Imperial College London
Projects

Environmental Research Group

Breathe London network report April – June 2022

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clarity

Bloomberg Philanthropies

MAYOR OF LONDON

The Environmental Research Group

Founded in the early 1990s, the Environmental Research Group (ERG) is internationally renowned for its work on air quality. The ERG's approach to tackling air pollution is extensive, covering air quality measurement and modelling, testing and deploying portable sensors and policy development. The ERG established and continues to operate the London Air Quality Network, Europe's most advanced air quality monitoring network, with over 100 stations providing a comprehensive picture of air pollution across London. The ERG works closely with government at all levels to shape policy around air pollution. Over the last 15 years all major air pollution strategies in London, including the congestion charging scheme, have been devised and tested using emissions and air pollution models developed by ERG. It was the first UK organisation to make air quality information publicly available online, leading the way for the development of air quality apps used by thousands every day. The Environmental Research Group is led by Professor Frank Kelly, Humphrey Battcock Chair of Environment and Health. It is part of the School of Public Health at Imperial College London.

Contents

Summary of key performance indicators

This quarterly report details work undertaken by the Environmental Research Group to deliver the Breathe London network contract awarded by the GLA in December 2020.

Work is described in relation to seven key performance indicators (KPIs), as specified in the contract and summarised in Table 1. The report is not intended to be an exhaustive description of the network and its outputs, which will be captured on the network website (www.breathelondon.org) and in associated reports.

This report delivers the seventh KPI: "Network evaluation report to be produced every three months including performance of sensors (e.g., number online, number of QA/QC issues) and number of visits to the website"

Table 1: Summary of key performance indicators.

KPI	Target	Status
Install, maintain and ensure air quality sensors at 100+ sites	100+	GLA-funded: 136 Other: 172
Demonstrate sensors continue to meet the uncertainty requirements of the EU Air Quality Directive for indicative (Class 1) methods for particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2)	NO_2: 25% uncertainty $PM_{2.5}$: 50% uncertainty	NO_2: 9% uncertainty $PM_{2.5}$: 19% uncertainty (network means)
Ensure a minimum 90% of sensors are in operation at any given time (target shows % of hours where >90% of sensors were operational).	100% of hours	99.9% of hours
Increase the number of sensors in the network by an additional 5% per year by allowing the website to integrate data from sensors owned by Londoners, businesses and organisations	5% expansion year on year	12% expansion in Q1 and Q2 2022 combined
Website must be live continuously and display data in real time from the sensors	End of March 2021	Launched 15 March 2021
Data must also be available via an Application Programming Interface (API)	Not specified	Launched December 2021

1. Introduction

Breathe London is a new partnership between the Mayor of London, Imperial College London (facilitated via Imperial Projects) and Bloomberg Philanthropies. The Mayor initially provided funding for 130 air quality sensor nodes at hospitals, schools and other priority locations. This was subsequently increased to 136 to include Business Low Emission Neighbourhoods and other projects. Data are displayed on the network website – www.breathelondon.org.

Community groups, charities, businesses, individuals, academics, and boroughs are also able to “buy in” to the Breathe London network to source air pollution data for local projects or schemes.

This report summarises progress on building the network during April to June 2022.

2. Deployment of nodes

KPI: Install, maintain and insure air quality sensors at 100+ sites

During the second quarter of 2022 an additional fifteen nodes were deployed (Table 2). These were a mix of Bloomberg sponsored Community group nodes, commercial and local authority buy ins and Southeast London Clinical commissioning Group nodes, bringing the total number of nodes to 308.

3. Quality assurance and quality control

KPI: Demonstrate sensors continue to meet the uncertainty requirements of the EU Air Quality Directive for indicative (Class 1) methods for particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2)

The quality performance of the nodes is assessed using the methodology recommended in EU guidance. Uncertainty is calculated at the hourly limit value (200 µg m^{-3}) for NO_2 and the indicative threshold is 25%, the uncertainty for $PM_{2.5}$ is calculated at the daily limit value of 35 µg m^{-3} and the indicative threshold is 50%.

The basic calibration and scaling process applied to Breathe London nodes is described in the first quarterly report (available at https://www.breathelondon.org/network-reports). In December 2021 we implemented phase 2 of our calibration process with the introduction of dynamic network scaling. To develop this method we needed a long time series of sensor data incorporating a wide range of meteorological conditions, thus it could not be applied from the network launch.

All network data, historical and ongoing, are now scaled using the new correction method. Users of the data prior to 1 January 2022 should note that they should update any historical data archives that they hold to reflect this change.

Table 2: Number of GLA and other sponsored nodes deployed and in operation in each London Borough as of the end of June 2022

Borough	Reference sites	Hospitals	Schools	Special projects[1]	Hot & cold spots	Local Authority designated	Other sponsored	Total
Barking and Dagenham						1	5	6
Barnet			2		1	1		4
Bexley	1				1	2	1	5
Brent	1				1	2	1	5
Bromley					1	1	1	3
Camden		2	2			1		5
City of London					1	1		2
Croydon				1		1	11	13
Ealing			1		2	1		4
Enfield						1		1
Greenwich	5		2			6	1	14
Hackney			1			1	1	3
Hammersmith & Fulham		1	1	1		1		4
Haringey		1	1			1	1	4
Harrow						2		2
Havering	1		1		1	2		5
Hillingdon						2		2
Hounslow			1		1	1		3
Islington			2			1		3
Kensington & Chelsea	1	1	3		2	1	3	11
Kingston					1	1	11	13
Lambeth		1	1			1	1	4
Lewisham	3		1	1		2	1	8
Merton					1	1	68	70
Newham		1		1		1		3
Redbridge	1		1	1		2	1	6
Richmond			1			1	45	47
Southwark	1	1	3		1	2	1	9
Sutton	1					2	7	10
Tower Hamlets	1	1	5	1	1		2	11
Waltham Forest		1		1	1	1	1	5
Wandsworth			3	1		1	1	6
Westminster	3		1		3	2	8	17
Totals	19	10	33	8	19	47	172	308

[1] Business Low Emission Neighbourhood, Greener Together and Ella Roberta Family Foundation

The basic correction method used a linear correction algorithm generated from the node and the reference instrument derived from an initial 10-14 day co-location at the Honor Oak Park London Supersite prior to deployment. These correction factors were applied to all subsequent data collected at the node's destination location. However, it is well established that electrochemical NO_2 sensors and light scattering $PM_{2.5}$ sensors of the type used in Clarity nodes, and most other lower capital cost sensor units on the market, perform differently dependent on meteorological conditions. Breathe London therefore developed and uses a dynamic correction method that can react to changes in conditions.

As described in our previous report, the dynamic network scaling method now implemented takes advantage of the network's partner reference monitoring network – the London Air Quality Network (LAQN). As shown in Table 2, 19 nodes are permanently co-located with LAQN reference monitoring sites. These sites are in a range of locations from kerbside central London to suburban outer London. Every hour the previous 24 hours of data from the node and its paired reference monitor are compared to produce a multivariate correction factor incorporating relative humidity, regional ozone concentration, reference NO_2 concentration and reference $PM_{2.5}$ concentration. These factors are aggregated according to site classification – kerbside, roadside and background – and then applied to the node measurements across the network according to their own classification. Dynamic scaling is applied in real time and prior to dissemination on the network web pages and API. Thus, correction factors dynamically adjust to current for meteorological conditions and pollution climate.

This hybrid monitoring network approach, where a small number of expensive higher performance reference monitoring sites are used to improve the accuracy of a larger network of low cost sensor nodes, is now being presented as a way of rapidly increasing the scope and quality of air quality information in cities across the world without prohibitive associated direct costs (but dependency on suitable reference monitoring networks remains essential to the performance of this sensor network). Breathe London is a case study for the effectiveness of this method.

Network mean uncertainty at the EU Limit Value across the quarter is shown in

Table 3. These percentages are based on all nodes passing through the co-location dynamic calibration process during the reporting period. We can only report uncertainty for sensors when they are undergoing their 10-14 day calibration. After deployment, we use well established methods similar to those used to manage the LAQN and other UK reference monitoring networks to identify sensors that are not performing as they should.

10 nodes passed through the calibration process prior to deployment during this quarter. All passed the $PM_{2.5}$ target uncertainty of 50%. 10% (1 node) failed the tougher NO_2 target of 25%, although only marginally. The mean uncertainties are shown in Table 3.

Table 3: Uncertainty targets for indicative methods and corresponding uncertainties at the EU Limit Values during the reporting period (January to March 2022)

Pollutant	Target uncertainty (%)	Mean measured uncertainty (%)	Proportion of nodes not achieving target
NO_2	25	9	10% (1/10 nodes)
$PM_{2.5}$	50	19	0% (0/10 nodes)

4. Data capture

KPI: Ensure a minimum 90% of sensors are in operation at any given time

The data collection system created to interface between the nodes and Breathe London website is described in the first quarterly report (available at https://www.breathelondon.org/network-reports).

Data capture across the quarter is shown in Table 4. These percentages are based on a count of all valid hourly mean concentrations recorded by nodes deployed at permanent sites (i.e., not undergoing calibration at reference sites) throughout the period April to June 2022.

As expected during this quarter data capture rates increased in comparison to the previous two quarters when solar power was reduced during the winter months. As Table 4 shows, almost no measurements were lost – 99.9% of all hours in the quarter reported measurements from at least 90% of the network. During periods of low battery power the node will incrementally reduce its sampling frequency until, occasionally, it reports less than one measurement an hour. In these cases, a measurement will be reported the next hour ensuring that a continuous data series is maintained.

Table 4: Data capture for all deployed nodes over the reporting period (January to March 2022)

Pollutant	Network mean data capture	Hours with 90% of nodes in operation
NO_2	99.0%	99.9%
$PM_{2.5}$	98.7%	99.9%

5. Network expansion

KPI: Increase the number of sensors in the network by an additional 5% per year by allowing the website to integrate data from sensors owned by Londoners, businesses and organisations

The Breathe London network continued to expand in the second quarter of 2022, adding 15 nodes to the 19 added in the first quarter. The total number of nodes being 308, an increase of 12% compared to the total number of nodes deployed in 2021. All GLA sponsored nodes have been deployed.

Additional funding provided by Bloomberg Philanthropies to provide free nodes to disadvantaged communities was described in the first quarterly report (available at https://www.breathelondon.org/network-reports). The Breathe London Community Programme was launched in October 2021, offering the first 10 nodes to community groups who applied to the scheme. A second round of 30 further nodes will be launched in the autumn of 2022. Further details can be found at https://www.breathelondon.org/apply.

6. Website development

KPI: Website must be live continuously and display data in real time from the sensors

The website launched in March 2021 with a live map showing the location and current daily air quality index of each deployed node alongside a selectable layer of LondonAir reference sites. Air Quality England data has been included since February 2022. Further details were provided in the first quarterly report. The website is continually updated with community stories describing use of Breathe London data, feature enhancements and events, such as the Community Programme.

Following recent feedback, updates to the website are being undertaken and are expected to be completed during September.

The number of visitors to the website has slightly increased since the first quarter averaging at over 550 per week.

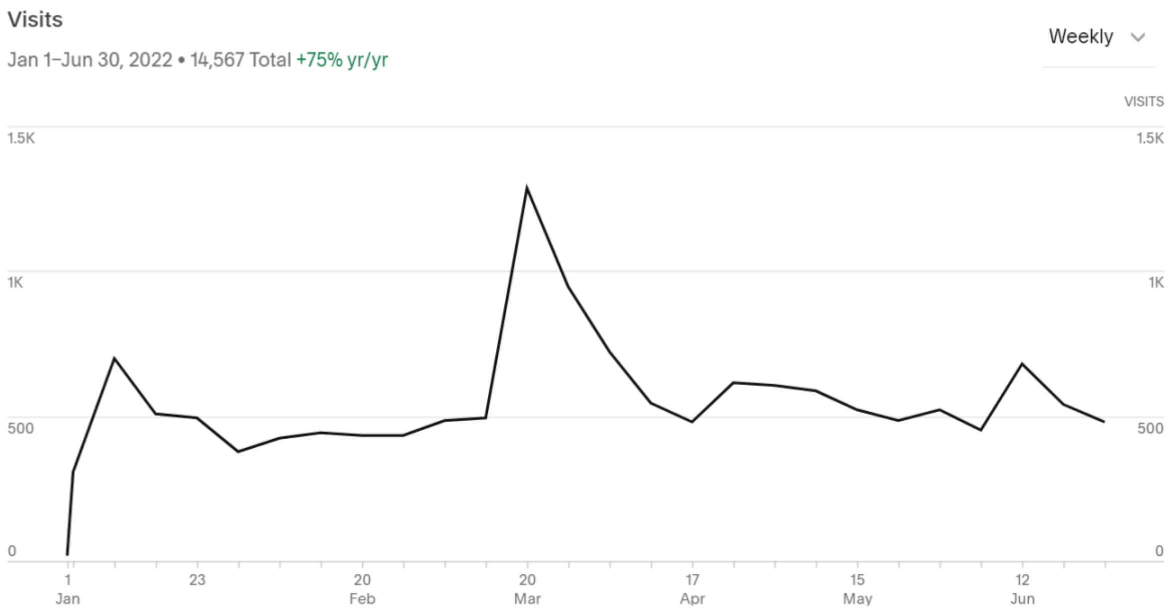

Figure 1: Weekly time series of visits to the breathelondon.org website year to June 2022.

7. Application Programming Interface (API)

KPI: Data must also be available via an Application Programming Interface (API)

An Application Programming Interface (API) for Breathe London data has been available since November 2021, following the update to our correction method. This allows users to request site details and data feeds from all nodes between specified dates. Technical details can be seen here: https://api.breathelondon.org/docs/. Users can register for use on the Breathe London website linked from the home page: https://www.breathelondon.org/developers.

The full launch was in June 2022 and the developers page now includes the new automated key sign-up flow. A caching layer has also been developed to ensure load resilience as more users come on board.

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