FACULTY OF
PUBLIC HEALTH

Air Pollution & Climate Change: Two sides of the same coin

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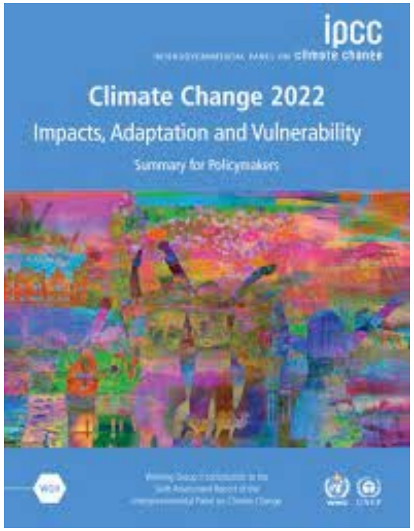
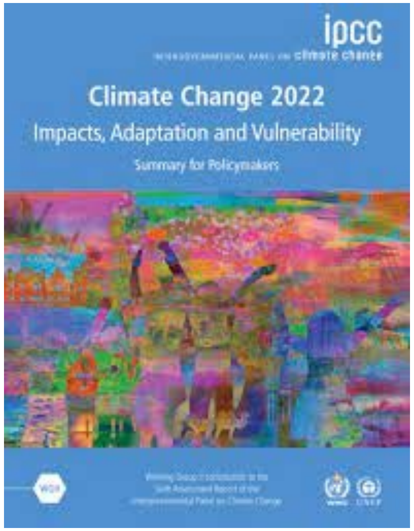
Professor Sir Chris Whitty
Chief Medical Officer

Air pollution & climate change.

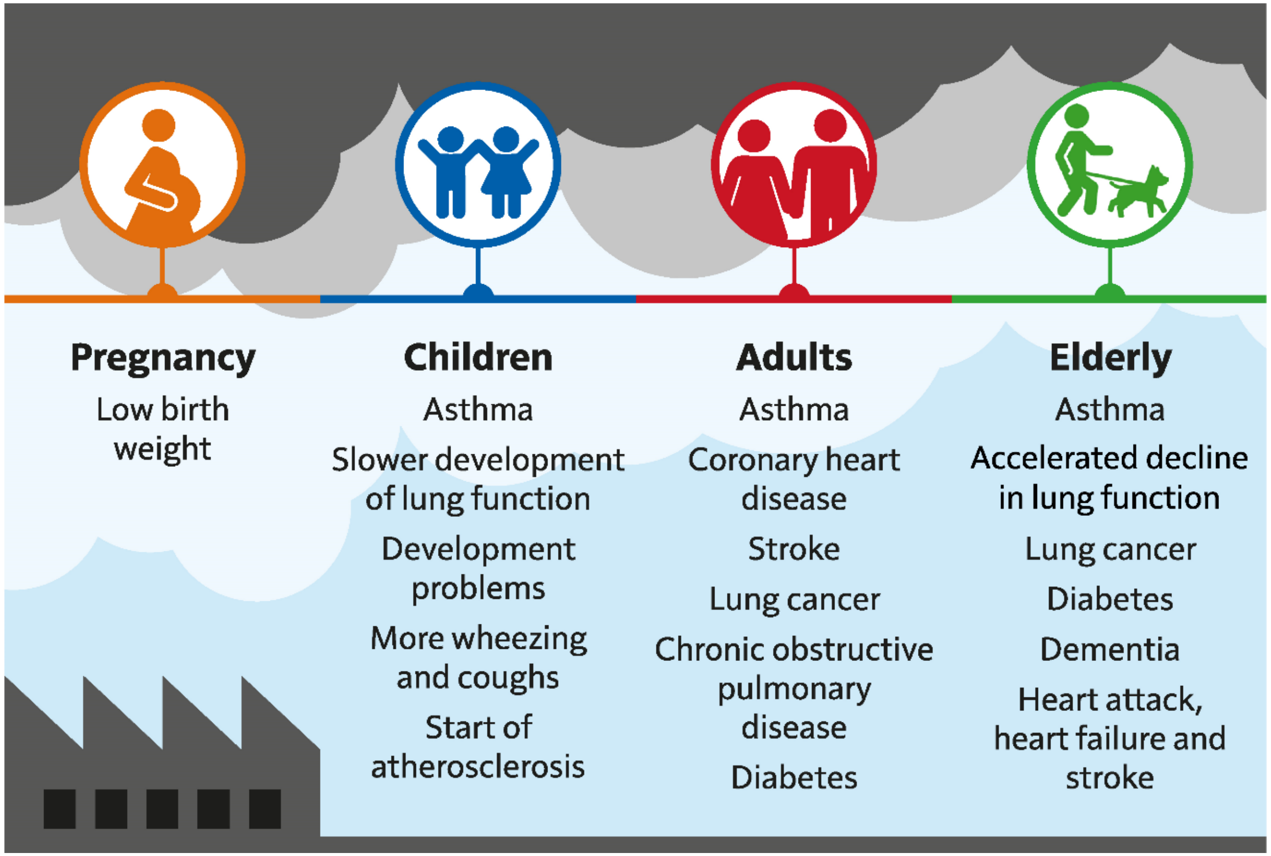


Air pollution & climate change.

- Air pollution and climate change both significant threats to health.
- Air pollution effects substantial, although improving.
- Climate change over a longer timeframe- but for practical purposes irreversible. AUC large.
- CC health effects will be even more severe in many parts of Africa, Asia.
- Running through most of this is the central role of engineers.

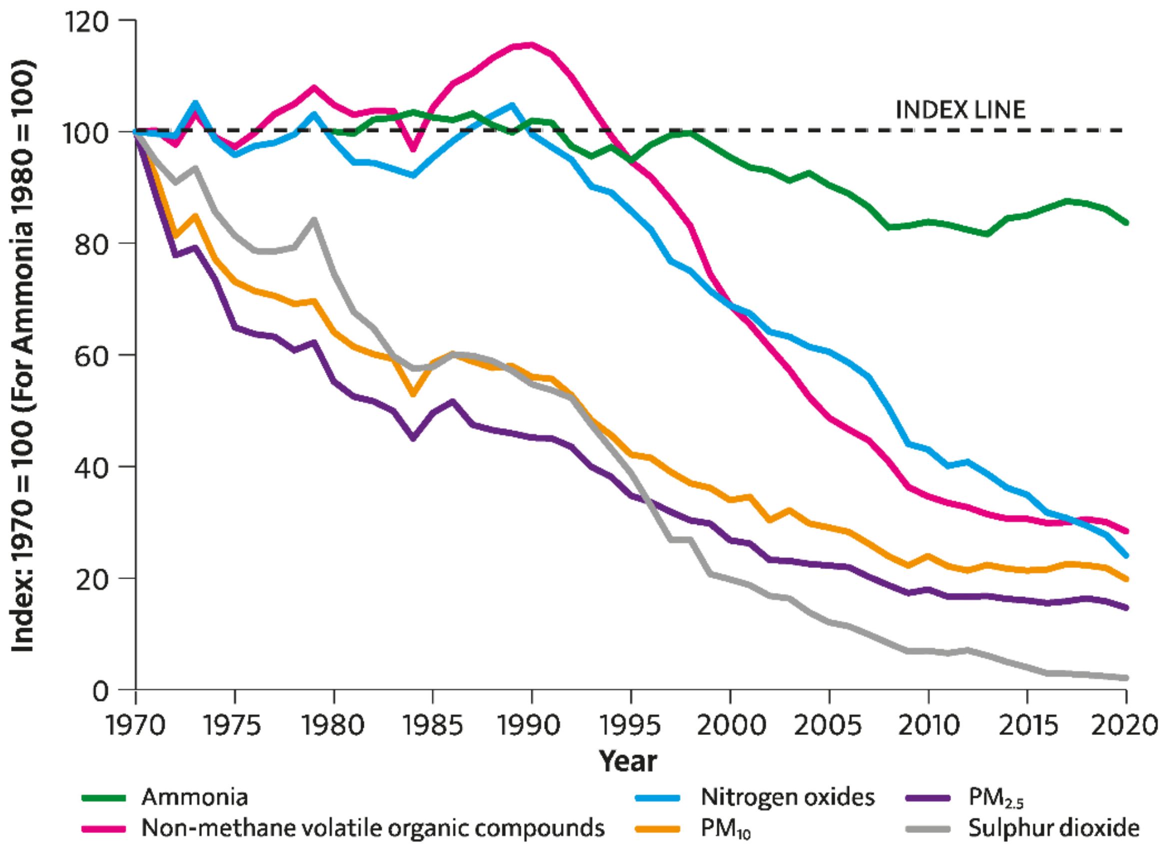


Health effects of air pollution throughout life



Source: Adapted from Public Health England (2018)

UK outdoor air pollution emissions 1970 to 2020

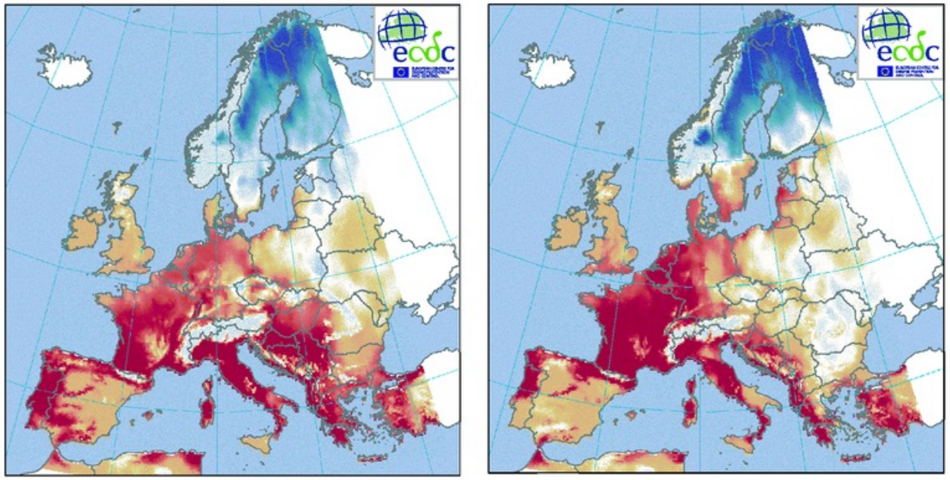


Trends in annual emissions from 1970 to 2020 expressed as a percentage change from the base year of 1970 (for ammonia the base year is 1980)

Source: Ricardo Energy & Environment. Defra (2022)

Major impacts of climate change on health include:

- Direct impact via heat stress.
- Water and temperature on agriculture, water supply.
- Vector borne diseases.
- Natural disasters, especially floods, droughts, storms.



Areas of possible establishment of *Aedes albopictus* (the tiger mosquito) in Europe for 2010 and 2030

Left: maximum-change scenario for 2010; right: minimal-change scenario for 2030

Less suitable areas — Most suitable areas

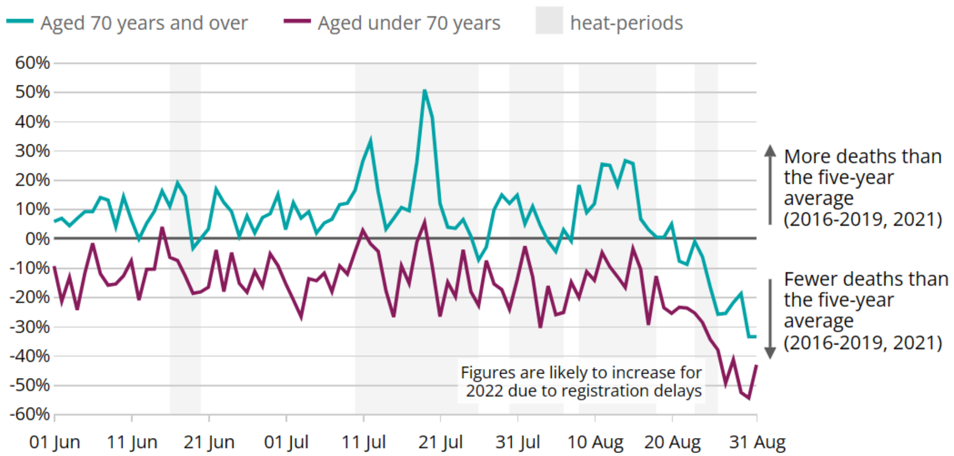
0 25.5 51 76.5 102 127.5 153 178.5 204 229.5 255

Direct effects of heat / cold.

- Extreme- heat-stroke.
- Heat stress increases mortality in youngest and older people.

- Temp >40.3°C, a UK record, on 19th Jul.
- 10 to 25 July 2022 there were 2,227 excess deaths (10.4% above average), E&W.

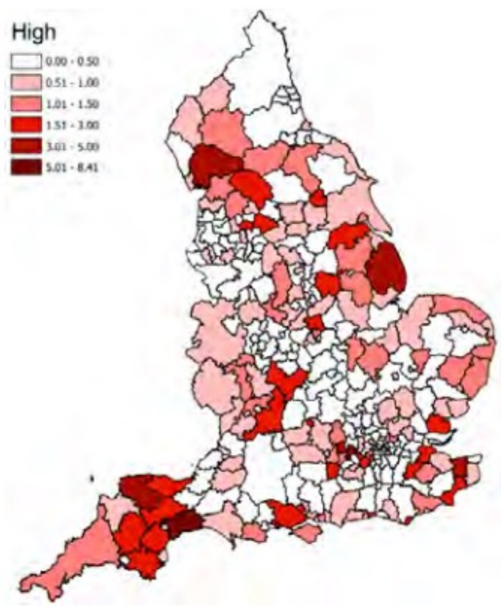
Mortality by day. Age 70 and older.

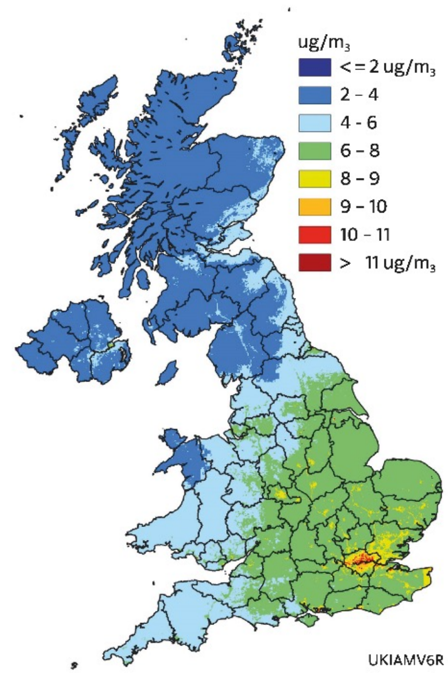


ONS/UKHSA 2022

Future $PM_{2.5}$ concentrations worst in SE. CC effects more widespread, eg coastal storms, flooding.

Households at high risk of flooding. CCC



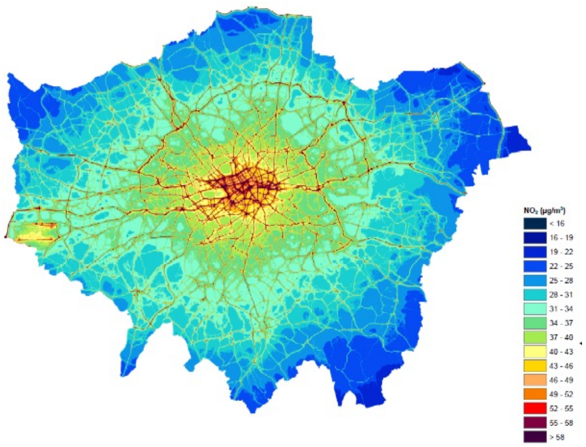


Modelled annual average concentrations of $PM_{2.5}$ in 2030 based on a 'baseline' (existing agreed government policies) emissions reduction scenario

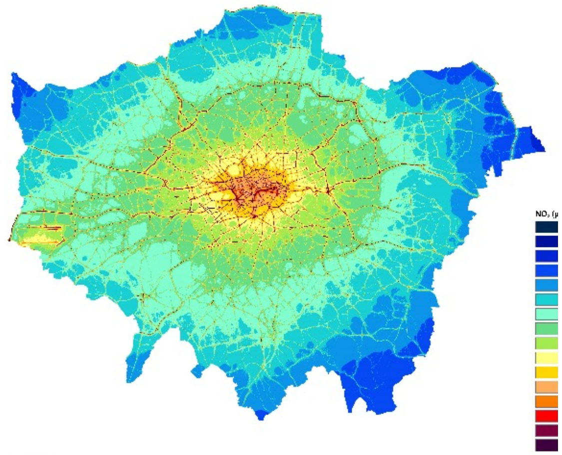
Source: Air Quality PM2.5 Targets: Detailed Evidence Report. *Department of Environment Food and Rural Affairs*, 2022.
Flooding risk from Climate Change Committee 2023. .

Highest risk of AP shrinking (albeit too slowly); highest risk of CC expanding.

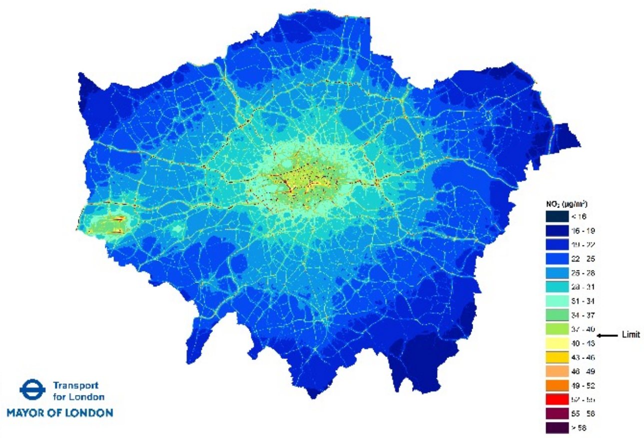
Change in nitrogen dioxide (NO_2) concentrations 2013 to 2019



2013



2016

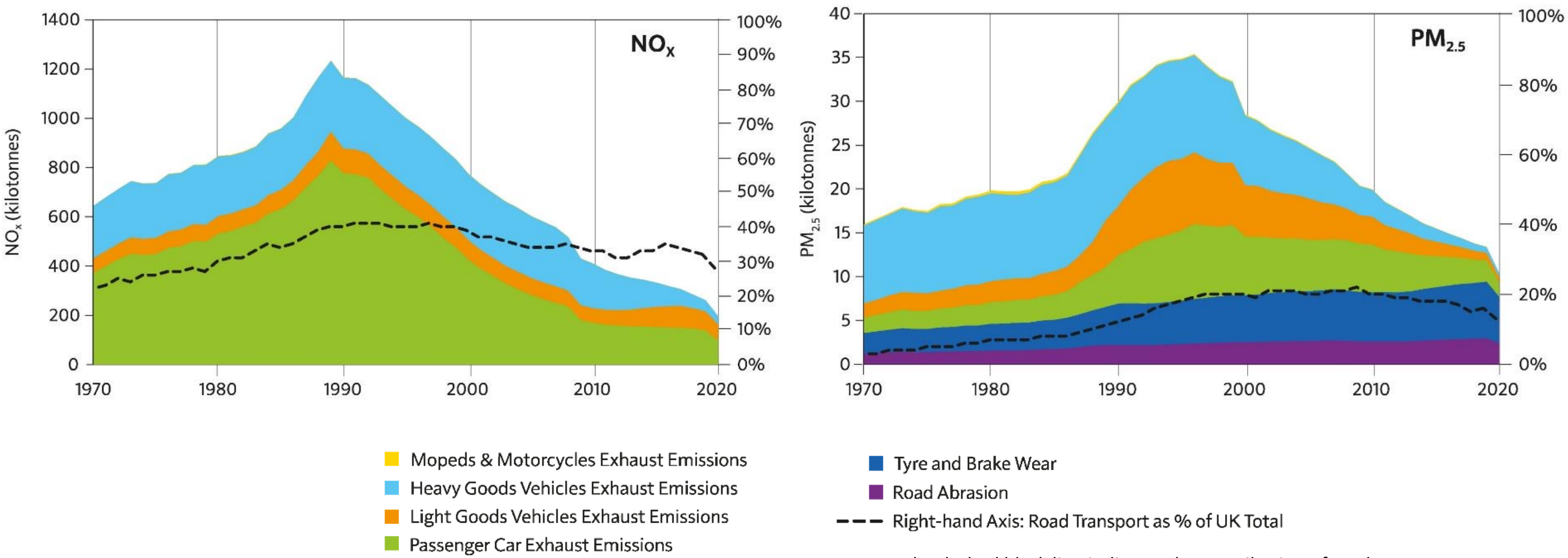


2019

Source: London Atmospheric Emissions Inventory (2019)

Road vehicles an example where run together.

NO_x and $PM_{2.5}$ emissions from road vehicle sources since 1970

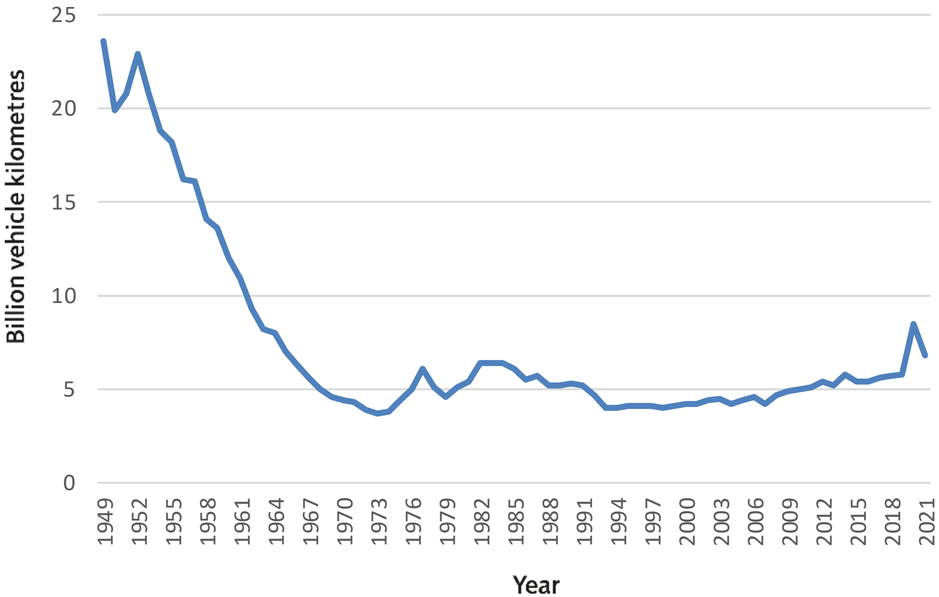


The dashed black line indicates the contribution of road transport to the overall emissions on the right-hand axis

Source: National Atmospheric Emissions Inventory analysed by Air Quality Consultants Ltd

Urban planning and active travel- run together.

Kilometres travelled by bicycle in Great Britain from 1949 to 2021

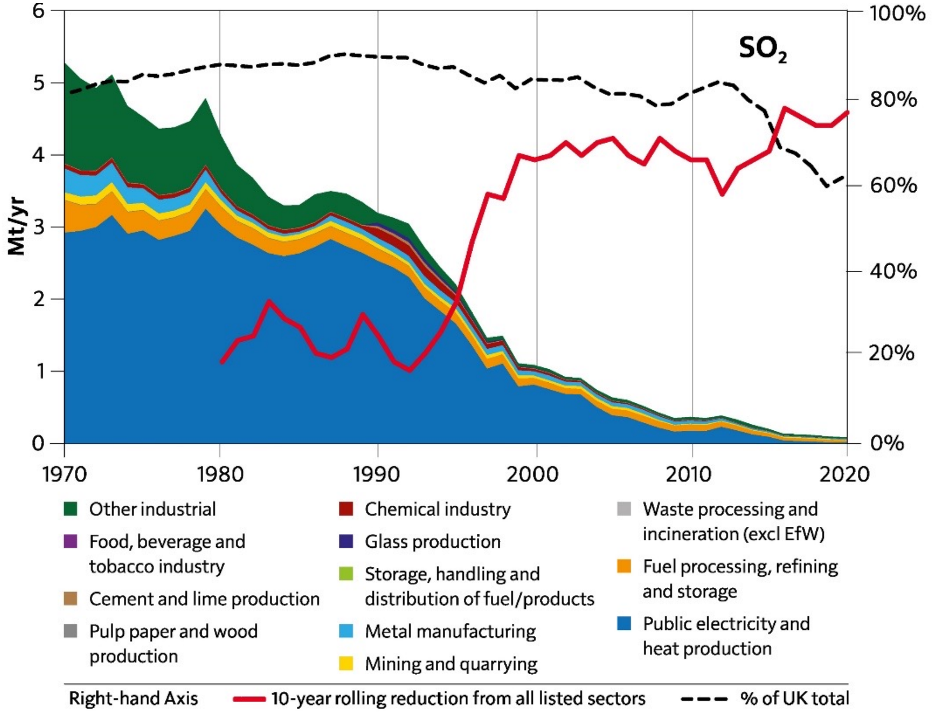


Source: Department for Transport

Pop up cycle lane

Industry. Largely run together.

Total UK emissions of SO_2 from industrial sectors



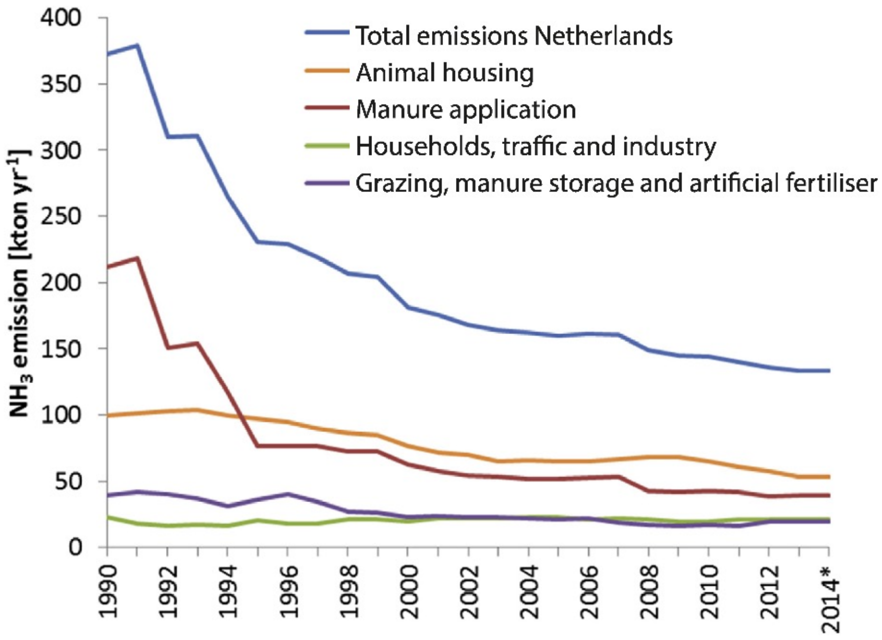
Source: National Atmospheric Emissions Inventory

Hope Valley cement works

Source: Wesley Kristopher Photography

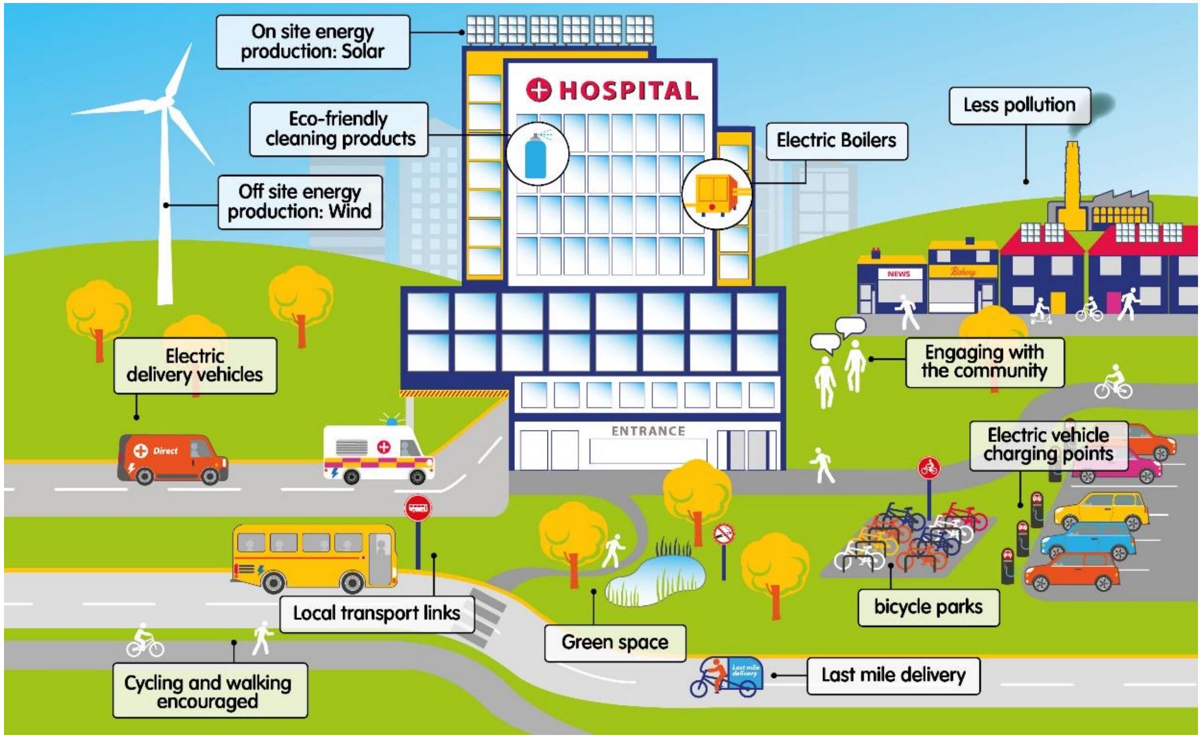
Agriculture- largely run together.

Estimated contributions to the changes in NH_3 emissions from agriculture in the Netherlands, 1990 to 2014



The NHS. Largely run together.

Example - the Clean Air Hospital Framework vision for a Clean Air Hospital

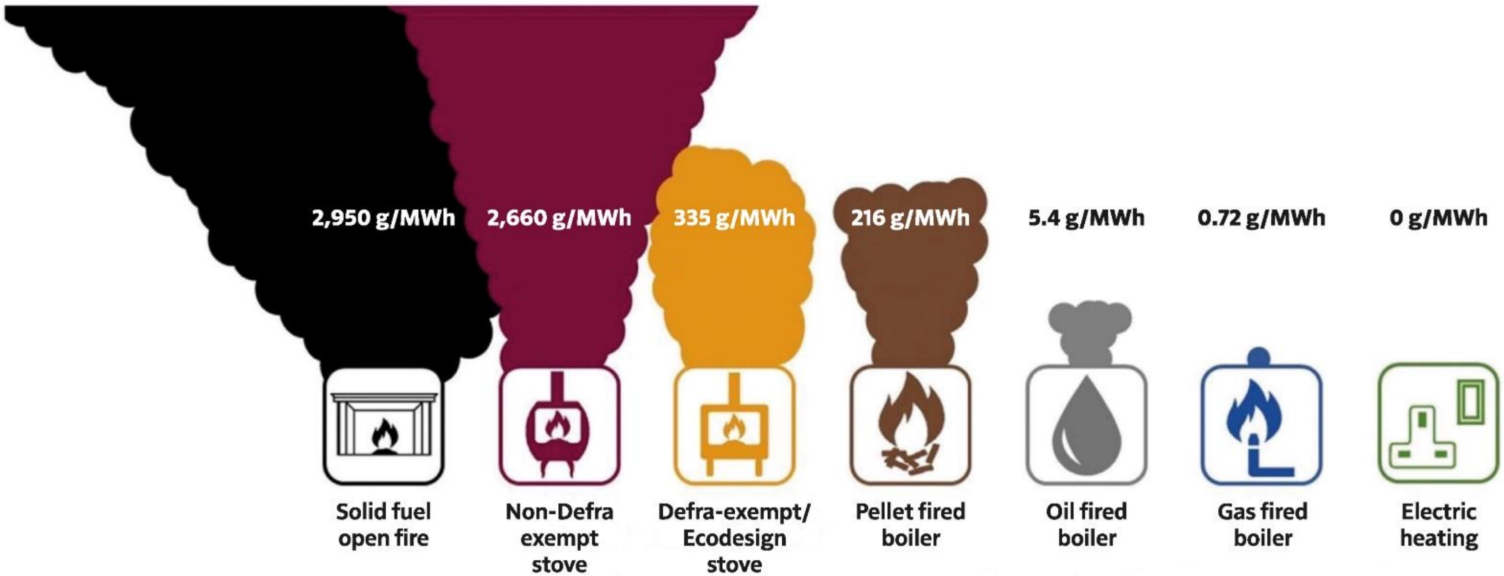


Source: Global Action Plan

Indoor air quality solutions. Ventilation in tension.

Domestic space heating. Largely run together but mixed.

$PM_{2.5}$ emissions from different domestic heating methods



Note: The air pollution emissions will also depend on the age of the appliance, how it is maintained and used and the fuel burned (for example, dry or wet wood). The following definitions were used: *Solid fuel open fire*: wood burned in an open fire. *Non-Defra-exempt stove*: wood in a conventional stove. *Defra-exempt/Ecodesign stove*: wood in an advanced/ecolabelled stove. *Pellet fired boiler*: wood in pellet stoves and boilers. *Oil fired boiler*: fuel oil in a medium (>50KWth <1MWth) boiler. *Gas fired boiler*: natural gas in a small (≤50kWth) boiler.

Source: Emission factors taken from EMEP 2019 Guidebook (1A4 small combustion tables). Adapted from the Clean Air Strategy with updated data

We should be clear-eyed about the areas where interventions to improve air pollution and mitigate greenhouse gas emissions overlap, where they are neutral, and where they compete.

Overlap include:

- Reducing air pollution from vehicles. Incudes active transport.
- Reducing air pollution emissions from industry.
- Some actions to reduce air pollution in agriculture.
- Many activities which make any system, including space heating and the NHS, less carbon intensive.

Potential competition includes:

- Ventilation v conserving heat on indoor air pollution.
- Some policy choices- e.g. the 2001 push to diesel in light vehicles.
- Example of neutrality: resiting polluting activities away from habitation.

Air Pollution & Climate Change: Two sides of the same coin

Professor Kevin Fenton CBE PrFPH FRCP PhD

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The greatest threat to health

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- The Faculty of Public Health has stated clearly that climate change and environmental degradation is the **single biggest health threat facing humanity**.

- **Ambient and household air pollution**, most significantly from burning fossil fuels which also drives climate change, is causing more than seven million premature deaths each year (WHO).

- Between 2030 and 2050 climate change is expected to cause approximately 250,000 additional deaths per year from **malnutrition, malaria, diarrhoea and heat stress** (WHO).

Actions for health organisations

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- Health organisations, including Royal Medical Colleges have a key role to play in tackling climate change and **advocating for sustainable climate action.**

- We must lead by example to inspire and influence, but also to have real **impact through our own footprint**.

- The Kings Fund estimates that the health and social care sector in England represent around 25% of government spend and around 10% of the workforce. Efforts to reduce the system's environmental impact and natural resource footprint are vitally important.

Climate change and sustainability

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- Recognising the interconnectedness between planetary and human health, climate change and sustainability is a priority for the Faculty, as outlined in our Organisational Strategy 2020-25 and Focus Areas 2022-25.
- Our work on climate and health is underpinned by principles of equity and justice.
- Our work in this area is led by our Climate and Health Committee and our Sustainable Development Special Interest Group, guided by our Climate and Health Strategy.

FPH Climate and Health Strategy 2021 - 25

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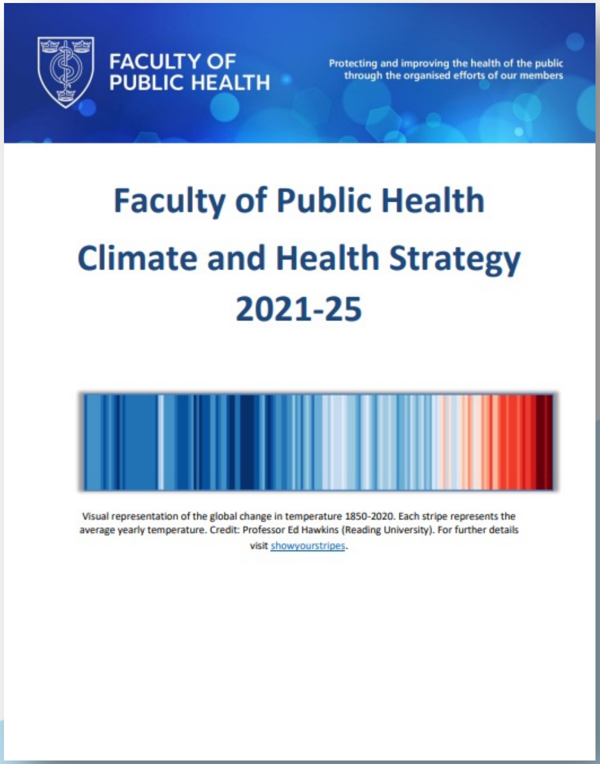
- Ensure that the public health workforce has the knowledge, skills and capability to work on mitigation and adaptation to the climate emergency and environmental breakdown, including access to resources and the confidence to make the case for the health co-benefits of action on climate change.
- Advocate for inequalities to be essential to all work on climate, the environment and health, recognising that climate injustice creates health inequalities locally and globally.
- Demonstrate leadership by becoming a net-zero organisation.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Protecting and improving the health of the public through the organised efforts of our members

Faculty of Public Health

Climate and Health Strategy

2021-25

Visual representation of the global change in temperature 1850-2020. Each stripe represents the average yearly temperature. Credit: Professor Ed Hawkins (Reading University). For further details visit showyourstripes.

Faculty of Public Health's work on climate and health

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- The FPH has already taken action over recent years - by declaring a climate emergency, divesting from fossil fuels, amending its curriculum and contributing internationally to the health voice on climate action.

- Our Sustainable Development Special Interest Group and Climate and Health Committee have played an important role by
  - Developing FPH's Climate and Health Strategy
  - Achieving observer status at COP26
  - Responding to the UK Government's draft Clean Air Strategy in 2018
  - Developing a series of resources on sustainable development to support the public health workforce
  - Organising conferences and events on climate change

Faculty of Public Health's work on climate and health

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2018
- FPH fully divested from oil, gas and coal companies

2019
- FPH declare a climate emergency

2020
- FPH Climate and Health Committee established

2021
- FPH invited to COP26 with Observer status, lead submission of joint health statement to the UNFCCC secretariat

2022
- FPH host major conference on Climate and Health, new Focus Areas for 2022 – 25 identify Climate action as a priority for the Faculty

2023
- FPH review Climate and Health Strategy and launch new Reverse Mentoring Programme

Knowledge and resources on climate change and sustainability

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- A key element of the Faculty's work on climate change is supporting public health practitioners in developing the knowledge and skills they need to work on climate change and sustainability

- Visit the Faculty website to access these resources

Knowledge Resources

K1 Principles of sustainable development

K2 Sustainable economy

K3 Climate change – overview

K4 Health impacts of climate change

K5 Health benefits of action on climate change

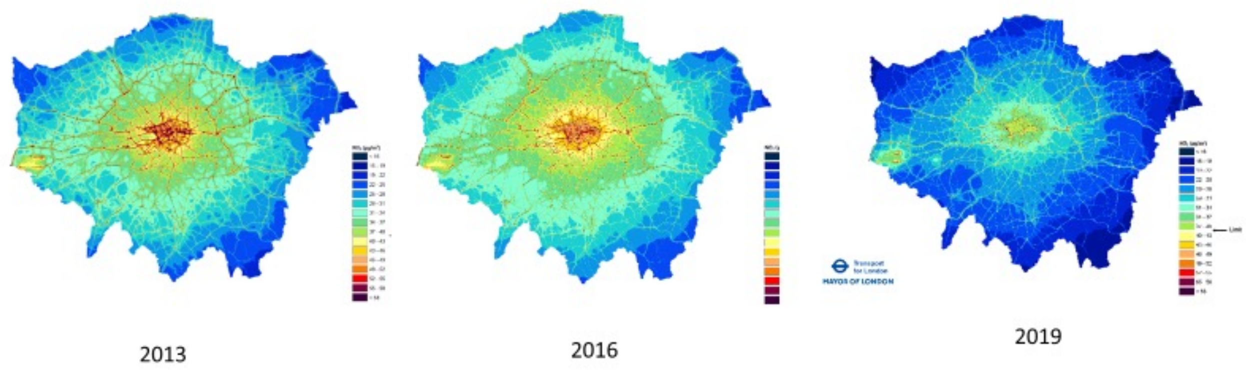
K6 Natural capital and ecosystem services

K7 Sustainable food systems

K9 NHS carbon footprint

K10 Air Pollution and Climate Change

Greater London: Change in nitrogen dioxide (NO_2) concentrations 2013 to 2019



Source: London Atmospheric Emissions Inventory (2019)

Air pollution is a major public health challenge in London, with levels often exceeding legal limits, although significant improvements are being made.

Strong collaborative partnerships have been key to reducing air pollution levels and improving air quality in the region.

Air pollution in London: The story thus far

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- Progress has been made in improving air quality in London, but there is still a long way to go. Between 2016 and 2020, there was a 44% reduction in the number of state schools in areas exceeding legal limits for nitrogen dioxide (NO2), but London still has some of the worst air quality in the UK.

- Road transport is the biggest contributor to air pollution in London, and reducing emissions from vehicles is a key priority. The Ultra Low Emission Zone (ULEZ), which charges drivers of high-polluting vehicles to enter central London, has already contributed to a 44% reduction in roadside NO2 concentrations in the zone.

- Tackling air pollution requires a multi-faceted approach. Alongside measures to reduce emissions from vehicles, we need to promote active travel, such as walking and cycling, and improve public transport infrastructure. The Mayor's Streetspace plan has delivered over 100km of new or upgraded cycle lanes, and 40% of London's streets now have a 20mph speed limit.

Air pollution in London: The story thus far

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- Air pollution disproportionately affects the most vulnerable communities, including children, the elderly, and those with underlying health conditions. It is crucial to ensure that measures to improve air quality do not exacerbate existing inequalities, and that all Londoners can breathe clean air.
- Data and evidence are crucial in shaping policy and monitoring progress. The London Air Quality Network (LAQN) provides real-time air quality data across the city, enabling targeted interventions in areas with high pollution levels.
- Partnerships and collaboration are key to success. The Breathe London project, a partnership between the Mayor of London and leading universities and research institutions, has deployed over 100 air quality sensors across the city, providing hyperlocal data on air pollution.
- There is still much work to be done to improve air quality in London, and we need to continue to push for ambitious policies and investment. The upcoming Environment Bill, which will establish legally binding targets for air quality, presents a key opportunity to accelerate progress and ensure that Londoners can breathe clean air.

Air pollution: A narrative for change

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Build upon the evidence

- The evidence is clear. If we want to protect our communities and reduce health inequalities, we must tackle the health threat that is air pollution.

Create a burning platform

- We know that air pollution across the capital is still breaching legal limits, it far exceeds World Health Organization recommended guidelines and it is deadly. And it is not just a London issue. In December, the Chief Medical Officer released his annual report highlighting the need to go further to address air pollution across the country, and many other cities are implementing policies such as Clean Air Zones to address this.

- It's also important to point out that in 2019, toxic air contributed to the equivalent of around 4,000 premature deaths in London. The highest number of life years lost due to toxic air were in outer London boroughs such as Barnet, Bromley and Croydon.

Air pollution is everyone's business

- Air pollution affects everyone who lives and works in London, and its impacts are felt throughout life from before birth to old age. It increases the risk of developing heart disease, strokes, lung disease and lung cancer and it reduces life expectancy. In fact, there is an increasing body of evidence showing the link between breathing in polluted air and a wide range of health effects including dementia, Type 2 diabetes and adverse effects on foetal growth and birth outcomes.

Air pollution: A narrative for change

FACULTY OF PUBLIC HEALTH

A resolute focus on inequalities

- Sadly, the poorest Londoners have the highest levels of exposure, which means they are disproportionately impacted by our city's toxic air. And as the Chief Medical Officer's report shows, this is a trend seen across the country. Improving air quality is an urgent public health priority for London and the entire country, as it is crucial to reducing the health impacts and disparities seen across communities. That's why policies like the Ultra Low Emission Zone (ULEZ) are so needed.

Discuss the comprehensive approach

- ULEZ is one of a range of policies being implemented in London to improve the city's air quality and reduce exposure to pollution. Extending the ULEZ will have significant health benefits for Londoners and reduce health inequalities. We also know that people across the capital will need to be supported through this right now. That's why City Hall is rolling out a range of offers and mitigations to help prepare Londoners, such as the scrappage scheme and additional grace periods.

Alignment of London's leaders and communities

- At this moment, we have the committed leadership to help drive the necessary change to improve the health of Londoners right now and the health of future generations, and we must support that.

Air Pollution & Climate Change: Two sides of the same coin

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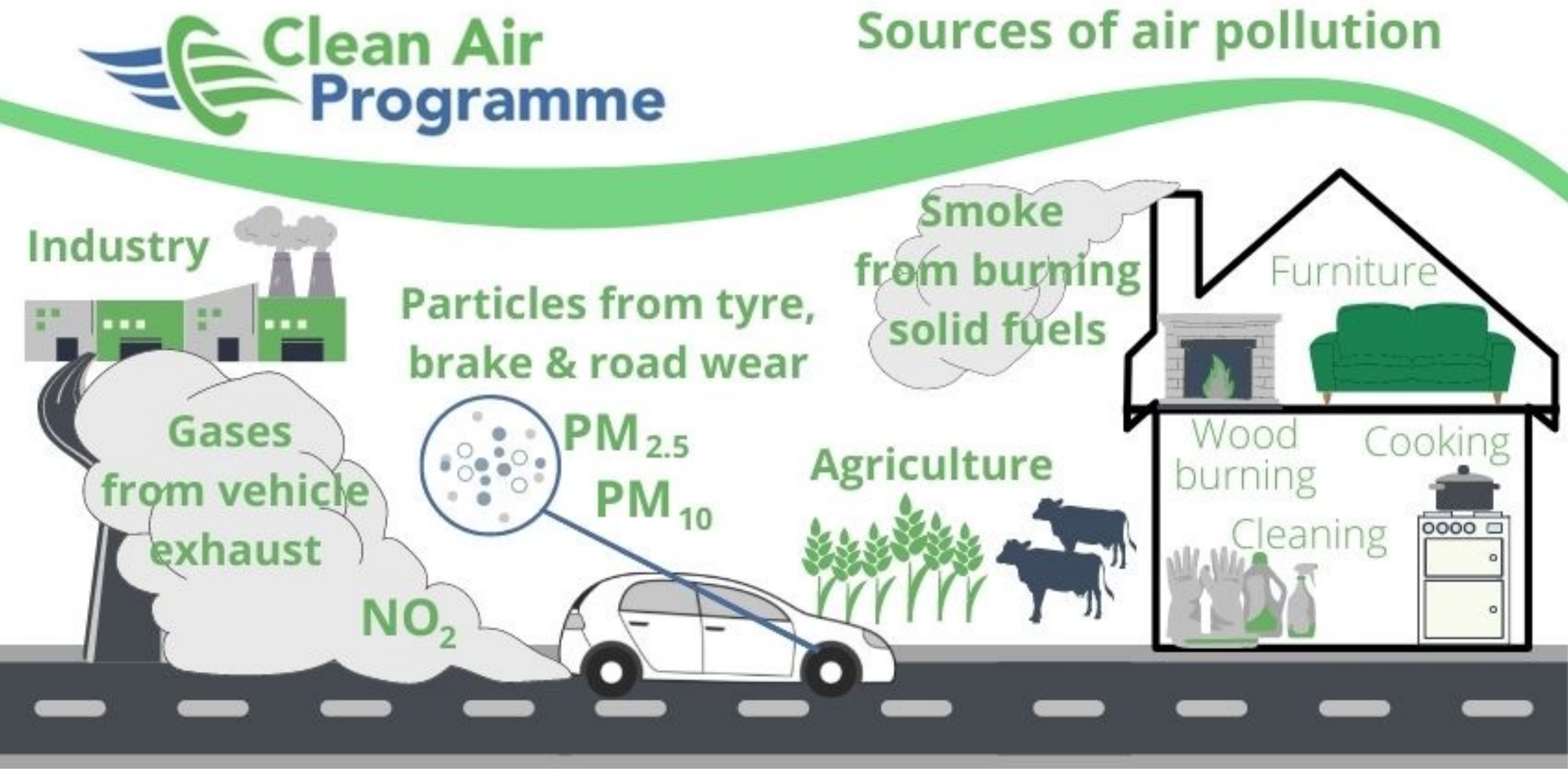
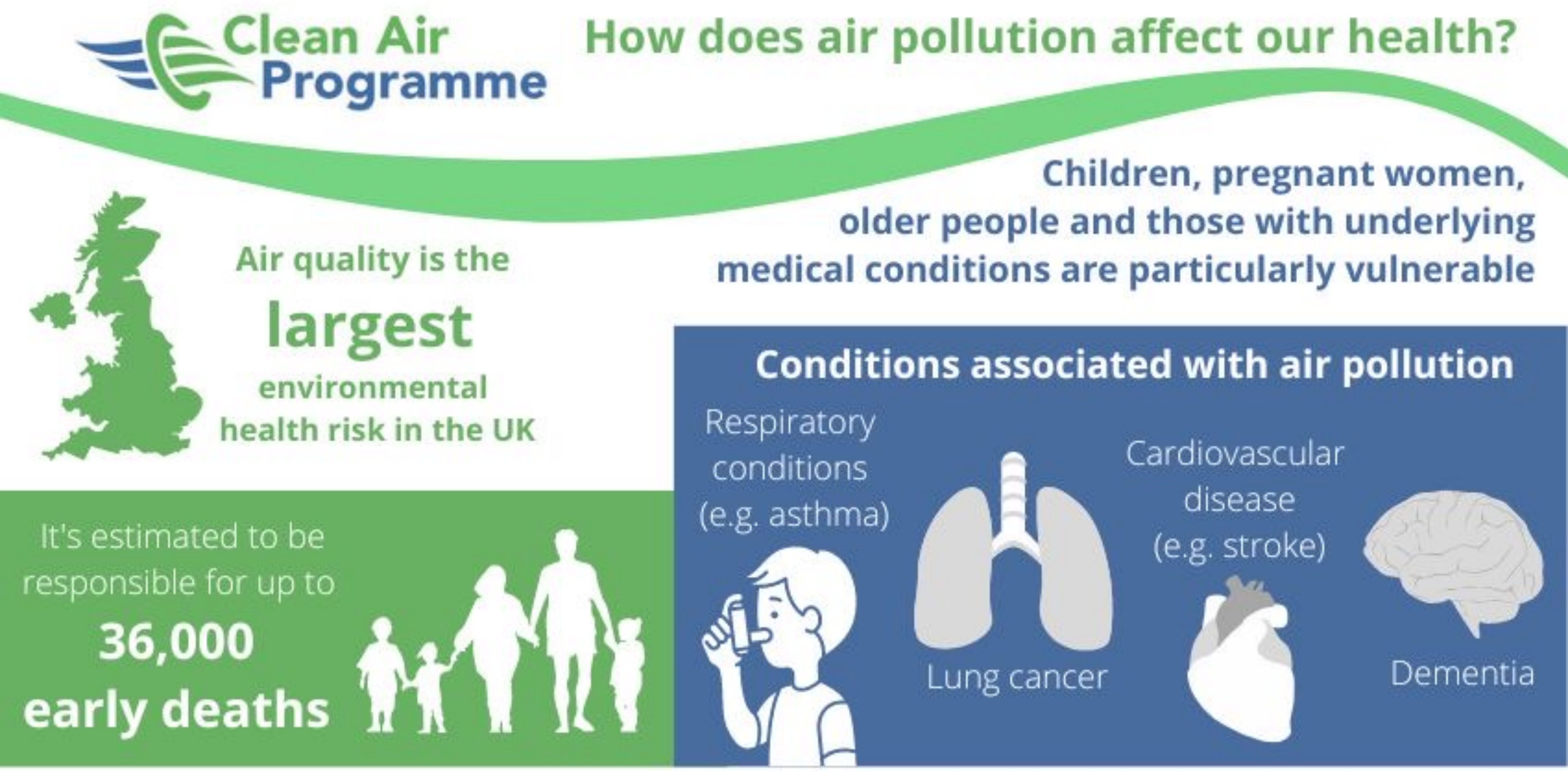
Stephen Holgate
MRC Clinical Professor, University of Southampton.

UKRI Clean Air Champion, Advisor to RCP on Air Quality,
past FPH Bazalgette Professor.

Where does air pollution come from?

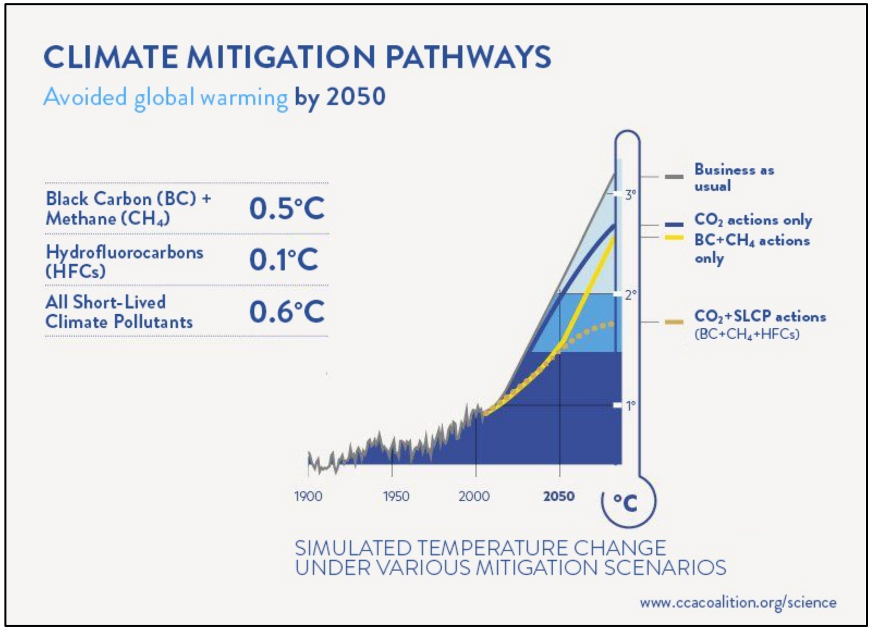


Why does air quality matter?



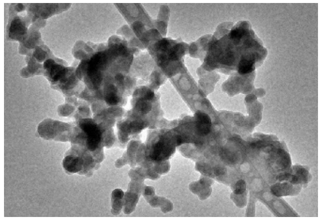
Short-lived climate pollutants (SLCP)

- Beyond CO_2 there are many other equally dangerous gases - short-lived climate pollutants (SLCP): **black carbon, methane, tropospheric ozone, and hydrofluorocarbons responsible for up to 45% of current global warming.**
- Widespread and fast action to reduce SLCP emissions has the potential to reduce warming by as much as 0.6°C over the next few decades.
- Immediate implementation of SLCP control measures could reduce the rate of sea-level rise by ~20% in the first half of this century.
- By 2100, full mitigation of CO_2 and short-lived climate pollutants could reduce the rate of sea-level rise by up to 50%, which would give coastal communities and low-lying states time to adapt.



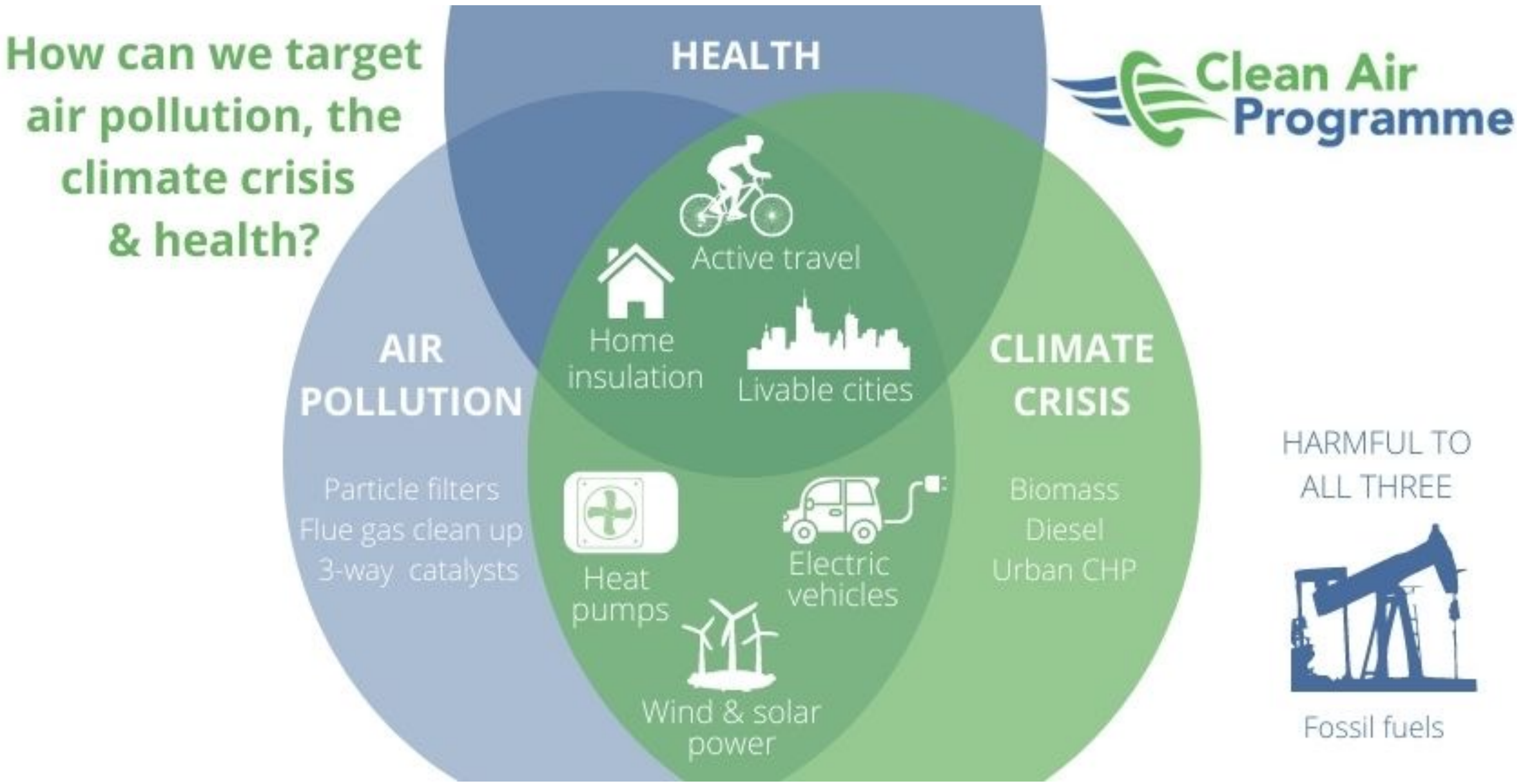
Air pollution and climate change

- Black carbon (BC) through household burning or diesel causes CV disease, cancer and birth defects.
- Global warming potential 1,500 times greater than CO_2.
- BC perturbing Indian and East African monsoons by heating a specific part of the atmosphere and inhibiting cloud formation.
- If BC lands on ice or snow, it can make the ice darker, absorbs more sunlight and melts faster.



Black carbon Particles (soot)

Benefits to air quality, health and climate

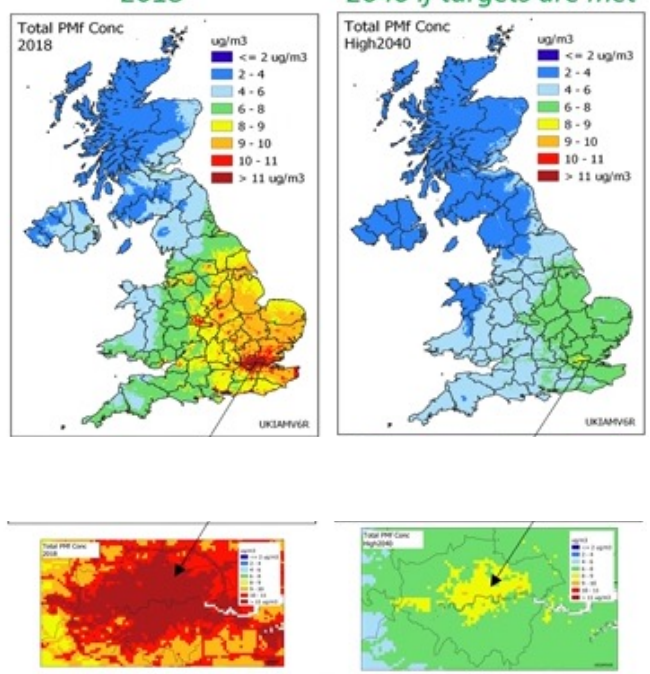


Proposed target values and dates

- The proposed targets are:
  - An annual mean concentration target of $10\ \mu g\ m^{-3}$ by 2040
  - A population exposure reduction target of 35% by 2040 compared to 2018
- Views on the level of ambition are being sought through the ongoing public consultation.

Meeting the proposed targets will reduce concentrations everywhere, but greatest impact in urban areas where levels are highest

2018 *2040 if targets are met*



Health benefits

- The targets are expected to deliver a reduction in population exposure of $3.5\ \mu g\ m^{-3}$ by 2040 compared to 2018.
- It is estimated that over 18 years this reduction would result in:
  - 231,100 fewer case of coronary heart disease
  - 75,600 fewer cases of children's asthma
  - 61,100 fewer cases of stroke
  - 24,800 fewer cases of lung cancer
- There are also benefits for ecosystems in sensitive habitats and in carbon reduction (many measures benefit both AQ and NZ).


01-12 NOV 2021
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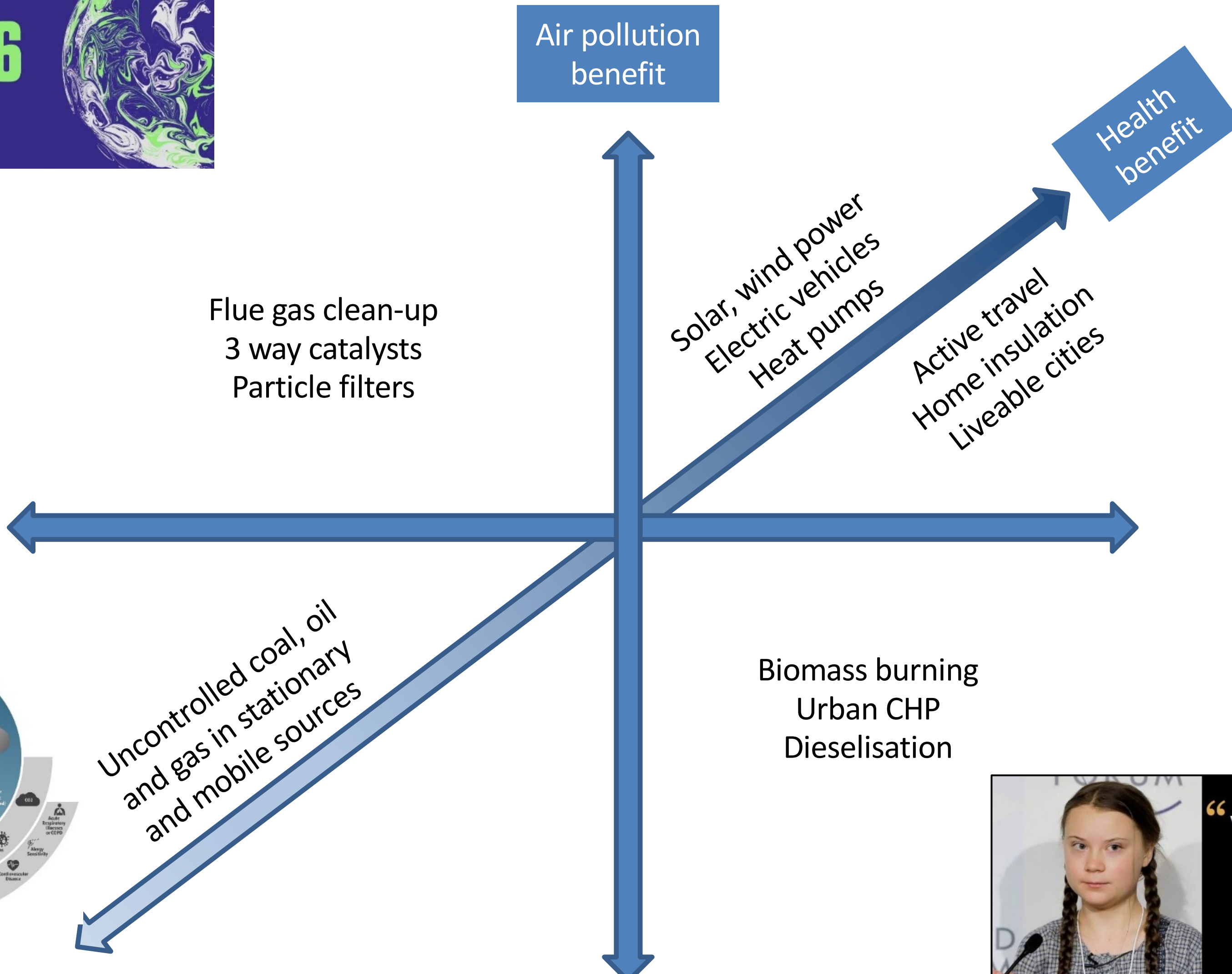
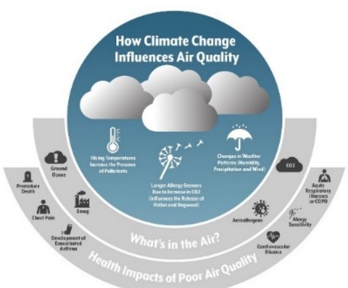

Air pollution benefit
Health benefit
Climate change benefit
Flue gas clean-up
3 way catalysts
Particle filters
Solar, wind power
Electric vehicles
Heat pumps
Active travel
Home insulation
Liveable cities
Uncontrolled coal, oil
and gas in stationary
and mobile sources
Biomass burning
Urban CHP
Dieselisation


How Climate Change
Influences Air Quality
What's in the Air?
Health Impacts of Poor Air Quality


Young people must hold
older generations
accountable for the
mess they have
created.
Greta Thunberg

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Professor Catherine Noakes
Professor of Environmental Engineering for Buildings

Climate and Indoor Air Quality

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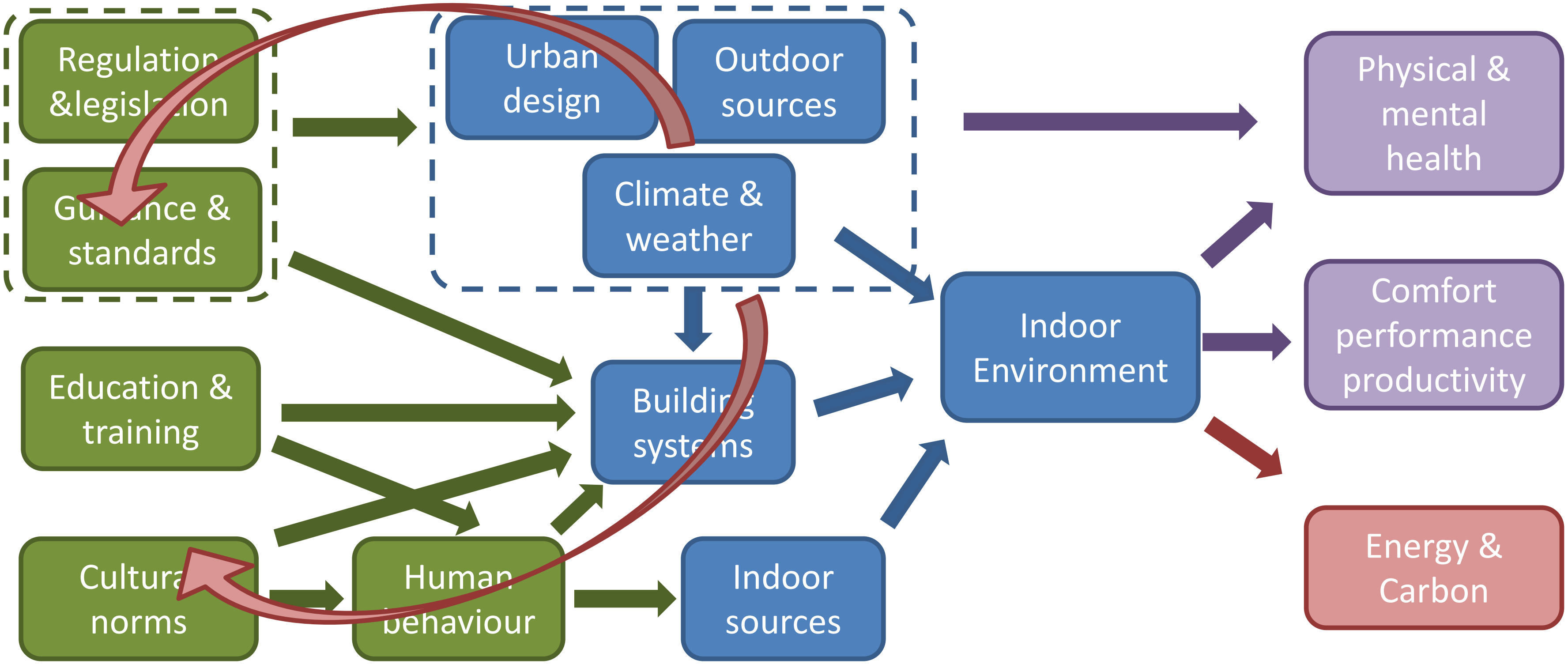
Direct Impacts

- Temperature
- Humidity
- Extreme weather
- Outdoor air pollution

Indirect Impacts

- Energy retrofit
- Decarbonisation
- Energy costs
- Changing population and disease patterns

Complex system



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Professor David Fowler CBE
Professor of Environmental Physics, Centre for Ecology and Hydrology, Scotland

Royal Society report 2021

Royal Society report on Effects of net zero policies and climate change on air quality 2021

Table 1.1. Summary of key climate change impacts on UK air quality

Climate Process	Surface Concentrations over UK					
	NO_x	VOC	NH_3	PM	O_3	
Wildfires	+	+		+	+	Affects global O_3, PM; local PM, NOx, O_3
Wetlands/Permafrost					+	Increased CH_4 increases global O_3
Lightning NO_x emissions	+/-				+/-	Affects global O_3, but uncertain
Soil emissions	+				+	Global O_3; local effects small?
Vegetation emissions		+	+	+	+	Global and local O_3, local NH_3, PM
Stratospheric O_3 influx					+	Increased O_3 input to troposphere
Stratospheric O_3 recovery					+/-	Slower O_3 formation/destruction
Higher temperatures	+	+	+	+	+	Higher emissions, PM/O_3 formation
Higher rainfall			-	-		More effective scavenging of PM
Higher humidity				+	-	Lower O_3 from Atlantic; PM growth
Greater stagnation	+	+	+	+	+	Pollutants build up more, episodes
Regional transport				+	+	Greater European influx; dust, fires
Summertime drought	+	+		+	+	Reduced deposition; more dust

Summary of Air Quality effects of climate change

•**In summertime**, more frequent and intense heat waves are likely to lead to more episodes of high ozone (O_3) and particulate matter (PM). In **wintertime** air quality is expected to improve as the cold stagnant conditions that lead to pollutant accumulation are expected to become less frequent.

•**Responses of air quality to climate change will vary across the UK**, with the southeast more exposed to stagnant meteorological conditions, high temperatures and continental inflow. The **difference between urban and rural air quality is expected to narrow** in response to changes in both emissions and meteorology

•**European sources are likely to become more important for the UK's air quality**, particularly for **O_3 and PM** during pollution episodes. It is thus important to consider UK air quality in a wider international context and to encourage cooperation on control strategies.

•Changes in temperature, humidity and precipitation will alter the emissions, formation, processing and removal of PM. While increased 'scavenging' by rainfall is beneficial, greater formation of PM from organics and ammonia (NH_3) emissions is a concern**.**

•**Emissions of NH_3, methane, biogenic VOCs and soil NO_x are expected to increase with the rising temperature, which creates an additional motivation to reduce such emissions** now. Reducing NH_3 emissions would reduce PM concentrations and have an added benefit for biodiversity by reducing deposition of reactive nitrogen on sensitive ecosystems

.

•**O_3 will remain an important global and regional pollutant throughout the period to 2050 and beyond.** Climate-driven increases in input from the stratosphere, increased CH_4 from wetlands, will lead to increased O_3 in many parts of Europe,

.

Air Pollution & Climate Change: Two sides of the same coin

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www.fph.org.uk

Professor Alastair Lewis
Professor of Atmospheric Chemistry at the University of York and the National Centre for Atmospheric Science
Chair of the Defra Air Quality Expert Group (AQEG).

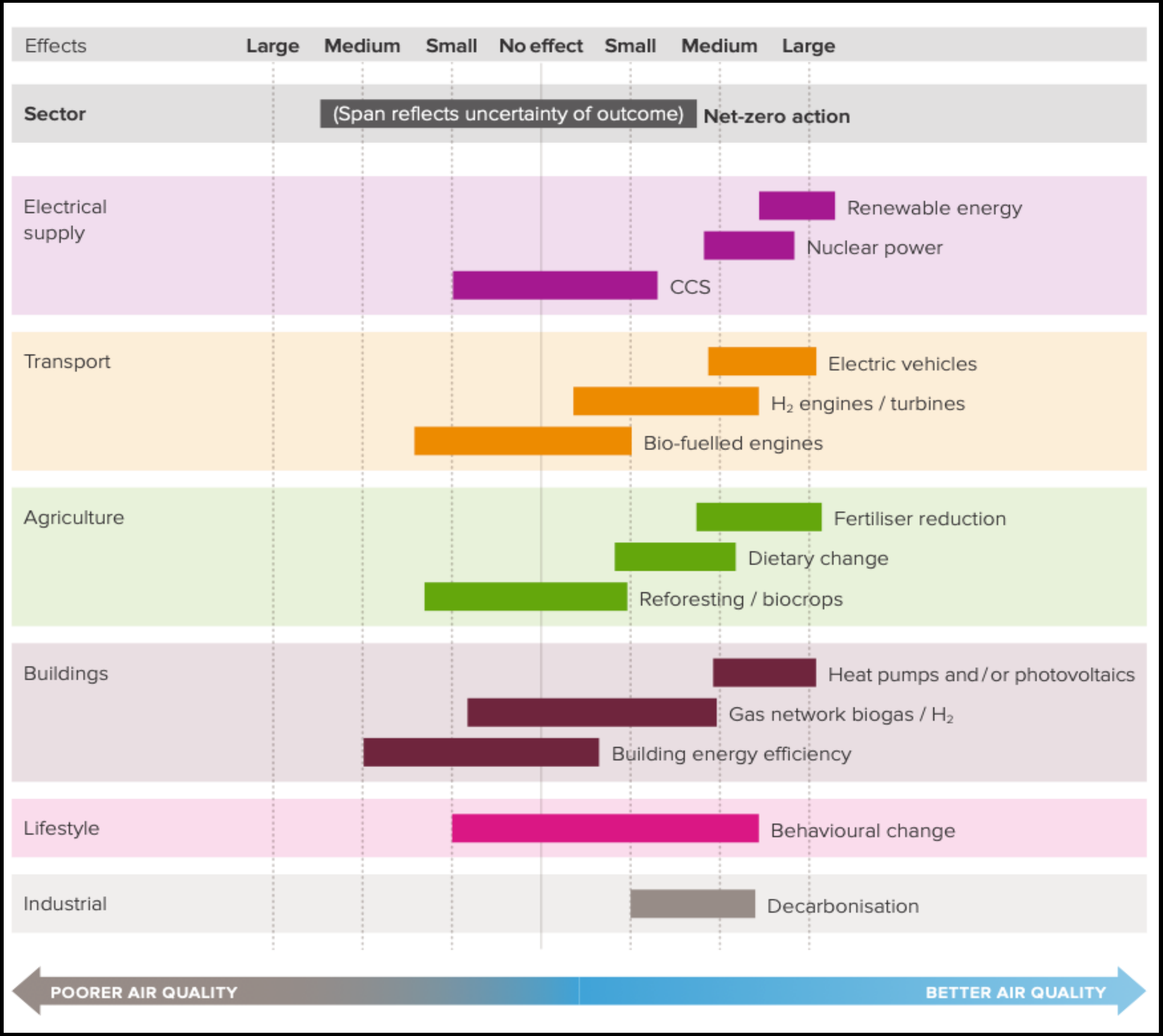
Impacts of UK net zero measures on air pollution

Prof. Alastair Lewis

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

WACL
Wolfson Atmospheric Chemistry Laboratories

Net zero impacts on air quality

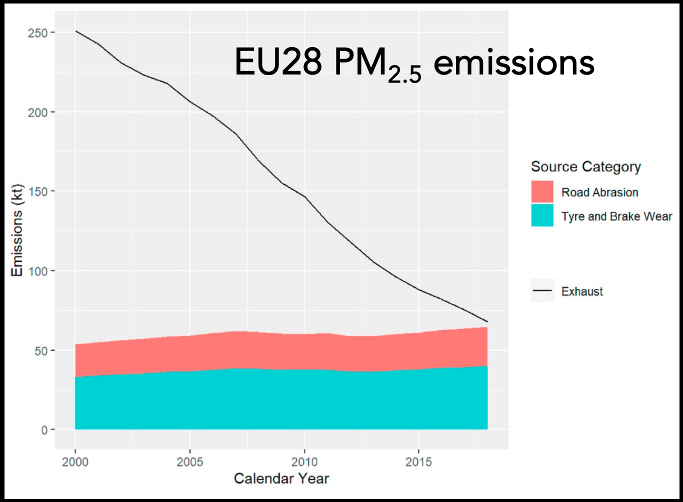


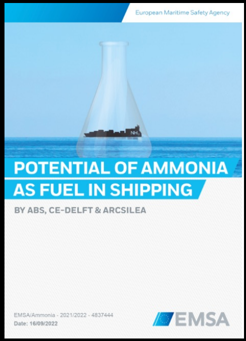
- Net Zero is *mostly* beneficial or neutral for air quality
- Where possible antagonisms exist, mitigations are generally available.
- Some effects are highly uncertain, for example biogenic VOCs from afforestation.
- Many outcomes are technology dependent

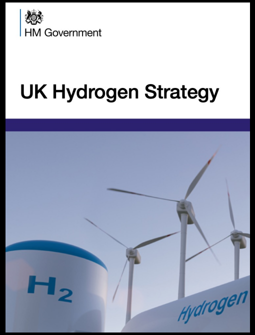
Chapter 3: Climate Change, Air Quality and Net Zero *Royal Society*, 2021.

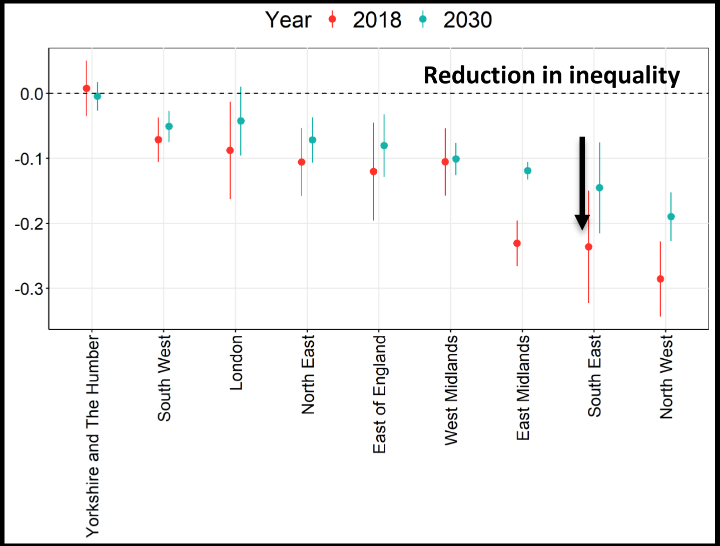
Some key considerations

- Vehicle electrification will solve NO_2 problems in cities.
- However Non-Exhaust Emissions (NEE) of $PM_{2.5}$ already exceed those from the tailpipe. Possible increases in overall mileage + heavier vehicles?
- Burning low carbon fuels leads to continued pollution emissions, notably NOx. This includes fuels H_2 (*boilers*), NH_3 (*marine*) biofuels and SAF (*aviation*).
- Different UK regions may see different levels of AQ benefit from net zero, depending on local sources.









Air Pollution & Climate Change: Two sides of the same coin

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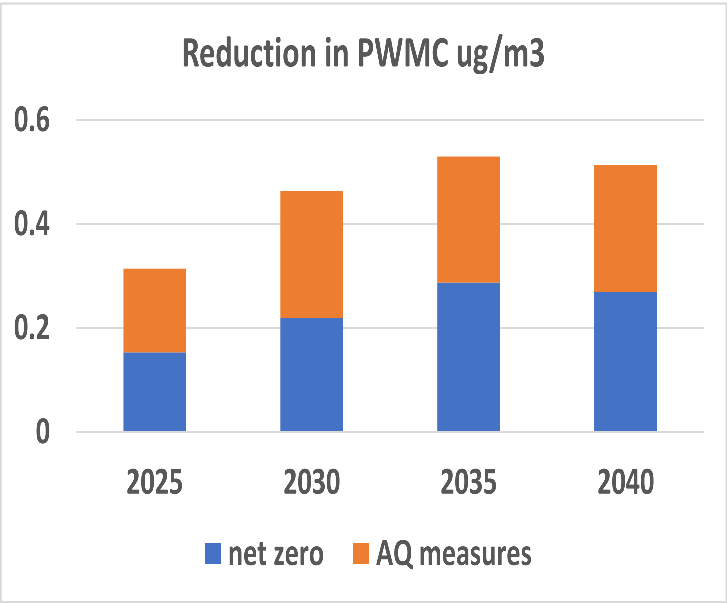
Professor Helen ApSimon, Professor of Air Pollution Studies, Faculty of Natural Sciences, Centre for Environmental Policy, Imperial College London

Helen ApSimon, Imperial College



Relative contributions to improvement in population exposure to PM2.5 relative to the baseline from net zero and added AQ measures for illustrative scenario.
NB EVs included in net zero

Post Brexit experience: assessing future air pollution scenarios for the UK to 2050- setting targets for $PM_{2.5}$ in Environment Act by 2040:

i)annual maximum concentration of 10 ug.m^{-3}

ii)35% reduction in population exposure

In scenarios superimposing pollution abatement measures on net zero scenarios, the net zero measures can account for a large part of the improvement in AQ.

But this varies with the energy scenario.

Temporal aspects: **Emission ceilings and Climate targets -> focus on specific years; e.g. UK electricity production carbon neutral by 2035. But timing of measures and cumulative effect is important.**

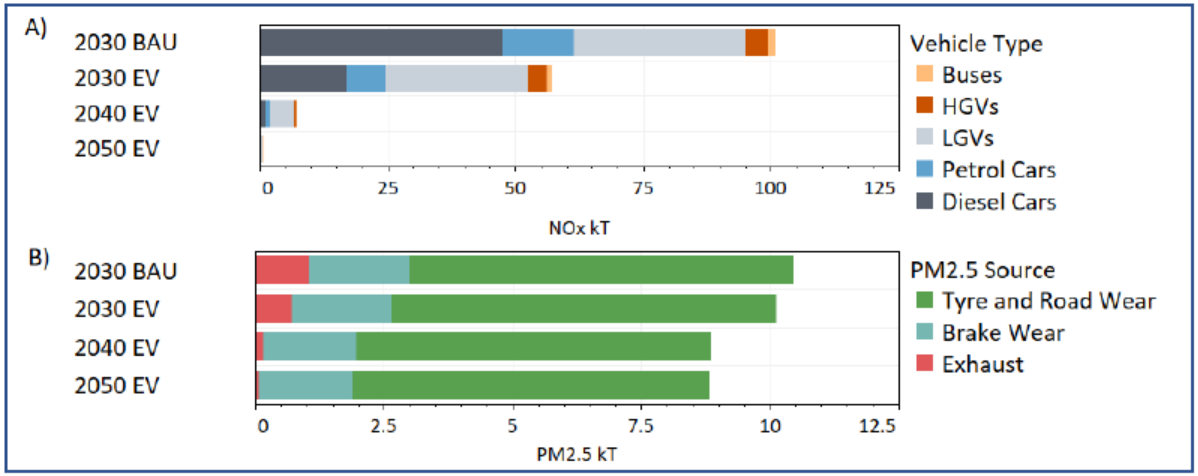


Figure 5.3. Projected emissions from road transport to 2050 for EV scenario. . A) Emissions of NOx, where colour shows the emissions from each vehicle type. B) $PM_{2.5}$ Emissions where colour shows the emission source.

Mehlig D, Woodward H, OxleyT,Holland M, ApSimon H, Electrification of road transport and the impacts on air quality. Atmosphere 2021,12, 1491. https://doi.org/10.3390?atmos12111491

Example electrification of road transport

In UK no new ICE vehicles from 2030 or hybrids from 2035.

AQ: Reduction of NOx but less impact on PM2.5 where non-exhaust emissions dominate.

Needs to be synchronised with energy projections :

If brought forward insufficient clean electricity production

But if delayed by e,g, 5 years adds 0.5 GT to cumulative CO2 emissions by 2050

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Dr Gary Fuller

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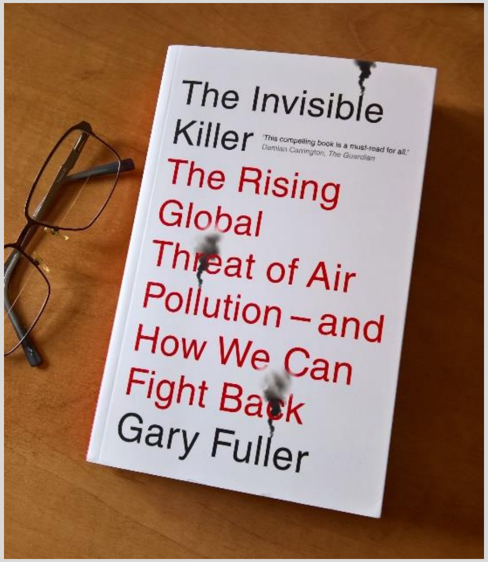
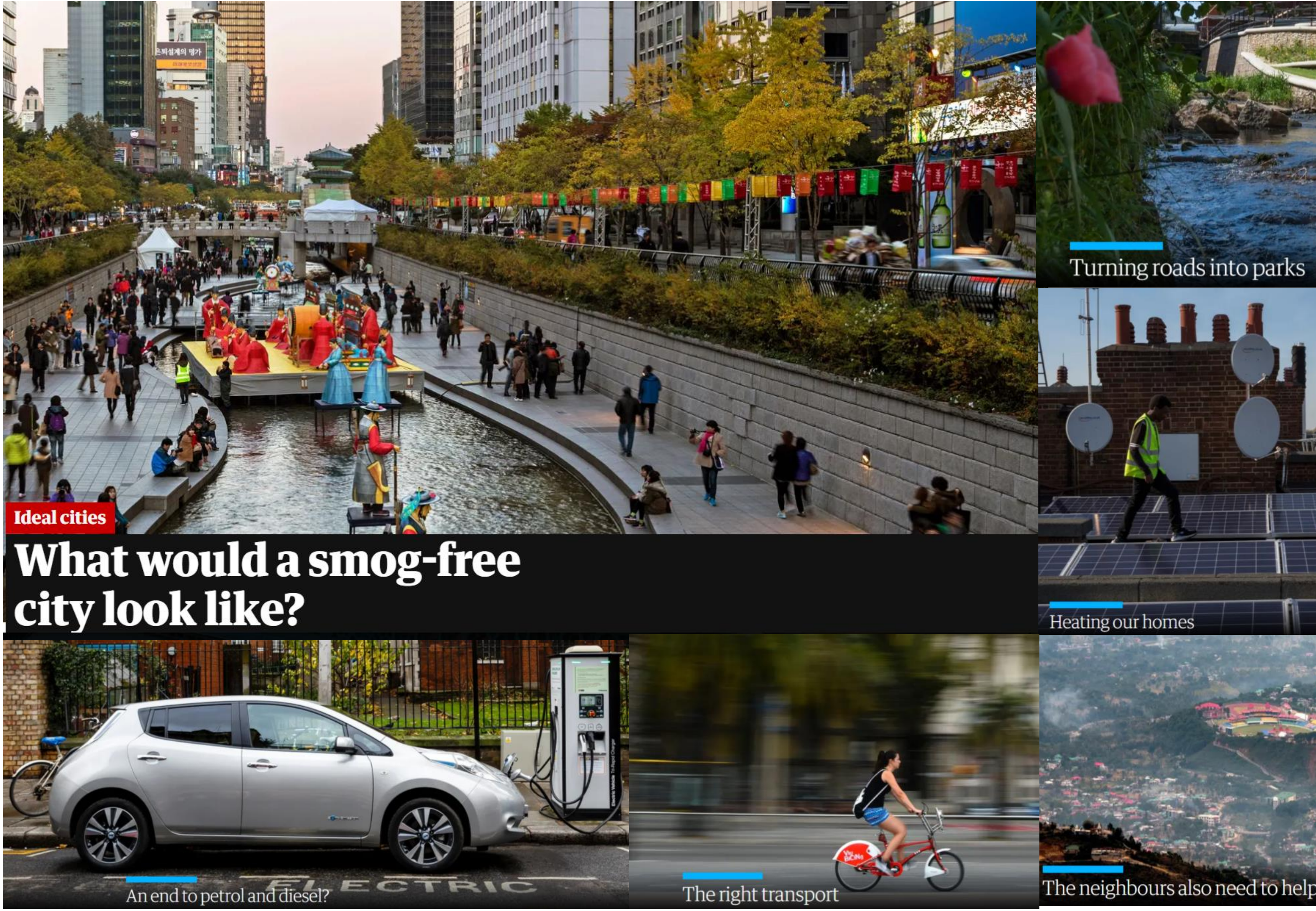
www.londonair.org.uk



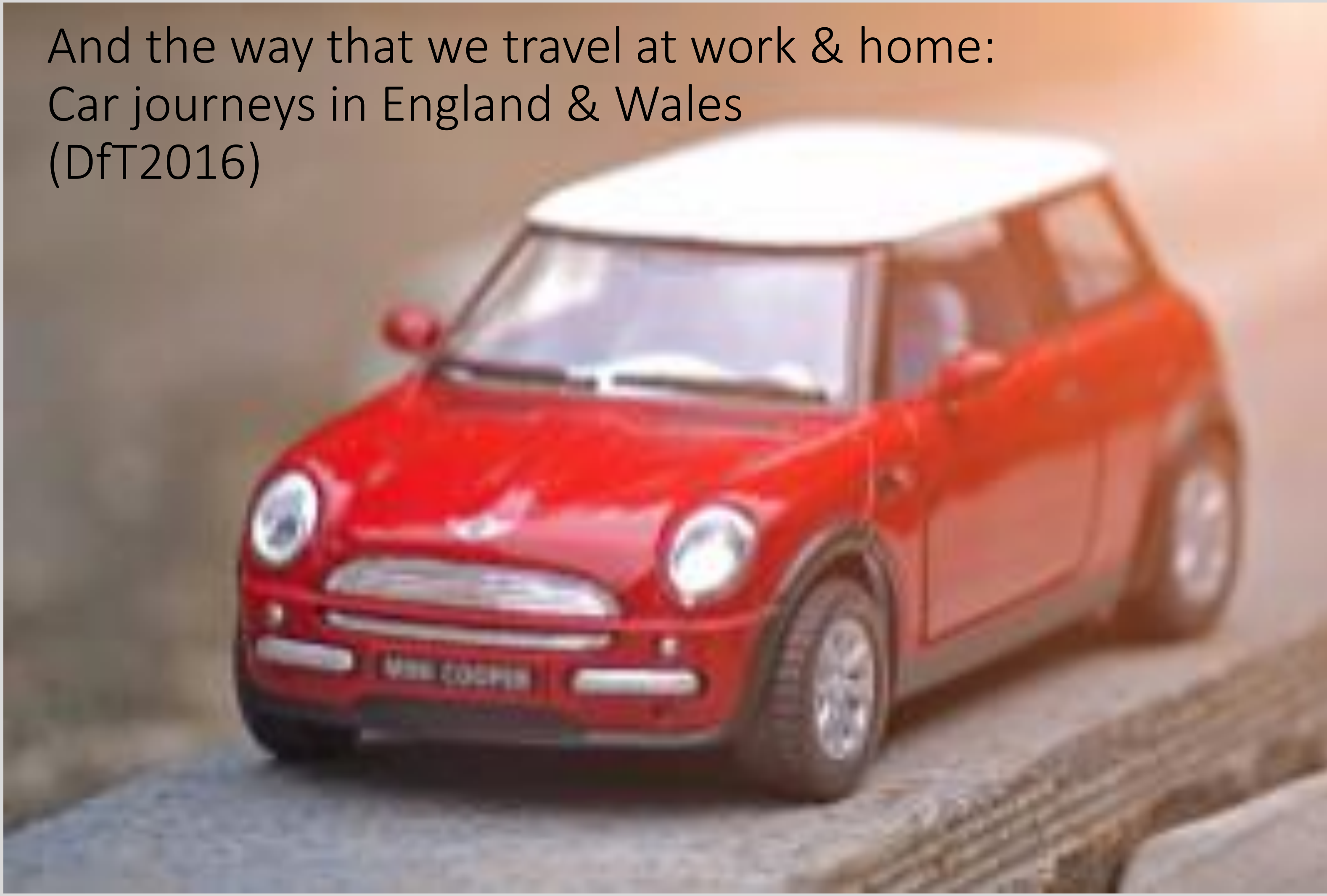
Clean Air Programme

www.ukcleanair.org/



https://www.theguardian.com/cities/2018/nov/13/what-would-a-smog-free-city-look-like-air-pollution

And the way that we travel at work & home:
Car journeys in England & Wales
(DfT2016)



- 60 % are less than 5 miles
- 23 % are less than 2 miles

260,000 UK workers studied for five years

- Cyclists commuters were living longer….
- Walking commuters had less heart disease…

- Compared to car commuters

- Celis-Morales et al 2017

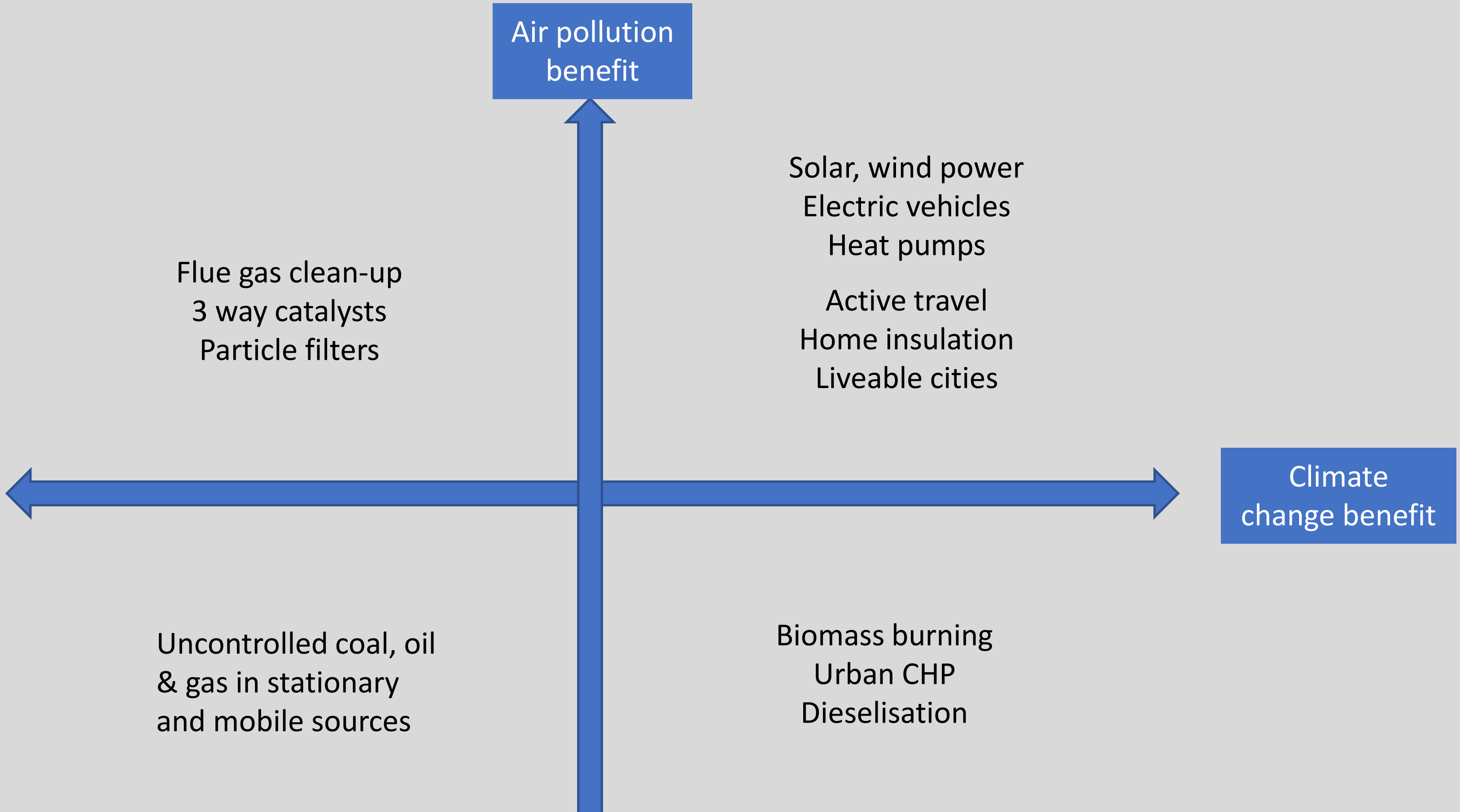
biobank uk

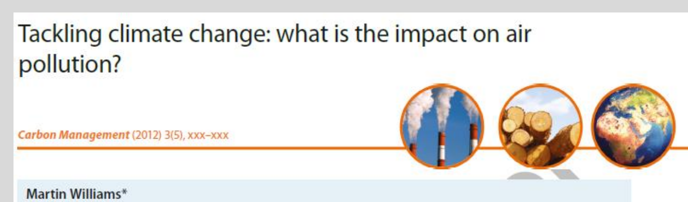
Improving the health of future generations

benefit to risk ratio = 70:1 !

Rojas-Rueda et al 2011 BCN photo labn Martinez, Santander bikes,

Tackling air quality and climate change together

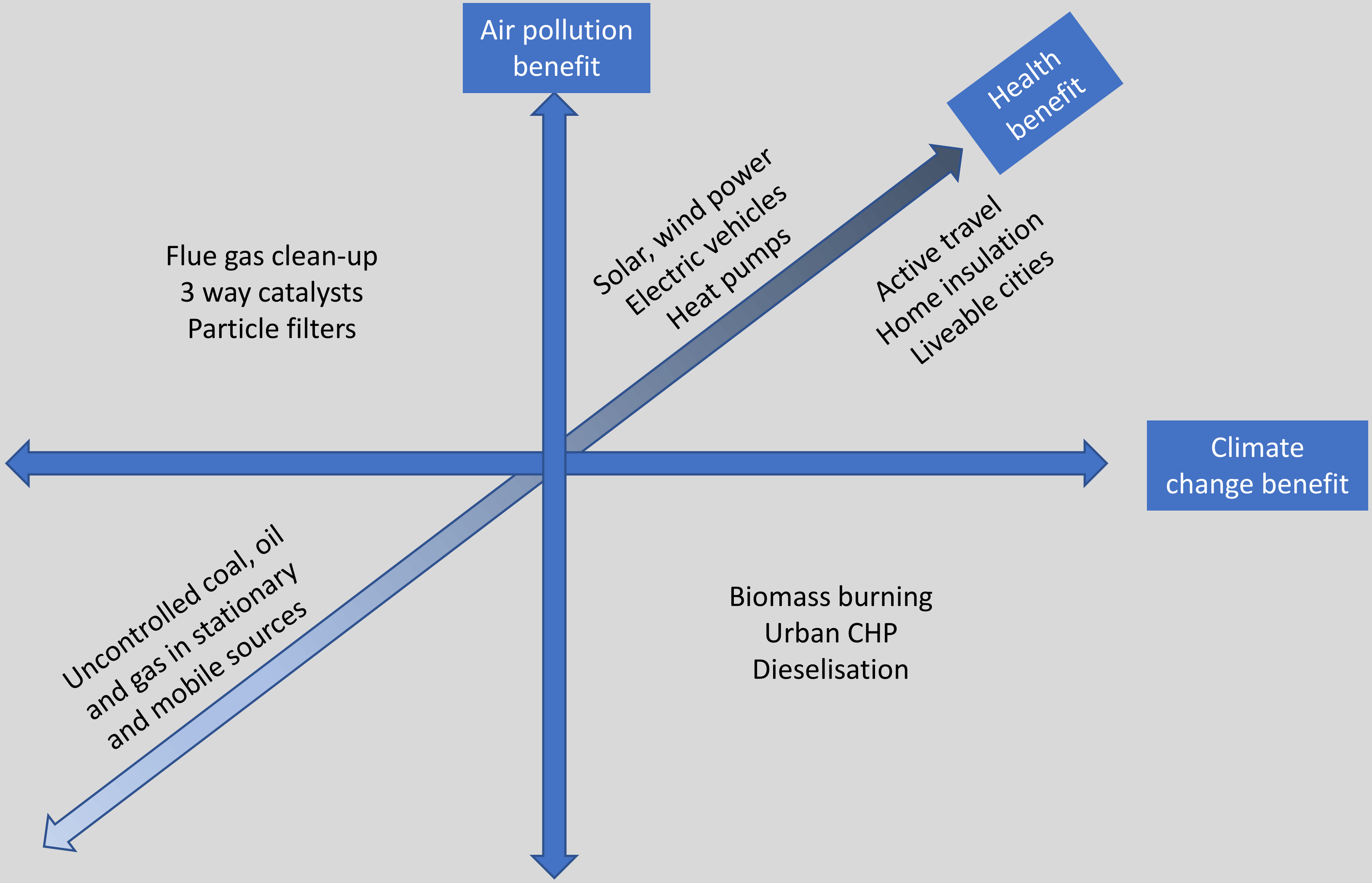



Tackling climate change: what is the impact on air pollution?

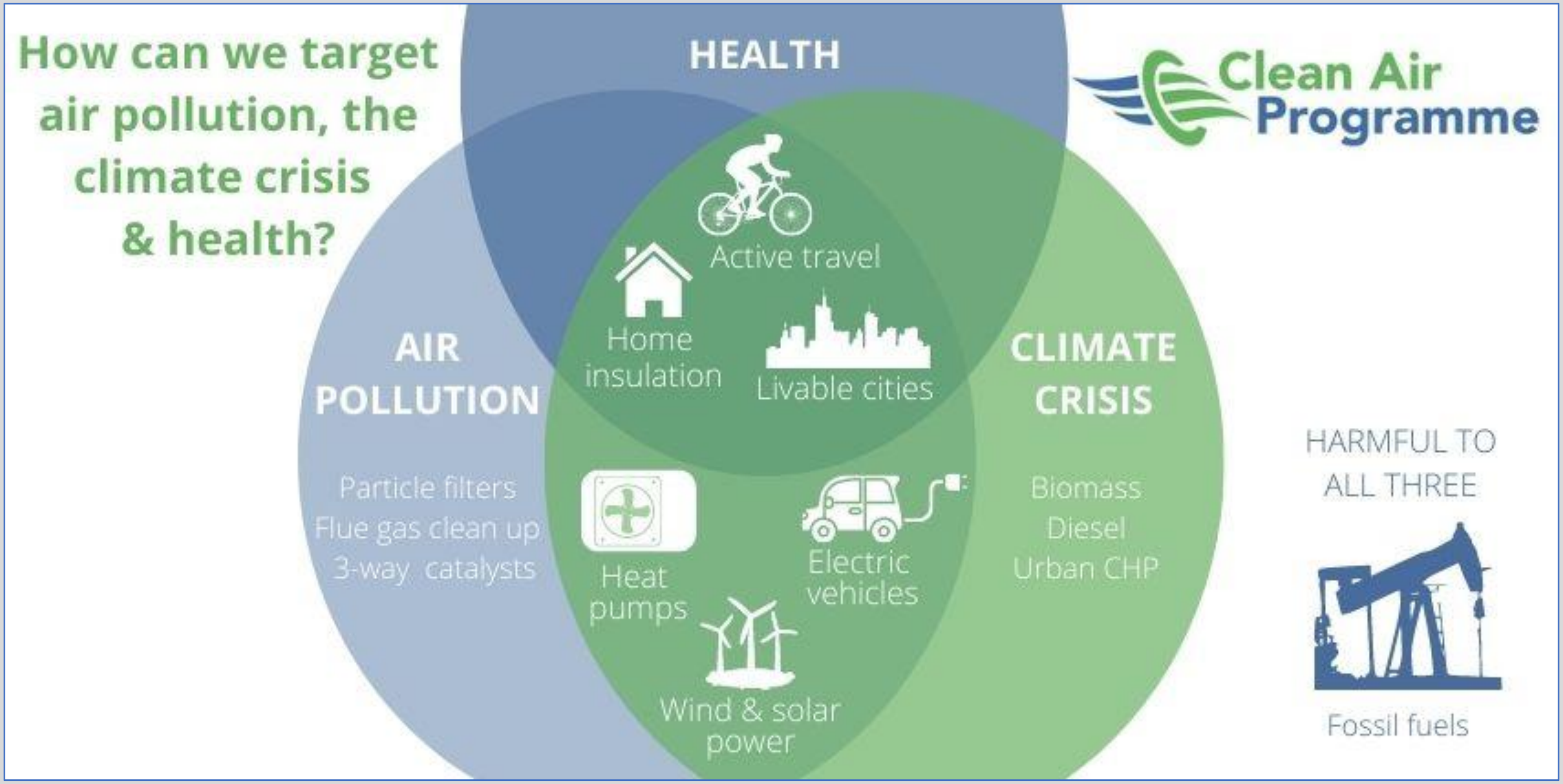
Carbon Management (2012) 3(5), xxx–xxx

Martin Williams*

Tackling air quality and climate change together



Tackling air quality and climate change together



With thanks to Alice Pengelly, University of Southampton

Future urban areas?