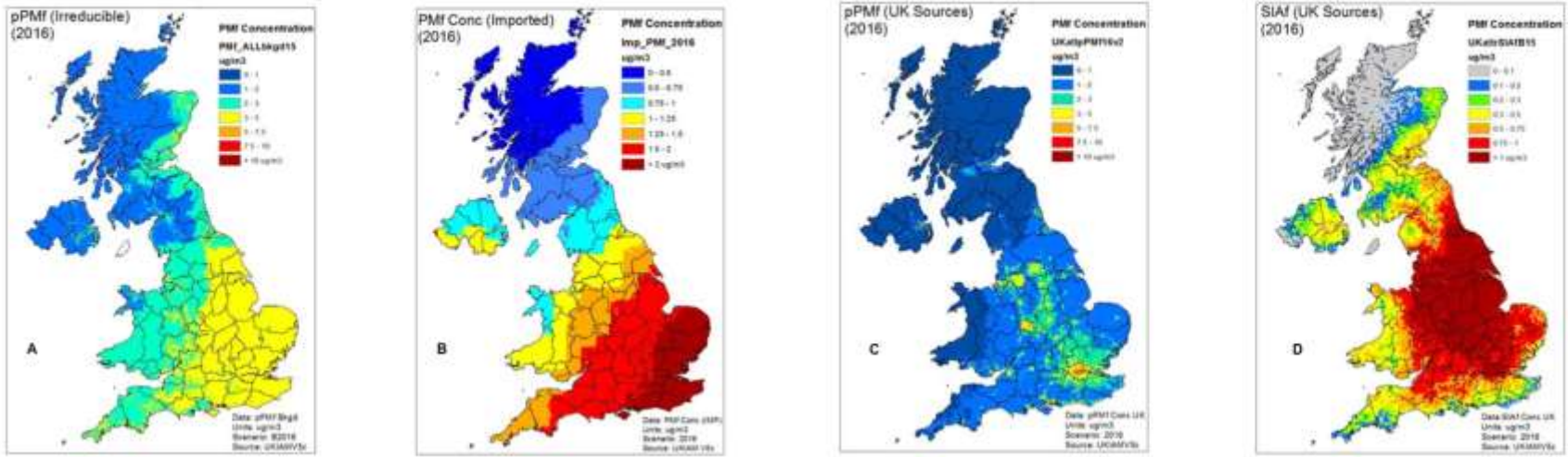
Figure 4.1 Total $PM_{2.5}$ concentrations for BAU2030 scenario



ApSimon et al., 2019. $PM_{2.5}$ exposure and reduction towards achievement of WHO Standards.

$PM_{2.5}$ Contributions from A) natural sources; B) imported C) UK primary D) UK Secondary (2016)

Figure 3.2 Contributions from A) natural sources,B) imported $PM_{2.5}$, C) UK primary and D) UK secondary $PM_{2.5}$



Yellow 3-5 µg/m^3

Yellow 1-1.25 µg/m^3
Brown > 2 µg/m^3

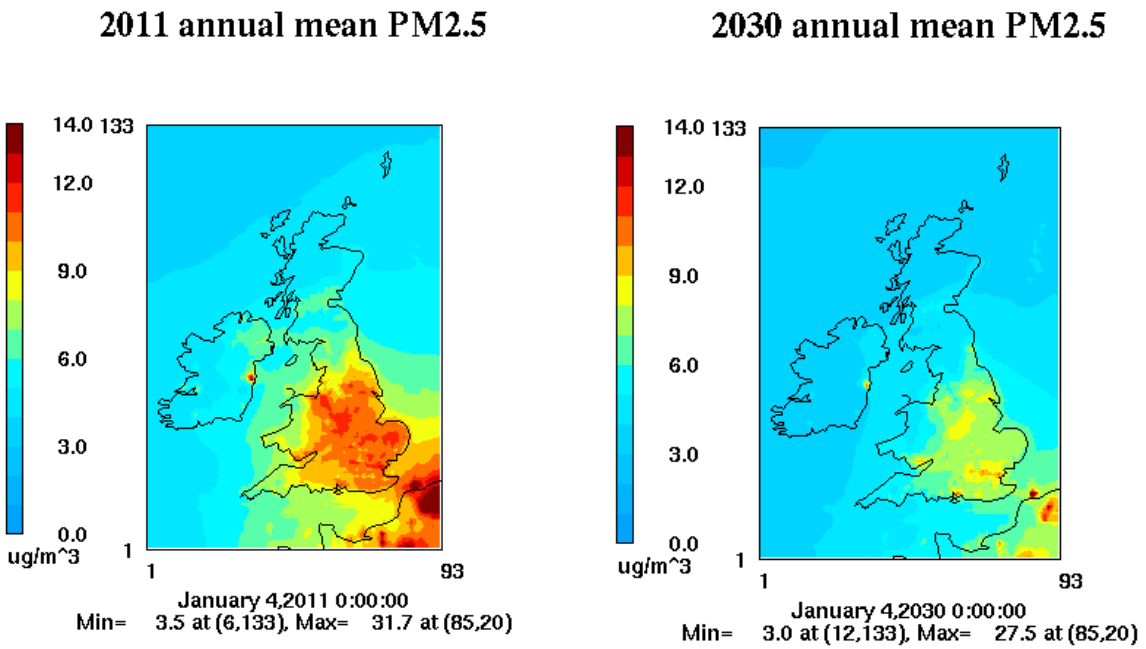
Yellow 3-5 µg/m^3
Orange 5-7.5 µg/m^3

Yellow 0.3-0.5 µg/m^3
Brown >1.0 µg/m^3

ApSimon et al., 2019. PM2.5 exposure and reduction towards achievement of WHO Standards.

Modelling the future
Annual mean UK concentrations of $PM_{2.5}$

(Williams, Beevers, Kitwiroon 2018)

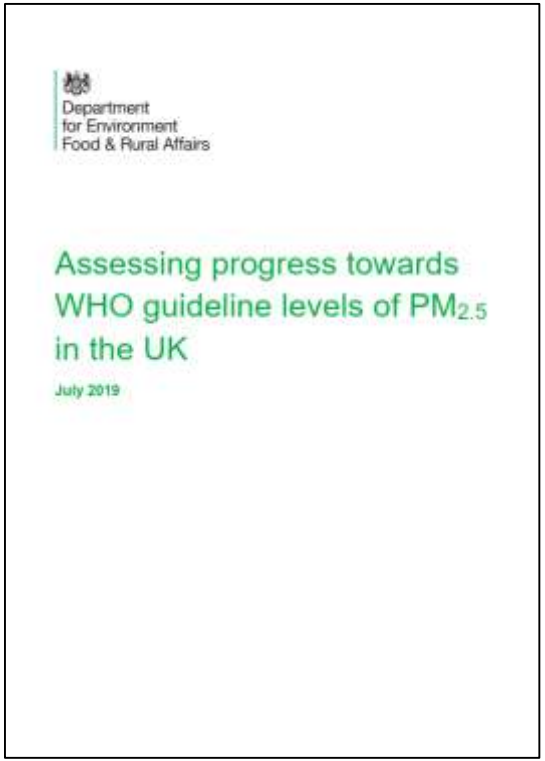


Urban Wood Burning

MRC-PHE
Centre for Environment & Health

Defra's Conclusion

"On the basis of scientific modelling, which has not considered full economic viability and practical deliverability, we believe that, whilst challenging, it would be technically feasible to meet the WHO guideline level for $PM_{2.5}$ across the UK in the future. Substantive further analysis is needed to understand what would be an appropriate timescale and means, and we will work with a broad range of experts, factoring in economic, social and technological feasibility to do this."


Department
for Environment
Food & Rural Affairs

Assessing progress towards WHO guideline levels of $PM_{2.5}$ in the UK

July 2019

AQEG Views on future $PM_{2.5}$ targets

- Any target that drives reductions in exposure both above and below 10 µg/m^3 will give health benefits
- A threshold-based target is crude, BUT is a useful basis for driving progress.
- Limited use for driving continuous improvement for areas that achieve the target and may drive unintended negative behaviours such as ‘polluting up to’ the limit value.
- To motivate continuous improvement for areas below 10 µg/m^3, a population-weighted mean concentration metric should be considered.

Annex 3. Air Quality Expert Group - commentary

‘Task and Finish Group’ report – Achievability of WHO Guidelines for PM2.5 in the UK

James Allan, Mathew Heal, David Carruthers, Roy Harrison, Sarah Moller and Eiko Nemitz on behalf of the Defra Air Quality Expert Group

Q1. What role might the setting of a new long term target for PM2.5 play in reducing health impacts of air pollution in the UK?

$PM_{2.5}$ is considered a non-threshold pollutant and there is no evidence that there is a safe level of $PM_{2.5}$ below which human health impacts can be ruled out. The $PM_{2.5}$ Air Quality Guideline of 10 µg m^{-3} was set by the WHO under consideration of what was deemed possible “in the context of local

Summary

- PM2.5 a real air pollution challenge
- WHO limit by 2030 seems “*achievable*”
- Reductions required in a combination of
  - primary sources e.g. road transport and woodburning
  - secondary – e.g. Agriculture
- Dependent in transboundary air pollution action (role of imports)
- Role for limit values vs. exposure reduction for PM2.5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