# D5-4: Estimated impacts across the customer base

# Table of Contents

# 1. Introduction

The Helsinki metropolitan Air Quality Testbed is expected to have various impacts on society. It will affect different parts of society in different ways: for example, the residents of the Helsinki metropolitan area will be able to follow air quality in their surroundings in a more precise way than earlier, and the project will give city authorities deeper insight to air quality issues, which will support them in city planning and construction, among other things.

In HAQT deliverable report D5-3, “Analysis of services to support decision making”, we proposed several services and applications that utilize the AQ measurement data and the ENFUSER-modelled AQ data, including local forecasts. These services and applications include an AQ-based route planner, a warning system for occasional bad air quality, support to city authorities in street dust situations, and others. This suggests that the HAQT project itself and the opening of the ENFUSER data may present valuable possibilities to improve the health and well-being of citizens and the society.

In this report, we consider the impact of the project and its possible by-products in a more generalized way. The expected effects on each customer group – citizens, city authorities, companies and academia – will be presented separately.

In addition, we look at the international significance of the project and the interest already shown towards it. The NAQT project in Nanjing, China is presented as an example of the international possibilities and also as a means to improve the whole concept of HAQT.

# 2. Benefits for citizens and societal impacts

The residents of the Helsinki metropolitan area now have an easily accessible source for their local air quality in good spatial and time resolution as well as forecasts of the air quality for hours ahead. This makes it easier for them to plan their outdoor activities, routes etc. from the perspective of air quality. This is especially useful for people with asthma or other respiratory illnesses. Additionally, they can benefit from the opening of AQ measurement and forecast data if applications such as a warning system for bad air

quality (see D5-3, chapter 3) are implemented. Other services presented in D5-3 can have a positive effect to the health of other demographic groups, such as elderly people or children in daycare.

The obvious benefits of avoiding places with bad air quality are related to health. Risk groups can take better care of their health, but the same goes for healthy people too: choosing the cleanest route and the most suitable time for outdoor activities helps them maintain their health and increase their well-being. The data can also be used in e. g. sports tracking applications. After data has been gathered over a longer time period, it can be used to compare residential areas by their average air quality; this will support people who are planning to move house.

In a more general sense, the availability and spread of any environmental information will increase the general public's understanding and interest in environmental issues, energy production and politics, to name a few. As these issues have become more and more important in public discussion, people are also more likely to make use of any useful, well crafted applications in this territory. HAQT and its possible add-ons and successors will be a part of a movement building a cleaner and smarter society. Along the way, all this will possibly create all kinds of jobs that don't even exist yet.

In this sense, citizens will benefit indirectly from any assets gained by city authorities, businesses etc. These are presented in the following chapters.

## 3. Benefits for city authorities and government

The fact that citizens can take better care of their health is of course beneficial to the government also: it may reduce the costs of public health care in the long term. But HAQT brings other, more direct benefits from the governor and city authorities' point of view also.

The most obvious of these impacts is the help that HAQT provides for the mandatory environmental monitoring, which is a responsibility of project partner HSY (Helsinki Region Environmental Services Authority). Adding the new sensor network and model forecasts into their air quality monitoring procedure will certainly benefit HSY. Also, the information gathered during the project will be usable in future development of low-cost air quality

monitoring networks as well as applications for e.g. warning the citizens about bad air quality.

As presented in D5-3 (chapter 4), HAQT data was opened for Helsinki City Construction Services (Stara) in the spring of 2018. The purpose of this is to support Stara in management of street dust situations, which are an important cause of decrease of air quality in urban areas particularly in springtime Finland. The availability of high resolution AQ data can also help city authorities locate the spots where air quality is decreased due to traffic. This information, gathered over a longer time period, may be used to reorganize traffic and transport in urban areas.

More generally, there are several benefits for urban planning and construction. With the help of long-term air quality information and research, optimal solutions for both small and larger scale planning can be found. For example, the ENFUSER data can help in tracking the spread of particles that decrease air quality. If city planners understand the spreading of pollutants, it is possible to make progress in air quality issues throughout the whole urban area instead of only moving the existing problems to different locations.

It may also be worth noting that decentralization of services – be it due to urban air quality issues or any other reason – can encourage private motoring, which can have an adverse effect on AQ and the mitigation of climate change. Thus, accurate information about the spreading of pollutants is needed in planning. On the other hand, air quality information can be used to encourage climate-friendly actions, such as riding the bicycle instead of driving a car – in HSY's map, air quality is clearly and continuosly worse along roads with heavy traffic, and this well visualized fact may be used as an easy "marketing tool" for climate friendliness.

Another benefit from the governor's perspective is improving the brand of the Helsinki metropolitan area and making it more attractive to tourists as well as foreign companies, scientists and labour. With the help of HAQT, Helsinki can act as a forerunner in air quality matters, smart cities, healthy living and digital services, for example. The achievements of HAQT can be made visible in marketing. In airports and harbours, where tourists enter the city, air quality maps can be shown on screens in the same way that is already done in public transport (trams, metro) in Helsinki. Tourists, of course, bring money to the city and increase revenues of companies and the liveliness of the area.

# 4. Benefits for business and export

As people in Finland are growing more and more interested in environmental issues, there could be interest to further develop the HAQT network as well as expand it to other Finnish cities. This would create more business opportunities for participating companies – who have already, during the project, had the possibility to develop and test their equipment. Depending on how the network would be developed or expanded, other companies could also benefit.

It is fairly obvious, however, that the market for AQ networks like the one built in HAQT is mainly abroad. Different countries and market areas provide different opportunities. While air quality issues are clearly most prominent in East Asia, a HAQT-like system could be applied in any urban area as long as the required resources are available.

In fact, it could be worth considering to offer HAQT to specific European cities and municipalities where green values and non-polluting solutions are held in high regard on governmental level. In Western democracies, there will always be discussion about how to use public money. So, if a regional government already is favorable towards such solutions, it will probably be easier to market the project and actually have it implemented.

India and China are the two countries that are most commonly brought into discussion regarding air quality matters. AQ-wise, the countries differ from each other in two ways. Firstly, in China practically everything is regulated by the national government, while in India, the regional governments have more power. Authorities in some parts of India could be more favorable towards the project than others – on the other hand, in China bigger projects could be initialized with fewer negotiations.

Secondly, the consciousness about bad air quality has been increasing in China, while in India this is not the case[1]. China probably will not publish any statistics that would reveal health-worsening consequences of bad air quality, whereas the general public in India might not be in a position to demand improvement. So problems might arise in both

1 This assessment is based on a discussion with a Helsinki Business Hub business advisor who specializes in smart and clean solutions.

countries. In addition, in countries that suffer from very bad air quality, authorities might not even want to publish air quality info, because that could be harmful to tourism and business and possibly to the support of the government.

All this aside, the demand is emerging rapidly for service platforms such as HAQT that intelligently and cost effectively utilize measurement data with variable quality and modeling approaches with data fusion. The Nanjing Air Quality Testbed (NAQT; see subchapter 4.1) is one of the first projects that meet this demand abroad, and the implementation of similar testbeds in other cities in China has been discussed. Based on inquiries from abroad, it is expected that testbed projects will be piloted in other regions as well, e.g. in India, Eastern Europe and South America. In areas where demand for these type of services exist, there can already be an existing high quality measurement network; in China nowadays there can also be a dense sensor network available. However, the provided data is commonly not being utilized to its full capacity, which is something that a HAQT-based service can offer.

All in all, when marketing any air quality solution to authorities, a major challenge is to give them a reason to alter things. In many countries, the authorities have an obligation to monitor air quality and share information about it. They need to be convinced that they need a better monitoring system, better air quality model etc., – and that they need it so badly that they are willing to pay for it. Optimally, the service in question (data, application etc.) should be important for more than one authority (emergency services, city and traffic planning etc.) so that the costs could be divided between them.

For the companies associated with HAQT, an existing network – an air quality measurement ecosystem – will make it easier to commence negotiations with possible clients. They can discuss the entire network and not only a single sensor or a few of them; they can present results obtained in the HAQT framework. What could a client do with such sensors? Build a network like we did, combine it with this sort of AQ model, and these are the benefits you get – everything in one readily tested package.

On the other hand, a HAQT-like network itself might not always be the best possible object to make business with – you can probably only sell it once to a certain city or area (of course, there are lots of these areas in the world). An equally important part is what comes after: if the air quality situation somewhere in the region requires improvement, business

opportunities arise for those who have solutions. Again, the regional authorities must be convinced that these solutions are worth implementing, for the right amount of money.

An extended air quality monitoring network, together with the model, can provide answers to what really decreases local air quality in certain places. A business opportunity could then be to try and clean or remove these sources of bad air quality. There could be business potential in e.g. harbours and other traffic. Other possibilities include systems with intelligent advertising – ads for respirator masks on one side of the air quality map screen when AQ is bad; umbrellas when rain ties the pollutants down. The opening of the ENFUSER data may present numerous opportunities for anyone willing to use the data and forecasts in any way possible. The services and applications presented in D5-3 may also be developed further to suit whichever part and region of the world.

In addition, any companies that announce the use of HAQT data in their operations will basically improve their brand.

## 4.1 Nanjing Air Quality Testbed (NAQT)

The Nanjing Air Quality Testbed project (NAQT) is a sister project for HAQT, funded by Business Finland. The overall aim of NAQT is to install a local dense sensor network to supplement the existing reference level measurement stations in Nanjing, China and use this extended network for the assessment of local air quality both operatively and for research. Approximately 20 Vaisala AQT sensors will be installed in Nanjing with the help of a local consortium member Nanjing University.

Just as in HAQT, the tool for intelligent selection of measurement locations provided by the ENFUSER model will be utilized. In addition to AQT sensors, there will be multiple Vaisala WXT meteorological measurement devices installed, as well as ceilometers for the accurate measurement of boundary layer height, which heavily impacts the overall air quality in the area. ENFUSER model is installed locally, and using all available information for the area, it operatively predicts the air quality in the area and provides forecasts.

NAQT also contains research of air quality in the area and the impact of meteorological conditions on air quality. University of Helsinki is studying the air quality using the data from the installed sensor network and also with the data from a local high quality

measurement site in Nanjing. The effect of boundary layer height, secondary aerosols, particle numbers and black carbon are of particular interest. The findings of this research are aimed to be utilized in the model development of ENFUSER to improve the model predictions and forecasts provided by the system. Finally, the added benefits of having the complementary sensor network is assessed just as in HAQT.

The terrain and elevation profile in Nanjing is quite different from Helsinki; near the center of Nanjing there is an area called “the Purple Mountain”, rising approximately 400 m above sea level. There are also multiple small chains of mountains nearby that affect the flow of air masses and thereby the air quality in the area. At the center, there are also skyscrapers more than 400 m in height. These elevated locations make it possible to measure pollutant concentration in multiple heights (3D). An AQT sensor will be installed at the Purple Mountain as well as in one of the skyscrapers2.

In Nanjing the factors that affect air quality are different from those in the Helsinki region, while unfortunately the level of detail for data that is available to describe the properties of the testbed area is significantly lower in Nanjing than in the Helsinki region. In Nanjing there are multiple large industrial areas and coal power plants in a metropolitan area that contains more than 12 million inhabitants, and these emission sources are not well known initially. There is also a large amount of shipping traffic in Yangtze River that is curved around the city center area. To address the highly dynamic shipping emissions in the area, FMI-STEAM shipping emission inventories are used for ENFUSER modeling. For unknown industrial and power plant emission locations a large amount of measurement data, including the installed sensor data, as well as satellite remote sensing data is utilized in NAQT.

Based on what is said above, we can see how every such project in various parts of the world can provide useful information for developing the methods used in a HAQT-like environment – in addition to creating business and export opportunities, of course.

2 Requires the permission of the property owner, for which there is an ongoing discussion.

# 5. Benefits for academia

The project benefits the academia in several ways. The benefits are both methodological and scientific.

The main scientific benefit is increasing the understanding of how residential wood combustion in small house areas impacts the Helsinki air quality spatially. The results will elucidate the dispersion of residential combustion emissions and how they relate to emissions from road transport. This combination gives us better understanding of the roles of different emission sources and their impact on urban air quality.

HAQT will also benefit the scientific community by initiating the collection of new long-term measurement data sets from supersites and SMEAR stations in new cities where the HAQT concept will be adapted. Arising from the continuous measurements with the observation networks, the understanding of pollutant transportation in different cities will be improved.

During the project, several proxies are developed for non-traditional air pollutants, such as aerosol particle number concentration, black carbon mass concentration, and sulphuric and nitric acid concentrations. The proxies, which are based on the variables observed with Vaisala AQT420 and modeled with ENFUSER, can be applied to estimate the variability of these derived concentrations in city scale, pointing out their hot spots and source areas.

By introducing a network of LDSA (lung deposited surface area) observations and deriving proxies for pollutants not observed directly with the sensors, HAQT makes possible the future comparison between these non-traditional air pollutants and health statistics.

HAQT analysis will advance the methods for comparing model results with observations. By making detailed analysis of the circumstances during which the model results are biased, we can learn the weak points of the model. This analysis helps us improve the models at least, but it may also produce new knowledge in case the model bias is due to a lack in understanding some process or pollutant source. Improving the ENFUSER itself is a step forward in the area of fusion modeling, which is a fast progressing area in computer

sciences. In terms of air quality nowcasting and forecasting the progress in this project pushes the limits of the current state-of-the-art.

# 6. Conclusion

In this report, we present impacts that the HAQT project and its probable and possible follow-ups are expected to have on various parts of the society. The most obvious effects include the residents' easy access to important health-related information and increasing their knowledge of environmental issues in their whereabouts.

Some of the other expected impacts are related to the improving understanding of air quality issues in general, while others depend on the opening of the ENFUSER data, applied during the project. The project itself has already made air quality issues more visible than before and, as a smart digital system based in the Helsinki region, it will lead the way for future smart city projects, both in the Helsinki region and abroad.

Most importantly, all possible consequences of the project can not be predicted. The opening of the ENFUSER data and forecasts will provide a platform for any third party to build on. Be it commercial applications or charitable work, the possible uses of the data are virtually limitless. What we already know, however, is that there is a growing interest towards HAQT – the whole concept as well as individual parts of it – and that HAQT-related activities will continue after the pilot.

HAQT Work package 6 – Roadmap for Future Air Quality Networks – will produce concrete plans regarding the future of international HAQT-related activities.