SPF Clean Air Programme Annual Review 2022/2023

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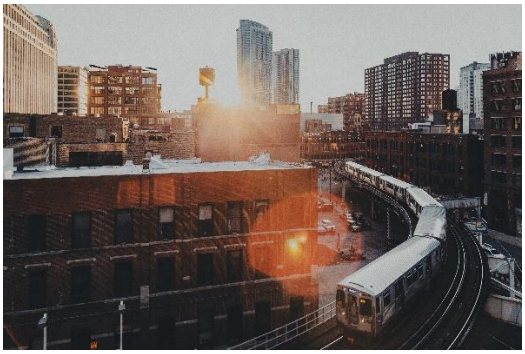

Executive summary

The SPF Clean Air programme is a £42.5 million investment that brings together the UK's world class air quality research base and supports high quality multi- and inter-disciplinary research and innovation to develop practical solutions to today's air quality issues in the UK.

The SPF Clean Air programme aims to bring together leading researchers from across atmospheric, medical, and social science to better predict exposure to air pollution and its effects on vulnerable groups such as children and the elderly. The programme will identify practical and usable solutions to air pollution to help policy makers and business protect health and work towards a cleaner economy.

The programme is jointly led by UKRI and the Met Office and delivered in two waves:

- Wave 1 - Clean Air: Analysis & Solutions (£20.5 m) is focussed on near-term outdoor air pollution issues and the funded projects will leverage existing long term strategic investments in order to develop short-term policy relevant outputs, support commercialisation of near-market solutions for non-exhaust transport emissions and deliver a pilot systems framework for clean air analysis.
- Wave 2 - Clean Air: Addressing the Challenge of the Indoor/Outdoor Continuum (£22 m). Wave 2 aims to equip the UK to proactively tackle new and emerging air quality challenges related to changing emissions and exposure patterns and health impacts on groups of people most at risk.

This review covers the period from April 2022 to end of March 2023. This is an opportunity to celebrate successes and reflect on learning to ensure continual improvement of the programme and maximise benefits from achieving the objectives.

During this phase, the SPF Clean Air programme has seen considerable development with many key milestones completed or progress made towards them. Some of the highlights are presented below:

April 2022	• SPF Clean Air Annual Conference – Seeking Solutions for Clean Air
June 2022	• The Wave 2 Clean Air Champions team announced on Clean Air Day
July 2022	• Defra/NCAS Research Policy Forum – Presentation of Wave 1 projects
August 2022	• Start of Wave 2 Support for the Clean Air Champions "Addressing the Challenge of the Indoor/Outdoor Continuum"
Sept. 2022	• Start of the Clean Air "Data and Tools" Task & Finish group • Wave 2 'Monitoring' Innovation Projects close • Clean Air Champions/Wave 1 meeting
Oct. 2022	• New Regional Champions for the West Midlands to North West England and East Midlands to North East England announced • Networks roundtable with Clean Air Champions
Dec. 2022	• Start of the Clean Air "Community" Task & Finish group • Publication of Chief Medical Officer (CMO) report
Jan. 2023	• Clean Air Tech Sector report completed
Feb. 2023	• Wave 2 'Mitigating' Innovation Projects close
March 2023	• Outputs map finalised and being uploaded on the Clean Air website portal • First meeting of the Clean Air Knowledge Exchange Group

The top **programmes successes** were identified as:

- Creation of outputs map
- Establishment of new Regional Champions for the West Midlands to North West England and East Midlands to North East England
- Creating links between certain academic disciplines, policymakers and businesses
- DEFRA approached IUK to run Clean Air competition
- Input to Chief Medical Officer Report

The key **lessons** that should be taken into consideration for future learning were identified as:

- **Programme still needs to engage with other disciplines.**
- **Some funding should have been allocated for legacy work.**
- **Programme needs to be more adaptable and flexible in a changing context.**

Introduction

Background and purpose

This Annual Review provides a review of the SPF Clean Air Programme (Wave 1 & Wave 2), and captures the headlines on successes, lessons learnt and progress towards the aims from April 2022 to March 2023.

The UKRI SPF team previously required all SPF programmes to submit an annual review. This was intended to provide reassurance that the programmes are on track to meet their stated objectives and highlight early successes, which could then be used to promote the value of the SPF fund.

While this is no longer a requirement, the need for due diligence and programme monitoring remains. Therefore, it was decided by the Programme Board (PB) that an annual review should still be produced.

The purpose of the Annual Review is to help inform the programme-level analysis of the Clean Air Programme, to promote accountability, and to provide enough time for lesson learning and course correction for the continuation of programme implementation.

Approach

The review is focused on delivery of outcomes and benefits related to the programme's strategic objectives. The programme was reviewed against evaluation questions, adapted from the end of programme evaluation questions, as set out in the Monitoring and Evaluation Plan. We have used programme documents (e.g., meeting minutes, the risk register and finance reports), monitoring data from monthly dashboards, Researchfish, Innovate UK periodic project reviews and the Met Office input to support the review process where necessary.

Audience

This annual review is primarily intended for internal use and will enable the Programme Board and programme management team to learn lessons about the design and management of the programme, informing:

- discussions on potential improvements in the management and delivery of the Clean Air Programme; and
- the development of similar programme approaches and other interventions in the future.

Sections of this review will be shared with the Steering Committee (SC) to enable them to give advice and guidance on maximising benefits, and extracts may be shared more widely with stakeholders or through comms opportunities.

Notable press coverage

Events and stakeholder engagement have been important for promoting the SPF Clean Air programme and progressing towards the aims. Both Met Office and UKRI owned communication channels have promoted the programme since the launch. The Met Office and UKRI websites have dedicated sections for the SPF Clean Air programme including latest news and funding opportunities, and the dedicated Clean Air programme website contains more content in regard to the projects, events, news etc. The other main channels utilised are the Met Office Science, UKRI and Clean Air twitter pages that amplify the messages and news.

The most notable press coverage during the review period is listed below.

- Gary Fuller's air pollution pieces for the Guardian are published each two weeks and can be found at: https://www.theguardian.com/profile/gary-fuller. These included:
  - "Pollutionwatch: the sad end of the Met Office's atmospheric survey plane" (05/05/2022)
  - "How high fuel bills can worsen air pollution in our homes", that quoted the NERC funded Breathing City network and flagged the evidence need for an indoor air observatory programme in the UK (07/10/2022)
  - "Building works responsible for 18% of UK large particle pollution", included the Innovate UK funded CAGE project (21/10/2022)
  - "Home wood burning pollution expected to rise due to UK cost of living crisis" included the NERC funded OSCA project's work on wood burning tracers (04/11/2022)
  - "Arsenic found in London air raises fears over use of waste wood as fuel" reported arsenic in London's air from the burning of salvaged waste wood from construction. This data came from the NERC OSCA supersites in London and Manchester (09/02/2023)
  - "Pollutionwatch: London Ulez cuts traffic fumes but heating is concern" reported results from air pollution measurements and analysis made at BT Tower by the NERC OSCA project. This provided information on the effectiveness of the ULEZ as well as the future impacts of air pollution from commercial and home heating (24/02/2023)
- Jenny Baverstock contributed to an article for UKRI "Why air pollution is one of our biggest challenges – and how the Clean Air Programme is helping tackle it" as part of Clean Air Day activities (16/6/2022)
- A Clean Air Day interview with Larissa Lockwood, GAP was posted on the Clean Air website and twitter (16/06/2022)
- On Clean Air Day, Paul Lewis (Regional Champion for Wales) was invited to assist Newport Council hold a Clean Air Day event for local school children in the city to raise awareness of air quality https://www.southwalesargus.co.uk/news/20215849.newport-marks-clean-air-day-pupils-tredegar-park-event/ (16/06/2022)
- A number of interviews and blogs were published on the Clean Air website, including:
  - Interview by Alice Pengelly with Dr Helen Freeman "Breathing City: How does ventilation affect indoor air quality?" (03/08/2022)

    - Interview by Alice Pengelly with Dr David Shaw "INGENIOUS: How our behaviour affects air quality in our homes" (10/08/2022)
    - Interview by Alice Pengelly with Esther Lie "WellHome: measuring air pollution in homes with children with asthma" (01/09/2022)
    - "Mitigating the impact of air pollution on dementia and brain health: Setting the policy agenda" by Professor Brian Castellani, Dr Suzanne Bartington and Professor Stefan Reis (21/09/2022)
    - Gary Fuller and Sonia Emslie interview with Henry Burridge on Ventilate Day "Air flow expert gives his insight into why indoor air quality is just as important as outdoor" (08/11/2022)
- HS2 celebrates big emissions cuts through trial of innovative Clean Air engine funding as part of the Clean Air SPF https://mediacentre.hs2.org.uk/news/hs2-celebrates-big-emissions-cuts-through-trial-of-lpg-generator (31/08/22)
- The NERC funded TAPAS wrote a blog for the #AskAboutAsthma campaign about the work TAPAS are doing and what tools are available to help schools reduce air pollution https://www.healthylondon.org/tackling-air-pollution-at-school/ (30/09/2022)
- Neil Rowland (Regional Champion for Northern Ireland) commented in the Belfast Telegraph on the smoky coal ban being introduced I the Republic of Ireland https://www.belfasttelegraph.co.uk/news/politics/dups-edwin-poots-president-biden-visit-to-ireland-will-be-a-funeral-for-good-friday-agreement-if-protocol-not-resolved-42038388.html (04/10/2022)
- The NERC funded ANTICIPATE project was featured in an online article in the Daily Express https://www.express.co.uk/news/science/1692499/uk-ev-plans-dealt-blow-switch-electric-cars-traffic-congestion-science (05/11/2022)
- Gary Fuller was interviewed on BBC News live on-air on the health impacts of pollution from solid fuel heating and the winter energy crisis (06/11/2022)
- Gary Fuller was interviewed for ITV news on air pollution and the possible growth of solid fuel use in the winter (10/11/2022)

Programme successes

The programme had many successes and highlights throughout the review period. Below are the key successes identified by the programme team and Champions (in no particular order).

- Creation of output map
  This activity was carried out by NERC, Innovate UK and Met Office programme managers. The outputs map is a live document listing and describing the NERC, Innovate UK and Met Office outputs since the start of the programme and has been made available to the Clean Air community via the Clean Air website portal (https://www.ukcleanair.org/clean-air-outputs-map/). This activity will contribute to the programme legacy.

- Establishment of Regional Champions
  Two new Regional Champions have been announced for the West Midlands to North West England and East Midlands to North East England, joining the already existing Regional Champions for Northern Ireland, Scotland and Wales.

- Creating links between certain academic disciplines, policymakers and businesses.

- Defra approached IUK to run Clean Air competition
  Defra, inspired by the impact of the innovation programme, approached Innovate UK to organise a similar innovation competition that would address some of their outstanding strategic needs around air pollution. Defra have agreed to allocate £4m to run an innovation competition to develop products or services that reduce the volume of harmful pollutants entering the atmosphere as a result of domestic burning or agricultural practices. The competition will be further developed for launch in Q1 2023.

- Input to Chief Medical Officer Report
  Clean Air grant holders have contributed to the 2022 Chief Medical Officer's Annual Report on air pollution published in December 2022.

- Launch of the Clean Air Tech Sector Report
  Innovate UK commissioned a report aimed at understanding the position and potential of the clean air tech sector in the UK. The report gathered new information and insights, synthesising those into recommendations on how to support the sector to grow and prospect in the UK and globally.

Lessons learned

The lessons learned throughout the review period are an important part of reflecting on progress so far and can be used to inform future decisions. Below are the key areas we can take learning from that have been identified by the programme team and Champions (in no particular order).

- Programme still needs to engage with other disciplines – key academic gaps identified include health economics, and environmental law.

- Some funding should have been allocated for legacy work.
  As Wave 1 is approaching the end and Wave 2 projects are delivering outputs, the need to achieve a programme legacy is now often discussed and a number of activities have been identified during management and steering meetings. Unfortunately, no funding is available to support these activities, including the supersites and a period of continued funding for the Champions beyond the end of the projects. Some of the activities have taken place only thanks to resource extra-time, volunteers, and extra-funds. These include:
    - The creation of an outputs map, which required extra-time from the NERC, Met-Office and Innovate UK programme managers and from the project Principal Investigators and whose publication required additional SPF funds that had to be requested and approved.
    - The creation of a series of Task & Finish Groups on a series of selected topics (e.g., Data and Tools, Clean Air Community), composed of members of the programme and academic communities. While members of the Task & Finish groups dedicate their time and efforts at no cost, no funding is available to support outputs from the group work.
    - Training and maintenance requirements for the effective use of the programme outputs by the Clean Air community beyond the end of the programme. Plans are being discussed but no funding is available for this activity.
    - Training budget for PhDs (although this was never part of the SPF).

  Activities to support programme legacy should be planned at the beginning of the programme and funding to support these activities should be allocated accordingly. An interdisciplinary

Doctoral Training Programme could also be supported as a way of maintaining and further developing legacy.

- Programme needs to be more adaptable and flexible in a changing context.

Programme case studies

This selection of case studies highlights successes of the programme and illustrates the breadth of good stories there are to tell.

- The ANTICIPATE team worked with a local community-based organisation (Zero Carbon Guilford) to host an installation of the EV section of the trilemma map (following their recent publication "Adopting a whole systems approach to transport decarbonisation, air quality and health: an online participatory systems mapping case study in the UK") as an augmented reality version and a sculptural 3D version to bring the project and its methods to a wider audience via a public outreach activity. The exhibition drew over 19,000 visitors during its installation.

- Measurements of air quality species are made using a variety of instruments. The performance of these instruments varies and can be challenging for the wider air quality community to understand. The National Physical Laboratory have been leading an activity reviewing the current state of the art of air quality monitoring and its quality, uncertainty and traceability as well as contributing to the development of international standards for low cost air quality sensors. A particular focus has been nitrogen dioxide (NO2) measurements – a key pollutant where measurement technologies of different levels of performance and cost are used. This activity has shown that traditional diffusion tube measurements can be significantly improved if the tubes are mounted in protective shelters or if new tube designs are used. This finding will have an immediate impact on the quality of results from Defra's UK Urban Nitrogen Network and also help in the selection of technologies for future monitoring networks.

- The Clean Air Champions and several SPF funded researchers contributed as subject experts to the Parliamentary Office of Science and Technology briefing note 'Urban outdoor air quality' https://post.parliament.uk/research-briefings/post-pn-0691/ (published January 2023). The briefing also cites the collaborative publication 'Adopting a whole systems approach to transport decarbonisation, air quality and health: an online participatory systems mapping case study in the UK") https://doi.org/10.3390/atmos13030492

- DIMEX-UK: The majority of research related to the health effects of air pollution has been at the population level, based on measured and modelled concentrations of ambient pollution at people's residential address. However, there is a need to increase our understanding of the personal exposures actually experienced by individuals as they move between different locations, such as the home, workplace or transport, throughout the day. The Data Integration Model for Exposures (DIMEX-UK) activity has produced an open-source integrated modelling framework, together with tools for implementation, that allow variations in exposures between different populations to be quantified over space and time. Understanding differences between the exposures experienced by individuals is crucial in informing policy decisions aimed at reducing the adverse effects on health, reducing inequalities, developing interventions and in tracking progress to targets and compliance to standards.

- The Wave 1 Innovation projects concluded last year but Innovate UK continues to support them in their efforts to commercialise the innovations. The background to these projects was captured in a blog launched in February 2022 https://www.ukri.org/blog/research-and-innovation-to-develop-solutions-to-air-pollution/

- The CAGE project has secured additional funding £380k as part of the BEIS Red Diesel Replacement funding secured. They have a 6kW biogas generator now on sale, are moving to bring an ultra low emission bioLPG 6kw generator to market and have a 15 kW generator in development. £200k of market trial generators were sold in 2022. CAGE have submitted two patents to protect their IPR.

- AutoAlign have sold a UK commercial license for their product, and are negotiating a European commercial licence. They have secured a three year Knowledge Transfer Partnership, which brings aboard additional research capacity to extend the product from 2 wheel alignment to 4 wheel alignment.

- CoolRun is now a market ready product with ten units on trial by early adopters. These paid for trials are generating initial, limited income of £12,000 per annum.

- The Wave 2 projects funded under the competition "SBRI: monitor and visualise domestic pollution to safeguard health" completed their R&D phases in this period. The background to the projects are covered in this blog https://www.ukri.org/blog/developing-innovations-to-monitor-air-pollution-in-homes/.

    - "Measure, inform, nudge" (ARBNCO LTD): The project has developed and piloted an innovative air pollution monitoring and visualisation solution for domestic properties. The developed solution is based on arbnco's 'arbn well' platform for monitoring and reporting indoor air quality and thermal comfort in commercial buildings. The project team and delivery partners (Modulous, SNRG and Mitsubishi Electric) see significant scope and potential for exploiting the work. Modulous see value in monitoring the air quality and other environmental parameters in their innovative housing designs to validate building performance particularly in the first 3 to 5 years after construction. SNRG are also interested in the solution for building performance validation purposes as well as automated, demand driven control of Mechanical Ventilation with Heat Recovery systems. Mitsubishi Electric R&D Centre are continuing to develop a prototype dashboard for Mitsubishi Electric's cloud-based control platform to illustrate the end-to-end integration between the Heating, Ventilation, and Air Conditioning system and air quality monitoring. Further, a proposal to develop novel demand driven control algorithms, bespoke dashboards and a deployment framework is currently being negotiated with Mitsubishi Electric Inc in the U.S.

    - "Smarter Home Indoor Air Quality Monitoring System" (APPLIED NANODETECTORS LIMITED): The team developed an ultrasensitive home-based Indoor Air Quality (IAQ) sensing system that detects adverse pollution levels, predict and identify the pollution sources, and provides actionable suggestions to help people improve IAQ. Using the system enbles users to correlate household tasks to pollution events and

take action to reduce them. The team are now aiming to customise the device for families who have asthma as the first target application. Asthma UK are working as a partner to support the project reach out to test participants. Applied Nanodetectors are currently exploring a variety of avenues to secure the funding to conduct the new R&D exercise with Asthma UK that should result in an enhanced, market ready product.

- "FamilyAIR" (FILAMENT PD LTD): The FamilyAIR project entailed building and testing prototypes our cost effective, human centred air quality monitoring system that engages with each member of a family personally, helping them understand and improve air quality within their home. The product saw overwhelming positive feedback after a prototype was exhibited at an international innovation showcase in Berlin. The Asian market was particularly keen due to their heightened awareness of IAQ and love of character-based products. Filament PD have rebranded the product as Nooku (https://nooku.co/) , have run a successful crowd funding exercise (https://www.kickstarter.com/projects/nooku/meet-nooku-your-air-quality-monitor-guide-sidekick) attracting almost twice the original value sought. Filament PD have filed a patent covering the novel modular nature and character-based elements of the solution and await the grant of IP protection.

- The two Wave 2 projects funded under the competition "SBRI Removing air pollutants from homes to safeguard health" also completed their R&D phases in this period.

  - "Codikoat: Harnessing nanoparticle array technology for the removal of domestic atmospheric pollutants" (CODIKOAT LTD): In this project nanoparticle-based photocatalytic technologies were developed to exceed the performance of existing photocatalytic materials in removing pollutant gases from the atmosphere. The material formulation was optimized through spray coating on filters and their gas absorption efficiency was tested using an experimental setup. The route to market for the innovation will initially be via Volution (Vent-Axia) who has been working with Codikoat to provide real world testing through the course of the project. Volution aim to include Codivent in their future Mechanical Ventilation with Heat Recovery models. Codikoat will then also pursue licensing agreements with manufacturers of other relevant appliances.

  - "Platform technology for the removal of critically underserved air pollutants in homes" (IMMATERIAL LTD): The purpose of this project was to identify, develop, and test metal-organic framework (MOF) materials for the filtrations of under-served volatile organic compounds. MOF materials were identified, synthesized and tested by Immaterial. Unlike activated carbon, Immaterial's MOFs were shown to retain adsorption performance at realistically low toxin concentration. Immaterial Ltd are in discussion with leading potential customers around pricing and volume structures. Further material testing is still required to specify the exact materials to use with particular commercial products.

Annual programme evaluation questions

Question 1: To what extent, and how, has the programme progressed towards building multi- and inter-disciplinary capacity and communities?

- A lot of work underway with regards to getting various projects to collaborate and how it joins up.
- Excellent work with building links between funded activities - particularly between academic disciplines and civic sector. Possibly less at present with industry partners.
- Great links have been established between different academic disciplines (e.g., engineering, environmental science, health & medicine). Moreover, new links have been built between academic and the third sector that seem sustainable. However, more could be done to bring in industry.
- Good connections have been made and maintained with the Clean Air Champions and Regional Clean Air Champions doing more engagement work and the projects working together more. A Task & Finish group has been started to look at community building.
- A lot of work is underway with regards to getting various projects to collaborate and how they join up. As well as building multi-disciplinary research groups, the work has also brought together external communities (e.g., charities, pressure groups)
- The Champions in particular have been effective in connecting the businesses to other relevant parts of the SPF programme and further opportunities.

Question 2: To what extent, and how, has the programme progressed in providing national leadership to coordinate and facilitate knowledge exchange between the programme and: i. the wider UK stakeholder community; and ii. relevant international groups?

- Work to date includes the development of a knowledge exchange forum, bringing together Clean Air PIs with other scientists and policy developers.
- The knowledge exchange group provides a mechanism for coordinating the knowledge exchange process between the programme and wider UK stakeholder community. Ideally this interaction will be iterative, enabling feedback from the community. There has been less of an emphasis on knowledge exchange with relevant international groups to date.
- Knowledge exchange and CARFuG groups have provided great thought leadership on a variety of issues. Useful linking up with some international initiatives too.
- Covid has meant that many of the outputs were delayed but progress is good and Wave 1 projects as well as Wave 2 Networks are using no cost extensions to engage more.
- The outputs map will be available on the Clean Air website portal and further allow knowledge exchange.
- International engagement is limited and has not been a priority of the programme.

- The Clean Air Tech Sector research report is a powerful statement regarding the potential of the UK's Clean Air Tech sector, and includes practical, deliverable actions to improve the cohesion of the whole sector (academic, industry and policy), and to open up international markets to UK business.

Question 3: To what extent, and how, has the programme been engaging with policy makers, the health sector, and industries?

- Good progress overall engaging to deliver change. Knowledge exchange will facilitate collaboration with these groups.

- Covid has limited some engagement with the health sector but other areas are good.

- The outputs map will allow policy makers to get more involved and utilise the programmes outputs more.

- The programme has engaged with some policy makers (UKHSA & NHS England, Dept Health & Defra). Less so with Industry from the Met Office's perspective.

- Some initial conversations have taken place with DfT, with the AutoAlign project advocating for the inclusion of wheel alignment testing as part of MoT requirements. In February 2023 representatives from the SPF took part in a meeting organised by the Chief Medical Office during which he advocated for a coordinated approach across UKRI and Government to deliver on the recommendations in his 2022 Clean Air Report.

- The Clean Air Champions have interacted directly with Government civil servants including for preparation of the Chief Medical' Officers report (Dec 2022) and POSTnote ''Urban outdoor air quality' (Jan 2023).

- Wave 1 lead investigators and the Clean Air Champions attended a Defra/NCAS Research Policy Forum to discuss development of research outputs into accessible products, insights and tools and to exchange knowledge and identify opportunities for future work.

Question 4: To what extent, and how, has the programme been driving new applied knowledge such as IP, TRL advancement, process, and conceptual innovation?

- These developments have been taken place but there is a gap in taking these to commercial markets. Some good work has been done by Innovate UK to encourage market led solutions to poor air quality.

- 17 new products and/or services have been development through feasibility in the programme, with 8 going forward through comprehensive development and testing exercises toward commercialisation. These are now all exploring their routes to market, with some already seeing significant sales or licencing agreements.

- A lot of our outputs are open access. Developers retain their IPR. NPL is developing useful policy relevant guidelines.

Question 5: To what extent, and how, has the programme been engaging the public in activities in order to raise the profile of, contribute towards the development of, and increase the uptake of possible solutions?

- The programme has been undertaking some public engagement initiatives, however the core focus of the programme is with relevant Clean Air stakeholder groups.

- Programme investments have been engaging the public at various points (research design, communication etc). However, this does not seem like the main thrust of the Programme's work.

- More Network and Clean Air Champions activities have happened to bring in public engagement this year. For example, ANTICIPATE held an event where they had a visual representation of their map; and the programme annual conference that included members of the public.

- GAP are developing activities for use by the public. Workshops have been attended to discuss Clean Air relevance to inequalities in air quality. Infographics and blogs have been generated for public consumption. A discussion on the London Smog with GAP also took place.

- With regard to the innovation projects there has been limited public engagement as a cohort. Individual consumer focused projects have worked directly with the public in their testing, but perhaps there is an opportunity to showcase the full suite of innovations developed at a future event, conference or exhibition.

Question 6: To what extent, and how, has the programme been identifying scalable, sustainable technologies that are ready for deployment and commercialisation in a) the UK; and ii) internationally?

- Technologies (and tools) have been advanced and developed but will require further work before deployed in the UK/internationally.

- Some of the products have already been sold and deployed in the UK and internationally despite the products being quite young and relatively new to market. CAGE has deployed in Kenya and AutoAlign has sold 1 UK licence for its product and is negotiating a European licence currently.

Question 7: To what extent, and how, has the programme integrated the different work packages to create coherence?

- There is some further work to synthesise elements across the programme, however there are notable example of joint work (e.g., QUANT used the OSCA supersite data to augment low-cost sensor data with measured and modelled physic chemical parameters; BioAirNet and TRANSITION co-funded a project on exposure to chemical and biological aerosols in a public transport environment).

- The investments seem joined up, through collaboration across different networks (involving different sectors). More could be done to bring Innovate investments into network discussions.

- As projects get closer to having outputs and more activities are happening there has been a noticeable increase in cross-programme working. However, there is still room for improvement and it is still early days for the Wave 2 Consortia. No cost extensions for the Wave 1 project and Networks will allow more cross over time.

- Clean Air Champions continue to facilitate the integration of programme's work packages and the annual conference helped highlight the aims and objectives of each project to each other.

- Work is underway to show how the combined effects will be of use to the Government and the wider Clean Air community.

- Coherence in the programme is improving as more tangible activities and results are emerging. The role of the Champions has been central to signposting and connecting seemingly disparate activities.

Question 8: To what extent, and how, has the programme identified, improved, and expanded the evidence and knowledge base on new air pollution challenges and associated health risks?

- Much of this work is in programme (e.g., pre-publication) but there is a significant expansion in the evidence based on new pollution challenges and risks (e.g., indoor air pollution, transport microenvironments, non-exhaust emissions among others).

- Much great work has been done to develop new knowledge, in particular related to indoor air quality. There has also been a lot of agenda setting research that will be invaluable in directing future investigations.

- Outputs are starting to become realised for the projects and the creation of an outputs map will allow easy identification of these. It is still too early for the Wave 2 consortia to have outputs.

- Both existing and newly designed models were used during the pandemic. DIMEX has investigated various issues regarding exposure, which has opened up new areas of concern for policy makers.

- The sum of all of the activities across the programme has contributed considerably to understanding of air quality and the health challenges that result. Increasingly, with assets such as the https://ukcleanair.org/ website and social media channels, the programme is building prominence and reputation across the sector.

Forward look

- 2023 annual conference focuses on the Networks and will be held at the University of Birmingham on 5-6 July 2023.
- Wave 1 completion and evaluation, and 2024 annual conference will be focused on Wave 1 achievements.
- The 2024 conference will aim to bring in more Industry, Charities/NGOs, Social Scientist and Economists.
- Wave 2 projects to keep generating outputs and the outputs map will be updated on the Clean Air website portal.
- Outputs and outcomes from existing "Data and Tools" and "Community" Task & Finish Groups, and new groups (Engaged Stakeholders; Increased knowledge and understanding; Growth and co-benefits).
- Innovate UK to support the Clean Air innovation projects in their journey to product commercialisation, highlighting market opportunities, potential collaborations and further funding or support options.
- Knowledge Exchange Group meetings.
- Media training (second course) for Early Career Researchers.

- Regional topic focussed events (e.g. solid fuel/domestic woodburning) and local government.
- Clean Air Research Futures Group (CarFUG) meetings.
- Roundtable meetings.