NewStatesman

Air pollution: the fight for clean cities

Innovative research, city planning and policy

Sadiq Khan / Jon Gibbins / Paul Linden / D K Arvind

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The biggest public health crisis for a generation

The Mayor of London Sadiq Khan explains how he is planning to clean up London's polluted streets, and what he needs from central government to achieve his vision

In 1952, the Great Smog fell over London, killing an estimated 12,000 people. Toxic air caused by the use of coal in homes and power stations, such as Battersea, was a real and deadly problem.

While the government of the day initially failed to grasp the severity of the issue, it did eventually take bold action to introduce the Clean Air Act, which set a legal framework backed up by a package of effective measures to protect the environment and clean up London's filthy air. For the following decades, the Clear Air Act did its job and kept the city's air relatively clean.

Fast forward 65 years and London is facing a repeat of the toxic air challenge of the early 1950s. But this time, instead of coal, the cause is predominately diesel. Every year, thousands of people are dying prematurely because of London's polluted air, which has also been linked to strokes, heart attacks, asthma and dementia.

But it's children who are bearing the brunt of this air quality crisis. Some of London's worst pollution hotspots are around schools – with more than 400 in the capital located in areas exceeding legal levels – and research shows that many children could be stuck with smaller lungs and negative health effects for life. Sadly, it has been estimated that a child born and raised in London in 2010 could lose around two years from their life expectancy as a direct result of air pollution.

This strikes at the very heart of the kind of city we want to be. Put simply, air pollution has become the biggest public health crisis for a generation, hitting many of the most vulnerable and disadvantaged people in our society the hardest. It's clearly time for action.

As Mayor, I feel I have a responsibility to act. That's why I am doubling funding to improve London's air quality and delivering the boldest and most ambitious plan to tackle air pollution anywhere in the world.

This includes reducing exposure to air pollution around schools, cleaning up London's bus and taxi fleet and introducing a Toxicity Charge on the oldest polluting vehicles coming into central London. The new T-Charge is the toughest vehicle emission standard of any major city and is a crucial step towards implementing the Ultra Low Emission Zone with even tougher standards.

I am doing everything in my power to tackle air pollution in London, but this is a national crisis and the government also needs to step up. Just as in the 1950s, we need to see a government that is willing to take bold action to help save lives. This means introducing a new Clean Air Act fit for the challenges of the 21st century, devolving to Mayors, cities and regions the powers we need to get on with tackling emissions from the river and construction sites, and fully funding a national diesel scrappage fund to help those who bought diesel cars in good faith.

There is a huge opportunity for the government to work in partnership to position London and the rest of the UK at the forefront of a zero-emission revolution. We must also work together to redesign our streets and encourage more people to walk, cycle and use public transport.

We are delivering big changes in London, but I can't solve this crisis with one arm tied behind my back. It's time for the government to take responsibility and to join me in rising to meet the scale of the challenge. This is the only way we can ensure we preserve the health of our children and improve the quality of life for millions of people in London and across the country.

To find out more about the Mayor's plans to improve air quality visit: www.london.gov.uk

Cutting emissions requires foresight

Professor Jon Gibbins, director of the UK Carbon Capture and Storage Research Centre, explains why reducing emissions in cities needs to be part of a much broader environmental plan, and the role carbon capture can play

Efforts to achieve low levels of local pollution from energy use in cities must be placed firmly in the context of the wider target to achieve net zero greenhouse gas emissions.

The Paris agreement states that to hold the increase in temperatures below 2°C, "parties aim to reach global peaking of greenhouse gas emissions … and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases".

To reach net zero greenhouse gas (GHG) emissions in time to limit the GHG inventory in the atmosphere to levels that won't cement dangerous climate change, major changes in energy supplies, used mostly by city dwellers, are required. Firstly, there must be a change in mindset.

Much of the thinking and policy around energy has been shaped by the "oil crises" of the 1970s and 80s; having a limited supply of fossil fuels and a need to reduce demand and use of non-fossil energy to lower excessive market prices. The reality in a world with limited greenhouse gas emissions is rather different. There is an excess of fossil fuels available – that is why there is a climate problem – and once net zero is reached, fossil fuels can't be used in conventional ways, even frugally.

Net emissions must stop; either use carbon-free energy vectors (that transport or store energy) such as electricity, heat and hydrogen or, if carbon-based fuels are used, removal of CO^2 from the air has to be made with carbon capture and storage (CCS), or, with limited biomass supplies, direct air capture.

This is an ideal set of targets for reducing city air pollution. Electricity and heat produce no pollution and hydrogen, especially in fuel cells, very little. Biomass, which emits more CO^2 than most fuels, will need to be processed in larger facilities to give net negative emissions.

Hydrogen may appear the most novel component for zero-carbon city energy but, as town gas, it is actually one of the oldest. The Northern Gas Networks H21 Leeds City Gate project has recently shown how Leeds could successfully switch over to hydrogen in stages, aided by the gas-tight new yellow plastic pipes that have replaced older gas mains.

Hydrogen is very significant in the UK; the peak rate of energy for heating from natural gas is about five times the amount from electricity. For electric heating, much larger electricity connections would be required, and more power plants. Hydrogen can be manufactured relatively cheaply from natural gas, with CCS to reduce emissions, and stored between summer and winter to even out demand.

Once hydrogen is available in cities, supplying hydrogen filling stations is much easier for transport that should look a lot like electric vehicles, but with smaller batteries and range-extender fuel cells.

When will it happen? Hydrogen infrastructure won't happen overnight; a rollout in the first half of the next decade is more likely. Hydrogen filling stations could happen relatively quickly if supplied by locally-produced hydrogen, from natural gas. Vehicles won't have zero associated emissions immediately, but infrastructure will be established and associated CO^2 emissions will be cut as the electricity supply is decarbonised and hydrogen supply networks, also using CCS, are rolled out. Crucially, biomass use without CCS needs to be recognised as an unacceptable emission of CO^2.

Achieving net zero greenhouse gas emissions requires a long-term focus on making 100 per cent use of carbon-free energy in cities a reality, rather than partial reductions in CO^2. This will lead to a progressive reduction in local pollutants.

The UK Carbon Capture and Storage Research Centre (UKCCSRC) is supported by the Engineering and Physical Sciences Research Council (EPSRC), as part of the Research Council's UK Energy Programme

Scientists are using aircraft to measure the levels of pollutants emitted by London in real time

Chasing the London plume

James Lee, principle investigator on EMERGE, describes the London plume as "a large quantity of air pollutants emitted from London from its traffic, buildings and industry. These pollutants are often blown out over the North Sea on prevailing westerly winds." EMERGE is a NERC (Natural Environment Research Council) project that aims to measure the amount of pollutants coming out of London, with regular flights over a number of weeks. The aircraft measures the air coming into the city, before flying down to the coast to measure the air coming out of it, air that will then travel over the sea and into Europe. "In very simple terms, we take this [air coming out of London] and subtract it off this [air going into London] and we'll get what London has emitted." "Today you'll see the whole of the London plume," briefs Lee.

Much of the data around air pollution in London is based on modelling, but the data that will be collected from these flights is significant because it is measured "in the real world as millions of cars are driving around London" – no predictions or modelling at the initial measurement stage, but in real-time, in the air. "That helps to validate a proper scientific steer on what the actual emissions are." This is crucial in order to shed light on the full scale of pollutant levels in London, particularly of NOx (nitrogen oxides), which is principally produced by cars: "There are higher levels of NOx and particularly NO2 (nitrogen dioxide) than there should be." "These emissions inventories are what is used to drive government policy, so if they're not right you could potentially have false policies being developed based on a piece of evidence that isn't true."

Lee's research centre has instruments running at the BT Tower, measuring pollutant levels in the centre of London. He is concerned that the existing data and predictions are underestimating the scale of pollution. "Using the aircraft, we can make an estimate for how much NOx London is emitting as a whole. The idea would be to compare that to what the estimates say based on manufacturers' data from cars, which may not be as accurate as you want it to be … I published a paper a couple of years ago from the BT tower that suggested what was being emitted from central London was maybe 40 per cent higher than the estimates."

The aircraft is an early British Aerospace 146, which is used by FAAM (Facility for Airborne Atmospheric Measurements) as an airborne laboratory. As it was previously a commercial plane, it's big enough to accommodate multiple

instruments used by scientists to measure pollutants. The plane is filled with lots of small hosepipe-like tubes lining the walls, racks upon racks supporting monitors, and what look like gas cylinders bolted to the floor. "As [the plane] is flying along, the air is forced through. The different instruments sub-sample off the pipe … then it heads back out the other side." This flight has representatives from FAAM and the Met Office, as well as researchers from the National Centre for Atmospheric Science, and York, Manchester and Leeds universities, all with their own instruments, measuring various pollutants. We encounter some wet weather during the flight, and a growl of frustration is heard from a PhD student at the front of the aircraft; he is studying particulate pollution that is dissolved by rain, and his data has fallen off a cliff.

At the helm are two ex-RAF test pilots. "It's a perfect job to come to out of the military because a lot of my colleagues will go and fly in the airlines … they don't have the low flying, and it's also working with the scientists. We're trying to think with them to help them, and almost pre-empt where we see a problem with their plan," says pilot Steve James. They have to be flexible; although there is a planned flight path, it is rarely stuck to as the scientists hunt the best data.

At one point in the flight, to make sure the air at the surface of the water is the same as just beneath the cloud, the aircraft drops to 50 feet, before quickly climbing back up to a less hair-raising level. A cargo ship can measure in at 200ft, so it is clear why highly trained former RAF pilots are commissioned for these flights, "[there is a] very controlled, scientific approach to descending such a big airplane so close to the sea".

Lee and his team are measuring NOx. Pointing to his screen, he tracks a line on a graph which monitors the level of the pollutant. "That's when we were flying to the west of London (the line is near the bottom of the graph), and this is to the east (the line has risen sharply) and that is the difference. These peaks are the actual London plume, we think."

Prior to leading this project, Lee was working in Beijing, "where they're making massive strides to improve their air pollution". He explains that, in China, much of the pollution is very visible and leads to the characteristic Chinese smog, which may have sped up efforts to cut it down. "I think the difference in Beijing is that their main pollution problem has been particulates, so you can see when it's polluted. You can't see NO2, so you're being polluted but it's not obvious that it's there." He is confident, however, that the situation in London will improve rapidly, with changes in technology and public perception. "You can see in 10 years' time London being almost a completely fossil-free vehicle zone … it will improve because it's out there – people know about it. It's very much in the public consciousness."

NewStatesman
71-73 Carter Lane
London EC4V 5EQ
Subscription inquiries:
sbrasher@newstatesman.co.uk
0800 731 8496

Commercial Director
Peter Coombs
+44 (0)20 3096 2268

Special Projects Editor
Will Dunn

Special Projects Writers
Rohan Banerjee
Augusta Riddy

Design and Production
Leon Parks

Cover illustration
Sam Falconer

Cover image
Shutterstock/Joker1991

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The air we breathe: reimagining ventilation in cities

MAGIC project principal investigator Professor Paul Linden and project coordinator Elaine Paterson write about their research into ventilating buildings naturally

By 2050, it is estimated that 70 per cent of the global population will be living in cities. The inevitable social, environmental, economic and political demands that will ensue from this increased population pressure present a challenge for urban planners and politicians seeking to develop sustainable cities. Local and national population pressures, combined with the need to hit global targets set out in the Paris climate agreement and UN Sustainable Development Goals (SDGs) ensure the pressure is on to explore ways to provide a comfortable future for urban dwellers.

Researchers from the Universities of Cambridge, Surrey and Imperial College London are currently working on a project that aims to combat air pollution and urban warming within cities. The aptly named MAGIC project seeks to "look outside the box" to explore ways in which we can naturally ventilate buildings. The modern trend is to build sealed buildings and maintain internal comfort using mechanical heating and cooling which are carbon intensive and contribute to urban warming. Harnessing cost-free and emission-free natural ventilation to provide a high quality internal environment is the challenge MAGIC addresses.

The project aims to engage key industry players and politicians to understand and influence urban design. The project will consider not just the buildings, but will account for socio-environmental interactions inside and outside buildings, aiming to understand how cities can use blue (water courses) and green (park) spaces to filter pollutants, cool the environment and improve the general health of city dwellers. By considering these issues, it is intended that the output of the venture will be as user friendly, realistic and implementable as possible.

The principal aim of the project is to create an integrated suite of computer models and associated management and decision support tools that will help urban planners to reduce the need for reliance on existing ventilation systems.

Data is now being collected from a test site in Elephant and Castle in London. Sensors capturing information on temperature, humidity and pollution levels have been placed inside, and within a 200 meter radius of, a naturally ventilated room belonging to London South Bank University. The team are also capturing meteorological data and monitoring the internal space for window and blinds usage and occupancy levels. By analysing the data captured at the test site, the team anticipate they'll be able to begin to comprehend the complicated fluid dynamics of air flow around the site and the exchange between the interior and exterior of the building.

This field work is complemented by state-of-the-art air computational models and laboratory and wind-tunnel experiments, which seek to better understand the movement of air in and around the test environment. The second phase of the MAGIC project will develop these initial experiments and apply them to more complicated test environments.

If MAGIC is going to be a success, it relies on impetus for change. How we approach the design of urban areas must be reconsidered if we are to meet the targets laid out by Sustainable Development Goals and the Paris climate agreement. MAGIC will not succeed without help and the team encourages contributions from researchers, wider industry and politicians to ensure policy change for a sustainable future.

MAGIC is funded by the Engineering and Physical Sciences Research Council (EPSRC). More information can be found at www.magic-air.uk

Monitoring at the individual level

Professor D K Arvind of the University of Edinburgh looks at new technologies for collecting local data on air pollution in cities and empowering citizens to use that data to mitigate its effects on their health

The Lancet Commission on Pollution and Health painted a dystopian picture last month when it published its findings. In pollution, the world is facing a profound and pervasive threat to our health and wellbeing. The update to the Global Burden of Disease exercise estimates that air pollution killed 6.4m people worldwide in 2015, with 40,000 deaths in the UK alone – among the worst in western Europe. These numbers are based on mounting clinical evidence linking air pollution with lung cancer, stroke, heart disease, asthma, emphysema and chronic bronchitis. This has grave economic implications for healthcare provision, productivity losses and environmental degradation.

Over 90 per cent of deaths from air pollution occur in rapidly industrialising low and middle-income countries, in which smoke belches from factories, smelting works and old vehicles. The UK Natural Environmental Research Council and the Medical Research Council are both funding projects as part of the Air Pollution and Human Health programmes in two of the most polluted cities – Beijing and Delhi – to investigate the measurement, modelling and management of urban air pollution.

One such project, called DAPHNE (Delhi Air Pollution: Health and Effects) probes the association between air pollution exposure during pregnancy and the health of the child in the early years, and its role in exacerbating the condition of asthmatic adolescents.

New air pollution monitors have been developed at the University of Edinburgh that are small and lightweight. They can be worn as belts and provide accurate exposure measurements to a mobile phone. Other low-cost monitors attached to street furniture such as lamp posts provide air quality information with a finer spatial resolution than hitherto possible. Accurate local data can also be used to advise people in a way that is personalised for their condition, such as an app on their mobile phone which recommends a cleaner route into town.

The silver lining in the dark pollution cloud is that the problem is solvable. Air pollution can be reduced, and its effects reversed substantially.

Communicating information such as personalised tolerable doses, which balances risks with uncertainties, is a challenge that the scientific community can overcome. But there is a major task ahead to raise awareness amongst the public of the insidious health effects of air pollution, and a need for a national campaign in the mould of recycling promotion or the public smoking ban.

The long-term solution, however, is to reduce pollution at the source, with new legislation that sets safe limits informed by scientific research, and fiscal incentives for companies to innovate new technologies could help meet them. A dense network of low-cost data collection points to measure pollution concentrations at local, city-wide and national levels is essential to monitor the effectiveness of the proposed mitigation measures and control strategies. Once proven in the home market, the UK will be in pole position to export clean air technology and consultancy to the rest of the world. Ultimately, air pollution costs lives and affects the disadvantaged and the least able in society disproportionately. The Great London Smog forced Parliament to pass the 1956 Clean Air Act, which improved the quality of life for children and the elderly significantly. The Lancet Commission report is a similar clarion call to UK civil society, decision makers, and the scientific community to act decisively to avert a major public health crisis.

Professor D K Arvind is director of the Centre for Speckled Computing and principal investigator of the DAPHNE research project investigating the health effects of air pollution in the early years

BY THE NUMBERS

The big smoke

An average of **29,000** premature deaths are caused by air pollution in the UK every year. The UK has the second-highest number of annual deaths in Europe caused by a major pollutant

Carbon monoxide levels can be up to **four times** lower in side streets that run parallel to main roads

On the sheltered side of a street, carbon monoxide levels can be up to **three times** higher than on the windward side

London breached its annual air pollution limits just **five days** into 2017. Marylebone Road has the highest levels of nitrogen dioxide in Europe

The cost of air pollution in the UK, including to business and health services, adds up to more than **£20bn** a year

In 2030 caps for five air pollutants will be instated by the European Parliament, new limits which are expected to cut the number of deaths caused by air pollution by **50 per cent**

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