PART OF ADEPT LIVELABS

SIMULATE LIVE LAB

Air Quality Challenges

Staffordshire County Council

amey

CATAPULT Connected Places

Keele University

Setting the scene

Air pollution is the top environmental risk to human health in the UK, and the fourth greatest threat to public health after cancer, heart disease and obesity. It makes us more susceptible to respiratory infections and other illnesses, and it is estimated that the current cost of poor air quality is between £22.7 Billion and £71.1 Billion [(1)]. Poor air quality is also linked with a host of other societal factors from reducing worker productivity [(2)] to lowering crop yields [(3)].

The relationship between our own health and prosperity and that of our natural environment has never been more pronounced than it is today. The air pollution that we generate, not only impacts our built society, but permanently changes the natural ecosystem we live in.

Air pollution can be defined as the presence of toxic chemicals or compounds in the air, at levels that have harmful or poisonous effects on the health of people, wildlife and the environment.

The air quality issues that we face in urban dwellings today are inextricably linked to the sharp rise in motor vehicle use that started in the 1980s and has shown few signs of slowing down. Motor vehicles are the most significant causal factor in urban air pollution, although industrial activities such as fuel refinery, electricity generation manufacturing and farming also contribute significantly at a macro level and often locally as well.

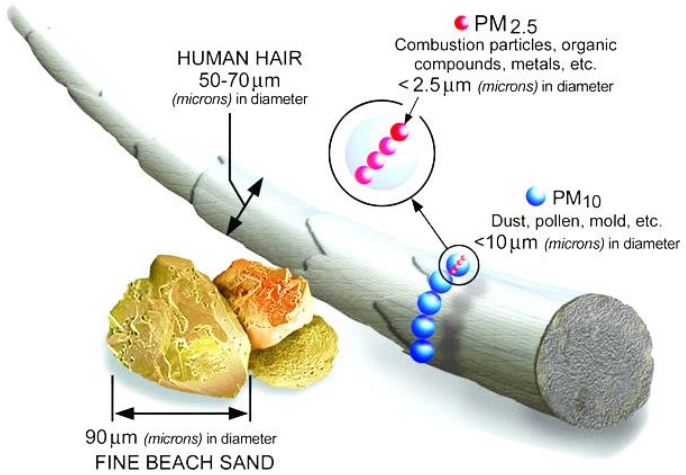
Whilst the issue of poor air quality can appear simple, the matter of correction and abatement is complex and requires us to think radically about how we deliver planning, policy, cultural shift and innovative technological change.

Success in tackling air pollution brings with it the opportunity to benefit mental and physical health, environmental factors, productivity and general quality of life. But we must value our innovation and investment around these outcomes if we are to deliver real change.

As providers of *place*, in local government our greatest challenge is how we implement digital transformation that delivers better services, while realising a sustainable value-chain and a truly circular economy.

What do we mean by poor air quality?

In urban areas, poor air quality primarily refers to raised levels of **Nitrogen Dioxide (NO_2)** and **Fine Particulates (PM).** However, Ozone (O_3), Sulphur Dioxide (SO_2) and Ammonia are also significant factors in reduced air quality at a macro level.



Nitrogen Dioxide (NO_2)

(NO_2) is a brown gas that is released when fossil fuels are burned. Prolonged exposure to NO_2 has been linked with inflammation in the lungs in the short term and reduced lung function in the longer term. NO_2 is especially harmful for people with pre-existing respiratory conditions such as asthma, while increased levels have also been shown to negatively impact vegetation and wildlife [(3)].

NO2 is measured in micrograms per cubic metre of air (µg m-3). 1 µg m-3 means that one cubic metre of air contains one microgram of pollutant [(4)].

Two air quality objectives exist in the UK to combat NO_2: the first is an hourly objective, referring to the concentration of NO_2 in the air averaged over one hour. This measurement focuses on the short-term implications of NO_2 exposure. The second objective is 'annual NO_2 concentration', whereby NO_2 is measured over a period of one year and is focused around the macro effects and longer-term impact of NO_2.

Fine Particulates (PM)

Particulate matter (PM) refers to small pieces of solids or liquids that are suspended in the air. PM is a much more complex group of pollutants than NO_2 for example. PM varies in shape, size and composition. Primarily, the PM that is of greatest concern comes from motor vehicles, including carbon emission and small bits of metal and rubber exuded through the normal running of a vehicle, such as braking and engine rotation.

Large particulates tend to be successfully filtered by our noses and throats. However, particles smaller than 10 micrometres (PM10) and even smaller particles (PM2.5) can enter our airway and lungs, causing significant health problems. PM10-2.5 has been linked with a range of health risks, with recent evidence showing PM10.2.5 as a significant causal factor in increased cardiovascular and cardiac mortality rates, especially among the elderly [5].

Measurements of the concentration of particulate matter in air tend to be made by recording the mass of particulate matter in one cubic metre of air, using the unit; micrograms per cubic metre, µg m–3.

Two air quality objectives exist in the UK to combat PM10-2.5: a 24-hour objective, referring to the concentration of PM in the air averaged over 24-hours. This measurement focuses on the short-term implications of PM exposure. The second objective is 'annual PM concentration' whereby PM is measured over a period of one year with this focusing around the macro and longer-term impacts of PM.

Key drivers of poor air quality in urban areas

Historically, the main air pollution problem in both developed and rapidly industrialising countries has typically been high levels of smoke and sulphur dioxide emitted following the combustion of sulphur-containing fossil fuels such as coal. However, these days, the major threat to clean air is now posed by traffic emissions, and this is exacerbated in urban areas by high levels of traffic congestion. Petrol and diesel-engine motor vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NO_x), volatile organic compounds (VOCs) and particulate matter (PM). In addition, pollutants from these sources may not only prove a problem in the immediate vicinity of these sources but can be transported long distances through wind and terrain.

Photochemical reactions resulting from the action of sunlight on nitrogen dioxide (NO_2) and VOCs, typically emitted from road vehicles, lead to the formation of ozone (O_3). Ozone, a key component of 'smog' often impacts rural areas far from the original emission site as a result of long-range transport. Furthermore, Ozone oxidises the NO produced from vehicles to create further NO_2.

While motor vehicles are undoubtedly the primary source of air pollution at a local level in Staffordshire, industrial processes and road-side machinery also pose a significant risk in some scenarios.

Air quality gaining recognition in policy and regulation

In 2019 the UK government released their *Clean Air Strategy* [6], focused on providing an integrated and strategic plan on delivering air quality objectives. One of the key drivers that *Clean Air Strategy* outlines, is the need to rapidly integrate proven new technology into society at scale.

The government also released a 25-year Environmental plan with poor air quality as its key focus. 265/408 or (65%) of District, County, Unitary & Metropolitan Councils have declared a 'Climate Emergency' to date, alongside 8 Combined Authorities/City Regions [7].

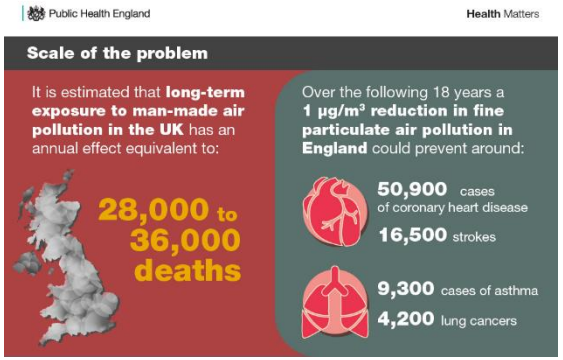
There is undoubtedly a welcome political awakening to the scale of the problem that pollution poses, however, the fact remains that the systematic proving of technology and techniques in delivering solutions is critical barrier in delivering the *Clean Air Strategy*. SIMULATE, as part of the ADEPT Live-Lab programme represents a key step for Staffordshire and other local authorities in engaging this problem head on.

Impacts of urban air quality

Health

Air pollution has a significant effect on public health, and poor air quality is the largest environmental risk to public health in the UK. In 2010 the Environment Audit Committee considered that the cost of health impacts of air pollution was likely to exceed estimates of £8 to £20 billion. Epidemiological studies have shown that long-term exposure to air pollution (over years or lifetimes) reduces life expectancy, mainly due to cardiovascular and respiratory diseases and lung cancer [8].

Short-term exposure (over hours or days) to elevated levels of air pollution can also cause a range of health impacts, including effects on lung function, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions and mortality [9].



Productivity and Economic Growth

Evidence suggests that improvements in air quality lead to improvements in worker productivity across a range of sectors, including agriculture, manufacturing [10], the service sectors [11] and even professional sport [12]. Interestingly, many of these effects also arise at levels of air quality that are below pollution thresholds in countries with the highest levels of environmental regulation.

Wild-life and Agriculture

Pollutants produced in urban environments can has catastrophic impacts on surrounding crops and vegetation. One study found that nearby air pollution cut crop yields in half [13]. The most likely causal factor here is the increase in ground-level Ozone (O_3) which is a by-product of NO_x production from motor vehicles. When exposed to sun-light, NO_x reacts with other VOCs in the environment to produce O_3. This is highly variable based on time of day and season, however, high levels of O_3 can travel significant distances due to wind and terrain.

Obstacles for change

To deliver widespread strategic change there are several critical challenges that lie in the way:

Culture

Resistance to change and continued reliance on private car ownership, fossil fuels and methods in agriculture, have contributed heavily towards the air quality crisis we face today. Whilst we have seen a shift towards renewable sources in the

energy sector, fossil fuels remain a staple in today's market.

Privately-owned vehicles also have a huge impact on both issues and the UK car market has remained strong, with electric cars only accounting for 1.6% of sales in the automotive market in the UK [(14)]. In the UK we exhibit a deep and emotive relationship with petrol-fuelled vehicles. Unlike our European counterparts, the UK also has a general antipathy towards shared methods of transport, such as bike share or ride share presenting a further behavioural challenge for new providers.

Policy and Regulation

The UK will miss its new goal to cut carbon emission to "net zero" by 2050 unless it takes "urgent" action to change **consumer behaviour**, such as regulation to make green sources of energy cheaper and a tax on frequent flyers, according to the first assessment of the target for the government's environmental advisory body. The report, commissioned by the UK's influential Committee on Climate Change, warned little had been done to tackle household consumption, which accounts for nearly three-quarters of global greenhouse gases. It pointed out that the 40 per cent reduction in emissions by the UK since 1990 was largely as a result of the decarbonisation of the electricity supply [(15)].

A lack of forward-thinking policy is a significant hindrance to new sustainable transport modes, with policy now playing catch up to new and exciting methods of active and eco-friendly travel.

New forms of regulation are also essential for ensuring clean growth is fully integrated into new infrastructure developments from both private and public perspective. Clean energy and sustainable travel modes must be built into the fabric of new developments.

Defining return on investment in air quality Solutions

In order to attract the appropriate investment required for radical clean growth at a local level, we must re-think the way in which we value investments in infrastructure. The current 'blind-spot' between capital investment and social, health and environmental outcomes is a critical blocker in delivering sustainable growth. We must become better at realising and demonstrating value in sustainable outcomes to ultimately drive new models of contracting and investment in this sector.

Programme

SIMULATE is looking to select 10-12 partners within the SME sector through a challenge-based selection process. Successful entrants will be provided with a bespoke 6-month incubation cycle, while having the opportunity to secure funding from the programme through submission of a costed pilot in the first 2-months of the programme. Three Air Quality Management Areas (AQMAs) have been pre-deployed with a pervasive sensor network, in preparation for the deployment of solutions, while full analysis and support will be provided as part of the programme. Further detail about what to expect on the programme can be found here.

What we are looking for

SIMULATE is on the lookout for highly innovative and game-changing companies, currently operating around the TRL-5 level. However, this should be considered a 'target' rather than 'rule'. Solutions should be submitted in response to one or more of the three AQMAs identified in the document. Each location represents a different topographical area, necessitating different perspectives and approaches to deliver solutions.

Providers will be selected based on several key criteria, information for which can be found here Following closure of the challenge process, a shortlist of participants will be invited to a 'Dragons' Den' style event to present their solution to a panel of experts picked from partner organisations within the programme.

End-to-end solutions and 'bit-part' players

The vision for the programme is to develop a holistic and dynamic supply chain that can deliver solutions in a variety of ways and locations. Therefore, SIMULATE is a programme open to providers who operate across the value chain, both in terms of scale and variety.

Piloting within SIMULATE

Prospective entrants into the programme will be expected to build towards a demo day, which will remain flexible based on the requirements of the solution, with start-dates for trials and pilots no later than November 2020. During selection, a high emphasis will be placed on the evaluation of a provider's capability to deliver a trial within the period defined.

As part of the submission form, providers will be asked to submit high-level costs for a pilot within the programme, alongside the amount (up to £120k) they intend to bid for within the programme. Successful entrants will be supported in developing their pilot proposals into detailed designs within the first 2-months of the programme, with the opportunity to secure the funding amount identified in their initial submission. Funding is not guaranteed as part of entry into the programme and is dependent on the quality of entrant detailed pilot proposal. All entrants will have the opportunity to secure the funding amount identified in their initial submission into the programme. Entrants will be expected to provide evidence of match funding in their pilot proposals, which can be demonstrated through a variety of means.

There will also be the opportunity for the funding that participants secure through SIMULATE being used as match for other innovation programmes within the UK - participants should provide details of any proposed strategy in their submission form.

Where will trials take place?

The trials will take place in three different Air Quality Management Areas (AQMA's) in Staffordshire. Each location has a pre-deployed pervasive sensor network to collect baseline data and track solution impact. Solutions can be deployed for up to 12-months.

The Challenge

Note: the icons on each diagram relate to the position of the air quality monitoring sensors in each location. These will be in place for the duration of the programme and will monitor the air quality throughout. Successful SMEs will be given access to this data.

The challenge is to improve air quality in the specific locations by significant and impactful levels. This could be achieved through the removal of harmful pollutants from the air or reducing the amount of pollutants emitted from transport using the road network in the specific locations.

Specifically, removing / reducing particulates ($PM_{2.5}$ and PM_{10}), NO_x and NO_2. It would be desirable for the solution to also tackle SO_x and SO_2. We will accept and consider all proposals that cover any of the particles or gases mentioned, i.e. if the solution only tackles $PM_{2.5}$ then it will be considered, as its solution could work in conjunction with others.

The objective of this challenge is to explore how innovative solutions can be used to tackle these problems, such as;

- Air scrubbing or filtration technology.
- Encouraging behaviour change (for example, encouraging parents to not drive their children to School)
- Encouraging the use of public transport
- Promoting new environmentally friendly *Mobility* solutions (e-bikes, cycling etc.)
- Tackling congestion and enabling free flowing traffic through infrastructure schemes and network/traffic management (e.g. traffic signals)
- Any other solution not mentioned above which tackles poor air quality

Locations

The challenge locations have been selected as they are currently areas of poor air auality in Staffordshire and are part of the county's AQMA's. More information on AQMA's for each location from the various boroughs can be found here:

- East Staffordshire Borough Council: http://www.eaststaffsbc.gov.uk/environmental-health/pollution/air-quality
- StaffordshireMoorland Distict Council: https://www.staffsmoorlands.gov.uk/article/1096/Air-quality
- Newcastle- under-Lyme Borough Council: https://www.newcastle-staffs.gov.uk/all-services/environment/environmental-protection/air-quality-newcastle-under-lyme

Outcomes

- To identify solutions, demonstrated through trials, which improve air quality in the identified locations in Staffordshire.
- To understand the commercial model behind making these solutions sustainable.
- Where trials are successful, explore how, through working with Staffordshire County Council, these can be transitioned to fully commercial solutions which can be deployed as a service on the Highways network (both major and local roads).

Location 1: Schools

Burton on Trent

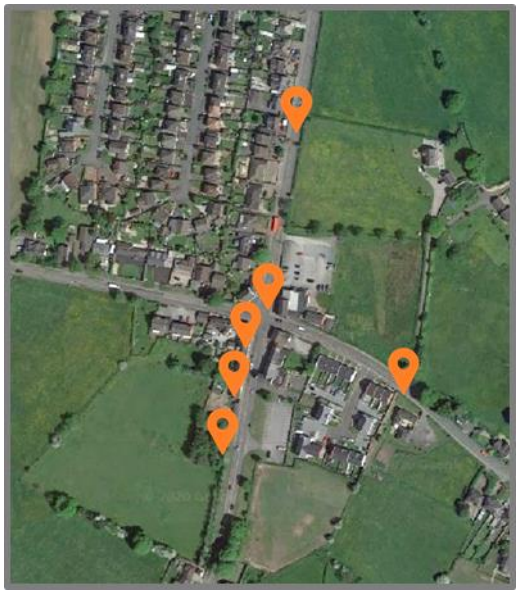
Location reference - 52°47'23.3"N 1°37'09.1"W

Part of Stanmore Road and Violet Way, Burton-on-Trent (Specifically around Violet Way Academy, Paulet High School & Sixth Form College and Edge Hill Junior School).

Location 2: Semi-Rural Cross Roads

Cellarhead

Location reference - 53.025523, -2.065372



Cellarhead crossroad, where the A52 and A520 meet.

Location 3: City centre ring road

Newcastle Under Lyme

Location reference - 53°00'43.4"N 2°13'50.3"W

Newcastle-under-Lyme Ring road centred on Lower Street between the roundabout for Knutton Lane and the roundabout for the A525. A specific focus should be on the Belong Care Home adjacent to Lower Street.

Air quality sensor network

Next steps

- The deadline for submissions is 27th March 2020
- Further information about the programme can be found here
- For submission forms click here
- If you have any questions about the programme please contact:

  info@simulate-adeptlivelabs.co.uk

References

1. University of Oxford and Bath (2018). *Clean Air Day*. 1. Oxford: The University of Oxford, p.5.

2. NUS News. (2017). NUS study finds that severe air pollution affects the productivity of workers. [online] Available at: https://news.nus.edu.sg/press-releases/air-pollution-affects-productivity [Accessed 3 Jan. 2020].

3. PNAS. (2014). *Recent climate and air pollution impacts on Indian agriculture*. [online] Available at: https://www.pnas.org/content/111/46/16319 [Accessed 3 Jan. 2020].

4. Uk-air.defra.gov.uk. (2004). [online] Available at: https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/nd-summary.pdf [Accessed 3 Jan. 2020].

5. Ec.europa.eu. (2014). Deadly effects of particulate matter pollution shown in French study. [online] Available at: https://ec.europa.eu/environment/integration/research/newsalert/pdf/French_study_reveals_deadly_effects_of_particulate_matter_pollution_397na4_en.pdf [Accessed 10 Jan. 2020].

6. Uk-air.defra.gov.uk. (2020). *Causes of air pollution - Defra, UK*. [online] Available at: https://uk-air.defra.gov.uk/air-pollution/causes [Accessed 25 Jan. 20203. Climateemergency.uk. (n.d.). *List of Councils who have declared a Climate Emergency | Declare a Climate Emergency*. [online] Available at https://www.climateemergency.uk/blog/list-of-councils/ [Accessed 28 Jan. 2020].

7. Assets.publishing.service.gov.uk. (2020). *Clean Air Strategy 2019*. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf [Accessed 12 Jan. 2020].

8. GOV.UK. (2020). *Health matters: air pollution*. [online] Available at: https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution [Accessed 12 Jan. 2020].

9. GOV.UK. (2020). *Health matters: air pollution*. [online] Available at: https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution [Accessed 2 Jan. 2020].

10. Zivin, J. and Neidell, M. (2011). The Impact of Pollution on Worker Productivity. [online] NBER. Available at: https://www.nber.org/papers/w17004 [Accessed 3 Feb. 2020].

11. Chang, T., Zivin, J., Gross, T. and Neidell, M. (2016). The Effect of Pollution on Worker Productivity: Evidence from Call-Center Workers in China. [online] NBER. Available at: https://www.nber.org/papers/w22328 [Accessed 3 Dec. 2019]..

12. Lichter, A., Pestel, N. and Sommer, E. (2017). Productivity effects of air pollution: Evidence from professional soccer. Labour Economics, 48, pp.54-66.

13. PNAS. (2014). Recent climate and air pollution impacts on Indian agriculture. [online] Available at: https://www.pnas.org/content/111/46/16319 [Accessed 3 Jan. 2020].

14. SMMT. (2020). *New UK EV and AFV Registrations - SMMT monthly data*. [online] Available at: https://www.smmt.co.uk/vehicle-data/evs-and-afvs-registrations/ [Accessed 2 Jan. 2020].

15. Ft.com. (2019). UK set to miss goal to cut carbon emissions to 'net zero' by 2050 | Financial Times. [online] Available at: https://www.ft.com/content/6fb7fce0-ec37-11e9-a240-3b065ef5fc55 [Accessed 15 Jan