„Developing a Guide to Best Practices in Other European Cities" under European project Contract BMP1/2.2/2169/2017 for „Efficient use of innovative technologies for clean air" (AIRTHINGS), funded under the Balkans - Mediterranean Program (2014-2020) of the European Union

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Проектът е съфинансиран от Програма „Балкани-Средиземно море" (2014-2020) на Европейския съюз и националния бюджет на Р България/ Project co-funded by the European Union and National Funds of the participating countries.

Content

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1. Introduction

Air pollution is a global problem that has a significant negative impact on human health and the state of the environment but also on the economic side. Although the topic is present on the EU's political agenda and actions are being taken to combat air pollution, much effort is still needed in all sectors and with all actors in order to achieve a sustainable solution to this problem.

The latest annual report by the European Environment Agency on air quality[1] shows that in European cities, still most people are exposed to levels of air pollution above the permissible, according to the World Health Organization criteria[2]. From the pollutants the greatest damage is caused by the fine particulate matter (PM), nitrogen dioxide (NO_2) and ground-level ozone (O_3).

Currently, The Bulgarian Government is subject of an infringement procedure in the Court of Justice of the European Communities due to a non-compliance with the ambient air quality standards in 25 municipalities (World Bank, 2018). Pollution with PM_{10} remains a major problem for air quality in the country, with 88.7% of the population (from 3.5 million population living in settlements) being exposed to PM_{10} pollution levels above the permitted levels (MOEW, 2017[3]). For Bulgaria as a whole, the biggest sources of air pollution are household heating (burning of solid fuels - mainly wood and coal) and emissions from traffic and public transport (to a large extent - emissions from diesel engines) (MOEW, 2017). According to the Emissions Inventory of the Ambient Air Quality Management Program for Sofia, 42% of the PM_{10} emissions are due to domestic heating and 57% is the share the emissions from the transport. At present, Bulgaria has no real problem with exceeded norms for nitrogen oxides and ozone but taking into account the expected climate changes that would lead to frequent drought and hot summers (Sofia Municipality, 2016), timely measures should be taken to prevent their exceedance.

Ambient air quality on the territory of Sofia Municipality is controlled at 6 automatic stations, which are included in the National Environmental Monitoring System of the Ministry of Environment and Waters (MOEW). Data are measured in real time and send to the National Database and are published on the Sofia Municipality website. They still are considered preliminary and subject to verification. Once verified by the Executive Environment Agency (ExEA), the final data is published in quarterly newsletters issued by the ExEA.

Meanwhile, air quality has become a topic of overriding public interest and public pressure for provision of real time data has grown. Within just one year, a network of hundreds of small and inexpensive sensors has been built on a private and voluntary basis in Bulgaria, which has become the main air quality reference for most of the people concerned. The network is presenting itself as follows: "We created AirBG.Info due to the complete information blackout regarding the air we breathe. We immediately created a map of Sofia at

[1] https://www.eea.europa.eu/publications/air-quality-in-europe-2017

[2] http://www.who.int/

[3] http://eea.government.bg/bg/soer/2015/soer-bg-2015.pdf

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http://airsofia.info. Today, after thousands of hours of volunteer work, we carry out over 100,000 daily measurements on the territory of Sofia."

Unfortunately, analyses show that the quality of the above-mentioned data is not sufficient, especially during the winter period. The public interest, however, demonstrates that Sofia Municipality needs improved network of stations to measure air quality to provide reliable data.

Currently (May 2018), Sofia Municipality is a partner in the implementation of the European project "Efficient use of innovative technologies for clean air" (AIRTHINGS), funded under the Balkans - Mediterranean Program (2014-2020) of the European Union. The project is aiming at fostering resource efficiency and climate change resilience including best available solutions to clean air.

This report aims to assist Sofia Municipality in the implementation of project activities and, in particular, in the development of a guide to best global and European practices for the improvement of ambient air quality in cities.

To achieve this goal, the following activities were carried out in the context of this survey:

Activity 1: Evaluation of the technical aspects of the project

- Evaluation of the international experience of projects related to the installation of intelligent analysers for ambient air quality measurement and forecasting systems;
- Evaluation of best practices on the installation of analysers for ambient air quality measurement;
- Evaluation of the possible technical solutions to reduce the pollution from household combustion by installing chimney filters;

Activity 2: Evaluation of the communication-related aspects of the project

- Evaluation of best practices on the provision of open data on air pollution (accessible via web or smart applications);
- Evaluation of best practices regarding the communication of problems and measures related to air quality management.

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2. Methodological approach

The survey activities were carried out through:

1. **Desk research**

Desk research on the international experience related to the installation of intelligent air quality analysers and the possible technical solutions for the reduction of the pollution from household combustion was carried out in order to fulfil the planned activities. The most up-to-date relevant European strategic and guidance documents, online portals, platforms, websites, articles, presentations and reports were reviewed. Special attention was paid to the media coverage of the topic in individual EU Member States. The information gathered was structured in two main sections: (1) technical aspects of the survey and (2) communication aspects of the survey.

2. **Online questionnaire**

In addition to the desk research, an online questionnaire was developed for the purpose of the survey in several versions adapted according to the specific stakeholders. The questionnaire was sent to: (1) producers of sensor devices (16); (2) producers of chimney filters (14); (3) larger municipalities from different EU Member States (7); (4) experts - from ministries (11), NGOs and participants in European projects (13), (Annex I).

3. **Additional consultations with key stakeholders**

In addition to the online questionnaires, selected respondents were consulted, including producers and distributors (for Bulgaria) of sensors and chimney filters, communication agencies and coordinators of international projects (Life, Horison 2020).

4. **Overview of the legislative framework**

In the context of the survey, a review and a summary of the applicable regulatory framework at national and European level related to the conditions for the location of the air sampling points (sampling of sulfur dioxide, nitrogen dioxide and nitrogen oxides, lead, benzene, carbon monoxide and ozone) as well as the requirements for performance and quality assurance of the measurements were performed. At national level, the legislative act, which sets these requirements is Ordinance №12 of 15 July 2010 for air pollution standards[4], which transposes the requirements of Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. Several Annexes to Directive 2008/50 / EC laying down rules on reference methods, validation of data and location of sampling points for the assessment of air quality assessment have been amended by Commission Directive (EU) 2015/1480 of 28 August 2015 year.

5. **Analysis of the gathered information**

On the basis of the wide-ranging desk research, consultations and correspondence with Bulgarian and foreign experts, online questionnaires and review of relevant documents, an analysis of the collected information was

[4] http://dv.parliament.bg/DVWeb/showMaterialDV.jsp;jsessionid=C4701A1E3C04E39A4405C33D96F92486?idMat=115272

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made. The analysis was also structured in 2 sections (1) with respect to technical aspects of the survey corresponding to the implementation of Action 1 of the survey scope and covering Tasks 1.1, 1.2 and 1.3. and (2) with regard to communication aspects of the survey corresponding to the implementation of Action 2 of the survey scope and covering Tasks 2.1 and 2.2.

3. Review of the gathered information and analysis

3.1. Evaluation of the technical aspects of the survey

3.1.1. Evaluation of the international experience related to intelligent analysers for air quality measurement

Based on the desk research on smart analysers for ambient air quality, six producers of sensor devices were selected from Italy, New Zealand, England, Germany, Switzerland and Finland, with those from Italy, New Zealand and Finland having also distributors in Bulgaria (Annex II). The producers were selected according to the main technical characteristics of the sensors (range of pollutant measurement, operating range of humidity, temperature range, accuracy and response time), price range, and the climatic characteristics of Sofia. Companies have been asked to provide more detailed information about the products they provide. Several producers have been consulted on the specifics of their products. The collected information was then summarised and analysed (Annex III). Of all researched models, the Orion SrL ETLOne sensor and Vaisala's AQT420 sensor were selected as most suitable for the objectives of Sofia municipality. These sensors can simultaneously measure $PM_{10,2.5}$, NO_2, CO, SO_2, O_3. Another advantage is that these manufacturers have representatives in Bulgaria, respectively Unitec and Finnconsult. Moreover, besides the product, they also provide installation and maintenance of the installed sensors locally. In addition, Vaisala has recommended the installation of a Ceilometer for cloud height detection, which detects three cloud layers simultaneously and helps to better predict changes in ambient air quality. The Ceilometer measures the aerosol and particle mixing altitude layer in the atmosphere and gives more precise and repeatable measurements for vertical ozone distribution up to 3 hPa, as well as for temperature, humidity, wind and pressure. For the territory of Sofia Municipality two Ceilometers would be sufficient (Annex III).

Further information on the international experience regarding smart analysers for air quality was collected through the online questionnaire sent to municipalities from different EU Member States, experts from ministries, NGOs, and others. The results of the questionnaire show that most common are sensors that measure individual pollutants separately ($PM_{10,2.5}$, NO_2, CO, SO_2, O_3). In Italy, for example, beta analysers are used for PM measurements, while photochemical analysers are used to measure other pollutants. In France, for PM measurement are used Tapered Element Oscillating Micro-Balance (TEOM) Analysers in combination with Filter Dynamic Measurement System (FDMS) as well as gravimetric methods. For measuring of NO_2, France and England use Palms diffusion tube or real time sensors.

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In this regard, Aeroqual's sensors could also be a suitable option for Sofia Municipality, as this producer offers a different sensor model for measuring different pollutants and also has a distributor in Bulgaria - SANTAKT-BG OOD. These sensor models have an appropriate range of measurement, considering the ambient air quality standards in Bulgaria and they offer optimal accuracy. Another producer that offers a separate sensor for different pollutants is Alphasense, however, no installation and maintenance are provided. Also, the upper limit of the measuring range is too high. The other producers that have been consulted offer sensor devices that measure gaseous pollutants only and not PMs.

3.1.2. Evaluation of best practices on the installation of analysers for ambient air quality measurement

Data collection and criteria for deploying analysers to measure ambient air quality on European scale in the individual EU Member States, are defined based on the requirements of the European legislative framework (including Directive 2008/50 / EC on Ambient Air Quality and Cleaner Air for Europe). The review of the international information portals providing forecast data and analysis of air quality shows that some of the most developed and popular sites use the Free Forecasting Systems of **Copernicus**[5] or **Openair**[6]. Part of the first are the Copernicus Atmosphere Monitoring Service (CAMS), which provide maps and data for regional air quality forecasts, health information and warnings; Retrospective assessments of air quality; Identification of pollutants and their source; Concentration levels; Resources for assessing possible emission control measures. For the analysis of air pollution in the UK, Openair tools are used. A detailed guide has been developed for this software[7]. Barcelona Supercomputing Center, which is one of Spain's leading air quality institutions, uses the **CALIOPE**[8] system. The system provides forecasts for 24 and 48 hours in three directions: weather forecast, NO and NO_2 emissions, VOCs, CO, SO_2 and PM; air quality forecast: O_3, NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$ and benzene. More detailed information on the available forecasting systems is presented in Annex IV.

3.1.3. Legislative framework

Below is a summary of the applicable legal requirements for the location of sampling points for ambient air and for public informing disclosure.

1. **Locations for sampling points**

Art. 7 and Art. 10 of Directive 2008/50/EC, lay down the conditions for the location of sampling points for the measurement of the levels of sulfur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter (PM10, PM2,5), lead, benzene and carbon monoxide in ambient air - on the one hand, and ozone on the other. These

[5] http://www.copernicus.eu/main/atmosphere-monitoring

[6] http://www.openair-project.org/

[7] https://www.dropbox.com/s/2n7wdyursdul8dk/openairManual.pdf?dl=0

[8] https://ajuntament.barcelona.cat/qualitataire/en/

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conditions have been transposed into Bulgarian legislation by Chapter Four and Five of Ordinance №12 of 15 July 2010 on standards for sulfur dioxide, nitrogen dioxide, fine particulate matter, lead, benzene, carbon monoxide and ozone in the ambient air.

Annex III and Annex VIII of Directive 2008/50/EC as well as Annex II and Annex III of Ordinance №12 define the specific criteria for the location of sampling points. On a **macro-scale**, the points are located so as to provide data on the areas in Sofia where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s). Data should also be provided for levels for other areas in Sofia that are representative in terms of population exposure. Sampling points, whenever possible, should also be representative of similar locations not in their immediate vicinity. Locations with good air exchange should be selected where well-mixed levels of pollution can be measured, such as: residential and commercial areas in cities, parks (away from trees), large streets or squares with low or no car traffic, open areas for sports facilities or leisure facilities. On the other hand, the impact of local emissions from vehicles, petrol stations, etc. should be avoided. The sampling points shall be located so as to be representative of the air quality of a segment of a street of not less than 100 m length at traffic-orientated sites and at least 250m × 250m at industrial sites, where feasible. Urban background locations shall be located so that their pollution level is influenced by the integrated contribution from all sources upwind of the station.

On a **micro-scale**, the points shall be positioned so that the flow around the sampling device inlet is not restricted (generally free in a sector of at least 270° or 180° at sampling points, located on the line of the buildings) and without any barriers preventing the movement of the air in the vicinity of the building; the inlet of the sampling device shall be located within a few meters of buildings, balconies, trees and other bulkheads and not less than 0,5m from the nearest building in the case of sampling points which are representative of the air quality at the building line.

The inlet sampling point shall be between 1,5m (the breathing zone) and 4m above the ground; if the site is representative of a large area, a suitable and higher positioning may be appropriate, with all exceptions being documented in detail. Also, the inlet probe shall not be positioned in the immediate vicinity of sources in order to avoid the direct intake of emissions unmixed with ambient air, while the sampler's exhaust outlet shall be positioned so that recirculation of exhaust air to the sampler inlet is avoided. In the case of traffic-oriented points, the sampling probes for all pollutants shall be located not less than 25m from major junction and no more than 10m from the curbside; in this case, a "big junction" should be understood a one that interrupts the traffic flow and leads to different types of emissions (when braking and starting) compared to the rest of the road.

According to Annex V and Annex IX of Directive 2008/50/EC, for a city with the size of Sofia, the total number of sampling points must be not less than 6. According to Annex VI of the Directive, for the assessment of the concentrations of the various atmospheric pollutants, international reference measurement methods are applicable. The Bulgarian equivalent of methods is set out in Annex 16 of Ordinance №12 of 15 July 2010 on the

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levels of sulfur dioxide, nitrogen dioxide, fine particulate matter, lead, benzene, carbon monoxide and ozone in ambient air.

As per Art. 11 of Ordinance №7 of 3 May 1999 on the assessment and management of ambient air quality for the points where continuous measurements are carried out, the measurement of the meteorological parameters is obligatory.

2. Public information

Annex XVI to Directive 2008/50/EC sets out the ways in which the public must be informed of the quality of ambient air. These methods have been transposed into Bulgarian legislation by Chapter Seven of Ordinance №12 of 15 July 2010 on standards for sulfur dioxide, nitrogen dioxide, fine particulate matter, lead, benzene, carbon monoxide and ozone in the ambient air. Data on concentrations of pollutants in ambient air shall be presented as average values according to the appropriate averaging period established for them.

The information shall contain as a **minimum** the levels exceeding the established pollutant limit values, the target values, the alert thresholds and the ozone information threshold. The information should also contain a brief assessment of the air quality objectives and the necessary information on health effects or, where appropriate, on vegetation.

Information on ambient air concentrations of sulfur dioxide, nitrogen dioxide, PMI (at least PM_{10}), ozone and carbon monoxide is updated on a daily basis and, wherever possible, on hourly basis. Information on ambient air concentrations of lead and benzene given as an average value over the last 12 months is updated once every 3 months or on a monthly basis when possible.

If actual or predicted exceedances of the alert thresholds (for sulfur dioxide, nitrogen dioxide and ozone) and the information thresholds (for ozone) are established, the following information shall be provided to the public in due time:

1. Information on the observed exceedance:

- the location of the exceedance area;
- type of exceeded threshold (information or alert);
- start time and duration of the exceedance;
- highest one-hour concentration; for ozone - the highest 8-hour average concentration.

2. Forecast for the following afternoon/day(s):

- geographical area of the expected exceedances of the information and / or alert threshold;
- expected changes in pollution levels ((improvement, stabilisation or deterioration) and the reasons for these changes.

3. Information on the type of population affected, possible health consequences and recommended behaviour:

- information on population groups at risk;

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- description of likely symptoms;
- recommended precautions to be taken by the affected population;
- sources of additional information.

4. Information on preventive action to limit pollution and / or exposure: indication of major sectors, sources of pollution; recommendations for action to reduce emissions.

3.1.4. Evaluation of the possible technical solutions to reduce the pollution from household combustion by installing chimney filters

On the basis of desk research about the technical solutions to reduce domestic household combustion pollution by installing chimney filters, 14 chimney filter producers were selected. To producers was sent a request to provide additional information on the efficiency, the size of the investment and the maintenance of the chimney filters. The following conclusions could be drawn from the responses received: (1) After all the available information and feedback from producers and other stakeholders has been compiled and analysed, the electrostatical OekoTube filter of the OekoSolve group emerged as the preferred one. This filter is practically dominating the market. The OekoSolve group is operating in ten countries, including Bulgaria, whose representative is Ekoproekt group Ltd. More detailed information about the technical features of the OekoTube filter are presented in Table 1. (2) Chimney filters market in Europe appears to be not well-developed - some respondents state that due to lack of customer's interest and of legal requirements, they do no longer produce household chimney filters (e.g. Schenck Process Norge, Norway and Tassu ESP, Finland). (3) In many European countries (UK, Ireland, Austria, Norway), the practice of placing chimney filters in households to reduce the pollution from domestic combustion is not widespread. The reason for this is that the installation of chimney filters is considered to be a less effective measure of pollution reduction than a complete replacement of the heating system. These results of the survey were also confirmed by the answers received from the online questionnaire on exploring the international experience and best practices for reducing the pollution from domestic combustion.

In addition, in support of the latest conclusion is the World Bank's 2018 air quality management study, which identifies replacing of non-compliant solid fuel stoves with more efficient or complete replacement with gas or central heating as the most effective measures to tackle the problem

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Table 1. Technical specifications of **OekoTube** chimney filters, manufactured by: OekoSolve, Switzerland

Filter OekoTube	Effectivness	Technical Specifications	Maintainance	Price
The OekoTube is an electrostatic precipitator suitable for a firing performance up tp 40 kW and thus in particular for single room firing, such as fireplaces, fireplace inserts, tiled stoves and pellet stoves. The wood material, together with the exhaust gas, goes into the drain pipe and thus generates PM emissions. In the filter, electrons are released from high-voltage electrodes that electrostatic forces bring to the walls of the furnace. These electrons charge dust particles that are also fed to the walls of the furnace. There the dust particles are collected, hardened and accumulated in the form of large flakes. These overlays are removed during the periodic cleaning of the chimney. The filter is installed on the top of the chimney.	The OekoTube ESP is most effective in reducing particulate emissions when the fire is operated at low burn setting (90-97% effective) compared with at high burn setting, and was around 39% effective during start up. Emissions at high burn, however, were much lower than at low burn meaning the lower efficiency was less significant. The OekoTube is therefore most effective when emissions reductions were important. Thus while the average efficiency across the burn cycles was around 47% the reduction in total emissions across the trialled burn cycle was around 58%.	▪ Exhaust gas temperature – up to 400 ° C for outdoor application and 250 ° C for indoor use; ▪ Power supply - standard 220 V; ▪ Operating voltage - less than 30 kW; ▪ Power consumption in operating mode - no more than 30 W; ▪ Standby power consumption - less than 1 W; ▪ Stainless steel construction; ▪ Possibility to regulate the working voltage of the filter according to each individual chimney; ▪ Warranty – 2 years of the electronic components and 5 years of the construction elements.	The filter should be cleaned every 2 to 5 years, depending on the capacity and frequency of use of the wood. To set the required cleaning interval in each particular household, the chimney owner must do periodic check-ups during the first month. The filter should be easily accessible: It can be cleaned from below (through a control door) or from above.	1748 EUR

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3.2. Evaluation of the communication-related aspects of the survey

As mentioned earlier in this report - the air quality stands out as a priority not only for the European union, but for more and more countries all over the world. Many projects and initiatives conducted in Europe, America and already in several Asia countries are in support of this. The work on this project has demonstrated that the information on the subject is almost infinite and the available sources are many. We chose to present and discuss some of the largest projects and activities aimed at informing about the importance of the problem and finding the best information tools supporting the improvement of air quality to increase the awareness of citizens, institutions, NGOs, businesses and the scientific community. The selection criteria for these examples is that there are sufficient good practices to be explored and that can be applied directly, suitably adapted by Sofia Municipality to further development of a Communication Strategy or other strategic documents defining policies, initiatives, campaigns and activities aimed at the general public, various professional communities and groups and other specific stakeholders.

3.2.1. Evaluation of the best practices in providing open source data for air quality

The first group that was analysed is large **web portals** with air quality information, **open data** and **measures taken**, covering large areas of the world (worldwide, Europe and other continents), which enclose databases with information on specific countries and cities. Best examples here are presented by the EU projects CITEAIR and CITEAIR II, also European Air Quality Index, Real-time Air Quality Index Visual Map, US Air Quality Index and Numbeo - one of the world biggest data base.

Below the main goals and the used information tools within these projects and portals are presented:

- **CITEAIR и CITEAIR II**[9] - presents up-to-date information about air quality, CO_2 emissions and greenhouse gases in different European cities. All these data are published in a user-friendly web portal http://www.airqualitynow.eu. Although this project was conducted in the period of 2008-2011, the website is still accessible with latest information and even information on new cities could be added. In the framework of these projects several Guidebooks[10] with best practices about the air quality, the city traffic and its impacts on the urban pollution, greenhouse gases and emissions were published. A Sustainable Mobility Indicator, a tool that can describe the state of traffic and the impact of urban mobility has also been developed.
- **Air Quality Index**[11] – this index is developed by the European Environment Agency and allows users to learn more about air quality in different countries and cities in Europe. An interactive map shows the state of the air in 31 countries in Europe (and corresponding cities in those countries).

[9] http://www.citeair.eu/

[10] http://www.citeair.eu/fileadmin/Deliverables_and_documents/Guidebook_Air_Quality_Forecast_-_final.pdf

[11] https://www.eea.europa.eu/themes/air/air-quality-index/index

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- **Real-time Air Quality Index Visual Map** [12]– presents a real-time map for air quality in Asia, Europe, South and North America, Australia, Africa, Middle East, India, China. It shows air pollution data and the associated health impact.
- **Numbeo**[13] - the world's largest users database. Provides up-to-date information on the living conditions, including living standards, housing, health, traffic, crime and pollution. In terms of pollution, the data is based on a study conducted among 25,799 people in 4052 cities. Numbeo allows users to review, share and compare information on pollution (and cleanness) worldwide. It covers indicators such as Satisfaction with Air Quality; Quality and availability of drinking water; Water Pollution (total); Satisfaction with waste disposal; People perception on cleanness and order; Noise pollution and light pollution; Green and parks in the city; Perception of feeling comfortable in the respective polluted city.
- **USA Air Quality Index (AQI)** – it provides daily dissemination of information on the purity of the ambient air in a particular location, along with relevant health effects that could endanger people. AQI translates air quality data into numbers and colours that help people understand when to take action to protect their health. Forecast data are also distributed daily. It covers 400 cities 46 states in the United States and some parts of Canada.

3.2.2. Evaluation of best practices regarding the communication of problems and measures related to air quality management

Another analysed group is the **cities** that have considerable experience and apply the most effective communication approaches. The experience of Paris, London, Vienna, Barcelona stands out among European cities. Annex IV presents various communication practices in more detail, depending on the sources of information analysed and in particular the active side behind the project and/or initiative.

France and more specifically **Paris** provide the best examples of information campaigns and communication tools. The Paris Municipality, in partnership with several organizations, is implementing a special project dedicated to air quality. The "face" of this project is the website www.airparif.fr. Information on actual air status as well as forecast twice a day is provided on this information portal. The impact of various mitigation and improvement measures is evaluated and when the air pollutant levels are exceeded, it provides information to authorities, the media and citizens. Attention is paid to the **interactive tools** available through this platform - a quiz on how well consumers are aware of the city's ambient air and about the measures taken; various educational and information videos on the subject; a dedicated mini site and a tool for children; pollution impact assessment on drivers, while in the car; different mobile applications - emissions and pollution assessment depending on the chosen route and vehicle; for pedestrians and cyclists with exposure assessment in real time and the levels of environmental pollution. Various campaigns are carried out and specific measures are taken during polluting periods (see Annex IV).

[12] http://aqicn.org/map

[13] https://www.numbeo.com/cost-of-living/

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An interesting initiative is the creation of **AIRLAB**, in which the main partner is **Airparif**. It is a community that is committed to air quality improvement. Part of it are large companies, small and SMEs, start-ups, research institutes and public bodies and individuals - each of whom brings their ideas, skills and resources. This community organizes events in different formats, stakeholder consultations and the general public, networking, sharing of data and innovative ideas, technical and operational support to implement ideas for improving air quality.

In regards to air quality good practices, France has experience also at national level. The **ATMO**[14] Federation is a national network that brings together the Authorized Air Quality Associations. ATMO coordinates, unites and promotes the work of these Associations and represents them at national and European bodies, participating in debates on improving air quality. Among the activities of this Federation are: monitoring and information on air quality, dissemination of results and forecasts, direct transmission of information to local government structures (Prefectures) related to exceedances or forecast of exceedance of the alert thresholds and providing recommendations in the region concerned.

A separate national information platform for monitoring, managing and forecasting air quality in France is www2.prevair.org. The platform is managed by the Air Quality Associations, providing information at regional level on measures and actions for hazardous pollution.

London's experience is also very useful. First of all, it is worth mentioning the **Londonair Air Quality Network (LAQN) - Londonair**. This information portal shows air pollution in London and Southeast England by providing current and forecast information on ambient air quality, annual map and pollution episodes. Londonair is supported by the Environmental Research Group at King's College, London. The communication approaches and tools used are wide-ranging, diverse and tailored to different users and stakeholders. For example, a detailed Air Pollution Guide has been developed providing detailed information on the pollutants, their impact on the human health, health advices and specific actions to reduce exposure targeting both - the government and the citizens. An interesting feature is the possibility to subscribe for receiving forecasts and special notification if high levels of pollution are expected. Various platforms (Android, iPhone, Chrome) and Widget Builder have been developed to help install a map of air quality and pollution levels on various other sites (media, partner organizations, etc.).

The UK websites that provide air quality information are numerous and varied. A specific media site can be mentioned, which publishes specialized news related to air quality - https://www.airqualitynews.com. All this demonstrates the growing importance of the topic. Interesting information is provided by the Breath London website of the National Institute for Health Research. In addition to forecasting pollution levels, it contains advices on how to breathe fresh air when we are at home, on a walk, on a road to work, at school, in our neighbourhood, if we are biking or if we have health problems. A "Route Planner" tool is available, offering up to three different routes for each trip. Routes show current pollution levels in London so that everyone can easily choose the route with the lowest levels of pollution. The map shows pollution measurements made in

[14] http://www.atmo-france.org/fr/

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and around London and it is updated every hour. A good example of a campaign-based clean air site is https://www.healthyair.org.uk/. The Healthy Air campaign is targeting the public health crisis caused by air pollution. The aim of this campaign is to promote people behavior that helps reducing air pollution and exposure to it. The main focus that deserves attention is on the different ways and approaches by which everyone with personal effort can contribute to cleaner air. Another interesting approach is encouraging pupils to support the initiative by specially developed school package.

UK-AIR (Air Information Resource) also provides detailed information on air quality and pollution in the United Kingdom. The information provided is: actual levels of pollution, forecast of future periods and expected exceedances, data archive and details of the different monitoring networks. There is a free information and helpline for air pollution. Among the other communication approaches, more interesting are the **education videos** "How You Can Help" and "Clean Air Strategy 2018", currently available for comments and opinions (from May to August 2018). This platform also provides various tools for collecting information. An innovative tool for analysis, interpretation and understanding of air pollution data is also available for free -**Openair**, http://www.openair-project.org/.

Vienna is among the cities with the most varied measures to improve air quality. They cover several areas: public transport, development of renewable energy, promotion of e-mobility. Each of these areas describes a wide range of measures (https://www.wien.gv.at/umwelt/luft/luftqualitaet-2017.html). In terms of communication approaches, daily, monthly and annual reports are mostly used for dissemination. A computer-based service "Ozonix" of the Vienna Air Monitoring Network (with hourly update of information) was also developed to inform the public. The information is also distributed through a dedicated telephone line. In case of pollution, large-scale information campaigns are being carried out. Concerning the domestic heating in Vienna, an information campaign for proper wood burning is being implemented - http://www.richtigheizen.at.

A successful example in the same direction is the initiative of the US Environmental Protection Agency - **Burn Wise** (https://www.epa.gov/burnwise) providing useful information to citizens on the best practices in the use of wood heating and the effects thereof on human health. This initiative is supported by a numerous information and educational materials (brochures, posters, books, including for children), online and on social networks digital campaigns. Good examples of communication activities for proper burning of wood are also adopted in Nijmegen - various information materials and an online based tool with recommendations and assessment of atmospheric conditions (https://www.stookwijzer.nu/). The city is a good example for its overall policy of improving air quality. In addition to the public awareness campaigns, industry and citizen engagement activities are also in place - an independent environmental advisory commission - the **Smart Emission Consortium** is set up.

Scotland also has several successful practices and information tools related to air quality. The air pollution information on the web portal http://www.scottishairquality.co.uk/ is updated hourly. Information on actual air status and forecasts are provided. Also here there is a separate section "What can I do?" - on the one hand showing how everyone can help to reduce the emissions and on the other hand how people should protect themselves and their family from air pollution. This web portal provides a free "Know & Respond" service -

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sending registered users a warning message if the air pollution forecasts in their area are moderate, high or very high. Two separate educational websites have been created for children and high school students to help them learn about air pollution: *Air Pollution Detectives* (http://children.scottishairquality.co.uk/) - a project aimed at primary school children. This interactive resource contains information about pollutants, what actions anyone can take and offers many links to other information sites; and *Clear The Air* - http://cleartheair.scottishairquality.co.uk/. This project is targetting children aged 12-15 to learn more about air pollution and, if their school is registered, they can use Citizen Science to better understand air pollution. This tool also allows students to collect and analyse air pollution data as a school project and further allows the school emissions to be calculated.

The **Lombardy** Regional Environmental Protection Agency, **Italy**, also has implemented a number of educational initiatives. This includes lectures, seminars and visits to air quality monitoring stations. Special attention is paid to the youngest. The agency has created a series of 4 books, each with a different theme - Food, Air, Water and Waste. A free app is also available for each of these, which besides the booklet itself also contains quite interactive elements - games, animations, quiz and more - http://www.progettoambientiamoci.it/.

Numerous information portals exist also in **Spain**, mainly in the Catalonia and Barcelona regions. In addition to the actual ambient air quality and forecast, data maps the use of a variety of applications, interactive materials and videos is essential part of the communication tools.

The detailed research of best practices on communication activities and approaches to air quality leads to several conclusions:

- **More and more cities are preparing Plans to tackle air quality problems and define specific measures to reduce pollution**. Some of these measures are quite specific (in London, for example, a "traffic jam fee" was introduced when driving a car in the central city area during the day on weekdays).
- **More and more major European cities are introducing special measures that apply for predicted periods of pollution.** These include for example: speed limitation, wood burning ban, free public transport, reduced production for some industries, city separation in areas with restricted access to some vehicles in some areas, car labelling depending on the pollution they cause and limited access to central city areas, etc.
- **With regard to communication actions to inform the public, apart from the air quality information portals, information is disseminated through the local authorities' websites, state institutions, traditional media and increasingly – the social media.**
- **Increasing attention is paid to educational initiatives and campaigns targeting pupils, children and students.** The purpose of such campaigns is to engage and understand the importance and meaning of clean air, to create a culture and knowledge of how to improve air quality. The approaches used are different and include educational lectures, seminars, events, projects, interactive audio-visual products, mobile applications and games.
- **A good example, applied by some major European cities, is the formation of communities and groups in which various stakeholders are actively involved.** Representatives of local and state government,

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businesses (large companies or industry branch organizations), the non-governmental sector, the scientific community and universities, citizens' representatives (e.g. popular public figures) are attracted. Such community is responsible for the implementation of innovative approaches, the development of plans and policies, the implementation of information campaigns. This approach provides presentation of different perspectives and the use of the capacity of each of these groups to find the most effective and realistically applicable solutions for the respective region/city.

- In regards to citizens and the general public, it can be concluded that specific approaches to **increase engagement** are also being implemented. On the one hand, possible actions are being communicated more actively, good examples are given and the so-called "Call for action" activities - recommendations how each can contribute to better air quality – has been promoted. On the other hand, ideas are sought and **proactive citizen behaviour** is encouraged – by gathering proposals for initiatives that can be implemented to support the improvement of air quality.

4. Conclusions and recommendations

As a result of the conducted survey on different approaches to collect information and the review of the implemented good practices, the following conclusions and recommendations can be drawn up to help the Sofia Municipality in addressing the problem of air cleanness:

4.1. Technical solutions for air quality

- On the basis of this survey and the technical characteristics of **intelligent analysers for measuring air quality**, it is recommended to install 2 types of sensors devices: (1) sensors measuring simultaneously all pollutants - $PM_{10,2.5}$, NO_2, CO, SO_2, O_3. The most suitable of this type were the **ETLOne** (Orion SrL) and **AQT420** (Vaisala) sensors and (2) sensors that measure the specific pollutants individually. As a suitable sensor of this type, the **Aeroqual** sensor could be recommended. It should be mentioned, however, that in the international practice more often devices of the second type are used.
- Besides the technical specifications of the sensors proposed above, the advantage is that these manufacturers have distributors in Bulgaria that offer **installation and maintenance** of the analysers.
- For a limited budget, we recommend purchasing less but better quality sensors to obtain reliable and accurate measurement values than to rely on larger quantities but inappropriate as functionality devises. When deciding on the functionality of the sensors, consideration should be given to the **sensitivity of the sensors** on the one hand and the **measuring range** on the other. For example, a higher range of measurements may be more applicable for measurements in a work environment where the norms and the pollution are much higher. At the same time, at a lower limit of the measurement range, the sensor would only report pollution when the emission limit value has been exceeded several times.
- With regard to **chimney filters**: Although the installation of filters on old stove will lead to a certain reduction in PM emissions, based on the analysis of good and best practices in Europe and world-wide,

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it can be concluded that this measure is **not among the most effective for improving the air quality from domestic combustion**. It should be noted that purchasing of filters as well as their maintenance is not a more advantageous measure than a replacement with a new stove / combustion installation, especially if factors such as the total amount of reduced PM emissions and health costs are taken into account. In addition, more and more countries are introducing stringent regulations and standards on heating appliances, which in the long term means that, following trends in EU legislation, replacing old fuel-intensive stoves with more environmentally friendly ones will eventually be mandatory. If, however, Sofia Municipality wishes to test the efficiency of the application of chimney filters, it may initiate a pilot project to place filters in retail centers (hotels, restaurants, service stations), which are subject to much easier control.

- International experience shows that there are many other **priority measures** for domestic heating that should be taken into account by Sofia Municipality. Such are the above mentioned **regulatory measures for standards** regarding solid fuel installations, the quality of solid fuels, limiting the use of certain fuels / heating appliances. The number of European countries applying such standards is increasing (e.g. the United Kingdom, Germany, the Czech Republic, Austria, Poland, etc.); Introducing mechanisms for implementing and controlling these regulations - such mechanisms include **subsidy schemes**, other **economic incentives** such as preferential loans, tax incentives, etc.; Mandatory **replacement of old**, inefficient, solid-fuel stoves with more environmental-friendly and more modern (certified) stoves; Connection to central heating or gas supply (where feasible); Inventory of emissions from domestic heating, etc.

4.2. Communication solutions for air quality

- An important and preliminary step to address the ambient air quality problem is the **establishment of a professional community** - a **network of experts** responsible for policy development and decision-making, coordination between local and national authorities, in which to exchange different innovative ideas, methods and measures.
- It is necessary to develop a **Communication Strategy** and at a later stage, a plan with concrete activities, communication channels, support initiatives, events and as well as specific actions in crisis situations and periods of serious pollution.
- As a follow-up measure, it is necessary to develop different **interactive tools and mobile applications** in order to support the implementation of measures, their popularization and engagement with each of the stakeholders.
- With regard to **communication channels**, the most efficient and operational approach is the establishment of a **separate online platform**, which provides on one hand data on the current and forecasted status of air quality, and on the other hand that summarizes the activities, approaches and planned measures. At the same time, this is the place where all interested parties - local authorities, professional groups, academics and citizens meet and communicate.

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- With regard to the **communication mix**, the most effective and feasible option is the combination of traditional media (articles, analyses, interviews, broadcasts with experts) with the contemporary capabilities of digital communications in all directions and social networks, including development of supporting groups and communities.
- It is necessary to carry out **convincing and well-reasoned awareness-raising campaigns and educational initiatives** in order to create adequate expectations from citizens, so that society can have a real idea of what measures are in place, what can be achieved and what is the way to the clean air. Campaigns should raise citizens' awareness on the necessity of regulations, on the use of clean fuels and efficient heating appliances and their benefits on human health and on the opportunities for various incentives and reliefs. Although the public is more and more engaged in the topic, the role of society as a participant in the problem (including the cause of the problem) remains not well understood. This also applies to knowledge regarding the health aspects related to poor air quality. Effective campaigns also require specific planning for each type of activity. This means that both, the opportunities and the risks of information campaigns, should not be underestimated. It is of particular importance how certain topics related to the particular specifics of Sofia Municipality will be managed and communicated. There are a number of topics for which there is insufficient and inadequate presented information, which creates unrealistic expectations towards Sofia Municipality and the possible results to achieve. Such topics are, for example, the special features arising from the geographical location of Sofia, debunking of publicly accepted misconceptions about air cleanliness, the more environmentally friendly alternatives to heating rather than pseudo-solutions (such as the perception of wood as an environmentally-friendly resource for heating), what will be the impact of the incinerator on air cleanness, which air is hazardous, what are the health risks, how to react in case of pollution, etc. Each of these topics should be set out in a strategic document, that identifies the necessary actions, focus and tools from a communication point of view.

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5. Analysed sources of information

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6. Annexes

- Annex I – online questionnaire
- Annex II – producers of sensors and filters
- Annex III – technical specifications of sensors
- Annex IV – good practices for air quality
- Annex V – zip – additional information received from producers, projects

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Annex I – Online questionnaire

Best Practices in European Cities for Air Quality improvement

QUESTIONNAIRE

* Required

I. Smart devices measuring air quality

1. What specific type of air quality sensors have been installed in your city?

Your answer

2. Do you know how the air quality system data is gathered, processed and integrated into a user-friendly format (in terms of criteria for sensor location, data gathering methodology, software solution)?

Your answer

II. Chimney filters

1.Do you know what specific chimney filter type is the most widespread in your city?

Your answer

2. Was there a local or regional program designed to limit air pollution from household combustion? Please specify.

Your answer

3. If yes, did it lead to any measurable air quality improvement?

Your answer

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4. Based on your experience, what was the best way to engage targeted households in that program?

Your answer

III. Communication channels

1. Which communication approaches and channels seem to be most effective to engage citizens and establish dedicated community groups with air quality awareness raising campaigns in your city?

Your answer

2. Are you aware of any emergency communication measures which the city is ready to deploy at times of high air pollution? Please specify.

Your answer

IV. Contact information

Your Name

Your answer

Organisation / Institution *

Your answer

E-mail, phone etc

Your answer

SUBMIT FORM

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ANNEX II - Sensor Producers

Country	Organization	Sensor type	Website	Contact Person	E-mail
Finland	Vaisala + Finnconsult Ltd.	AQT420	https://www.vaisala.com/en	Hannamari Jaakkola Anton Tchavdarov	office@finco.bg hannamari.jaakkola@vaisala.com
New Zealand	Aeroqual Ltd + Scient Act BG Ltd	Aeroqual Series 300L, 900	https://www.aeroqual.com/contact	Anton Kacheriev	toni@scientact.com
Italy	Orion SrL + UniTec Srl	ETLOne	http://www.unitec-srl.com/site/wp-content/uploads/2015/04/ETL3000-Datasheet.pdf	Desislava Dimitrova	dessislava.dimitrova@orion-environment.bg
United Kingdom	Alphasense	Alphasense OPC-N2, AQM 60	http://www.alphasense.com/index.php/air/contact/	David Johnson Krzysztof Janiuk	dcj@alphasense.com kaj@alphasense.com
Germany	City Technology Ltd	3E 1 F, 3 E50	http://www.citytech.com/	Jason Kerr	Jason.Kerr@citytech.com>
United Kingdom	SGX Sensortech	MICS-2714	https://www.e2v.com/qormino-enquiriesthank-you/	Terry Brown	terry.brown@sgxsensortech.com
United Kingdom	AQMesh	AQMesh	https://www.aqmesh.com	Dimcho Lachev	dl@6ms.us
United States	Dylos Corporation	Dylos DC1100	http://www.dylosproducts.com/		support@dylosproducts.com
United States	FIGARO USA INC	Figaro TGS5042 (EC sensor)	http://www.figarosensor.com/		figarousa@figarosensor.com
United Kingdom	Cleantech		https://www.cleantech.com/		europe@cleantech.com
Netherlands	Thermo Fisher Scientific	Alphasense OPC-N3	https://www.thermofisher.com/bg/en/home.html		info.aq.breda@thermofisher.com

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ANNEX II - Filter Producers

Country	Organization	Filter Type	Website	Contact Person	E-mail
Switzerland	OekoSolve + Bulgarian representative Ekoproekt group Ltd.	OekoTube	http://www.oekotube.ch/joomla/oekosolve/index.php/en/	George Dermendjiev	greenfcons@gmail.com
Germany	Schrader Abgastechnologie	OekoTube	www.schraeder.com	T. Böhm	t.boehm@schraeder.com
United Kingdom	Poujoulat	Tubinox Starflex	http://www.poujoulat.co.uk/	R. Mayer	r.meyer@poujoulat.co.uk
Germany	Kutzner + Weber	Electrostatic precipitator "Zumikron"	http://www.kutzner-weber.de/		info@kutzner-weber.de
Switzerland	Spartherm	ESP AirBox	https://www.spartherm.com/en/home/	Volker Schmatloch	info@spatherm.com
Norway	Schenck Process	$R_{esidential}$ ESP	www.app.no	Ernst Henriksen	ernst.henriksen@app.no
Germany	Karlsruhe Institute of Technology	ESP Carola - KIT	www.kit.edu	Andrei Bologa	andrej.bologa@kit.edu
Germany	Otto Spanner GmbH	ESP SF20 - Spanner	www.spanner.de	Georg Kuffer	georg.kuffer@spanner.de
Finland	TassuESP	Nasu ESP - Tassu ESP	http://www.tassuesp.com/#contact	Mr. Ari Laitinen	Seppo.Paavilainen@tassuesp.com
Germany	TH Alternativ Energie	ESP Kamin-Feinstaubkiller TH-AE	www.th-alternativ-energie.de	Thomas Hipp	info@th-alternativ-energie.de
Austria	APF		www.apf.ag		office@apf.ag
Germany	Feinstaubkiller		http://www.feinstaubkiller.com/index.php?id=feinstaubkiller		info@th-alternativ-energie.de
Germany	On top Metaloterm	Ecostream	http://www.metaloterm.com/english/		info.de@ontop-abgastechnik.de
Italia	Stabile S.p.A		https://www.stabile.it/en/company/		info@stabile.it

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Interreg Balkan-Mediterranean
AIRTHINGS
European Union
European Regional Development Fund
denkstatt
create sustainable value

ANNEX III - Sensor specifications

Producer	Model sensor	Measured parameters	Operating temperature	Range	Accuracy/Sensitivity*	Relative Humidity	Response time	Size	Weight	Maintenance	Price
Finnconsult Ltd (Vaisala)	AQT420	$PM_{10,2.5}$, NO_2, CO, SO_2, O_3	from -40 to 85°C	SO_2 0 - 2 ppm NO_2 0 - 2 ppm CO 0 - 10 ppm O_3 0 - 2 ppm $PM_{2.5}$ 0 - 2000 µg/m3 PM_{10} 0 - 5000 µg/m3	SO_2 ± 0.05 NO_2 ± 0.025 CO ± 0.2 O_3 ± 0.06 $PM_{2.5, 10}$ ±3 µg/m3	0-100 % RH (non-condensing)	60 seconds	185 x 128 x 128 mm	1.25 kg	Finnconsult Ltd provides replacement of the electrochemical sensor cells and the filter of the PM laser detector every 12-36 months (depending on the level of contamination)	5000 EUR 6500 EUR (with the Vaisala's wireless modul and original power adapter)
	Optional: Ceilometer CL31 for Cloud Height Detection	boundary layer	from -40 to 60°C	/	/	/	/	1190 x 335 x 324 mm	31 kg	/	30 000 EUR
UniTec Srl (Orion Srl)	ETLOne	$PM_{10,2.5}$, NO_2, CO, SO_2, O_3	from -20°C to 60°C	NO_2 10 - 225 ppb SO_2 5 - 10 000 ppb CO 0,1 - 80 ppm O_3 10-250 ppb $PM_{1,2.5,10}$ 1 - 400 ug/m3	NO_2 10 ppb SO_2 20 ppb CO 0,2 ppm O_3 10 ppb $PM_{1,2.5,10}$ < 2% f.s.	10 to 95 % RH (non-condensing)	61 seconds	540 x 710 x 310 mm	~ 15 kg	every 6 month. UniTec Srl provides it.	1432 EUR (sensor, meteorological station, router, software + installation and maintenance)
Scient Act BG Ltd (Aeroqual)	HH S300L EU + SH PM sensor head	PM_{10}	from -5°C to 45°C (a heater will be installed to reach a lower temerature limit)	1 - 1000 µg/m3	± (0.002 mg/m3 + 15 % of reading)	0 to 95% RH (non-condensing)	5 seconds	195 x 122 x 54 mm (including sensor head)	< 460 g	Calibration in the Aeroqual's headquarter every 18 months	1297 EUR (sensor + maintenance)
	HH S300L EU + SH PM sensor head	$PM_{2.5}$	from -5°C to 45°C (a heater will be installed to reach a lower temerature limit)	1 - 1000 µg/m3	± (0.002 mg/m3 + 15 % of reading)	0 to 95% RH (non-condensing)	6 seconds	195 x 122 x 54 mm (including sensor head)	< 460 g		1297 EUR (sensor + maintenance)
	FM S900 + SH ECM sensor head	CO	from 0°C to 40°C (a heater will be installed to reach a lower temerature limit)	0-10 ppm	< ± 1 ppm 0-10 ppm	15 to 90% RH (non-condensing)	30 seconds	64 H x 130 Ø mm (including sensor head)	< 200 g	Calibration once every 6 months (60 € per sensor) in Sofia and changing of the sensor head every 12 - 18 months (330 € per sensor).	1005 EUR (sensor + maintenance)
	FM S900 + SH ENW sensor head	NO_2	from 0°C to 40°C (a heater will be installed to reach a lower temerature limit)	0-1 ppm	< ± 0.02 ppm 0-0.2 ppm; < ± 10% 0.2-1 ppm	15 to 90% RH (non-condensing)	30 seconds	64 H x 130 Ø mm (including sensor head)	< 200 g		1005 EUR (sensor + maintenance)
	FM S900 + SH ESO1 sensor head	SO_2	from 0°C to 40°C (a heater will be installed to reach a lower temerature limit)	0-10 ppm	< ± 0.05 ppm (concentrations from 0 - 0.5 ppm) or < ± 10% (concentrations from 0.5 -10 ppm)	15 to 90% RH (non-condensing)	60 seconds	64 H x 130 Ø mm (including sensor head)	< 200 g		1005 EUR (sensor + maintenance)
	FM S900 + SH OZL sensor head	O_3	from 0°C to 40°C (a heater will be installed to reach a lower temerature limit)	0-0.5 ppm	< ± 0.008 ppm 0-0.1 ppm; < ± 10% 0.1-0.5 ppm	10 to 90% RH (non-condensing)	60 seconds	64 H x 130 Ø mm (including sensor head)	< 200 g		1005 EUR (sensor + maintenance)
	Stylitis 10	Data logger - Telemetry: Device for data logging and telemetry with built-in memory alarm - SMS. The customer must install a SIM card with enabled GPRS, 3G or 4G									970 EUR

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ANNEX III - Sensor specifications

Producer	Model sensor	Measured parameters	Operating temperature	Range	Accuracy/Sensitivity*	Relative Humidity	Response time	Size	Weight	Maintenance	Price
Alphasense	SO2-B4	SO_2	from -30 to 50°C	100 ppm	275 to 475	15 to 90 % RH (continuous)	t90: < 40 sec. from 0 to 2 ppm SO_2	16.5 H x 32.3 Ø mm	< 13 g	do not offer any installation or maintenance solutions.	143 EUR
	CO-B4	CO	from -30 to 50°C	1000 ppm	420 to 650	15 to 90 % RH (continuous)	t90: < 25 sec. from 0 to 10 ppm CO	16.5 H x 32.3 Ø mm	< 13 g		144 EUR
	B43F	NO_2	from -30 to 40°C	1000 ppm	-200 to -650	15 to 85 % RH (continuous)	t90: < 60 sec. from 0 to 2 ppm NO_2	63.5 x 75 x 55	< 13 g		154 EUR
	OPC-N2	PM	from -10 to 50°C	0.1 - 1500 µg/m3	/	0 to 99 % RH (non-condensing)	60 seconds	0.075 x 0.0635 x 0.06	< 105 g		410 EUR
	Electronic Diffusion Tube	NO_2, CO	from -20 to 50°C	NO2 0-5 ppm; CO 0-500 ppm	±0.5°C	10 to 90 % RH	It is battery powered and is capable of logging over 320k readings on its in-built SD card for the study of measurement trends or pollution e				Due for launch within the next couple of months
AQMesh (6MS Ltd)	AQMESH	PM_1, $PM_{2.5}$, PM_{10}	from -20 to 40°C	PM_1 0-200 µg/m³ $PM_{2.5}$ 0-500 µg/m³ PM_{10} 0-1000 µg/m³	5%	15 to 95 % RH	10-20 sec.	170x220x250mm without antenna 170x220x430mm with antenna	2,7 kg	Periodic cleaning - 3 months; Calibration of each station can be done by calibrating one of the AQMESH stations by a referent MOEW station and it is used to transmit the calibration to the other AQMESH stations. This procedure has to be done at 6 months; Replacement of two-year gas sensors is a recommendation, but usually if they are calibrated regularly they have a longer life span. AQMESH offers free equipment for trial. The proposal includes a temporary provision of 2 stations for at least 4 weeks of test period.	17990 BGN without VAT; Installation and maintenance costs for 2 years are included in the price; After the first year: + 1000 BGN without VAT / year. per station - for communication, processing and provision of data; After the second year: + 300 BGN per station / year - maintenance costs + BGN 1000 after the first year of communication remain.
	AQMGP11-02	NO_2, O_3, SO_2, CO	from -20 to 40°C	NO_2 0-4 ppm O_3 0-1,8 ppm SO_2 0-10 ppm CO 0-6 ppm	NO_2 ± 0.01 ppm O_3 ± 0.01 ppm SO_2 ± 0.05 ppm CO ± 0.0003 ppm	15 to 95 % RH	10-20 sec.				

* Sensitivity range is given for the SO2 - B4, CO - B4, B43F

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ANNEX IV – GOOD PRACTICES

A. DATABASES AND PLATFORMS FOR AIR QUALITY MONITORING AND FORECASTS

Coverage	Project Name / Website	Description	Communication approach and tools
Europe	http://www.citeair.eu/ http://www.airqualitynow.eu	CITEAIR project - European indicators provide comparatively comparable information on the air quality of European cities, every day - or even every hour - through two indices: for ambient pollution but also for pollution near the traffic. They take into account the most problematic pollutants in the city, including nitrogen dioxide, ozone and particulates. CITEAIR II project Provide up-to-date information on air quality, greenhouse gases and emissions in European cities to local and regional authorities, the public and the media and enhance comparability of cities through the interactive website www.airqualitynow.eu Identify, test and transfer good practice to describe the traffic situation and its impact regarding CO2 emissions in urban agglomerations by a mobility indicator; Identify, test and transfer good practice to integrate greenhouse gases into existing air pollutant emission inventories for regulated pollutants and to select measures with a combined effect on reduction of urban pollutants and greenhouse gases;	• Guidebook on integrated emission inventories (also: IMACE database and IMACE guidebook); • Guidebook on Air quality forecast; • Guidebook on mobility and exposure indicators (annexes as separate document); • Final CITEAIR II Newsletter (with overview of the final products from the project & the final conference); • www.airqualitynow.eu.

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		Identify, test and transfer good practice for dedicated urban air quality forecasting addressing different levels of complexity that meet the needs of cities and regions depending on their local skills, resources and level of expertise; CITEAIR II (Common Information to European Air) was co-funded under the European Commission INTERREG IVC programme and ran from 2008 to 2011. The projects started in March 2004 and ended in December 2011. Throughout this period it supports cities and regions in developing efficient means to collect, present and compare air quality data across a multitude of sites and provides furthermore an input to the air quality reporting and action planning. Thus, CITEAIR supports European cities and regions in their efforts to meet limit values and improve the air quality for their citizens. Although the project are finished the initiative taken by the project partners and the collaboration continues. This is especially true for www.airqualitynow.eu that has become an operational service for European Cities. Any city that wishes to join is welcome, the project partners are prepared to incorporate data from new cities at any time.	• Option to check the air quality in different cities for a recent hour, for yesterday and for the past year in various cities; • Information about air pollution – what is it, what are the health effects, environmental problems, pollution sources, acting on pollution; • Comparing cities section – what is the current situation, forecasts and annual situation, separate page for different cities information; • Sustainable Mobility Indicator - methodology and a tool that is able to describe the situation of traffic and the related impacts in urban agglomerations by means of an indicator.
Europe	Air Quality Index https://www.eea.europa.eu/themes/air/air-quality-index	The European Environment Agency's European Air Quality Index allows users to understand more about air quality where they live. Coverage: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom.	• Displaying up-to-the-minute data for the whole of Europe, users can gain new insights into the air quality of individual countries, regions and cities; • Interactive map with option to choose country and period.

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Europe	Copernicus Atmosphere Monitoring Service (CAMS) http://www.copernicus.eu/main/atmosphere-monitoring	Copernicus is the European Union's Earth Observation Programme, looking at our planet and its environment for the ultimate benefit of all European citizens. It offers information services based on satellite Earth Observation and in situ (non-space) data (such as from ground stations, which deliver data acquired by a multitude of sensors on the ground, at sea or in the air). There are six thematic streams of Copernicus services, one of which is Atmosphere - Copernicus Atmosphere Monitoring Service (CAMS).	The Copernicus Atmosphere Monitoring Service (CAMS) supports many applications in a variety of domains including health, environmental monitoring, renewable energies, meteorology and climatology. It provides daily information on the global atmospheric composition by monitoring and forecasting constituents, such as greenhouse gases (carbon dioxide and methane), reactive gases (e.g. carbon monoxide, oxidised nitrogen compounds, sulphur dioxide), ozone and aerosols. More specifically, CAMS provide: • Maps and data for regional air quality forecasts; • Retrospective assessments of air quality; • Identification of pollutants and their source; • Pollen concentration levels in the atmosphere; • Resources for evaluating possible emission control measures; • Inputs to local air quality forecasts (a few days ahead), health information and warnings.
World / Europe	http://aqicn.org/map/europe/#@g/41.1642/5.4492/4z	Real-time Air Quality Index Visual Map Coverage: different section with option to choose maps of the World, Asia, Europe, North America, South America, Africa, Australia, Middle East, India, China	Assessment of Air Pollution Level and Health Implications
Worldwide	www.numbeo.com	Numbeo is the world's largest database of user contributed data about cities and countries worldwide. Numbeo provides current and timely information on world living conditions including cost of living, housing indicators, health care, traffic, crime and pollution.	Pollution survey is done by 25799 people in 4052 cities. Numbeo allows to see, share and compare information about pollution (and cleanliness and purity) worldwide. It surveys the following: Satisfaction with air quality;

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			Quality and accessibility of drinking water; Water pollution (general); Satisfaction with garbage disposal; Does people find the city clean and tidy; Noise pollution and light during the night in the city; Green and parks in the city; Feeling of being comfortable to spend time in the city because of the pollution.
US	https://airnow.gov/	Every day the Air Quality Index (AQI) inform how clean or polluted your outdoor air is, along with associated health effects that may be of concern. The AQI translates air quality data into numbers and colors that help people understand when to take action to protect their health. Over 3,000 state and local monitors transfer data hourly for over 450 cities Air Quality Forecasts - Nationwide daily forecasts. Current Air Quality Conditions - Nationwide and regional real-time ozone and particle pollution air quality maps covering 46 States and part of Canada. The maps are updated hourly.	Information dissemination through: • http://www.airnow.gov; • Social Media - Facebook and Twitter; • EnviroFlash email alerts; • Free AirNow App for iPhones and Android; • Customizable AirNow Widget ; • Print materials – poster, leaflet.

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B. AIR QUALITY OPEN DATA SOURCES AND SPECIALIZED WEBSITES, DEVELOPED IN EUROPEAN COUNTRIES

Region / Country / Municipality	Website	Description / How it works?	Communication approach / Campaigns' activities
Paris	http://www.airparif.fr	• 60 pollutants are assessed of which 15 are mandatory; • 10 mobile units; • More than 60 air quality stations including 50 automated stations; • Around 50 employees; • Around 7 million Euros of annual budget.	• Monitor air quality and forecast pollution - 2 daily forecast; • Assess the impact of mitigation measures and inform the authorities, media and citizens (daily during a pollution episode); • Development of interactive tools – quiz, videos, special tool for kids, for drivers exposure; • Mobile application – for pedestrians and cyclists: option to estimate exposure to pollution in real time; Ambient pollution levels; Evaluation according to a current journey \AirParif Itiner Air – application\; • Airparif is in charge of forecasting and informing in case of pollution épisodes and airparif is part of the crisis unit set up by the authorities (Prefect); • Most efficient communication mix – main channel: web site + an app + information on the social media and in the media (TV, newspaper).
Paris	http://www.airlab.solutions	AIRLAB - Launched by Airparif and partners. Community that is committed to improving air quality. Large companies, SMEs and start-ups, research institutes, public bodies and	• Stakeholder and public consultation \different topics related to Air quality improvement – for example to develop Air Protection Plan\; • Events organization;

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		individuals: each brings their own ideas, skills and resources to the table.	• One-stop-shop for innovative initiatives; • Network & share knowledge; • Data sharing; • Technical or operational support;
France	http://www.atmo-france.org	ATMO France, the network of approved Air Quality Monitoring Association	• Implementation of air quality monitoring and information; • Dissemination of results and forecasts; • Immediate transmission to the Prefects of information relating to overruns or forecasts of exceeding alert and recommendation thresholds.
France	http://www2.prevair.org/	National platform for air quality prediction. One of the components of the French air quality monitoring and management system. Observation systems managed by the approved Air Quality Monitoring Associations (AASQA). This air quality forecasting platform, developed and managed daily by INERIS, and the result of the work of a consortium integrating alongside INERIS, Météo France, CNRS and LCSQA (Central Laboratory Air Quality Monitoring). It is based on the results of numerical simulations and observations collected in the field to predict and map concentrations of regulated air pollutants.	Daily forecast on the quality of the ambient air of the French agglomerations.
London	https://www.londonair.org.uk	Londonair is the website of the London Air Quality Network (LAQN), and shows air pollution in London and south east England. The website provides information for the public, for policy users and for scientists.	• Air Pollution Guide with detailed information about pollutants, Health effects, Health advises, Action – government's actions and what can do each of the citizens, how to reduce exposure; • Research & Reports; • Videos;

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		Information about Air pollution – now, forecast, annual map, pollution episodes. • UK does not have emergency measures.	• News; • Conferences; • Forecast Signup Available for different platforms – Android, iPhone, Chrome; • Widget Builder – with different setting options; • Daily newsletter, forecasts; • Twitter.
London	http://www.breathelondon.org	Advises how to breathe cleaner air... At home; On a walk/run; Senior citizens; At school; Cycling; In the neighbourhood; On the commute and at work; With Asthma or COPD	• Route planner - suggest up to three different routes for each journey. The routes are showing current pollution levels in London so that everyone can easily select the lowest pollution route. The map is updated each hour from pollution measurements taken around London; • Air pollution forecast.
UK	https://www.healthyair.org.uk/	The Healthy Air Campaign is tackling the public health crisis caused by air pollution. Aim to encourage behaviour that helps cut air pollution and our exposure to it.	• Very strong "Call for action" communication: suggested different ways everyone can get involved; • Accents on children behavior - clean air for schools campaign.
UK	https://uk-air.defra.gov.uk/	UK-AIR (Air Information Resource) webpages providing in-depth information on air quality and air pollution in the UK. A range of information is available, from the latest pollution levels, pollution forecast information, a data archive, and details of the various monitoring networks.	• Data collection & statistical tools, including Openair - free data analysis tool http://www.openair-project.org/; • Air pollution forecast map; • Consultation and seek views on draft Clean Air Strategy 2018; • Videos - find out how everyone can help; • Social Media – Twitter ; • Free air pollution recorded information helpline on 0800 55 66 77.

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UK	https://www.airqualitynews.com	The UK's air quality, emissions news and information site	• Professional events and conferences; • Awards for business contribution.
Vienna	www.wien.gv.at	Responsible for Air Quality Services and initiatives - Vienna Environmental Protection Department Very wide range of measures to improve air quality: expansion of public transport; Forcing Renewable Energy; Forcing the e- mobility https://www.wien.gv.at/umwelt/luft/luftqualitaet-2017.html	To inform the public about the current air quality in Vienna, the Vienna Environmental Protection Department (MA 22) has set up "Ozonix" - the computer tape service of the Vienna Air Monitoring Network. This is updated every hour. Telephone: +43 1 4000-8820 The following key selection is available: for the ozone alert service; for the current air quality report including evaluation; for the current ozone levels (one-hourly means with percentage in relation to the information threshold); for the maximum ozone levels (one-hourly mean values within the last 24 hours with percentage information threshold) The air quality reports of the City of Vienna deliver hourly - updated air quality reports; Daily Reports (of the last six months); Ozone alarm reports Monthly and annual reports; certain additional information about ozone (O 3) and particulate matter (PM 10)
Vienna	http://www.richtigheizen.at/	Campaign dedicated to right heating with wood An initiative of the Ministry of Sustainability and Tourism in cooperation with the Federal Guild of Chimney Sweepers Austria,	• Various informational materials; • Online calculator - calculate energy demand, fuel quantity and particulate matter emissions.

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		the Austrian Tile Stove Association, the Austrian Medical Association and the physicians for a healthy environment.	
USA	https://www.epa.gov/burnwise	A voluntary partnership program between EPA, state agencies, manufacturers, and consumers to emphasize the importance of burning the right wood, the right way, in the right appliance	• Educational Materials; • Funding Opportunities; • Ordinances and Regulations; • Strategies for Reducing Wood Smoke; • Best Burn Practices; • Health Effects; • Social Media – Facebook and Twitter pages ; • Burn Wise Awareness Kit; • Tip Sheets available in English, Spanish, Chinese (simplified and traditional), Japanese, Korean, Laotian, Tagalog, and Vietnamese; • Brochures available in English and Spanish; • Posters; • Children's Activity Book.
Netherlands	www.stookwijzer.nu	The Stookwijzer uses the air quality index of the RIVM. This indicates the current status of air quality in the Netherlands per area of 1x1km. Combined with the wind speed you get an up-to-date local advice for burning wood. The information is refreshed every hour.	• Heating tips; • Currently air quality status and tips is it good or not recommended to burn wood.
Nijmegen, Netherlands	https://www.nijmegen.nl/	Air quality policies Nijmegen • Soot reduction norm; • Clean Inland shipping (CLINSH); • Wood burning;	• Stookwijzer.nu; • Brochure with wood burning guidelines; • Public awareness campaigns; • Participate in national platform 'Wood burning and health';

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		• Low emission zone (LEZ); • Smart Emission project (citizen science).	• Industry: Kronenburger forum - Independent advice committee on environmental problems; • Smart Emission consortium - A citizen-sensor-network in the city Nijmegen.
Netherlands	https://www.rivm.nl/en/Topics/A/Air	Dutch National Institute for Public Health and the Environment (RIVM)	RIVM monitors the amount of the hazardous substances in the air, researches effects of air pollution on health and environment and delivers the information to government authorities as basis for their policy decisions.
Denmark	envs.au.dk/air http://lpdv.spatialsuite.dk/spatialmap?	Department of Environmental Science Aarhus University Results of air pollution monitoring, inventories of Danish emission to the air, information on air pollution models.	http://lpdv.spatialsuite.dk/spatialmap? An interactive map shows air pollution in Denmark in general and in detail, even to the level of each single address (the service is currently in Danish only).
Scotland	http://www.scottishairquality.co.uk/	Air pollution levels across Scotland updated hourly. Summary from 96 monitoring sites; Work in cooperation with Committee on the Medical Effects of Air Pollutants; COMEAP advises the government on all matters concerning the health effects of air pollutants; https://www.gov.uk/government/groups/committee-on-the-medical-effects-of-air-pollutants-comeap Air Quality Analysis tools - Public Air Quality Information. Provides pre-filtered and analysed data for those interested in air quality at a local, regional and national scale across Scotland;	• Pollution map; • Forecasts; • Separate section: What can I do about air pollution? How to reduce the emission and how to protect myself?; • Know & Respond - a free service to subscribers in Scotland that sends registered users an alert message if air pollution in their area is forecast to be moderate, high or very high. The description of the level of pollution is based upon the Air Quality Banding System; • Air Quality in Scotland has two separate educational websites aimed at children and

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		The advanced data analysis provides a series of analytical and interactive platforms for air quality reporting. It brings together current and historic air quality data with other data sources (supported by SEPA - https://www.sepa.org.uk/).	secondary school pupils to help you learn about air pollution! **Air Pollution Detectives** - Aimed at primary school children, this interactive resource features information on pollutants, what actions everyone can take, and lots of links to other websites to explore - http://children.scottishairquality.co.uk/ **Clear The Air** - especially for 12-15 year olds to find out more about air pollution and if their school is signed up they can use *Citizen Science tools* to understand air pollution better. Citizen Science lets the pupils collect and analyse air pollution data as a school project. The project enables to map their school's data. Option to calculate emissions to school http://cleartheair.scottishairquality.co.uk/
Italy	http://www.arpalombardia.it/sites/QAria/_layouts/15/QAria/AttivitaProgetti.aspx	Regional Agency for the Protection of the Environment of Lombardy During high pollution episodes only the best performing wood stoves are permitted (if you have other heating systems) . Also limitation on diesel cars are enforced (ban of euro 3 and 4 diesel car; Petrol Euro 0 and diesel euro 0,1,2 are already banned during winter)	• Programs and study projects, involving other agencies, research institutes, universities and local authorities; • Active web communication; • Emergency action with ban during high pollution episodes improve public awareness on the problem; • Education activities at schools of various levels with the aim of developing a greater awareness of the students with respect to issues related to air quality. The activity includes lectures, workshops and visits to air quality monitoring stations;

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			• As part of environmental education activities, ARPA Lombardia have created the AmbientiAMOci series, a series of 4 booklets dedicated to primary school children. The topics covered in the 4 volumes are Food, Air, Water, Waste. Each book is associated with a free App available for Android and iOS that allows you to propose an attractive way to learn scientific knowledge, with innovative and interactive digital content . The application can be downloaded for free by teachers and families. In addition to augmented reality, the App contains a browsable pdf of the booklet, a cartoon presentation of contents, interactive games, textual and photographic analysis and a final quiz.
Italy	http://www.arpalazio.net/ Regional Center of Air Quality	Air quality monitoring activities with the management of the regional network of fixed detection control units and with the implementation of periodic campaigns carried out with mobile means in the potentially critical areas of the regional territory. Moreover, with the use of pollutant dispersion simulation models, it guarantees the assessment of the air quality over the entire regional territory and the five-day forecast of the same.	
Spain	Barcelona Supercomputing Center http://www.bsc.es/ess/success-story-urban-development	Platform Vodafone Connected City – the company collects different types of data generated by cities and citizens by means of sensors and other devices, and is able to process this data in real time and transform it into new information for the citizens	

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Spain	http://www.bsc.es/ess/information/caliope-app Barcelona Supercomputing Center CALIOPE air quality forecast system	The system operationally provides air quality forecast at 24h and 48h for Europe (12x12 km), the Iberian Peninsula (4x4 km) Andalusia (1x1 km), Canary Islands (2x2 km), Catalonia (1x1 km) and Madrid (1x1 km). The app uses the user location to show the air quality forecast at the closest stations through five categories: good, fair, deficient, bad and very bad.	The app for Europe has been financed by the European Commission in the framework of the project MYGEOSS. The Environment Secretariat of the Government of México (SEDEMA) has adopted CALIOPE to predict air quality in México City - Aire CDMX - and evaluate measures to reduce pollution levels.
Spain, Barcelona	https://ajuntament.barcelona.cat/qualitataire/en/	Detailed information about current air quality status, pollution, health effects, actions during episodes and articles describing measures and achievements in air quality improvements.	• Map of Barcelona's air quality; • Alerts by email for subscribers; • Check vehicle's environmental label; • Low emission zone \restrict the circulation of the most polluting vehicles within this area\; • Special Sub-section: Improvements which includes Proposals from the City council and information "What can I do"; • Special measures during episodes and informational campaigns.
Spain	http://mediambient.gencat.cat/ca/05_ambits_actuacio/atmosfera/qualitat_de_laire/	Department of Territory and Sustainability – Catalonia In Catalonia, the Air Quality Monitoring and Control Service is responsible for evaluating air quality, based on the data collected with the Atmospheric Pollution Prevention and Surveillance Network (XVPCA). Catalonia has divided 15 areas of air quality according to emissions and dispersion conditions.	• Current status of the pollution; • Forecasts; • Awareness campaign during episodes; • Videos, leaflets, presentations, graphics related to the cleanest air quality.

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Romania	http://www.calitateaer.ro/public/home-page/index.html?locale=en	Public information in real time on air quality parameters, monitored in over 100 stations all over Romania, that make up the National Network for Monitoring Air Quality (RNMCA) The site provides information by the 41 local centers for data collection	• Pollution and air quality map; • Reports; • Separate section "Alert and news" and banner position on home page with information about alerts.
Germany	http://mnz.lubw.baden-wuerttemberg.de/messwerte/aktuell/index.htm	Current emission data in Baden Württemberg with option to choose different component/pollutant and also forecasts	
Germany	http://deutschland.maps.luftdaten.info/#12/48.7345/9.2083	People build up their own sensor and operate it in a net	
Germany, Stuttgart	https://www.stuttgart.de/	Some emergency measures during episodes: • prohibition of the use of small furnaces; • convince people to use more public transport instead of cars.	Stuttgart uses different media to reach as much citizens as possible. The media used are social networks, information channels via Whats app, posters at roads and publicity in local radio channels. Informational brochure - https://www.stuttgart.de/img/mdb/item/573353/119434.pdf

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C. AIR QUALITY PROJECTS

Project / Country	Website	Description	Actions /Achievements
LIFE-IP MAŁOPOLSKA – LIFE IPE PL 021 PROKJECT Poland Slovakia, Czech Republic (over 50 municipalities, Associations, Institutes)	https://powietrze.malopolska.pl/en/life-project/	Southern Poland is one of the most polluted regions in the EU. The project aims at preparing Air quality strategy in Małopolska Region. The scope of the project includes: • Establishing a network of 60 eco-managers in order to support the implementation of air quality actions at the municipal level; • Strengthening advisory and administrative services for Krakow residents with respect to elimination of stoves and solid fuel boilers; • Operating a regional-level Excellence Centre, to provide training and knowledge base for local authorities and Eco-managers; • Conducting information and education campaigns at the regional and local levels; • Developing an instrument for high resolution modeling of pollution dispersion for Krakow and analysis of variants of possible actions aimed at emission reduction; • Preparing an international air-pollutants modeling system for Małopolska, Silesia, the Czech Republic and Slovakia.	• Accelerated control and the implementation of the air quality measures set out in the Malopolska Air Quality Plan (MAQP); • Recommendations to municipalities (for cooperation, capacity building, information campaigns, etc.); • Providing communities with competences, tools and expertise in the field of air quality protection; • Increased knowledge of citizens about air pollution and solutions how to change their habits; • The eco-managers take part in many events and campaigns for air quality improvement and directly communicating to people the benefits of change old heating systems for environmentally-friendly ones. Advisory teams visited citizens who are not convinced and who have difficult material situation; • By virtue of resolution of the Regional Assembly of the Małopolska since 1 September 2019 in Cracow will be forbidden to burn solid fuels (coal and wood) in boilers, stoves or fireplaces. In connection to this, regressive subsidies were introduced: for applications submitted in 2016 - up to 100% of eligible costs, in 2017 - up to 80% and in 2018 - up to 60%.

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Clean air for European cities - LIFE11/ENVDE/495 Germany, Austria, Denmark, Hungary, Slovakia and Belgium	http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE11_ENV_DE_000495_LAYMAN.pdf www.cleanair-europe.org	The nine project partners are located in six different European countries: Germany, Austria, Denmark, Hungary, Slovakia and Belgium. The project coordination was accepted by the German transport and environment organisation Verkehrsclub Deutschland (VCD). The project is devided into several subproject areas: capacity building, car traffic, public transport, bicycle policy, shipping and the advice and support of decision-makers. The objectives of the projects were to: - contribute to an improved implementation of the Air Quality Directive on a regional and local level. - challenge continuing violations of European air quality legislation; - communicate best practice cases and solutions to stakeholders through publications, workshops and online; - inform decision makers, media and the public about harmful effects of air pollution to both public health and the environment.	• Increased awareness of good clean air policy in municipalities, authorities and relevant stakeholders; • Knowledge transfer of created expertise on the topic; • Social and political impact on the sustainable and long-term decisions on improving air quality.
iResponse project: Improved air quality Norway: Oslo, Bergen, Trondheim	http://iresponse-rri.com/	Addressing pollution from wood burning for residential heating requires better knowledge of emissions. Detailed information is needed about the amount of wood consumed, type of burning stove, geographical distribution and when it takes place. Information about emissions is available in Norway although it is aggregated at regional levels, which is not suitable for urban studies. Within the iResponse project citizen participation is used and crowdsourcing techniques to gather data to improve the knowledge about emissions from residential heating	The iResponse consortium includes natural and social scientist, designers and innovators. In an early stage of the project, Oslo Municipality, The Norwegian Environment Agency, The Norwegian Data Protection Authority and ZERO joined the project. As it progresses, the number of stakeholders has increased and they keep growing.

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2015 -2018		with wood burning. A web-based application is developed based on a co-designing process. With this application citizens will track their energy use for residential heating with wood burning. The data reported by citizens is combined with data obtained from other sources such as Statistics Norway and public participation GIS surveys (i.e. Maptionnaire).	There have been a number of oral presentations and conferences in references to methods developed in the iResponse project. A number of smaller projects have been implemented within the iResponse project http://iresponse-rri.com/results
Project hackAIR: Making the invisible visible	http://iresponse-rri.com/2016/making-the-invisible-visible	The hackAIR project provides citizens with tools for measuring air pollution and visualizing their data to establish a collective awareness platform for air pollution. It combines official air quality data with results from people's own measurements – using Arduino sensor modules, sky pictures from mobile phone and webcams, as well as low-tech measurements.	Co-creation activities are the accent. Through their personal engagement, volunteers felt that they "own" part of the product, since they have been actively involved in the creation process. Ownership creates motivation to participate. The project provided its participants with user-friendly, easy to understand information on what implications the different air quality levels have on people's everyday life and what they can do with the obtained knowledge. (e.g. personalized air quality information – "today air quality is good - go outside for a picnic", "bad air quality today - rather stay inside today"). These activities will go beyond simple awareness raising and towards capacity building and behavioural changes of the participants.
GIS-survey to collect information about citizens'	http://iresponse-rri.com/2017/the-value-of-citizens-feedback	The survey is designed by using the cloud service Maptionnaire, and the participants answered it using their computers, smart phones and tablets. The	The survey showed that the citizens of Oslo and Akershus have a good perception of their environment, as 86% of them identified locations as air pollution hotspots which match the reported information with environmental data.

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activities and their environmental perception		questionnaire was addressed to citizens in Oslo and Akershus with questions around three main themes: • Place of residence and characteristics of their living space; • Wood burning for residential heating and type of wood stove; • Geo-localized information about citizens' environmental perception. Citizen perception of the environment is crucial for the response and acceptance of the implementation of policy measures, such as implementing car-free areas, the ban of diesel vehicles in specific areas or the ban of old wood burning stoves, which may be somehow controversial.	The distribution of the GIS-survey was carried out using social media (Twitter), stakeholder groups, municipalities, educational centers, associations of senior citizens, NGOs and other networks. There were also posters in shopping centers, cafes and restaurants and asked for people's contribution by providing an online link (Uniform Resource Locator - URL) to the survey or a Q-code that allowed direct access to the survey. The survey resulted in better understanding of emissions from wood burning for residential heating and basis for decision-making processes and awareness of the environmental impact of wood burning and urban sustainability.
Localized real-time information on outdoor air quality at kindergartens, using low-cost sensor nodes Oslo	https://www.sciencedirect.com/science/article/pii/S0013935117316584	The project involves the need to empower the kindergarten staff to take actions to minimize children's exposures to harmful air pollutants while at the kindergarten. Such actions could be based on accurate and timely locally specific air quality information in real time. Three different sources of information can be used to achieve that: 1. data from low-cost sensors deployed in the playground; 2. data obtained using an air quality model (EPISODE); 3. data obtained employing a data fusion technique, merging a static base map and real-time data from the sensors.	The low-cost sensorc nodes have demonstrated the big potential that lies within this new technology to provide localized real-time air quality information, especially when combining it with data fusion techniques. The participants expressed that they are very interested in receiving air quality information and rated the web portal as a useful tool to receive information on air quality.

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ClairCity	http://www.claircity.eu/	ClairCity is an innovative project involving thousands of people in cities across Europe, enabling us all to decide the best local options for a future with clean air and lower carbon emissions. ClairCity is funded by the European Union. It is as four-year collaborative project (2016-2020) involving 16 institutions from 10 different countries (including 6 local authorities, 3 universities, consultancies, a government agency and multi-national non-governmental organisations) to provide the range of experience and expertise necessary for the project. The project aims to involve as many citizens as possible in an online survey, so that the researchers understand what residents of Bristol, South Gloucestershire and the surrounding areas want for their future to make sure that action on reducing air pollution creates a better region for all citizens. Building on this research, the project is also developing complex new modelling so that local authorities have better data to monitor and predict poor air quality, allowing solutions (at local level) to air pollution to be targeted and successful.	Six cities are partners in the project; Amsterdam in the Netherlands; Bristol in the UK; Ljubljana in Slovenia; Sosnowiec in Poland; the Aveiro region in Portugal and the Liguria region around Genoa in Italy. Each city faces different issues and causes of air pollution, but all of the partner cities are working to improve their air quality. They are using existing data that will be applicable across many more cities to drive the innovative public engagement activities. They are examining data that is already collected by all cities with over 50,000 residents in the EU and using it to build new models of urban air pollution and carbon emissions. These new models and scenarios make it easier for cities to identify changes that they can make for society to reduce emissions and make a positive change in peoples' lives. The ClairCity project released an online game, workshops, a school competition and a smartphone app.
ICARUS: Decision Support System (DSS)	http://icarus2020.eu/project-overview/	A web-based, flexible and interactive platform aimed at assisting stakeholders in the selection, application and evaluation of the available datasets and tools for urban impact assessment in support of air quality and climate change governance at different spatial and temporal scales and taking into account the specific regulatory context.	To raise citizen awareness regarding the impacts of their activities on air pollution and increase societal acceptance of emission reduction policies, a web- and smartphone/tablet-based tool was developed to inform citizens in participating cities about how their life style affects their carbon footprint and the health impacts of their actions/. They could then explore individually how downstream impacts change from commensurate change

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			in their behaviour /activities or monitor the overall social responsibility in their area or neighbourhood and how it affects their quality of life.
"Internet of Things" to monitor air quality Scotland, Glasgow	https://internetofthingsagenda.techtarget.com/feature/With-IoT-air-quality-in-Glasgow-gets-smart	The "Sensing the City" initiative, a collaboration between the University of Strathclyde, Institute for Future Cities and the industry-led Centre for Sensor and Imaging Systems (CENSIS), was an effort to complement existing high-cost static sensing stations with a low-cost mobile offering that would help address gaps in coverage.	The static stations provide highly accurate data, but their cost limits the quantity of deployments. Low-cost systems can be deployed flexibly and rapidly in mobile configurations to complement static stations. This can provide indicative IoT air quality data in areas without coverage in order to support identification of pollution sources.

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D. EVENTS DEDICATED TO AIR QUALITY IMPROVEMENT AND AWARENESS RAISING

Country / Organizer	Topic and Website	Description	Objectives / Outcomes
Forthcoming events			
Bristol, UK	Festival of Nature - Bath Festival of Nature | Bath Pop-Up Wildlife Party 2nd June 2018 - Bristol Festival of Nature 9th - 10th June 2018 http://www.bnhc.org.uk/festival-of-nature/	Established in 2003, the Festival of Nature is the UK's biggest free celebration of the natural world. The Festival began as a two-day showcase of interactive activities and live entertainment across Bristol's Harbourside	Objectives: • To deliver entertaining and informative events and activities that inspire greater public interest, volunteering and action for nature. • To facilitate, develop, and disseminate novel communication techniques that engage the widest possible audience • To build and support effective partnerships that bring together diverse organisations that face similar challenges and issues, and to help organisations learn from each other.
UK	Clean Air Day 21st of June 2018 https://www.cleanairday.org.uk	Clean Air Day is a chance to find out more about air pollution, share information with friends and colleagues, and help make the air cleaner and healthier for everyone.	Clean Air Day aims to: • improve public understanding of air pollution, both indoors and outdoors; • build awareness of how air pollution affects our health, especially that of young children and people with heart and lung problems; • explain some of the easy things we can all do to tackle air pollution. The more of us taking steps to protect ourselves, the better it is for everyone else.

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UK, London	Annual National Air Quality Conference & Awards 4th October 2018 https://www.airqualitynews.com/event/save-date-national-air-quality-conference-awards-2018/	The National Air Quality Conference & Awards serves as a platform for business, local authorities and the third sector to learn, networking and celebrate as an industry.	• Conference - to discuss the practical steps being taken to tackle air pollution, to look at the future role of road transport and how car-makers are looking to tackle emissions, to hear about the latest innovations in cleaner air and more.; • Awards – to recognize the work of individuals and organizations whose efforts have contributed to improve air quality.
Completed events			
Bruxelles, Belgium	EU Green Week partner event 25th May 2018 https://www.eugreenweek.eu/partner-events/involving-citizens-air-quality-monitoring-through-citizen-science-initiatives https://www.iscapeproject.eu/category/news/	Involving citizens in air quality monitoring through Citizen Science initiatives	The event will be an opportunity to learn more about citizen science, citizen's engagement and environmental monitoring using sensor devices. Citizen science activities can be a means to raise awareness and help citizens to learn more about their exposure to environmental stressors such as air pollutants, take informed decisions which may also facilitate behavioural change. It also raises questions on the reliability of the data and their appropriateness and value for public use.
Bologna, Italy	iSCAPE Mid-term Event – 10 May 2018 https://www.iscapeproject.eu/save-the-date-iscape-event/	The event is organized by the iSCAPE project and it is part of the EU Green Week 2018. The experts will identify challenges and opportunities for the low-cost sensor development and sensor application to tackle air pollution. Event participants will learn more about the	It aims to bring together diverse perspectives and create a constituency for air pollution control in European cities that is grounded on evidence-based analysis.

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		importance of connecting multidisciplinary stakeholders and engaging citizens to increase collective awareness and knowledge of air pollution and its impact for healthier cities.	
Dublin, Ireland	HACK THE AIR: Sparks Hackathon 14 March 2018 https://www.iscapeproject.eu/hack-the-air-sparks-hackathon-14-may/	HACK THE AIR is part of the iSCAPE project and is delivered in collaboration with the Science Gallery and SPARKS. SPARKS, a travelling exhibition that has already been shown in 33 European countries, aims to stimulate conversations between citizens, scientists, policy makers and education professionals in order to encourage a shared responsibility for science in a way that makes it relevant to the needs of society	A highly interactive event at the Science Gallery Dublin where people have the opportunity to design innovative solutions to air pollution in cities alongside researchers from both University College Dublin and Trinity College Dublin were there to guide the participants throughout the day. The participants are young people (aged between 15-25) with a passion for bringing ideas to reality, using a variety of materials, with creativity and a curiosity to solve big problems with simple solutions. Working in small teams, they use a process of design thinking to generate new ideas aimed at reducing pedestrian exposure to air pollution.
Guildford, UK	Research study about the air quality in Guildford Duration three weeks, started on 19 March 2018. https://www.iscapeproject.eu/are-you-concerned-about-the-air-quality-in-guildford-opportunity-to-take-part-in-a-research-study/	Guildford residents can get involved in this study if they meet the following conditions. • have a valid driving licence and use of a vehicle or motorbike; • use an Android smart phone Participation involves filling in a few questionnaires and registering trips and activity via the free 'Sparrows' app. In this way participants' travel behaviour and exposure to air pollution are mapped.	Reports: https://www.iscapeproject.eu/scientific-reports/

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EU	21st European Forum on Eco-innovation 5-6 February 2018 in Sofia, Bulgaria http://ec.europa.eu/environment/ecoinnovation2018/1st_forum/index_en.html	The Forum attracted over 500 participants, more than twice the number that usually attend. Nearly 40 case studies on how to cut air pollution in energy and transport were presented at the Forum. Municipalities, companies and other experts presented new technologies, business or governance models.	Key messages and case studies http://ec.europa.eu/environment/ecoinnovation2018/1st_forum/report_en.html
Hasselt, Belgium	Dissemination and feedback event as part of the Living lab activity on 23rd January 2018 https://www.iscapeproject.eu/air-quality-and-citizens-behaviours-in-hasselt/	After finalising its study about the impact of behavioural intervention on urban air quality, the University of Hasselt organised this event. The participants to the study joined the event along with three representatives from Stad Hasselt, the Living Lab main stakeholder.	It was the opportunity to share the key findings of the research together with the feedbacks from the participants. The organisers also sorted one of the participants as the lucky winner of an electric bike.
Bristol, UK	ClairCity in schools 17th January 2018 http://www.claircity.eu/blog/claircity-in-schools/	Through additional funding from the University of the West of England, the ClairCity team in Bristol ran a fun-packed day of activities for 9-10 year olds.	In conjuction with Orchard School, nearly 90 pupils from Upper Horfield Community School and Horfield CE Primary School spent the day learning about the impacts, sources and solutions for Bristol's air pollution problem.
Bristol, UK	Mutual Learning Workshop July 2017 http://www.claircity.eu/2018/02/17/mutual-learning-workshop-for-bristol/	The participants are different stakeholders who are engaged in environment, health issues and policies in the city and was aimed at developing routes to a "clean air", healthy, zero-carbon Bristol by 2050. Each participant was asked to share their organisation's current actions towards air quality	Overall the Bristol mutual learning workshop successfully engaged with a variety of stakeholders from different sectors and organisations. The wide representation of civil and civil society organisations led to the identification of social and cultural barriers to change, but also opportunities and

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		and reducing carbon emissions, and to suggest their vision for a "clean air" healthy zero-carbon Bristol. They identified challenges and barriers to change.	potential policy actions to increase bottom-up community and citizen engagement in local governance and decision making
France, Paris	Car Free Day 1st October 2017	After a limited 2015 edition in the heart of Paris, then a 2016 edition on the scale of the city center expanded, the Day without a car was extended this Sunday to all Paris. For seven hours, Parisians, Parisians and visitors enjoyed a quieter, quieter and less polluted city by walking, cycling or using public transport.	• Car traffic dropped; • Decreased levels of nitrogen dioxide; • Levels of pollution and noise have marked a significant decline.
Spain	Life platform meeting on air quality: abating urban exposure to air pollutants September 26, 2017 - September 27, 2017 http://airuse.eu/event-airuse/life-platform-meeting-air-quality-abating-urban-exposure-air-pollutants/	The International LIFE Platform reviewed the state of the art strategies and measures to have better air in the cities. For this, the discussion was established to firstly know the current situation, the problems we are facing, and the available measures. Speakers from different areas presented their views on this matter aiming to prepare helpful guidelines for all European cities.	GUIDEBOOK: Measures To Improve Urban Air Quality http://www.cleanaircities.net/ Reports http://airuse.eu/outcomes/reports/

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