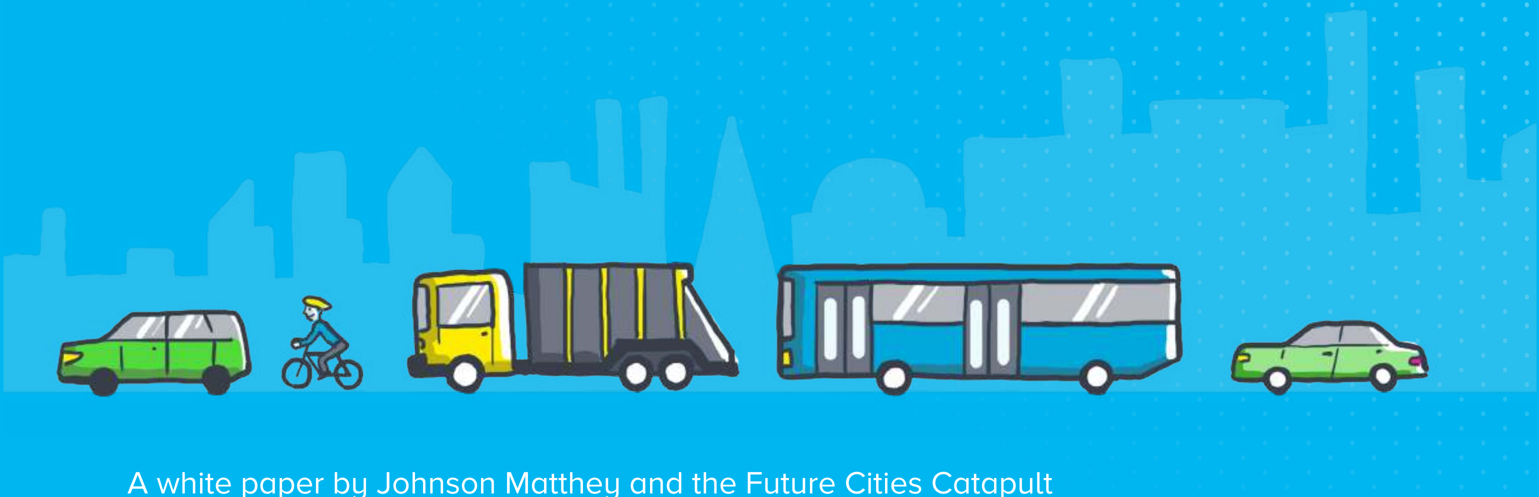
#CleanAirTech

Creating a clean air technology community:

Driving improved air quality through technology & collaboration



A white paper by Johnson Matthey and the Future Cities Catapult
September 2018

JM

CATAPULT Future Cities

FOREWORD

Johnson Matthey's vision is for a world that's cleaner and healthier, both today and for future generations. We have long recognised the issues that stem from air pollution and have been delivering science-led solutions to reduce emissions from industry and vehicles (through our catalytic converter technology) for nearly half a century.

Across the world, our technologies help prevent the emission of 40 tonnes of pollutants entering our air every minute of every day. Controlling regulated emissions at their source is an essential part of improving air quality, but opportunities exist beyond this to make the air we breathe even cleaner. And Johnson Matthey is playing its part by using science to develop new technologies such as battery cathode materials and fuel cell components, which will enable the journey towards pollution-free roads.

Poor air quality, whether outdoor or indoor, continues to blight peoples' lives and damage their health. Globally, air pollution is the second largest cause of premature deaths, and has resulted in $5 trillion being spent in welfare costs[1].

Alongside prevention and control, we also need mitigation. We must develop and implement air purification technologies to help improve the quality of the air around us while minimising the harmful effects of airborne pollution. At Johnson Matthey, we believe our science and technologies can help with the many challenges we face in this domain.

Beyond what is already being achieved through emission control, improving air quality remains a complex problem that we believe requires a creative, concerted effort from a multitude of different stakeholders to drive significant change. This is why we are excited to be collaborating with the Future Cities Catapult to convene and create an action-orientated #CleanAirTech community determined to tackle the air quality challenge.

We hope that this partnership establishes a solid foundation for an engaged ecosystem focused on finding solutions through science, technology, and collaboration to deliver a cleaner, healthier world for us all.

Alan Nelson, Chief Technology Officer
Johnson Matthey

1. World Bank, 2016. The cost of air pollution.

In an age of globalisation, rapid urbanisation, and demographic changes, cities are up against tough challenges, with poor air quality being one of the most critical. Toxic air claims millions of lives worldwide, lowers quality of life, and increases welfare costs for local and national governments.

Socio-economic shifts have made cities home to over half of the global population and drivers of economic growth. However, these advancements have also transformed urban areas into significant contributors to air pollution. There is now a widespread recognition that the cities must be at the forefront of the air pollution fight.

In the UK and worldwide, cities are already demonstrating leadership by taking measures to tackle air pollution and improve quality of life, but in a world of significant pressures on public spending, they need the right tools, capabilities, and partners. Air pollution is a complex urban challenge which requires coordinated effort from a wide range of stakeholders.

The #CleanAirTech community is an excellent example of how collaboration between academia, industry, and national and city leaders could foster a living ecosystem committed to providing solutions and driving long-term change. This community has the potential to create new transformational opportunities for the growth of UK firms while making cities a cleaner and healthier place for their citizens.

At the Future Cities Catapult, we are excited to be partnered with Johnson Matthey in their endeavour to tackle air pollution through innovation and technology, and we look forward to continuing our work with the community towards its goal of cleaner air for all.

Dr Jon Kirkpatrick, Chief Delivery Officer
Future Cities Catapult

About this White Paper

Commissioned by Johnson Matthey and authored by the Future Cities Catapult, this white paper looks at the issues of air quality and seeks to provide a high-level overview of the challenges and future actions that the #CleanAirTech community's current and future members intend to work on.

JM

CATAPULT Future Cities

1. The #CleanAirTech Community

1.1 Background

Outdoor and indoor air pollution remains an invisible but persistent cause of severe health issues while continuing to result in significant damage to our environment. Controlling emissions at their source is already delivering considerable improvements, though these results are simply not enough. Globally, 9 out of 10 people still breathe a mixture of toxic pollutants responsible for an estimated 8 million premature deaths and nearly $5 trillion in welfare costs—equivalent to 6% of global economic output.

In an attempt to address this, Johnson Matthey and the Future Cities Catapult have collaborated to lay a solid foundation for an engaged ecosystem driven to find solutions through technology and innovation. The #CleanAirTech community was launched with an Immersion Day held in July 2018, which was attended by over 50 participants from 36 organisations. Presentations, debates, and breakout sessions helped frame the challenges inherent in improving air quality and helped develop a shared vision for the future of the community. At the end of the event, the community members shared their findings and discussed future actions, acknowledging that collaboration will be vital for the ecosystem to move forward and achieve clean air for all.

1.2 Our aim

The #CleanAirTech community aspires to create a dedicated network of diverse stakeholders determined to tackle the air quality challenge through innovation and technology that delivers cleaner air. The community should not be seen as an advisory group, but rather as an action-orientated ecosystem. It will seek to create new opportunities for business growth in the outdoor and indoor air purification space and be recognised as a global thought leader in air quality improvement.

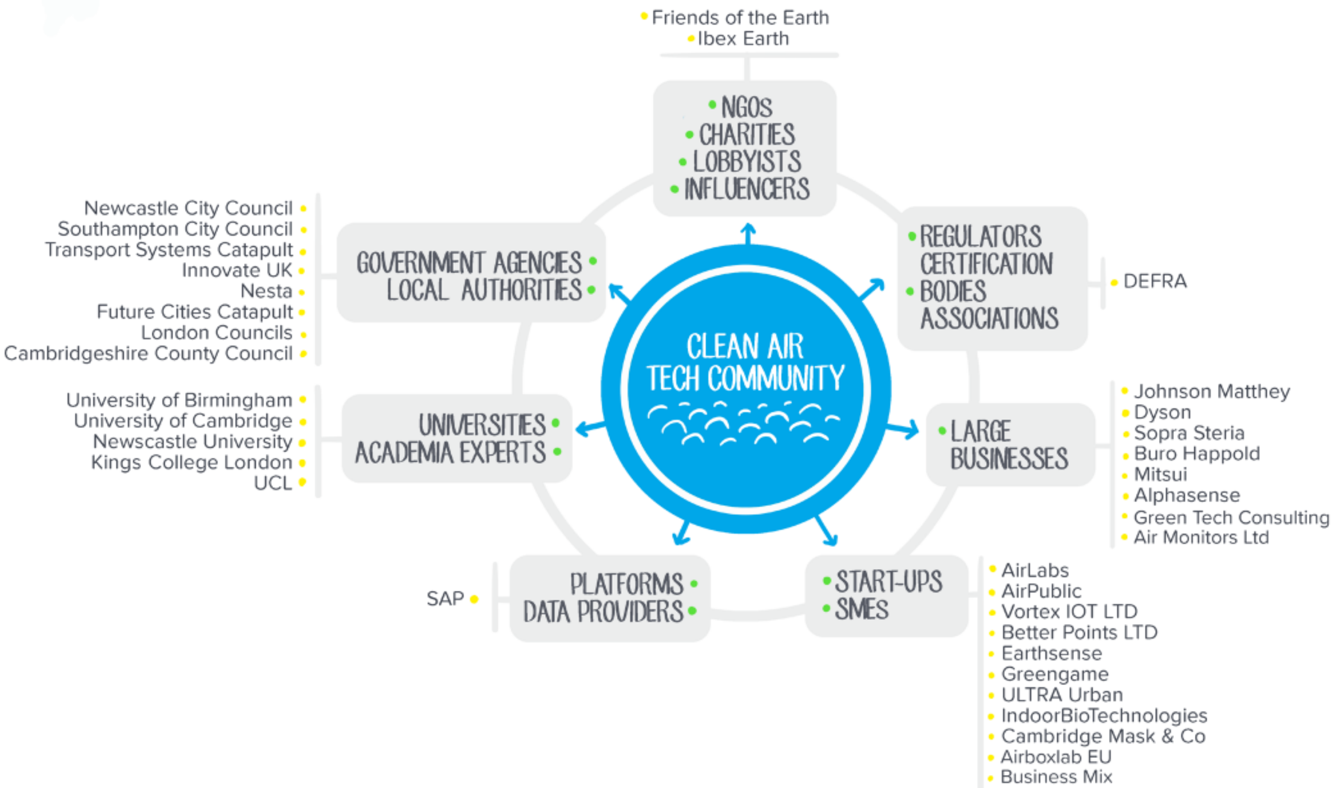
1.3 Members

Diversity is integral to generating ideas, sharing knowledge and encouraging innovation. Therefore, involving a wide and relevant range of stakeholders from the beginning was a crucial part of convening the #CleanAirTech community. We are proud to say that we have achieved this first objective.

As the chart below illustrates, over 50 participants were involved in the launch of the community coming from 30+ organisations and included academia, government agencies, and a number of SMEs and NGOs. As the #CleanAirTech community expands, it will ensure that diversity is central to its mission, creating an environment in which members can share information, search for evidence, and leverage investment to promote the uptake of clean air technology.

"A diversity of stakeholders, a diversity of views on how to tackle air pollution, as well as a diversity of solutions and innovations will help us define the challenges we need to address. It will help us to do something impactful together and... do it now!"

Olivier Le Roux – Johnson Matthey



2. The air quality challenge

We might think of pollution as a modern issue, but it could be argued that it is as old as humanity itself. The problem became noticeable during the Industrial Revolution when coal was used not only as a domestic fuel, but also for steam power and gas production, creating even more emissions. In 1952, London was affected by severe "smog" lasting five days and causing between 8,000 and 12,000 deaths[1].

The Clean Air Act of 1956 followed swiftly and was the first serious attempt to deal with air quality. Since then there have been considerable efforts to reduce emissions of harmful pollutants in the UK and worldwide.

References

1- Bell M. et al., 2004. A retrospective assessment of mortality from the London smog episode of 1952: the role of influenza and pollution.

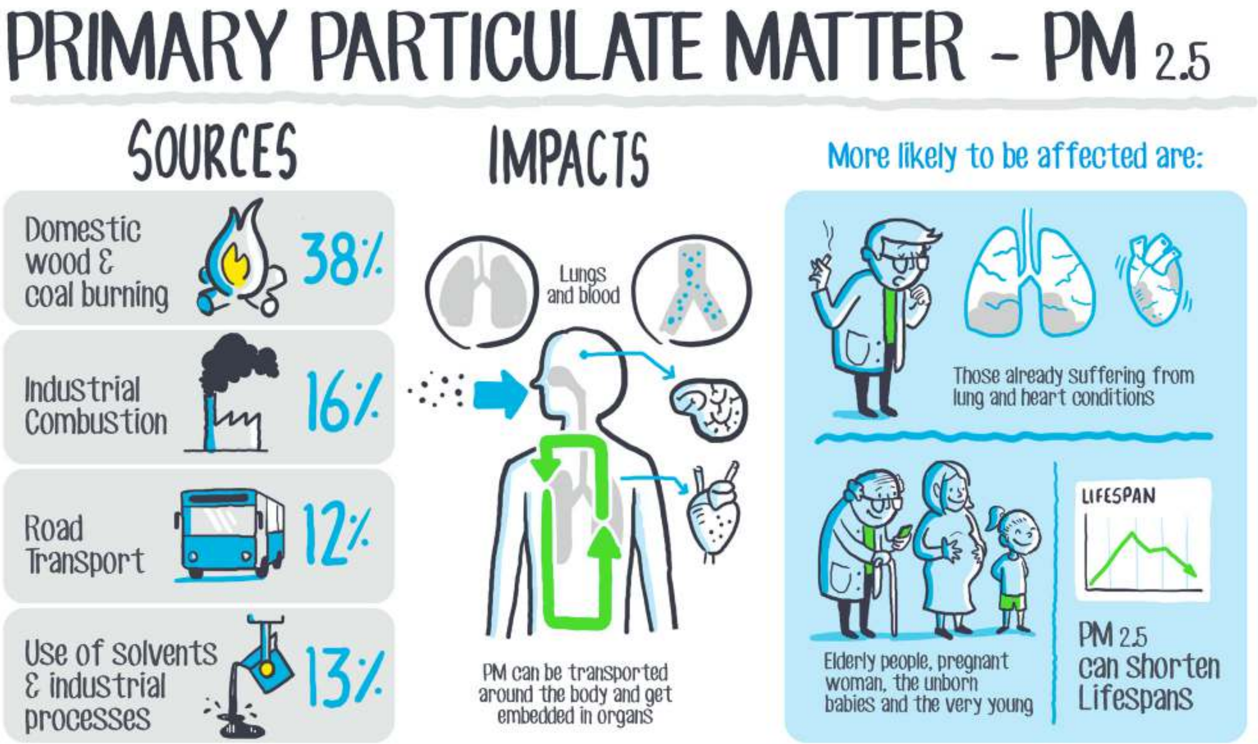
2.1 The impact of air pollution

However, air pollution remains a costly global challenge and one of the top health risks leading to premature death, second only to smoking. Over 90% of the global population lives in places where air quality guidelines are not met. Air pollution is responsible for an estimated 8 million[1,2] premature deaths worldwide. In Europe, the air pollutants cause 400,000 early deaths each year[3]. Frank Kelly, Professor of Environmental Health at King's College London and an opening speaker at the #CleanAirTech Immersion day, estimates that air pollution costs the UK 340,000 life years or 29,000 premature deaths.

The total global welfare cost of poor air quality amounts to 5 trillion dollars, including 225 billion dollars in labour costs[4]. By 2060, the world would have lost around 3.75 billion working days due to the negative impact of air pollution on employee wellbeing[5]. Moreover, a growing body of evidence suggests that vulnerable groups are at particular risk. Children, the elderly, people in low-income jobs, as well as schools and deprived communities are disproportionately exposed to air pollution and often lack the means to mitigate the effects, thereby amplifying the issue of health inequality.

Air pollutants come in many forms and are known to have adverse effects on both human and environmental health. Emissions can be natural—coming from the sea, the soil, and plants. Alternatively, they can be human-made—coming from various sources such as energy generation, transport, industrial processes, or even the use of household cleaning products.

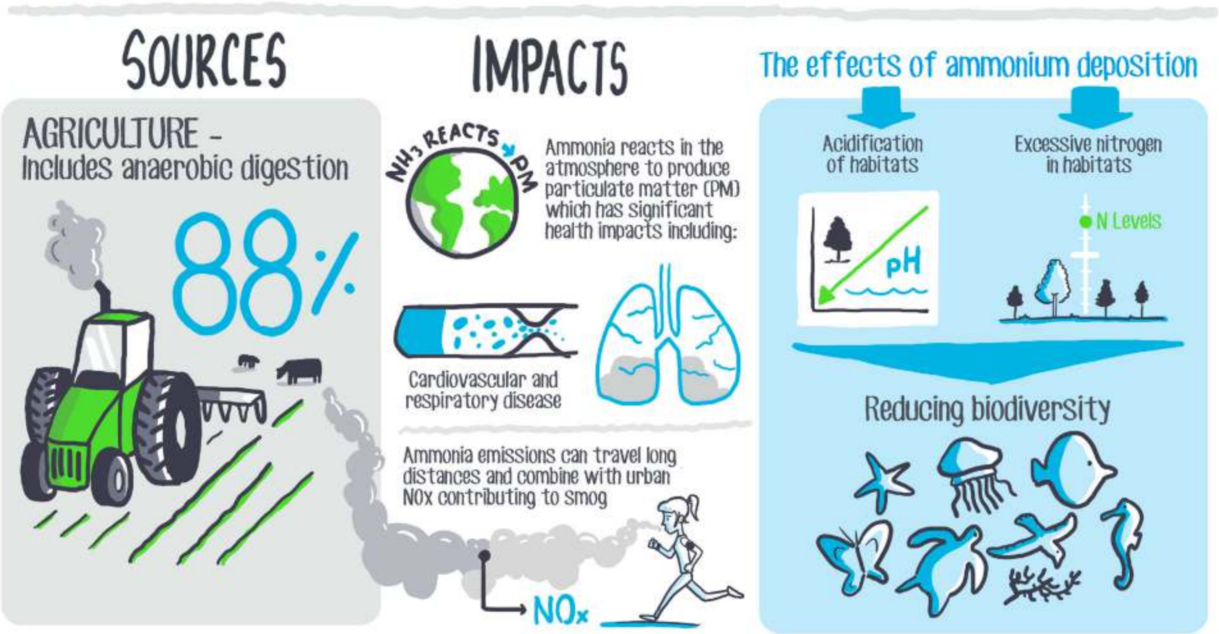
Particulate matter (PM) refers to tiny bits of solids or liquids suspended in the air which vary in size, shape, composition, and origin. PM are categorised according to their size. Particles smaller than about 10 micrometres (PM10) and particles smaller than 2.5 micrometres (PM2.5) are inhalable and can settle in the airway and lungs. In general, the smaller the particles are, the further they penetrate, and the more damage they can cause.



Source: DEFRA, 2018. Clean air strategy.

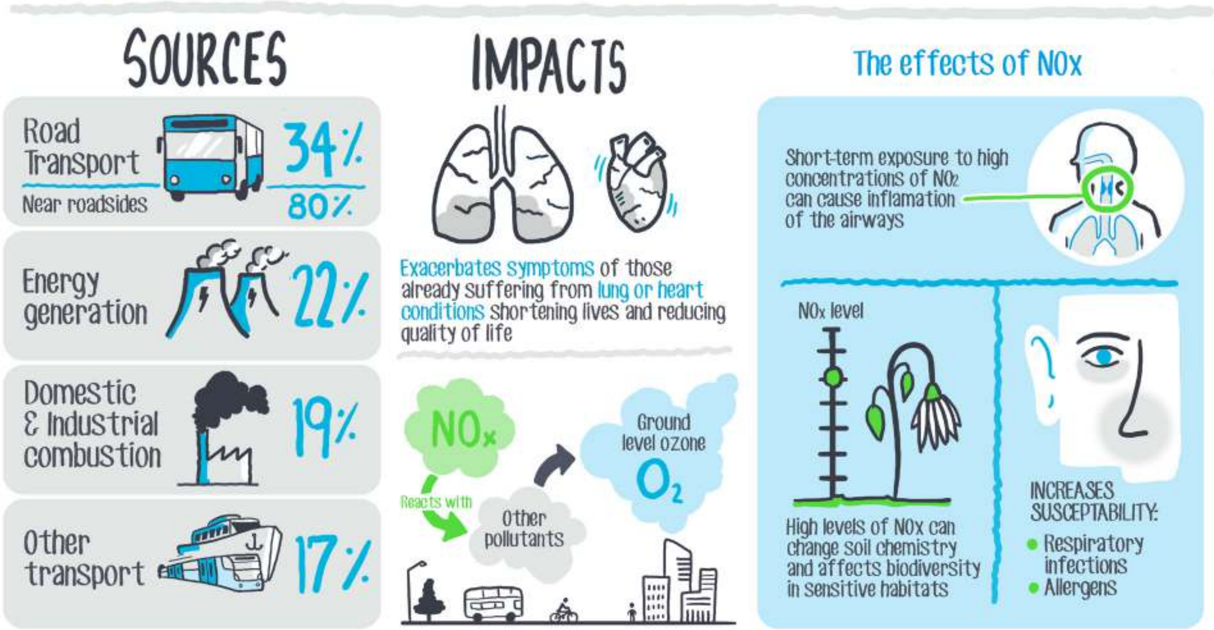
Agriculture is the dominant source of **ammonia** – a gas produced by rotting farm waste or fertilisers. On its own, ammonia is harmful only in high concentrations, but when combined with other pollutants it produces toxic secondary particulate matter deemed extremely dangerous to public health.

AMMONIA - NH_3

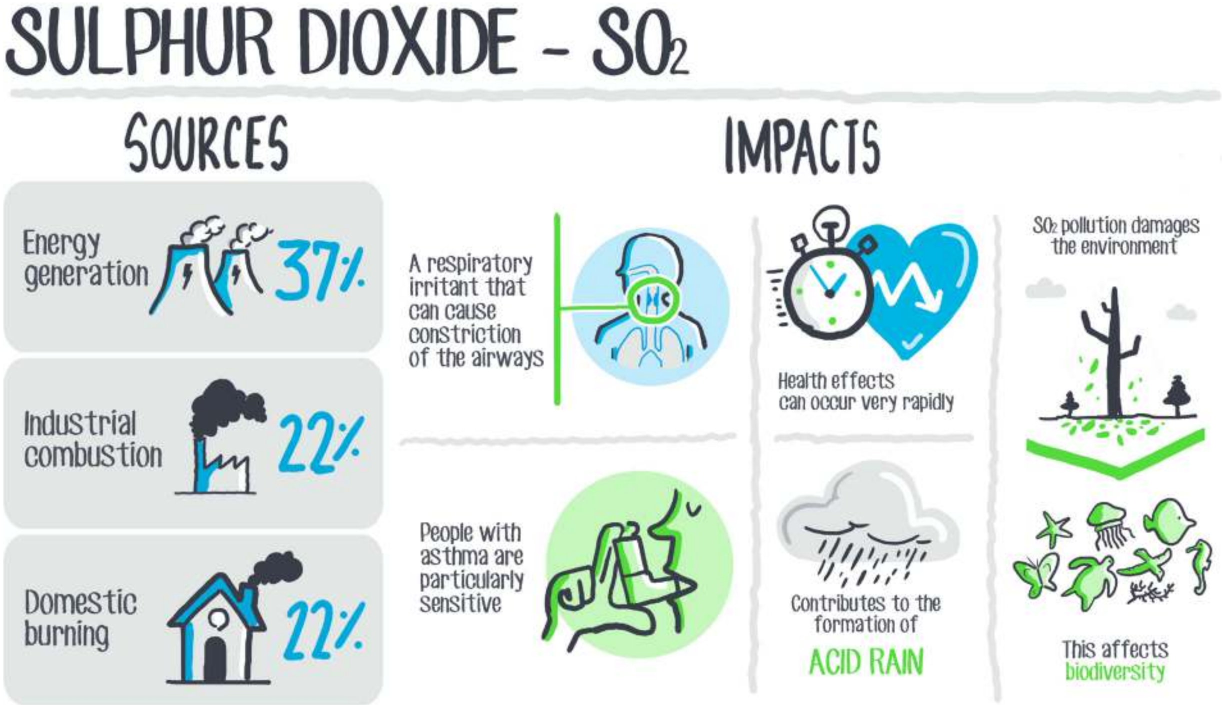


Nitrogen dioxide belongs to a group of harmful gases called **nitrogen oxides**, and is formed during fuel combustion. Road transport remains the primary sector responsible for nitrogen oxide emissions, leading to dangerous concentrations near busy roads and large urban areas.

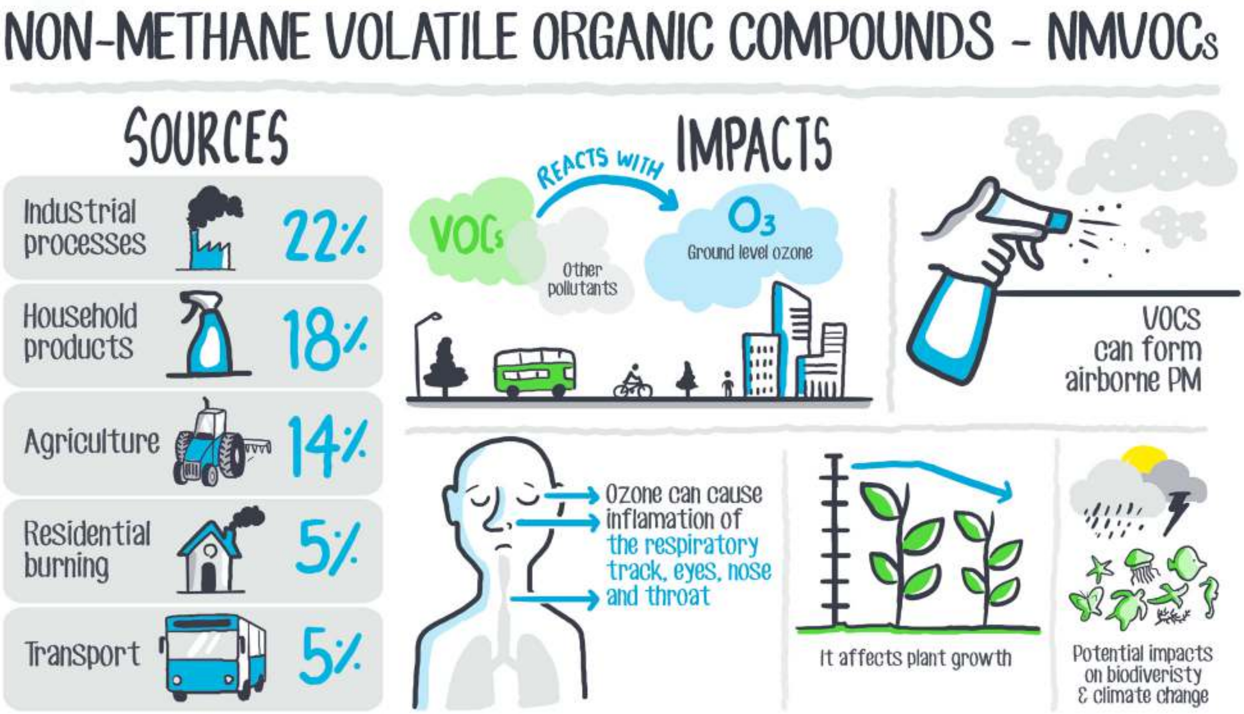
NITROGEN OXIDES - NO_x



Sulphur dioxide is colourless gas with a strong odour. It is produced by the burning of fossil fuels and the smelting of mineral ores containing sulphur. Major polluters include coal and oil-burning processes such as power generation and refineries.



Non-methane volatile organic compounds (NMVOCs) are a group of chemically varied organic compounds sharing similar behaviour in the atmosphere. NMVOCs are a major contributor to both outdoor and indoor air pollution. Outdoors, they combine with other pollutants to produce ground-level ozone, causing inflammation of the respiratory tract, eyes, nose and throat, as well as irreversible damage to vegetation.



The total global welfare cost of poor air quality amounts to 5 trillion dollars, including 225 billion dollars of labour costs[4].

References:

1 World Health Organisation, 2018. Household air pollution and health.
http://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health

2 World Health Organisation, 2018. Ambient (outdoor) air quality and health.
http://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

3 European Environment Agency, 2015. Air pollution.
https://www.eea.europa.eu/soer-2015/europe/air

4 World Bank, 2016. The cost of air pollution.
http://documents.worldbank.org/curated/en/781521473177013155/pdf/108141-REVISED-Cost-of-PollutionWebCORRECTEDfile.pdf

5 OECD, 2016. The economic consequences of outdoor air pollution.
https://www.oecd.org/environment/indicators-modelling-outlooks/Policy-Highlights-Economic-consequences-of-outdoor-air-pollution-web.pdf

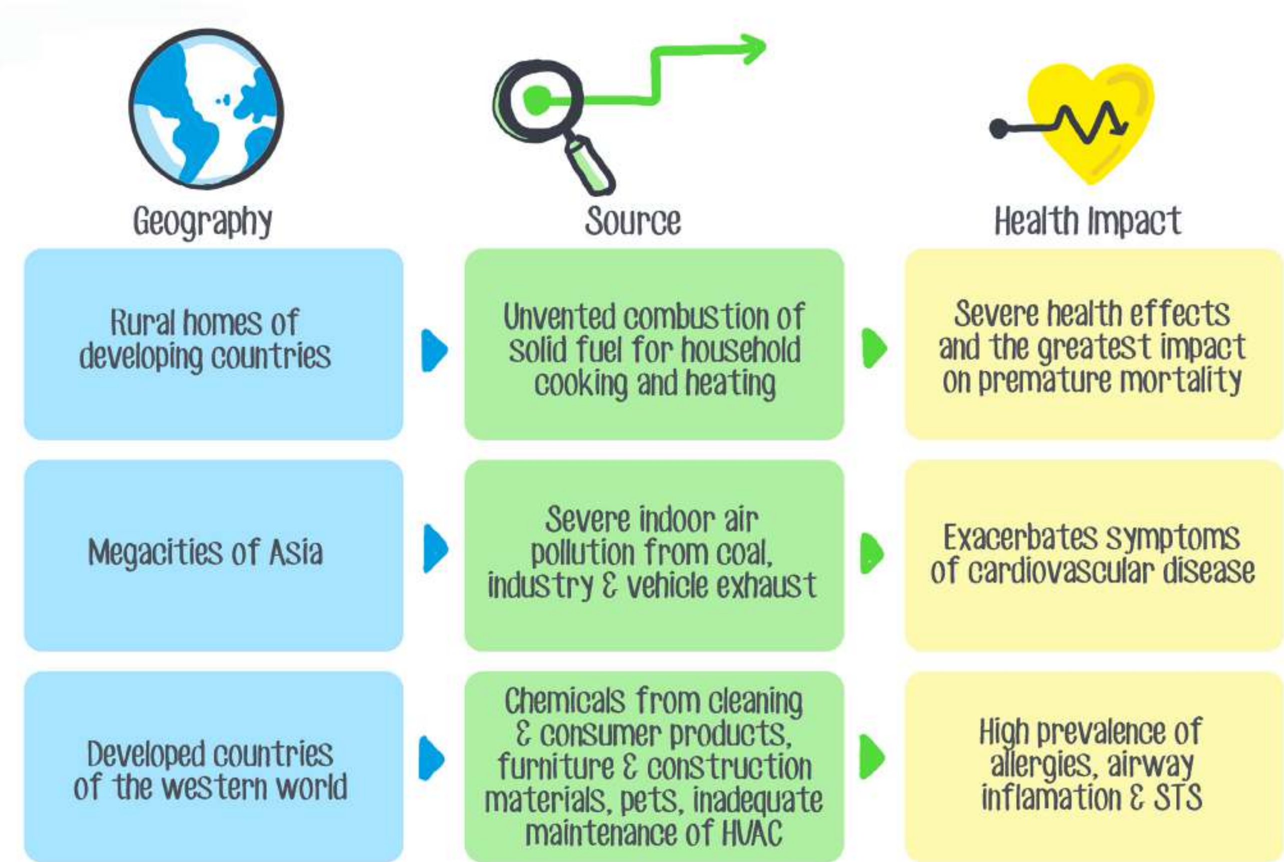
Infographics Source: DEFRA, 2018. Clean air strategy.
https://consult.defra.gov.uk/environmental-quality/clean-air-strategy-consultation/

2.2 Indoor air pollution

Although we have a good understanding of outdoor air pollution sources and mitigation measures, little is known about the growing problem of toxic indoor pollutants. Research conducted by Opinium as part of the Clean Air Day 2018 campaign found that while 85% of respondents were familiar with the health implications of poor outdoor air quality, only 36% of adults in the UK were aware of the of the effects of indoor pollution on their health[1]. At the same time, the WHO estimated that 3.8 million people die prematurely every year from an illness attributable to household air pollution[2]. This is important given that an average person spends up to 90% of their time indoors—in the office, in the car, at school or home—making those spaces the most important environment for human health and wellbeing.

When the issue of poor indoor air quality is considered, it is often associated with low-income countries and the use of solid fuels or open fires for cooking and heating. This is certainly true, and has a massive impact on mortality in these regions. However, indoor pollution is an underappreciated problem for both developed countries/cities and the burgeoning Asian megacities. The drivers, issues, and health impacts vary for each demographic, and Professor Frank Kelly of King's College, London highlighted the importance of understanding these variations (along with their underpinning drivers and issues) as a critical first step towards tackling the problem on a global scale.

Geographical variation of indoor air pollution



“Millions of Europeans in modern society spend approximately 90% of their time indoors: in their homes, workplaces, schools, and public spaces. It is estimated that approximately 2/3 of this time is spent at home. For many years, the housing environment has been acknowledged as one of the main settings affecting human health”

WHO Report[3]

References:

1 Opinium Research conducted an online survey of 2,000 nationally representative UK adults between 22nd and 25th May 2018
https://www.opinium.co.uk/clean-air-day-campaign-highlights-indoor-air-quality/

2 World Health Organisation, 2018. Household air pollution and health.
http://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health

3 WHO, 2013. Combined or multiple exposure to health stressors in indoor built environments.
http://www.euro.who.int/__data/assets/pdf_file/0020/248600/Combined-or-multiple-exposure-to-health-stressors-in-indoor-built-environments.pdf

3. Innovation enablers

Current technological advancements and innovation are encouraging efforts to improve air we breathe. Historically, efforts have been concentrated in understanding and reducing air pollution at their source. Advances in monitoring technology are enhancing our knowledge of the problem, thereby helping us to assess the effectiveness of air quality measures. Moreover, vehicle technology advancements such as catalytic converters, hybridisation or electrification, and improved traffic management systems have all served a visible role in reducing the emission of air pollutants, especially in urban areas.

These innovative solutions have been a significant driver behind effective actions to reduce emissions. Nevertheless, the reality is that we continue to breathe a toxic cocktail of air pollutants. In order to empower actions and improve awareness regarding non-visible air pollutants, innovation coupled with regulation must drive improved solutions for air pollution mitigation, especially in the area of air purification and targeted exposure information. However, cleaning the air around us is not a straightforward challenge. Rather, it is a multi-faceted issue which will require a multi-faceted response. There is a clear need for collaboration and large-scale deployment of solutions to drive substantial and visible change as opposed to merely scratching the surface of the problem.

“Zero emission vehicles are a misnomer. Even if we replace all vehicles in London we will still have a PM problem. More than 50% of PM emissions come from non-tail pipe sources such as brakes, tyres, and road wear”

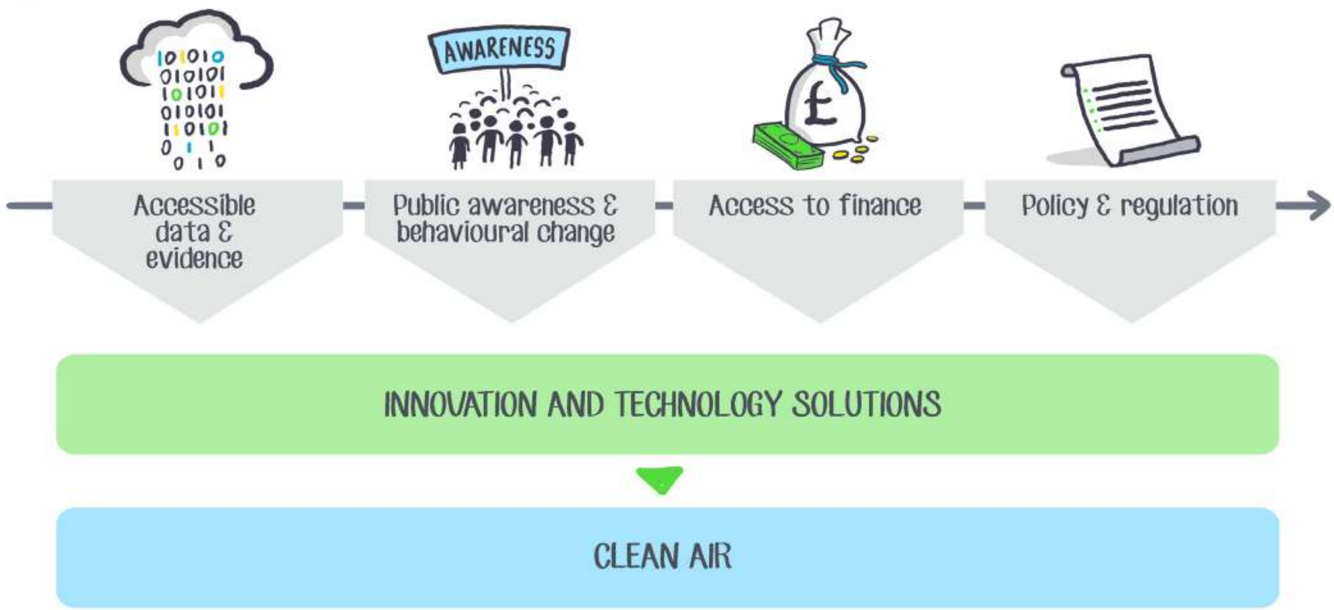
Frank Kelly- Professor of Environmental Health

3.1 Turning barriers into enablers

The #CleanAirTech community members developed six actionable challenge questions during the Immersion Day activities:

1. How might we change expectations and behaviours related to improving indoor air quality in offices and other non-domestic settings?
2. How might we incentivise innovation and the use of materials and systems that deliver lower indoor household emissions?
3. How might we reduce the emissions impact of 'final mile' goods movements and other fleet vehicles?
4. How might we cultivate more ambitious consortia and collaborations that are better placed to leverage investment in applied research and solutions?
5. How might we empower citizens, consumers and policymakers with simple and targeted information to make different consumer choices and lobby for change at the local and national level?
6. How might we personalise, localise and visualise the problem of air pollution to empower individuals to change personal and business behaviours?

These questions served as a foundation for further examination of the barriers impeding clean air initiatives and inhibiting the uptake of clean air technology, as well as the stakeholders who could influence them. Throughout the discussion, four factors emerged as being critical to the success of the clean air industry.



Despite initially identifying these factors as barriers, the #CleanAirTech community acknowledged that, once overcome, they could become enablers. Only when these barriers are brought down will the community achieve its goals of the wider adoption of existing technologies, improved mitigation technologies, a viable clean air technology industry, and—most importantly—cleaner air for all. The identified enablers are interrelated and self-enforcing. Data and evidence, for instance, will be essential in securing and enabling public awareness, behavioural change, and policy and regulation. Notably, public pressure arising from public awareness will drive policy and regulation.

3.2 Accessible data and evidence

Data is critical to the scientific understanding of air pollution and its sources, as well as for the creation of consistent evidence regarding their impact on health and quality-of-life. The #CleanAirTech community members reported limited availability of the monitoring, modelling, and localised air quality data they required. In addition to being inconvenient, this fragmented and inconsistent data landscape slows down new product development and prevents the measurement of the impact of implemented solutions.

Traditionally, air quality information is derived from models based on data from stationary monitoring stations and other non-air pollution data (weather, traffic, and others). These models are often limited in scope, offering only indicative values that prevent any real-time actions. The low density and high operating costs of such stationary monitoring stations network also means that large areas are left unmonitored, despite air pollution being highly localised in many cases.

Low-cost sensors are one solution to address these issues, as they would enable the expansion of monitoring points to improve the accuracy of air pollution data and models. Moreover, low-cost sensors have valuable advantages in terms of size, weight, and power consumption. However, data accuracy remains an issue with these sensors, which makes them a complimentary source of information rather than a direct substitute[1]. Although low-cost sensors could theoretically be integrated in existing stationary monitoring networks to improve air quality information, the lack of clear standards and data sharing guidelines, security and privacy concerns, as well as existing silos make the collection of consistent and comparable data extremely difficult in practice. The #CleanAirTech community members reported a necessity to address these challenges and aggregate generated data on open data platforms accessible by everyone.

References

1 Alistar C. et al., 2018. Low-cost sensors for the measurement of atmospheric composition: overview of topic and future applications

3.3 Public awareness and behavioural change

Raising public awareness and improving citizen engagement is a key enabler for the wider adoption of clean air technology. Notably, there is a disconnect between air quality information and those individuals affected by it that must urgently be addressed. Information must be personalised, localised, and visually compelling to empower individuals to take active steps towards protecting their health, doing what they can to reduce air pollution, and pressing for more large-scale action on the issue. Vulnerable groups are the worst affected, but are usually least equipped to mitigate the effects of poor air quality. These individuals should be of primary focus if we are to create cleaner, healthier, more liveable cities and buildings. Effective dissemination of personal exposure information through a set of simple, targeted messages backed by accessible evidence will serve as a powerful driver of behavioural change and be critical to facilitating a demand-driven clean air technology market.

3.4 Access to finance

The invisible nature of air pollution hinders market demand. The #CleanAirTech community members cited insufficient public awareness and a lack of consistent impact evidence as major obstacles in translating the effects of their solutions into value, which impedes investment and large-scale deployment. Increasing available public funding was also recognised as an important driver of growth within the clean air technology market. It is important to note that, when discussing investment, the community rated ‘in-kind’ funding—such as access to data or capabilities—as being as powerful as monetary grants.

3.5 Policy and regulation

National and local governments have significant powers to improve air quality regulation and provide the investment necessary to deploy large-scale technological solutions. Clean air zones and congestion charges were provided as examples of successful policies introduced to tackle air pollution in the UK and worldwide. However, the #CleanAirTech community members expressed their willingness to see more active partnerships and shared accountability between government bodies such as the Department of Transport, the Department of Business, Energy and Industrial Strategy, the Department of Health, and the Department for Environment, Food, and Rural Affairs. Furthermore, eliminating existing silos and fostering collaboration around the topic of air pollution could unlock various sources of funding and encourage growth in the clean air technology market.

Standards were another prominent topic of discussion. The #CleanAirTech community members highlighted an imminent need to ensure and assess the quality and reliability of data provided by various sensors. Such a measure would guarantee the consistent calculation of air pollution emissions on a national or global scale and allow for higher precision models. Improving outdoor air quality standards and establishing legally binding limits for indoor pollution were identified as another enabler for the wider adoption of clean air technology.

CASE STUDY

Indoor Air Quality in France

France is one of the first European countries to take active steps towards regulating indoor air quality in buildings accommodating children. The National Environmental Commitment Act sets out the regulatory framework for mandatory monitoring in:

- Facilities for children under six years
- Primary and secondary schools
- Recreation centres and
- Social establishments for children and minors

This act is being rolled out in several stages. As of January 2018, it has already been in force for kindergartens and elementary schools. Recreation centres and secondary schools, as well as all other establishments will be included from January 2020 and January 2023, respectively. Affected establishments must assess the building ventilation, measure air quality, and prepare an action plan identifying measures for air quality improvement. The pollutants measured include formaldehyde, benzene, carbon dioxide, and tetrachloroethylene—all deemed to have a negative impact on human health.

Source: French Ministry of the Environment, Energy and the Sea

4. Conclusion

The sheer magnitude of the goal to achieve cleaner air for all will require coordination and long-term commitment from multiple stakeholders—from national and local governments, public bodies, and industry, to voluntary organisations. Above all, it will require a strong #CleanAirTech community determined to collaborate, take effective action, and demonstrate visible progress.

As previously discussed in this white paper, innovative technology is already driving improvements in air purification, though the current results are insufficient and the speed of change must increase. There is an imminent need for a concentrated, co-ordinated effort to develop and improve mitigation solutions and drive behavioural change.

At the launch of the #CleanAirTech community, members spent time discussing follow-up actions that the group must take to transform barriers into enablers, move forward, and create a concrete roadmap for the ecosystem.

The suggestions detailed in this section do not aspire to be a 'magic bullet' to solve the clean air problem. Instead, across five key aspects, they endeavour to lay a foundation for the creation of a holistic framework for future discussion and collaboration, which should lead to concrete action. In the meantime, the #CleanAirTech community will continue to engage with key stakeholders to ensure scalable solutions and effective actions within the clean air technology industry for the UK and worldwide.

4.1 Expand the ecosystem

Cleaning the air we breathe is a complex and messy challenge that will demand continuous dialogue between key public and private actors as well as academia. The #CleanAirTech ecosystem will not be a closed group, but rather a living and continuously expanding community interacting with external and internal stakeholders to drive visible results. It will also seek to engage an even larger number of industry partners such as SMEs and large businesses to provide solutions and products for air quality improvement. Furthermore, the #CleanAirTech community will work towards the wider adoption of clean air solutions through large-scale deployment projects, which require the guidance and support of investors as well as infrastructure and asset providers. Further involvement of health and non-governmental organisations will be critical for a reliable evidence base and improved awareness on the negative effects of air pollution. Finally, the #CleanAirTech community recognises the importance of support from international, national, and local government bodies, and will always be open to collaboration with them.

CASE STUDY

Helsinki Metropolitan Testbed

The Helsinki Air Quality test bed is one of the first comprehensive city-wide air quality systems. The Finnish companies Vaisala and Pegasor have integrated low-cost sensors into existing urban infrastructure to complement and add to data provided by established measurement stations. This new dense network of sensors has already started producing data for more accurate models of current and future local air quality. Data generated by the network will be fed into the Finnish Meteorological Institute's environmental information fusion service, which will convert it into high-resolution air quality heat maps showing past, current, and forecasted pollution, as well as hourly concentrations. The central premise of the Helsinki test bed is to open available air quality data to third parties interested in exploiting the data to its full potential for building new services and applications.

Source: Helsinki Metropolitan Smart & Clean Foundation

4.2 Deploy #CleanAirTech testbeds

Clean Air testbeds will provide a valuable opportunity to deploy and showcase available technology within the #CleanAirTech community while providing crucial understanding to help solve the challenge of indoor and outdoor air quality. This would take place in real-world environments, at a relevant scale, and be able to provide meaningful impact assessment. The partnership could also involve a wide range of public and private actors coming together to trial innovation and existing solutions, create new products and services, and combine researcher know-how with the experience of companies in the clean air technology sector.

4.3 Engage with communities

An active and continuous dialogue with disadvantaged and vulnerable communities such as the elderly, children, those with pre-existing health conditions, and the financially disadvantaged is critical to enabling them to act and reduce their air pollution exposure. The #CleanAirTech community will work to ensure that these vulnerable groups are involved, engaged, and informed. A feasible first step would include a public campaign to raise awareness regarding the adverse effects of air pollution and improve dissemination of air quality information. This public campaign could include but will not be limited to:

- Audio-visual materials
- Public events and/or conferences
- Community projects
- Improved products and services to visualise and localise personal exposure information
- 5-a-day campaign on air pollution

4.4 Define a business case for cleaner air

A compelling business case quantifying the impact of innovative clean air technology would unlock future investment and encourage large-scale deployment of solutions. During discussions at the launch of the community, members already started identifying potential positive effects. For businesses, clean air technology could increase productivity, lower occupational risk, and offer a competitive advantage. Furthermore, national and local governments will benefit from decreased welfare costs, while individuals—especially vulnerable communities—will have more control over their health and quality of life.

A next step would be to translate these effects into monetary returns and cashable benefits, thereby establishing a strong and financially viable business case. To complement this, an ecosystem map of the products and services available within the #CleanAirTech community would facilitate consortia formation and attract further public and private investment.

4.5 Collaborate globally

The UK has significant expertise in developing highly innovative products and services. Its universities continue to conduct world-class research and provide education in subjects relevant to global challenges such as air pollution. These factors make the UK an excellent location to develop solutions to tackle poor air quality. The #CleanAirTech community could leverage these strengths to scale up technological solutions and replicate them worldwide to improve global air quality through thought leadership and innovation.

CASE STUDY

C40 Air Quality Network

London mayor Sadiq Khan and Bangalore mayor Sampath Raj will lead a global partnership of up to 20 other world cities on tackling air pollution in urban centres. As part of this initiative, London will trial a major new £750,000 street-by-street sensor air quality monitoring system that will be used to analyse harmful pollution in up to 1,000 toxic hot spots across the city. Results from London's new air quality sensor monitoring trial will not only be used to better target policies and engage citizens, but will also be shared with Bangalore and other cities in the new C40 Air Quality Network.

Source: C40

This report was commissioned by Johnson Matthey and has been authored by Future Cities Catapult.

Johnson Matthey and the Future Cities Catapult would like to express their gratitude to the following organisations that kindly spared their time for the purposes of this project:

Air Monitors Ltd
Airboxlab EU
AirLabs
AirPublic
Alphasense
Better Points Ltd
Buro Happold
Business Mix
Cambridge Mask & Co
Cambridgeshire County Council
DEFRA
Dyson
Earthsense
Friends of the Earth
Green Tech Consulting
Greengame
Ibex Earth
IndoorBioTechnologies
Innovate UK
Kings College London
London Councils
Mitsui
Nesta
Newcastle City Council
Newcastle University
SAP
Sopra Steria
Southampton City Council
Transport Systems Catapult
ULTRA Urban
University College London
University of Birmingham
University of Cambridge
Vortex IOT Ltd

About Johnson Matthey
Johnson Matthey is a global leader in science that enables a cleaner and healthier world. With over 200 years of sustained commitment to innovation and technological breakthroughs, we improve the function, performance, and safety of our customers' products. Our science has a global impact in areas such as low emission transport, pharmaceuticals, chemical processing, and making the most efficient use of the planet's natural resources. Today, over 13,000 Johnson Matthey professionals collaborate with our network of customers and partners to make a real difference in the world around us. For more information, visit:
www.matthey.com

About Future Cities Catapult
Future Cities Catapult accelerates urban ideas to market, to grow the British economy and make cities better. It brings together businesses, universities, and city leaders so that they can work with each other to solve the problems that cities face, both now and in the future.

Visit our website
www.futurecities.catapult.org.uk

Follow us on Twitter
@FutureCitiesCat

Or send us an email
info@futurecities.catapult.org.uk

CATAPULT
Future Cities