UIA URBAN INNOVATIVE ACTIONS

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JOURNAL

PROJECT

HOPE - Healthy Outdoor Premises for Everyone

Helsinki, Finland

TOPIC

Air quality

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The legacy of HOPE – final journal

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After closing in April 2022, the UIA HOPE project leaves behind a lasting legacy. The project piloted in Helsinki a next generation of air quality monitoring technology that gave residents of the Finnish capital the opportunity to track their own personal exposure to air pollutants, and at the same time supported the improvement of city-wide air quality modelling. HOPE has successfully demonstrated the suitability of cost-effective air quality sensor networks to support district-level urban planning and pollutant mitigation as well as reduction of individual-level pollution exposure.

Executive summary

The HOPE project was launched to empower the residents of the City of Helsinki, to contribute to the improvement of air quality in their neighbourhoods. Through setting up a comprehensive sensor network in various districts of Helsinki, HOPE provided detailed information on individuals' personal exposure to air pollutants. Networks of both stationary mid-cost sensors and portable low-cost sensors were piloted in the project. During participatory sensing campaigns volunteering citizens were asked to perform air quality measurements in exchange for access to personalized exposure data. The aim of using stationary and portable sensors was to gain better insight into the spatial and time-related variability of concentration of air pollutants in Helsinki, to test the applicability of the innovative technologies.

Measurements of the sensors helped the development of a novel air quality index that can better describe the adverse health impacts of particulates compared to conventional approaches. A participatory budgeting model was developed under HOPE that served to involve residents in the joint development of adequate air quality interventions to be implemented by the City of Helsinki. The participatory budgeting exercise built on the in-depth knowledge provided by the use of the sensor network and the new air quality index. As part of the HOPE project, a GreenPaths online route planning app was developed that shows the user walking and cycling quick routes with good air quality. The City of Helsinki also organized under the project innovation competitions supporting start-ups to develop novel solutions for better use of air quality data and for helping individuals to better understand air quality information. To be able to address different air quality problems, such as traffic, construction, and domestic wood combustion related air pollution, three focus districts were selected in Helsinki, where the activities of HOPE were undertaken.

HOPE proved to be an effective testbed for the application of the sensor technology. The project has successfully demonstrated that stationary mid-cost sensors are quite robust and reliable and that when these devices are deployed in a network, they can increase the understanding of the spatial variations of pollutant concentrations. More cost-effective portable sensor units, developed under the project, were found to be valid tools for indicative air quality measurements and for tracking personal pollution exposure.

HOPE has also delivered novel and easily transferable approaches and tools for reducing exposure to urban air pollution, such as participatory sensing practice or the GreenPaths route planner. The launching of GreenPaths routing tool in Helsinki Metropolitan Area has turned out to be a real success story of HOPE, as the app has become much more popular than originally expected.

Key achievements of HOPE

The HOPE project strived to empower individuals, the residents of the City of Helsinki, to contribute to the improvement of air quality in their neighbourhoods through a wide variety of innovative ways. HOPE was fundamentally citizen focused. Citizens' exposure to air pollutants, their health outcomes and wellbeing, their awareness about air quality, their conscious responses to urban air pollution, and their inclusion in the development adequate air quality interventions were in the centre of all of the actions of the project. The general aim was to raise awareness of air quality in general, and to provide comprehensive information on the various sources and impacts of air pollution. Major goals were to improve knowledge on air pollution hotspots across Helsinki and to strengthen the link between air quality data and responses of individuals and communities to urban air pollution.

In terms of air quality Helsinki is among the cleanest cities of Europe. One may wonder why the city focuses on air quality then? Despite the prestigious ranking of Helsinki, residents are still exposed to poor air quality in the city at certain times and in certain neighbourhoods. Air pollution in the Finnish capital is typically linked to traffic, street dust, wood burning, construction, and long-range transport episodes, when air masses with high particulate concentration arrive from neighbouring countries.

To be able to address different air quality problems, three districts were selected carefully in Helsinki, where the activities of HOPE were undertaken. Jätkäsaari is a rapidly growing new district that hosts a large passenger and cargo harbour and one of the largest construction sites in Helsinki. Vallila is an old city district, with many busy main streets and street canyons, that is exposed to high exhaust gas and particulate concentrations. Pakila is a suburban detached housing area, where the main air quality problem is wood burning in fireplaces and sauna stoves.

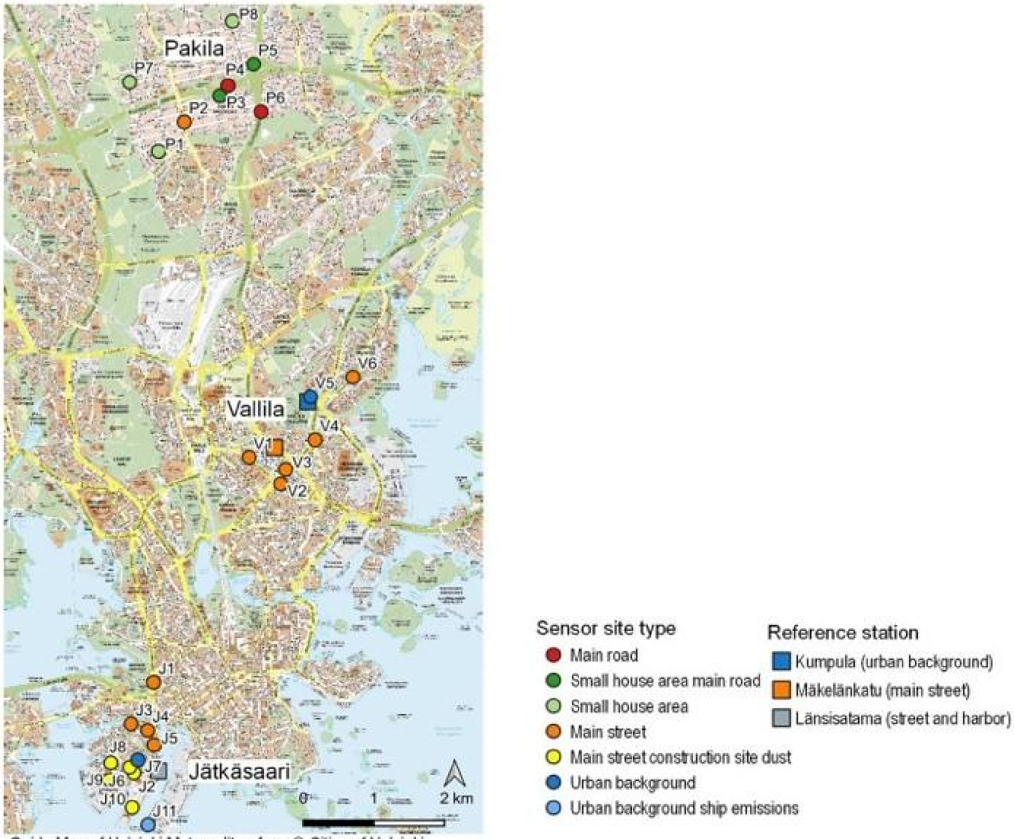
Deployment of a network of stationary air quality sensors

Urban air quality monitoring stations have a particularly high installation and maintenance cost, as well as a bulky nature. For this reason, official monitoring networks, comprising only a limited number of fixed monitoring stations, have a sparse coverage in most cities. Helsinki Environmental Services Authority operates only 11 monitoring sites in the entire Helsinki metropolitan area. These conventional monitoring stations are reliable data sources and are able to provide a good overview of concentration changes of various air pollutants on city-scale, but not necessarily on neighbourhood-level and certainly not on street level. However, pollution concentrations can differ substantially street-by-street in an urban environment. A recent hyperlocal air quality mapping in Copenhagen has shown that the major roads of the Danish capital had on an average five times higher black carbon concentrations than less busy residential areas and it was also indicated that there can be huge concentration differences even within a single city block.

The sparse coverage of large traditional regulatory instruments leads to a lack of reliable high-resolution data that is necessary to develop targeted neighbourhood- and micro-scale interventions that effectively reduce exposure of individuals. The cost-effective air quality sensor technology, which became more and more widely used in the last decade, can offer certain benefits in this regard, providing data with high spatial resolution. Air quality sensors have numerous advantages. They have a relatively low cost, they are easy to install and use, allow fast measurements, and due to their low power consumption and since they rely on wireless data transfer, they can be set up freely in the urban environment. Still, there are concerns about the use of the technology. Air quality sensors have lower accuracy as compared to traditional regulatory instruments, moreover their accuracy degrades further over time.

Vaisala AQT530 stationary mid-cost sensor installed in Helsinki (source: HOPE)

As a response to the sparse coverage of the official monitoring stations, three comprehensive local networks of stationary mid-cost sensors were deployed under HOPE project in Helsinki. The aim was to gain better insight into the spatial and time-related variability of concentration of air pollutants in Helsinki, to test the applicability of the technology, and to demonstrate the added value of the combination of sensors with official monitoring stations. Altogether 25 stationary (Vaisala AQT530) sensors were installed in HOPE. They were distributed within the three target areas of the project. In Jätkäsaari 11 sensors were placed, four of these were installed in busy streets next to the harbour, five nearby construction sites, while two served as urban background. In Vallila six sensors were set up in street canyons to be able to assess the variability of traffic-related air pollution. In the third district, Pakila, eight sensors were deployed to evaluate their suitability to monitor emissions from wood combustion.



A map of Helsinki area with the AQT530 sensor network sites in Jätkäsaari, Pakila and Vallila and with the location of three reference air quality monitoring stations (Source: Petäjä, Ovaska, et al., 2021)

Crowdsourcing high-resolution air quality sensing - portable sensors on mission

The coverage of a conventional air quality monitoring system can be improved substantially by massive deployment of small low-cost sensors, which can be carried around freely. Supplementing the mid-cost sensor network, small and portable low-cost sensor units have also been developed and manufactured under HOPE. The goal was to encourage Helsinki residents to actively participate in air quality measurements and to contribute to reducing pollution in their neighbourhoods. The activity also aimed to test the capacity of portable sensor units for detecting air quality fluctuations and their suitability to provide easily understandable information on real-time individual exposure. The HOPE partnership relied on crowdsourcing: volunteering citizens were asked to engage in participatory sensing campaigns, performing air quality measurements in exchange for access to personalized exposure data. The community-based monitoring system allowed simultaneous measurement of concentration of air pollutants in the three focus districts of the project.

The University of Helsinki, a partner to HOPE, developed the battery-powered sensor unit and a mobile phone application which, using the data measured by the sensor, visualizes personal pollution exposure. The sensor units register various air pollutants (PM_1, $PM_{2.5}$, PM_4, PM_{10}, NO_2, CO, O_3) and other parameters such as temperature, relative humidity, air pressure, UV, as well as positioning information. The size of the sensor units is only slightly larger than a mobile phone, they can be easily attached to a backpack.

HOPE sensor unit developed by the University of Helsinki attached to a backpack (Source: Rebeiro-Hargrave, Fung, et al., 2021)

A cyber-physical system design, MegaSense, was developed by the University of Helsinki to support the participatory sensing campaigns. MegaSense, functioning as a data platform managing the connected sensor units, receives and processes participatory sensing data and provides users of sensors with real-time air quality information. Sensor units can be connected to smartphones which communicate via the app with the MegaSense system.

Between 2019 and 2021 altogether seven data campaigns were organized by the HOPE partnership, during which volunteers living in the three focus districts were asked to carry the sensor units with them. Two data campaigns were held in Vallila and Pakila respectively, and three in Jätkäsaari. Campaigns lasted typically for two to three months. Forum Virium Helsinki, a smart city innovation unit of the City of Helsinki (as a project partner), organized events for distributing and collecting the sensors. Altogether 157 volunteers participated in the data campaigns and they made over 1 million air quality measurements.

Although volunteers were keen to use the sensor units at the beginning of each campaign, their motivation to measure tended to decrease after a couple of weeks. Volunteers were also reluctant to participate in subsequent data campaigns, therefore each time new users had to be approached. To make the scheme more attractive for the users targeted, motivation strategies were applied in the second wave of data campaigns. The look and feel of the user webpage showing personal exposure was improved, an online leader board was launched to encourage competition among participants, and super users were rewarded with 5 EUR vouchers that were accepted at local kiosks.

Improved air quality index and virtual sensors help health risk assessment

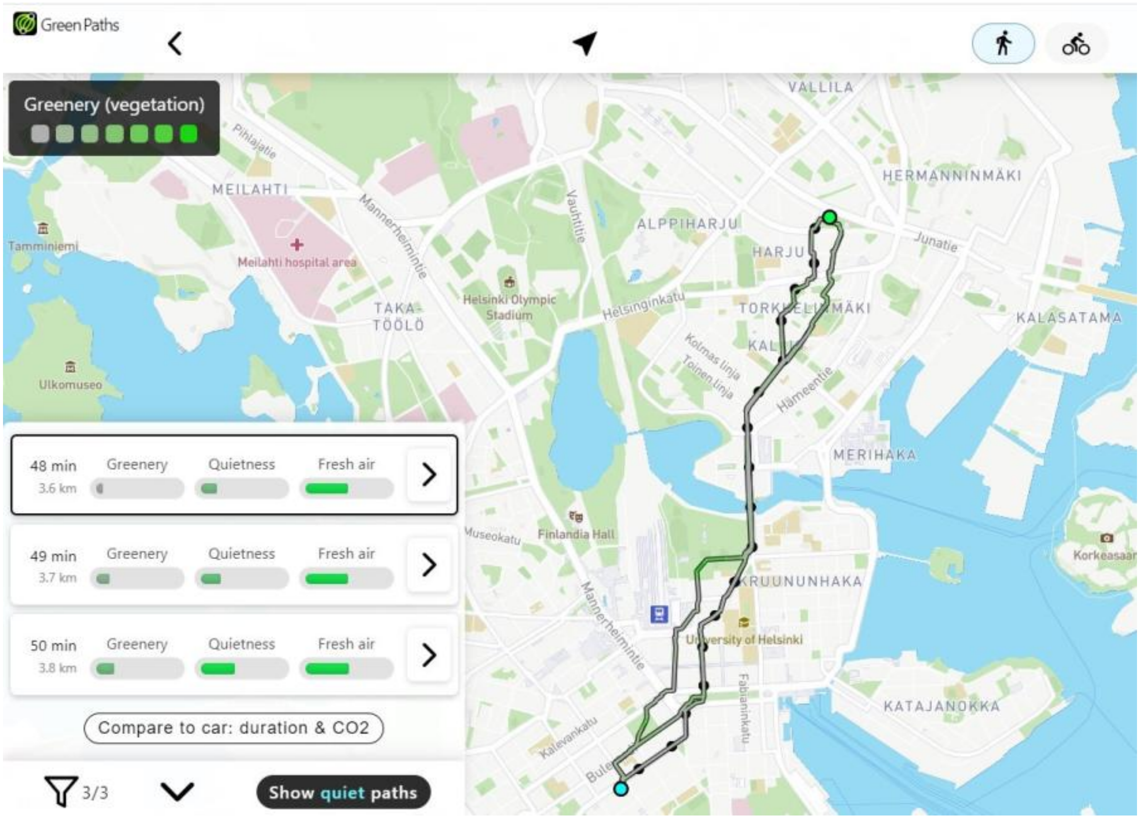
One of the key achievements of HOPE was that a new air quality index called Air Quality Index 2.0 was developed by the University of Helsinki that describes particularly harmful air pollutants in more details. The aim was to create a more user-centric air quality index that facilitates quantification of personal exposure to air pollution as well as more comprehensive health risk assessment. The conventional Air Quality Index used in Finland takes into account O_3, NO_2, SO_2, CO, $PM_{2.5}$ and PM_{10} concentration values. To be able to describe better the adverse health effects of particulate matter, new parameters were added to the updated air quality index, black carbon and lung deposited surface area (the concentration of aerosol expected to deposit in the lungs after inhalation). Air Quality Index 2.0 was tested in measurement campaigns organized in the three focus districts.

Ultrafine particles (UFPs), the size of which are less than 0.1 micrometres in diameter, have more harmful health effects than larger particles because they can penetrate deep into the lungs due to their extremely small size and can even pass through the lung tissue into the bloodstream. As low-cost air quality sensors do not measure UFPs, only larger particles ($PM_{2.5}$ and PM_{10}) statistical proxies that function as virtual sensors were created under HOPE to indicate the concentration of UFPs. The effect of UFPs can be assessed based on measurement of black carbon concentration and lung deposited surface area. Since black carbon and lung deposited surface area, similarly to ultrafine particles, are not monitored in the HOPE project, virtual sensors were developed for them. They are computed from other physically measured parameters and function as input values for Air Quality Index 2.0.

Thanks to HOPE sensor data, the Finnish Meteorological Institute upgraded their city-wide air quality model, ENFUSER, adding new features to the modified version. Among others, the new version includes black carbon, carbon monoxide concentrations and lung-deposited surface area as modelled parameters, it allows real time connection to air quality sensors, and it supports the use of Air Quality Index 2.0.

Route planner showing walking and cycling routes with good air quality

One of the ambitions of the HOPE partnership was to visualize real-time air quality for citizens and to guide them to healthier routes in their everyday routine. The Digital Geography Lab of the University of Helsinki has developed a novel GreenPaths exposure-optimised routing tool for the Helsinki Metropolitan Area building on real-time air quality data. With the help of the GreenPaths app, users can find quick routes while avoiding busier and noisy streets with poor air quality. The app covers the four municipalities of the Helsinki Metropolitan Area: Helsinki, Vantaa, Espoo, and Kauniainen. The GreenPaths route planner finds cycling and walking routes with the best air quality, or with the least noise, or with the greenest streetscapes.



View of the user interface of the Green Paths routing tool (Source: HOPE)

The app optimises route choices based on environmental exposure and the duration of the trip. The tool obtains air quality data from the upgraded ENFUSER modelling system. The GreenPaths software evaluates exposure to real-time air quality using Air Quality Index 2.0. A crowdsourced OpenStreetMap database is used by the tool for displaying the street and trail network. The source code for the route planner is freely accessible on GitHub.

A participatory budgeting scheme serving air pollution mitigation in Helsinki

The HOPE consortium was piloting a participatory budgeting model for air quality interventions in the three focus districts to foster citizen participation in the project and to raise awareness of air quality in general. As part of the participatory budgeting exercise, to help citizens, a list of interventions beneficial for the air quality was created by an expert panel and an online information and voting app was developed by UseLess Company. During a public campaign undertaken in November 2020, the users of the app could vote for air quality measures from the list to be implemented in their districts. The interventions were linked to sustainable lifestyle, transport, and domestic wood burning. Over 500 votes were cast during the campaign. The selected interventions were implemented by the City of Helsinki between January and December 2021.

Altogether twelve selected interventions were implemented under HOPE. The first six measures with the most votes were all linked to transport. As part of the most popular intervention, 230 free season passes were offered for the Helsinki City Bike System, a bike sharing scheme managed by Helsinki Regional Transport Authority. The implementation of a shared e-cargo bike system in Jätkäsaari was the second most popular measure. As street dust can be a significant problem in Helsinki, particularly in springtime, street washing and dust-binding activities also ranked quite high.

Each year, when the snow melts, the City of Helsinki struggles with a spring dust season. Street dust is mostly caused by pavement material that is ground off by studded winter tires. Consequently, the City of Helsinki aims to reduce the share of studded tires from around 70% to 30% by 2030. As a response, as part of one of the HOPE interventions, a discount campaign was launched in which sets of friction winter tires were offered to car owners at reduced price. During the campaign 109 sets of non-studded winter tyre sets were sold in less than a month. In another intervention novel winter tire monitoring systems were tested.

Domestic wood burning in Helsinki is responsible for the emission of more fine particles than traffic. The Helsinki Environmental Services Authority was taking responsibility for one of the interventions and organized communication campaigns to provide advice to residents on how to store wood and how to stack and ignite it in the fireplace to avoid incomplete combustion and excessive smoke. Under the scheme the chimney sweeper service provided in person guidance to homeowners on proper wood burning.

Visualisation of air quality data supported through innovation competitions

Visualisation of air quality information is key for making a difficult topic more understandable for citizens and urban practitioners. The project partnership sought new approaches for visualising the results of HOPE. To be able to draw on resources of external expertise, open innovation competitions was organized by Forum Virium Helsinki, a smart city innovation unit of City of Helsinki in 2020. The aim was to offer companies opportunities to develop solutions for visualising air quality data provided by the MegaSense system. A secondary goal was to raise awareness of air quality in general in Helsinki with the help of novel, innovative tools. In practice, the scheme was an effective mean for the HOPE partnership to buy pilots as services.

Originally only one round of innovation competition had been foreseen, but seeing the success of this one and due to some unspent budget amounts becoming available, a second round was also organized. Solutions building on internet of things, virtual reality, augmented reality and artificial intelligence were in the focus. In the second round of competition applicants were asked to submit plans for innovative digital solutions linked to air quality interventions implemented under HOPE. The winners had an opportunity to introduce their solutions in the focus districts of HOPE. Altogether ten solutions were selected to be implemented.

One of them, Gispo Oy developed an open tool that was designed to use the data from the ENFUSER air quality model of the Finish Meteorological Institute (FMI) and visualise it to promote the comprehensibility of air quality data. The user can upload ENFUSER data or other meteorological data of FMI to a free and open-source geographic information system, QGIS. As a result, 3D maps are developed on which higher peaks indicate higher concentration of air pollutants.

On the 3D map of the tool developed by Gispo Oy the highest peaks show higher PM2.5 pollution (Source: Gispo Oy)

In another pilot project, xD Visuals Oy provided direct support to urban planners, by integrating the ENFUSER air quality data into the three-dimensional digital twin of the City of Helsinki. Building placement, traffic arrangements, landscaping and their effects on air quality can be simulated by the digital twin, making possible the integration of air quality data into the city planning process.

The simulation of air quality impacts of building placement and landscaping by the digital twin of the City of Helsinki developed by xD Visuals Oy (Source: xD Visuals Oy)

In contrast, Stereoscape Oy was targeting residents by creating and air quality guide that is made of an animated map and detailed information cards.

Pegasor Oy opted for developing a new sensor that is suitable for real-time measurement of the concentration of ultrafine particles.

Other tools piloted included among others:

- an app using augmented reality that overlays digital content on air quality on top of the picture of the real world as the user moves the camera of a tablet or a smartphone;
- a tool that forecasts changes in pollutant concentrations using machine learning and artificial intelligence;
- an app, which using air quality data and location data monitors the user's personal air pollution accumulation;
- a gamified digital app for children and young people.

Progress since project closure and long-term sustainability

The HOPE project proved to be an effective testbed for the application of the sensor technology and for crowdsourcing-based air quality monitoring. The project delivered novel and easily transferable approaches and tools for reducing exposure to urban air pollution, such as participatory sensing practice, the GreenPaths route planner, or the Air Quality Index 2.0. Soon after project closure, HOPE already had lasting impacts, as based on its various activities a number of pioneering initiatives have been launched in the City of Helsinki and beyond Finland.

Following up on HOPE the University of Helsinki, the Finnish Meteorological Institute and the Helsinki Region Environmental Services Authority collaborates on the Urban Air Quality 2.0 project to establish in the Helsinki Metropolitan Area an open a data platform that is based on air quality measurements and modelling. The project aims to make air quality data more understandable and accessible, to discover new uses for air quality data with the help of researchers, residents and businesses, and to continue the development of the GreenPaths route planner.

The achievements of HOPE have already been taken forward beyond Europe. Under a programme of UN-Habitat and UNEP, building on the experiences of the HOPE project, the University of Helsinki together with other project partners was piloting sensor-based monitoring systems in Kigali (Rwanda), Quito (Ecuador), Kathmandu (Nepal) and Almaty (Kazakhstan). Under the project portable sensors were used to make air quality observations and basic versions of the ENFUSER air quality modelling system and the GreenPaths software were developed. One of the goals was to set up city-wide air quality forecast models based on a combination of citizen collected data and national and international datasets.

In the meantime, the researchers of the University of Helsinki are working on a newer version of the mobile sensor units, which were used in participatory sensing campaigns in HOPE. The upgraded devices are able to measure more frequently and, as compared to the previous generation of sensors, can be used to monitor the concentration of volatile organic compounds and noise level.

Some of these pilot projects implemented through the innovation competitions of HOPE have turned out to be more than only simple, short-lived experiments, as they still exist. Some pilot projects have triggered long-term cooperations with HOPE project partners. Since HOPE has been closed, xD Visuals Oy has been working with the urban planning team of the City of Helsinki. Pegasor Oy is currently involved in a project with Helsinki Region Environmental Services Authority on black carbon footprint, and continues collaboration with the City of Helsinki.

Generated knowledge

Key lessons learned

The HOPE project has provided a series of important lessons for urban practitioners dealing with air quality. Firstly, HOPE has successfully demonstrated that through hyperlocal, near real-time measurements, a network of stationary mid-cost sensors can increase the understanding of the spatial variations of pollutant concentrations.

The high-resolution data produced by such networks offers numerous practical benefits for urban planning and pollutant mitigation. If detailed and precise information is available on how construction-related PM_{10} concentrations are evolving in space and time, then dust-prevention actions, such as street cleaning and dust binding can be effectively optimized. Similarly, high-resolution information on the variations of transport-related NO_x concentrations can support traffic management and city planning. For instance, in Jätkäsaari the measurements of the sensor network indicated that the concentration of black carbon peaks on Saturdays and Wednesdays. As a response, traffic calming measures were adopted by the City of Helsinki on Saturdays and Wednesdays in the district. Data sourced from clusters of sensors can also be used to tackle emissions linked to domestic wood combustion and raise awareness regarding the issue.

It is crucial to bear in mind that mid-cost sensors have lower accuracy than conventional air quality monitoring stations. It was clearly demonstrated under HOPE that the accuracy of the sensors can be improved significantly if they are calibrated with the help of traditional regulatory instruments. Calibration allows the development of correction factors allowing data validation.

The results of the participatory sensing campaigns with portable low-cost sensors have also proven to be promising. A good correspondence has been found between the data of calibrated mobile lightweight sensors and the measurements of official air quality monitoring stations. The sensor units developed by the University of Helsinki proved to be valid tools for indicative air quality measurements and for tracking personal pollution exposure. Those who are involved in the measurements will have more conscious behaviour and will be more likely to avoid such hotspots, reducing their personal exposure to air pollution. If mobile sensors are connected to form networks, as it was the case under HOPE, then the personal exposure profiles can be aggregated to shed light also on population exposure to air pollutants. When sensors are used to monitor neighbourhood-level air quality, data gaps resulting from the ad-hoc pattern of citizen use can be bridged by continuous and long-term measurements.

Jussi Kulonpalo, project manager of the HOPE project, pointed out that HOPE could change the general opinion about the devices:

> There are lots of cheap low-quality air quality sensors on the market and the scientists do not regard the idea of low-cost air sensoring very highly. However, the portable sensors developed in the project turned out to be very accurate after being properly calibrated. Based on our experience we believe low-costs sensors can be valid tools for the citizens to use.

Potential recommendations to other urban authorities wishing to implement similar innovative projects

Lessons learned and experiences gained during the implementation of HOPE can be boiled down into a number of practical recommendations for other urban authorities aiming to make use of air quality sensor technology and to adopt participatory sensing approaches:

- The application of air quality sensor technology can support the development of targeted neighbourhood- and micro-scale interventions that reduce exposure of individuals.
- The deployment of stationary mid-cost sensors can help in optimizing actions targeting at street cleaning and traffic management, or in mitigating pollution linked to domestic wood combustion.
- Portable sensors are particularly useful for measuring individual pollution exposure and for locating air pollution hotspots.
- Gamification and offering small rewards can help maintain the motivation of volunteers engaged in participatory sensing campaigns.
- Visualisation tools that integrate hyperlocal air quality data can effectively support the city planning process.
- The adoption of an air quality index that includes black carbon and lung deposited surface area can describe better the adverse health effects of particulate matter.

Main legacy of HOPE in terms of knowledge creation

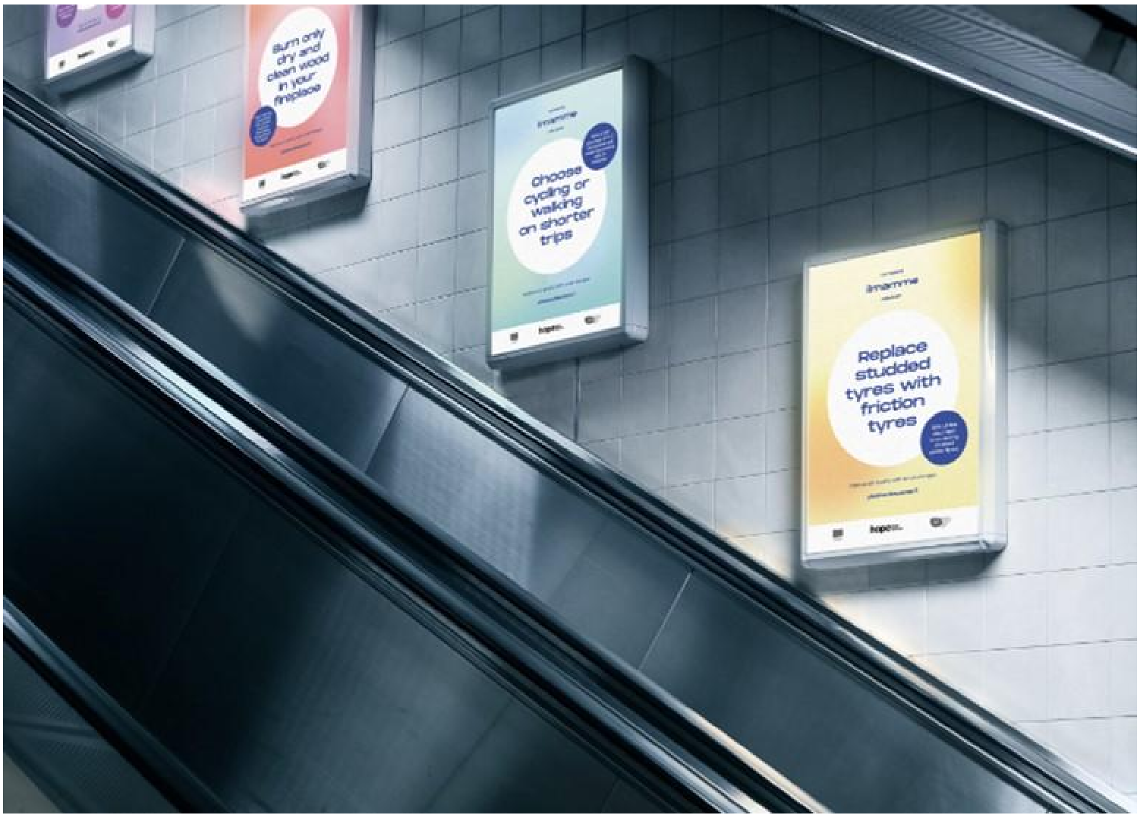
The HOPE partnership instead of relying on expensive measurements, made smart use of statistical proxies. The consortium managed to develop effective virtual sensors for black carbon and lung deposited surface area, which might be of use for urban authorities beyond Finland. These new virtual sensors can be feasible and economical alternatives to costly conventional physical sensors, acting as their digital twins. During the tests, the virtual sensing results were remarkably close to actual black carbon and lung deposited surface area values measured at the background site by physical reference instruments.

Virtual sensors were essential for some of the main outputs of HOPE, such as the Air Quality Index 2.0 as well as the updated version of the air quality modelling system of the Finish Meteorological Institute. Black carbon and lung deposited surface area are among air quality parameters included in the Air Quality Index 2.0 developed by the University of Helsinki. The Air Quality Index 2.0, that can help assessing health-related impacts of air pollution, has a potential to be adopted in other cities across Europe.

Respondents of a survey carried out under HOPE called for more accessible and personalized air quality information. The visualisation tools promoted by the innovation competitions, that converted raw data into attractive images, maps and animations, served to improve the comprehensibility of the air quality. The participatory budgeting exercise through active engagement have drawn the attention of Helsinki residents to the importance of street cleaning, the use of friction tires, and proper wood burning. A massive communication campaign with robust social media activity managed to put a spotlight on air pollution in Helsinki, one of the cleanest cities in Europe, where air quality is far from being considered a priority issue.

HOPE was advertised on a wide range of media outlets, such as television, social media, newspapers, and the website of the project. The activities of the project were presented in the morning show of the national public service television channel. During an intensive media campaign organized to promote the participative budgeting scheme, three one-minute drone-filmed video ads were produced, one for each of the three focus districts of the project. The videos were posted using the geographical targeting features of Facebook for residents living in the target areas.

The coronavirus restrictions forced the consortium to organize virtual events instead of physical ones. To avoid lower participation rates that are common in virtual events, a more robust communication campaign than originally planned had to be undertaken. At the end of the project, a large-scale final communication campaign was organized on HOPE using digital screens in metro stations and large billboards in tram stops across Helsinki.



Final communication campaign on HOPE in the Helsinki Metro (source: HOPE)

Main legacy of HOPE in terms of solutions implemented

The launching of GreenPaths route planer in Helsinki Metropolitan Area has turned out to be a real success story. The app has become much more popular than originally expected. There was a huge interest among Helsinki residents in the tool even when only its Beta version was available for users. GreenPaths had approximately 14,000 users in 2020. Jussi Kulonpalo has highlighted:

> Looking back, the GreenPaths clean air routing concept is probably the main output of the HOPE project. The consortium intended it originally only as a proof of concept, but it worked very well and became quite popular in Helsinki. I think it has great potential for other cities too in many ways.

By making publicly available the source code of the route planner on GitHub, the HOPE partnership invites other cities and developers to adapt the tool to their own specific needs.

The HOPE project also had a lasting impact on city-wide monitoring of air quality in Helsinki. Due to the results of the pilot activity undertaken in the project, the Finish Meteorological Institute updated ENFUSER, the air quality modelling system it uses in Helsinki Metropolitan Area. The upgraded model includes new parameters, such as black carbon and carbon monoxide concentrations, and it also enables the use of the Air Quality Index 2.0 that was developed by the HOPE partnership. Thanks to these changes ENFUSER provides a more comprehensive picture on health impacts of urban air pollution.

A key development of the project was, that the network of stationary mid-cost sensors has proved to be quite robust and reliable. For NO, NO_2, CO and PM_{10} the measurements by the individual sensors correlated well with the reference measurements (although the correlations were found to be weaker in case of O_3 and $PM_{2,5}$). The viability of the mid-cost sensor technology is well illustrated by the fact that after HOPE had ended, the Helsinki Environmental Services Authority, a partner to HOPE, has taken the sensors over, and following their relocation, successfully integrated them into the monitoring network of the city. During project implementation the Finish Meteorological Institute managed to integrate not only the data of mid-cost sensors, but also that of portable low-cost sensors into their system. After project closure the University of Helsinki started to lend the portable sensors used during participatory measurement campaigns to schools so that teachers can educate students on exposure to air pollution and on measuring various pollutants. All in all, based on the outcomes of the project, from the perspective of urban authorities, mid-cost sensor technology seems to be more promising in the short-term than low-cost sensor technology.

Conclusions

The results of HOPE indicate that a breakthrough in the sensor technology is imminent, which can radically transform air quality monitoring in cities. The high-resolution and near real-time data provided by sensor networks can support city planning, the identification of air pollution hotspots, forecasting changes in pollutant concentrations, and monitoring trends in air quality. As HOPE has revealed, sensor networks can be particularly useful for optimizing localized air quality measures linked to street cleaning, traffic management, or domestic wood combustion, as well as for detecting personal exposure to air pollutants. More sophisticated stationary sensors can already be integrated into official monitoring networks, as it has been demonstrated in the City of Helsinki. The fact that the accuracy of the devices tested under HOPE was higher than expected indicates that there appears to be a strong potential for various applications of the sensor technology.

The mission of the HOPE project was to raise awareness about urban air pollution and to empower residents of Helsinki to actively contribute to the improvement of air quality across the city. The GreenPaths routing tool, the participatory budgeting exercise and the innovation competitions, all served to bring the issue of air quality closer to people. The use of participatory approaches, such as crowdsourcing-based sensing campaigns and a participatory budgeting exercise had a crucial role in increasing awareness of Helsinki residents of air pollution and in making the topic of air quality monitoring more understandable for citizens.

References

Rebeiro-Hargrave, A., Fung, P. L., et al. (2021) City Wide Participatory Sensing of Air Quality. Frontiers in Environmental Science, Vol. 9, DOI=10.3389/fenvs.2021.773778, ISSN 2296-665X, https://www.frontiersin.org/articles/10.3389/fenvs.2021.773778

Petäjä, T., Ovaska, A., et al. (2021) Added Value of Vaisala AQT530 Sensors as a Part of a Sensor Network for Comprehensive Air Quality Monitoring. Frontiers in Environmental Science, Vol. 9, DOI=10.3389/fenvs.2021.719567, ISSN 2296-665X, https://www.frontiersin.org/articles/10.3389/fenvs.2021.719567

Mahajan, S. (2022) Design and development of an open-source framework for citizen-centric environmental monitoring and data analysis. Sci Rep 12, 14416, https://doi.org/10.1038/s41598-022-18700-z

https://blog.google/products/maps/100-million-air-quality-measurements-with-air-view/

https://www.uu.nl/en/news/project-air-view-measurements-result-in-hyperlocal-map-of-air-quality-in-copenhagen

https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution

https://www.hsy.fi/en/environmental-information/projektit-ja-hankkeet/urban-air-quality-2.0-project/

https://www.helsinki.fi/en/researchgroups/sensing-and-analytics-of-air-quality/about-megasense

Air quality

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