COMPAIR

DELIVERABLE

D8.3 Draft Exploitation Plan

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Executive summary

Draft exploitation plan represents the first step to developing a robust sustainability strategy for the project. All projects end eventually, and COMPAIR is no exception. The goal of sustainability is to ensure continuation of project impacts when this happens. One measure of successful sustainability is when project results are used by the wider community of stakeholders, not just original beneficiaries, because these results help address a particular need, or are seen as contributing to a desired outcome, whether it's to bring people together, improve policies, make money, or enhance technical tools.

This deliverable made an initial attempt at defining key exploitable results (KERs) for COMPAIR. In Horizon Europe, KERs are defined as the main interesting results that are selected and prioritised due to their high potential for exploitation. Stakeholders can use KERs to derive a certain benefit, or as an important input to policy, further research, technology, or social action.

Three results that made it to the preliminary KER list are MOOC (Massive Open Online Course), air quality data and traffic data collected by citizens. Initial KERs were selected during a co-creation workshop with partners and became the focus of market research carried out in the next stage. As we reviewed similar products, we took note of their strengths and weaknesses to better understand how our future tools (all KERs are still in development) compare to existing market offerings. We learned, for example, that no MOOC currently offers a comprehensive introduction to air quality monitoring in the context of citizen science. If designed well, our MOOC can fill a gap in the market and become a valuable source of knowledge for environmentally conscious citizens around the world.

There are many projects offering citizen science data on air quality and traffic, sometimes as static datasets, sometimes via API (Application Programming Interface), but usually in some visual form on a web map. By studying different initiatives we discovered features that our own tools (like the Policy Monitoring Dashboard) should have in order to be competitive e.g. option to combine historic and real-time data, to compare two or more cities, to measure distance from pollution emissions source to measurement location.

We extended the scope of market review by covering carbon (CO_2) calculators and Augmented Reality (AR) apps for air pollution, two tools we're also building at the moment, and which are likely to become KERs later. There are quite a few CO_2 calculators out there. We reviewed 16 but there are definitely more than 20 in total. To stand out from the crowd, we can include more domains from which to calculate emissions, we can offer intelligent simulations to offer personalised recommendations, and we can collect and aggregate user feedback to assess overall willingness to change and estimate possible future impact.

AR apps that visualise air quality aren't as plentiful. We found and reviewed just four so our insight into this market is limited. Nevertheless, from our findings we managed to distil some recommendations that the development team may want to implement during the ongoing development work. These mainly concern language support, clarity of visualisation, and display of real-time data. For all KERs and apps this deliverable also outlines a preliminary communication strategy to ensure the widest possible reach and effective exploitation during and after the project.

Introduction

COMPAIR is a three-year Horizon 2020 project that helps cities reduce air pollution to safe levels through better policies and behavioural change. The central theme of the project is citizen science, an approach in which non-scientists work with domain experts to produce new data and knowledge.

Keen to deliver robust results that make a real difference on the ground, COMPAIR is enhancing the citizen science framework with additional tools and methodologies. Some of them are technical in nature and include various hardware and software components e.g. low-cost sensing devices for measuring traffic and air pollution, a web platform for visualising citizen science data, an augmented reality app with gamification features. Other innovation elements are more participation-oriented.

COMPAIR is convinced that to deliver a lasting impact, all members of the urban social fabric must work toward a common cause: governments, industry, scientific community, and citizens. COMPAIR's engagement methodology is designed to promote horizontal collaboration between all members of the quadruple helix community, with a special focus on citizens from lower socioeconomic backgrounds. By going the extra mile on inclusion we hope to amplify the voices of groups that have traditionally been more exposed to urban air pollution due to their socioeconomic status or other vulnerabilities linked to age, gender and health. Further to this, by inviting these groups to COMPAIR, not only are we spreading the benefits of citizen science more equally within a society, we also increase the chances of their opinions being heard by people with decision making powers. This is important since knowing that your opinion matters can motivate people to change their attitude toward policies (e.g. Green Deal) and the kind of behaviours they promote e.g. cycling, walking, plant-based diet, public transport, green energy.

Stakeholder needs, however, are not one-directional. Just as citizens need policy makers to avail of better policies, so too policy makers need citizens (and their data inputs) to enact measures that command credibility and fairness. That's why engagement activities in COMPAIR are intended, among other things, to promote dialogue among groups that historically have viewed each other with incredulity or even antagonism e.g. municipal politicians and disgruntled city residents. In this respect, COMPAIR acts as a networking platform where competing top-down and bottom-up views align to form a shared picture of local reality as regards air pollution, its causes, effects and potential solutions.

The collaborative, innovation driven citizen science practised by COMPAIR is expected to deliver impact on several levels through the provision of better data (technical), environmentally-conscious behaviour (social) and evidence based decision making (policy), ultimately transforming cities into urban environments that are healthy and liveable for everyone.

In a nutshell, this is what COMPAIR is all about. This vision has guided our activities since the beginning of the project (November 2021) and will remain our North Star until the end. Although COMPAIR is still young, it's never too early to start thinking about pathways to success. This deliverable is a step in this direction, intended to provide an initial exploitation framework by answering two questions. Which project results are the most important in terms of impact and audience reach? How can we develop and promote these results to ensure their widespread appeal during and after the project?

The quest for answers took us on a journey in which first a collaborative approach was used. Here, project partners, leveraging their vast expertise in citizen science, air quality, climate change, urban planning and environmental sustainability, gathered to identify key exploitable results (KERs) and different exploitation pathways for their (re)use. Then, a market review aiming to identify similar solutions created by other initiatives and organisations was conducted. This allowed us to better understand the feasibility and uniqueness of COMPAIR's KERs and to formulate initial exploitation mechanisms for the year ahead. In the next edition, both KERs and exploitation tactics will be reviewed to ensure they reflect the latest project developments, stakeholder needs, and market dynamics.

For this edition, we can formulate the main objectives as follows:

- Identify project KERs, their unique characteristics and target audience
- Critically examine KERs' value proposition in relation to other products and services available on the market
- Propose pathways for effective exploitation based on the results of undertaken activities (a co-creation workshop and market analysis)
- Communicate key conclusions and recommendations to relevant partners so that they can take the steps necessary to put the strategy into action

Now that the reader knows about COMPAIR and the rationale for this deliverable, a few words can be said about the document's structure. We will start by presenting, in the next chapter, our views on exploitation, which we see as a multi-dimensional concept comprising several possible exploitation scenarios. Once these are described, we will explain steps that were taken to produce this deliverable, namely a co-creation workshop with partners and a market review of competitor solutions. The results of each activity are presented next in the same order. In the penultimate chapter we propose a range of exploitation pathways for the four selected KERs based on insights gleaned from competitor analysis. We will conclude with a summary of key findings and some considerations regarding new elements that may be included in the next edition of the deliverable.

Exploitation Framework

COMPAIR understands exploitation in a broad sense, as use of results by a wide range of stakeholders to pursue commercial, societal, scientific, technical and/or policy goals, one or several at a time. Associated with each pathway is a clearly defined target audience and a unique potential for wider impact. These will be discussed first to provide context for the exploitation strategy.

Commercial exploitation: Use of project results for commercial and monetisation purposes by any business or for-profit entity or person. This type of exploitation can contribute to the following:

- Supporting quality enhancement and further development of results (products, services, processes) as private-sector enterprises will be keen to maximise value proposition based on insight-driven consumer behaviour, needs, and preferences
- Improving the viability, sustainability, and long-lasting impact of results as private entities are motivated more by continuous revenue generation targets than time-bound deliverables of non-profit projects
- Spurring innovation and competition amongst private-sector enterprises, and therefore, accelerating the exploitation process in pursuit of developing new innovative, competitive solutions. Ultimately, further innovation and product development will contribute to the scaling-up of start-ups and SMEs, with potential to create new jobs and improve the overall economic activity

Societal exploitation: Use of project results by individuals, communities, NGOs, and environmental activists for the benefit of people (individuals, groups) and the environment. Societal exploitation can contribute to the following:

- Supporting public awareness and encouraging the pursuit of individual and corporate social responsibility initiatives to improve air quality
- Galvanising community action and prompting activism to combat air pollution and improve wellbeing for all
- Informing individual and family choices related to housing, wellness, sport activities, and travelling
- Strengthening public-private partnerships and engaging citizens in the making of policies that improve their health and daily lives

Scientific/Educational exploitation: Use of project results by researchers, scholars, and academics in schools, universities, and think-tanks to improve existing educational content and/or produce new scholarly literature on air quality. This pathway can contribute to the following:

- Generating new scientific knowledge on urban pollution, science-policy interfaces, community engagement, and related fields
- Creating more research opportunities to attract young talent and people from lower socioeconomic groups
- Supporting and improving results of new and existing citizen science projects
- Contributing to the development of new concepts and proposals to improve air quality and human health (project results can, for example, be used in human biomonitoring studies)
- Building stronger collaboration links between academia and actors in the public and private sectors, as more data and insights are produced and disseminated

Technical exploitation: Integration of project results into other tools, processes, and technological applications to improve interoperability, accessibility, and usability of the final solution, regardless of whether this integration is implemented for commercial, societal, or academic purposes. This exploitation pathway can contribute to the following:

- Improving the quality of results as well as the scope and viability of exploitation through the development of new product features and options that enhance interoperability, accessibility, usability, and device compatibility
- Providing comprehensible data outputs and visualisations for other forms of exploitation (e.g. education or policy)

- Inspiring and offering further opportunities for the development of results by technical experts in other sectors and development fields, for example rural areas, energy policy, Internet of Things (IoT)

Policy-oriented exploitation: Use of results to inform policy development, and to promote a culture of evidence-based decision making. This exploitation pathway can contribute to the following:

- Assisting policy actors in making well-informed decisions that speak to the needs of citizens and follow the recommendations of scientific research
- Supporting public authorities and municipalities with urban planning, citizen engagement, day-to-day city management, environmental policies, and long-term strategy development
- Enhancing the results of other development projects in tourism, smart cities, green development, and more

Maintaining such a broad focus on exploitation has several advantages. First, it makes us value different results more or less equally, not just those with technical or commercial potential. Second, it ensures that no one important is left out when thinking about potential adopters, beneficiaries, and end users. And finally, by considering five pathways instead of one or two we can better capture wider impacts of the project.

It was this multidimensional framework that guided co-design and research efforts that led to the production of main findings and recommendations. Specifically, input to this deliverable came from two activities that happened one after another. A co-design activity happened first, in the form of an interactive workshop conducted with partners during a project meeting in Samos, Greece. There, participants worked in teams to identify the most important results for their exploitation scenario. A simple ranking technique was used in the end to select a handful of initial KERs for the project.

The second stage – market review – used input from the workshop to compare KERs against similar products and services available on the market. The analysis identified strengths and weaknesses of competitor solutions and then used this insight to develop, for each KER, a unique value proposition, a refined target audience, and a multi-pronged delivery strategy.

Exploitation Workshop

The project meeting in July 2022 was the first time COMPAIR partners met face-to-face after the covid restrictions were lifted. It was a good opportunity to get partners talking about sustainability as they sat next to each other in one place. Given the setup, an interactive format was adopted to achieve the following:

- Validate a long list of project results that could be of interest to users and prioritise key ones for an in-depth exploration later on (i.e. during market review)
- Identify a number of pathways and mechanisms that can help increase project's popularity and impact

- Map results against different exploitation pathways to identify specific beneficiaries and use cases across a range sectors: policy, industry, science, community etc.
- Streamline possible exploitation pathways and mechanisms through open discussion

The workshop started with a brief introduction to the exploitation strategy and its role in guaranteeing a long-lasting impact of project results. The focus then shifted to group work and discussions about project results (What), target stakeholders (Who), and possible exploitation opportunities that are worth exploring and prioritising (How).

For the interactive part, participants were divided into five groups (one per exploitation scenario) and asked to select 3-5 most important results from the available categories: written, applications, processes, sensors, data, and 'other'.

Table 1. Categories of project results

Written	Apps	Processes	Sensors	Data	Other
Deliverables Publications Case studies	CO2 calculator Policy monitoring dashboard AR app or DEVA (Dynamic Exposure Visualisation App)	Measurement techniques (NO2) Calibration algorithms (to ensure accuracy of CS sensors compared with reference grade stations) New visualisation techniques using augmented reality (AR)	TRL increases in SODAQ and Telraam sensors	Traffic count Particulate matter (PM) Nitrogen dioxide (NO2) Black carbon Weather	MOOC Typology of citizen science regimes Project website Landing pages

All the mapping and brainstorming was done in MIRO. Some 20 concurrent users were working on the canvas live, connecting the dots between What, Who, and How. Specifically, participants had to select from the central area (project results from the above categories) those outputs that are most relevant to their exploitation scenario (commercial, societal, scientific, technical, policy oriented).

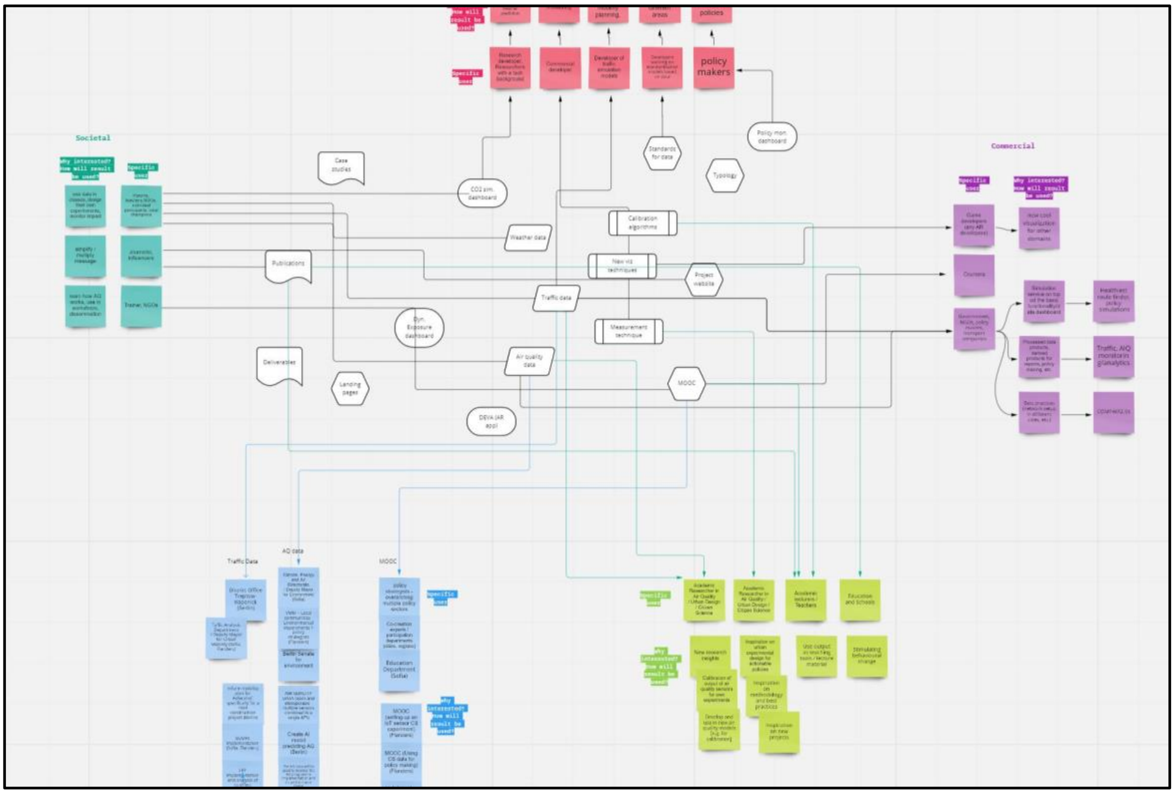

Figure 1. KER mapping template in MIRO

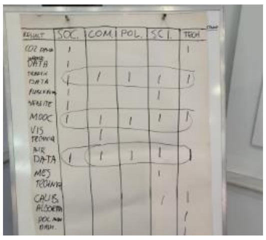

Figure 2. KER ranking

At the end, each group appointed a rapporteur to explain what results were selected, which stakeholders would use them, and for what purpose. Every time a particular result was mentioned, the moderator entered it into a ranking table. Results with the most mentions were ultimately selected as KERs. Three results that were deemed important by all groups, and therefore received five mentions each, are MOOC, air quality data, and traffic data.

Results: Key Exploitable Results Identified

MOOC

A MOOC is a massive open online course that is available and accessible to anyone online, delivered and completed virtually at any time, in a flexible and affordable way. MOOCs are widely used around the world by people from different professional and academic backgrounds for a variety of purposes e.g. to learn new skills, train on new technologies, develop their careers, switch to new careers or professions, and prepare for an advanced academic course at university.

In this project we have an official deliverable D8.5 COMPAIR Citizen Science Lab with MOOC to be delivered in M34. The fact that MOOC was selected by all five groups shows its huge potential as a vehicle for dissemination and exploitation. It can appeal to different audiences, from students and civil servants to IoT professionals, charity workers, and tech companies, because of convenience, affordability, quality of content and insight. That MOOC made it to the

KER list so early is a good thing, as it gives us plenty of time to prepare something with a widespread appeal, something that will meet and even exceed the expectations of future users. A review of existing MOOCs on citizen science and air quality, carried out for this deliverable, is the groundwork we are doing now to deliver a successful course in two years' time.

Table 2. Workshop results - MOOC

Exploitation pathway	Stakeholders and use cases
Commercial	• Commercial MOOC platforms such as Coursera, Udemy, EdX, FutureLearn, and Allison. For them, a good MOOC is a way to attract more learners and make money from paying users
Societal	• Non-profit organisations use MOOC to upskill or reskill their staff to offer new or improved services to beneficiaries
Scientific/ Academic	• Academic instructors, lecturers, and professors use MOOC as part of the curriculum to promote STEM education
Technical	• IoT companies and equipment manufacturers use MOOC to understand how their products compare to competitor solutions on the market, and reuse available components (open source) to enhance their value offering
Policy-oriented	• Policy strategists and civil servants in different departments use MOOC to understand the value of citizen science data and activities. Ultimately, public authorities can initiate or provide support for measurement campaigns, and use resulting data for policy making

Air Quality Data

This type of data shows how clean or polluted the air is at certain spatiotemporal resolution. Pollution level is determined based on the amount of pollutants found in the air, such as nitrogen dioxide (NO2), particulate matter (PM) or black carbon.

In COMPAIR, air quality data will be collected using two types of SODAQ sensors.

For PM measurements, a SODAQ AIR device will be used. It's only slightly bigger than a bicycle bell so can be easily mounted on a bike to measure dynamic exposure to PM1, PM2.5, and PM10. The device can also be used as a static environmental sensor to measure air pollution from a fixed location (home, street, garden) over an extended period of time.

NO2 measurements will be taken using a device conveniently called SODAQ NO2. It is currently in the prototype phase so won't be available to citizen scientists immediately. Once ready, however, it will be able to measure not only NO2 but also PM, humidity and temperature.

SODAQ's platform Know Your Air (https://knowyourair.net/) currently visualises all data (PM1, PM2.5, PM10, humidity, temperature) except NO2. Our goal is to visualise both pollutants on a single map, as well as environmental conditions, to provide a comprehensive profile of local air pollution in five pilot areas: Athens, Berlin, Sofia, Plovdiv, Flanders. This will be done by tapping into different data sources (citizen science, official reference stations) and then displaying information from them on an interactive web platform, which is called the policy monitoring dashboard (more on it below).

Table 3. Workshop results – air quality data

Exploitation pathway	Stakeholders and use cases
Commercial	● ICT companies can include citizen science data as part of the Sensing-as-a-Service package for pollutant monitoring, covering air quality measurement, data visualisation, and account management
Societal	● NGOs, community champions, individuals passionate about climate change, and parents all can use air quality maps to inform their decisions about travel, diet, energy consumption, and so on ● Journalists and pressure groups can study data visualisations to investigate causes of air pollution and hold those responsible to account
Scientific/ Academic	● Researchers at universities, think-tanks and institutes of different types can use raw datasets to cross-validate the works of others or provide backing for their own ● Schools can assess the situation by studying peak pollution times to introduce the necessary changes e.g. smoking ban, dedicated smoking areas, new ventilation policy
Technical	● Companies like Google can integrate project data into its Environmental Insights Explorer to support green mobility policies ● Developers working on standardisation models can use COMPAIR results to develop standards for citizen science data and metadata
Policy-oriented	● Environmental departments can combine citizen science data with other sources (e.g. data from monitoring stations and satellites) to improve the accuracy of air quality models ● For urban mobility departments, citizen science may be the only source of information on air pollution in certain inner city areas. Results can be used to introduce measures like school streets ● Public relations department can use data visualisations to link improvements in air quality to policy measures, and communicate the impact to citizens via different channels

Traffic Data

Traffic data is also spatio-temporal in nature as it indicates the number, speed, and directions of moving objects (vehicles, cyclists, pedestrians etc.) on a particular road/street at a certain point in time or some extended time period. In COMPAIR, we are mainly interested in vehicles as one of the lead causes of air pollution, although the device we're using to capture them is smart enough to recognise pedestrians, cyclists, cars, buses and other heavy vehicles. This device is called Telraam. It's a small box containing a Raspberry Pi microcomputer, IoT sensors and a low-resolution camera, that can be fitted on the inner window overlooking the street.

Telraam data is citizen science data because it is residents who, by putting sensors on their windows, supply information on local traffic conditions. Traffic data is collected every 15 minutes and is sent to the central cloud database managed by Telraam. Third parties can access this data via open API, calling the Telraam cloud, not the sensors directly. To make traffic counts more intuitive and easier to understand, we will build a dashboard with various 2D visualisations (e.g. line charts, bar charts) that urban planners can use to evaluate existing measures and propose new ones e.g. road works, school streets.

Table 4. Workshop results – traffic data

Exploitation pathway	Stakeholders and use cases
Commercial	● Tech companies that provide navigation services may integrate citizen science data into their traffic model to offer better services
Societal	● Residents and journalists investigate local traffic conditions to examine the need for a change in policy and increase bargaining power when communicating with policy makers ● Living Labs may want to use data on traffic in inner city areas as a basis for serious gaming involving quadruple helix stakeholders
Scientific/ Academic	● Researchers working at the intersection of transport, air pollution, climate change and citizen engagement. They use data to analyse correlations between multiple variables that have a bearing local living conditions
Technical	● Traffic simulation experts need alternative data sources to increase predictive power of their models
Policy-oriented	● Departments dealing with transport, environmental and urban planning. For them, citizen science data can be a complementary source of information that enhances official monitoring efforts, to support the design and implementation of SUMPs, LEZ, school streets etc.

MOOC, air quality data and traffic data are the three results that emerged as KERs from the exploitation workshop. We originally planned to conduct market review only for these outputs, but then decided it would be wise to include technical apps as well. The different apps are

- CO2 calculator which will estimate ones' carbon footprint across transport, energy, food, waste
- Policy monitoring dashboard which will display, on a city level, air quality data collected by citizen scientists
- DEVA app which will display air pollution in one's vicinity as floating particles

Although these apps weren't as popular with workshop participants as the three KERs – for instance, CO2 calculator was selected by two groups (societal and technical), policy monitoring dashboard by one group only (technical), and DEVA app by none at all – we think it would be beneficial for the technical team, pilots and project as a whole to know what similar solutions exist on the market, not least to be able to learn from their strengths and weaknesses and apply this knowledge to make improvements while the apps are still in development. And perhaps when results are reviewed in a year's time at another workshop, some or all of these tools will make it to the KER list because partners will be more aware of their market potential.

Market Review

The aim of the review was to help COMPAIR identify a unique value proposition of its results vis-à-vis existing solutions and to learn from best practices and successful examples that have been well-exploited by other stakeholders.

The market review researched and studied similar, competing, and even complementary results and products available on the market. In doing so, it helped identify Unique Value Points (UVPs) needed in each KER to be well developed, communicated, and most importantly, exploited. This value has been identified based on the assessment of features (strengths and weaknesses) of available products and results of other citizen science projects. Moreover, it provided the project team with an opportunity to build on and learn from the experience, outcomes, and best practices of other European citizen science projects.

As regards MOOC, the market review covered relevant training courses on air quality, air pollution and climate change, environmental sustainability, and citizen science; regardless of where they are offered, how, and by whom. The assessment includes those developed by academic institutions and other citizen science and EU projects, as well as those provided and promoted by private MOOC platforms such as Coursera and EdX.

As regards air quality and traffic data, and the corresponding visualisation platforms, we narrowed the focus on those solutions/providers that COMPAIR can realistically compete against. Governmental sources (e.g. open data platforms) and private sector initiatives (e.g. Google's Environmental Insights Explorer) generally enjoy widespread recognition that is difficult to achieve in a three-year EU project. A more direct competitor for us would be other non-profit citizen science projects that provide and display air quality and traffic data for the five COMPAIR pilots, either exclusively or as part of a wider city network.

Finally, deep dives on the CO2 dashboard and DEVA app sought to identify similar tools with features, functionalities and user reviews that contain useful learning points for our development team.

Competitor analysis

MOOCs

A wide variety of MOOCs that cover air quality are available on the market. However, their main focus is not necessarily air quality monitoring and measurement, but rather environmental sustainability in general, climate change, outdoor and indoor air pollution, or atmospheric monitoring. Apart from MOOCs offered by local universities in each country, which are usually more expensive than others or are delivered as part of a postgraduate degree, most available MOOCs are provided in English. Below we provide our sample of reviewed MOOCs.

Table 5. MOOCS on air quality

Name	Owner	Access
Air Quality Management	World Bank	Free
Introduction to Indoor Air Quality	Hong Kong University of Science & Tech	Free
Air Pollution – a Global Threat to our Health	University of Copenhagen	Free
Air pollution: causes and impacts	Institut Mines-Telecom	Free or $49
Environmental Protection and Sustainability	IsraelX	Free or $49

The Health Effects of Climate Change	Harvard University	Free or $149
Environmental monitoring and protection	The Open University	£2,120
Environmental Quality Monitoring and Analysis	Advanced Learning	Free
Bürger schaffen Klima Wissen	EU-Citizen.Science	Free
Monitoring Atmospheric Composition	EUMETSAT, Copernicus AMS	Free
Introduction to Low Carbon Road Transport	CENEX	$69
Chemometrics in Air Pollution	Universiti Malaya	$69
Monitoring Atmospheric Composition MOOC	EUMETSAT, Copernicus AMS, ECMWF	Free
Odour Pollution for the Public	D-NOSES Project	Free
Air Pollution and Control	Indian Institute of Technology	Free

Only a few of these MOOCs provide subtitles in other languages such as German and French in their video learning material. No video learning material with Dutch/Flemish, Greek, or Bulgarian was found in any of the identified and assessed MOOCs.

The duration of available MOOCs ranges from 3-12 weeks, with the majority being delivered in a time period of 3-4 weeks, or 12-30 hours in total. Only a few of the available MOOCs cover citizen science, but mostly to highlight the significance and role of citizens in improving air quality or to train participants on air quality research and data analysis methods. None of the courses however provide training material on how to technically collect air quality data using DIY sensors. At the same time, many of the available courses address air-quality-related policymaking and provide knowledge on the different types of air pollutants. Almost all of the found MOOCs make use of video learning material, assess the progress of trainees using quizzes or assignments, and provide digital certificates upon completion of the course. Private MOOC platforms such as Coursera charge trainees for an e-certificate.

Although MOOCs are recently common and widely produced by different EU projects, no citizen science project on air quality has been found to produce one. Most MOOCs on air quality are produced either by other projects that are not involved in citizen science, or universities that deliver their courses in English language on global MOOC platforms such as Coursera, EdX, Alison, and FutureLearn. National or country-specific MOOC platforms that offer training courses in other languages, such as OpenHPI and Iversity in German, appear not to offer any training courses on air quality.

Citizen Science Data Visualisations

More than 20 maps and apps that share, either as raw data or visualisations of some kind, data on air quality and traffic, for some or all COMPAIR pilots, were identified and assessed. Most of these maps are showing data that has been collected by citizen scientists in these cities. However, some platforms such as iQair show, in addition to citizen science data, data from other sources such as PurpleAir.

Table 6. Projects supplying air quality data

Name	Cities	Sector	RT Data[1]	API	PM	NO2 etc.
PurpleAir	Athens, Flanders, Sofia	Private	Yes	Yes	Yes	No
iQAir	Berlin, Plovdiv	Private	Yes	Yes	Yes	-
Sensor.Community	All cities	Non-profit	Yes	Yes	Yes	No
CanAirIO	Berlin	Non-profit	Yes	Yes	-	-
uRADMonitor	Berlin, Flanders	Non-profit	Yes	Yes	Yes	-
Clarity	Berlin, Flanders, Sofia	For-profit	Yes	Yes	Yes	-
Openaq	All cities	Non-profit	Yes	Yes	Yes	-
iScape	None	Non-profit	No	No	-	-
World Air Quality Index	All cities	Non-profit	Yes	Yes	Yes	-
HackAir	All cities	Non-profit	Yes	Yes	Yes	-
Sensebox	All cities	Non-profit	Yes	Yes	Yes	Yes
CurieuzeNeuzen	Flanders	Non-profit	No	No	-	Yes
HasselAIR	Hasselt	Non-profit	Yes	Yes	Yes	-
InfluenceAir	Brussels	Non-profit	Yes	Yes	Yes	-
Mechelen Meet Mee	Mechelen, Antwerp	Non-profit	-	No	No	Yes
Curieuzenair	Brussels	Non-profit	-	No	No	Yes
Luchtpijp	Brussels	Non-profit	Yes	Yes	Yes	Yes
OdourCollect	Berlin, Sofia, Athens	Non-profit	Yes	Yes	No	-
AirBezen	Flanders	Non-profit	-	No	Yes	No
Smart Citizen	All except Sofia	Non-profit	No	Yes	Yes	Yes
Stadtpuls	Berlin	Non-profit	Yes	Yes	Yes	Yes

Although many of the applications show data collected using low-cost air quality or traffic sensors, only a few display data collected through DIY sensors. The majority of the applications show real-time data and can be well-integrated into other systems and web applications through a clear application programming interface (API). In addition to the air quality index, a measure and a public communication tool indicating the level of pollution in the air, the type of data displayed differs from one platform to another. The majority of the platforms show different types of PM (PM1, PM2.5, PM10), while some show CO, NO2, O3, odour, or other air pollutants. Many applications show data of air temperature, humidity, and pressure next to air pollutants. Moreover, most of the identified maps and applications are supported by mobile applications and can be accessed through different types of devices.

The best and most competitive platform that was found is Sensor.Community, a citizen science project for air quality monitoring. Many other platforms such as AirBG.info (Bulgaria), Airtube (Sofia and Plovdiv), and HasselAIR (Flanders) and Luchtpijp (Flanders) display their data using

[1] Real-time data

the Sensor.Community data display map. Accordingly, it shows data collected by citizen scientists that were involved in different EU projects, whether they used DIY sensors or not. It displays up-to-date air quality data for all of the pilot cities using hexagons of different colours to indicate air quality index, in addition to PM2.5 and the code of the sensor that collected the data. All data is real time, API is easy to use, and the platform is supported by a mobile application and can be viewed in 20 different languages, most of which are European.

Specifically for traffic data, with the exception of Telraam, very few applications that cover pilot cities were found. Most of the data we came across was not real-time data, however when it comes to accessibility, many datasets were provided as open source. In terms of focus, this varies from one platform to another, with some showing road traffic, congestion, and driving behaviour, some traffic emissions (e.g. NO_2, CO_2), fuel consumption, duration travelled, and distance, and some vehicle speed and type (cars, trucks, etc.). Not many of the identified applications are supported with or can be accessed via mobile.

Table 7. Projects supplying traffic data

Name	Cities	RT data	Traffic	Congestion	Emissions	Vehicle type	Mobile App
Envirocar	Berlin	Yes	Yes	No	Yes	Yes	Yes
WeCount	Leuven	Yes	Yes	No	Yes	Yes	No
pNEUMA	Athens	No	Yes	Yes	-	Yes	No
HighD Dataset	Berlin	No	Yes	Yes	No	Yes	No
TomTom Index	All	Yes	Yes	Yes	Yes	Yes	Yes

CO2 Calculators

A CO_2 calculator, or a carbon footprint calculator, expresses quantitatively the amount of greenhouse gas emissions produced by one's daily activities. The results can be of interest to different stakeholders. For example, policy makers can use it to identify and study the most significant sources of emissions in order to try and mitigate the risks of climate change. Citizens, for their part, can use it to increase awareness of adverse impacts their behaviour has on the environment, and to learn what they can do to change their behaviour to lower the carbon footprint.

Table 8. Some examples of CO2 calculators

Product Name	Creator	Domains
Conservation	NGO	Household, transportation, travel
PS Lifestyle	Project	Flights, building, shopping, food, transport, pets, waste
Ecowalla	NGO	Energy, transport, food, consumption, investment
WWF	NGO	Housing, food, travel, stuff
Henkel	Private	Housing, nutrition, mobility, holiday, leisure
The Nature Conservancy	NGO	Travel, home, food, goods, services
Climate Hero Calculator	Private	Housing, travel, consumption

Terra Pass	Social Enterprise	Public transit, private transit, air travel, home energy
Carbon footprint	Private	House, flights, car, motorbike, bus, rail
Carbon Independent	Community	Electricity, gas, bus, train, food, flights
Arbor Day	Foundation Program	Travel, home, food, goods, services
EPAM Systems, Inc.	Project	Travel, transport, utilities, pets, food, services
DECC 2050	Public	Transport, buildings, industry, electricity, land use etc.
eduMedia	Private	Household, transport, food, shopping
Footprint Calculator	NGO	Household, transportation, food, waste
My Carbon Footprint	Private	Diet, household energy, driving, waste, flights

In our market review, 16 carbon footprint calculator platforms were identified and assessed. The majority of these calculators measure or evaluate the user's carbon footprint across several domains e.g. household and energy consumption, land travel, air travel, waste management and disposal behaviour, food consumption trends. A few calculators also measure CO2 emissions based on the user's water consumption, shopping behaviour, purchase and use of different services, and even pet ownership.

The results of different calculators vary significantly due to different methods, sources and conversion factors used. Furthermore, most calculators show results per domain and compare it with the average in a country, the EU, or the world, with some also providing recommendations on how to improve behaviour and minimise one's footprint. Only one of the identified calculators, the UK Government Mackay Carbon Calculator, offers users the option of simulating their behaviour, with multiple what-if scenarios to evaluate and anticipate the person's footprint in different situations. Most of the carbon footprint calculators are user friendly, visually appealing, multilingual (English and other European languages), and open for the public free of charge.

Augmented Reality Apps

Augmented Reality (AR) technology does what it says on the tin; it helps users augment the perception of the real world using a combination of virtual elements, digital content and one's current location. Smartphones, tablets and other visual gadgets are some of the common ways in which people can experience AR. COMPAIR will utilise AR technology to visualise air quality data in one's surroundings. The app that we're going to develop will help us raise awareness about air pollution, encourage people to take less polluted routes and get rewarded for it (gamification), attract more people to citizen science, make people consider behaviours that are kinder to the environment.

Table 9. A selection of AR apps visualising air quality

Name	Measurements	Visualisation	RT data	Status	Cities	Cost
IQAir	PM, NO2, CO, SO2, O3	Floating particles	Yes	Market	10000+	Free
Air Apex	Pollution from poor to good	Four different emojis	Yes	MVP	N/A	N/A
AiR	PM, NO, NO2, NOx, CO	Floating dirt & particles	No	Beta	India	Free
NYT app	Air pollutants in µg/m3	Microsized particles	Yes	Market	Global	$0.25 p/w

Four AR data visualisation applications were found in the field of air quality monitoring. Two are already developed, one is still a beta version with more than one thousand downloads, and one is a minimum viable product that is not yet fully accessible. All applications use AR technology to depict air pollution in different forms such as different-size particles, emojis (four different feelings based on level of pollution), or dirt spots. In addition to portraying air quality index, most applications provide other measurements such as PM, CO2, NO2, and O3 in real time and free of charge. All applications are designed for mobile devices and are compatible with iOS, Android, or both. They portray data based on the user location or GPS coordinates. The New York Times uses AR technology in one of its articles to locate readers and provide them with an immersive experience that visualises air pollution in their cities. Readers are also able to compare pollution levels in their cities with others around the world.

Now that we covered all four sets of results, it's time to develop exploitation pathways for their uptake and long-term sustainability. This will be done in the next chapter, where we elaborate for each output:

- Users across three broad categories - early adopters, early majority, and late majority
- Specific needs and interests arising from five exploitation scenarios - commercial, societal, scientific/educational, technical, and policy-oriented
- a unique value proposition (What), target audience (Who), and the optimal delivery model (How) all presented in a graphic form

Exploitation Mechanisms

MOOC

The **early adopters**, the fastest and most socially-forward group of users to take, recommend, and advocate for the MOOC are citizen scientists involved in the project, other project followers and subscribers, youth activists, climate activists, students, and local communities in the five pilot cities. The **early majority** of users who follow suit and have a similar profile as early adopters but are located in other parts of Europe and are eager to adopt the model and make it work in their city. The **late majority** includes staunch critics of the green agenda, and those who are not easily swayed into action by scientific evidence. These people may change opinion and jump on the bandwagon eventually, for instance after experiencing first-hand the devastating effects of natural disasters, reading local news about health impacts of air pollution, or even simply talking to people who took part in citizen science.

Although a study by the Global Web Index[2] says that environmental consciousness has no age, Generation Z, or GenZers (born in 1997-2012) and millennials (born in 1981-1996) are some of the most environmentally conscious categories of consumers. Further, based on a study by Lendvai, Kovacs, Balazs and Beke (2022)[3], this group of users is most concerned about health, personal growth, the environment, sustainable living, and social justice. They are very keen to purchase organic, eco-certified, and/or fairtrade products. They seek experiences and social and environmental sustainability as well as enjoy perceptual, attitudinal, and ethical lifestyles. They hold more authentic, ethical, emotional, spiritual, and health and environment conscious values than their older counterparts.

According to another paper by the global tech giant Oracle,[4] GenZers are early adopters of high-tech and internet-of-things products. MOOC is also one of the best learning tools to educate GenZers or younger generations in general as they enjoy short video material and interactive assessments and quizzes more than the traditional long academic articles, videos, and tests.[5] Ultimately, those who are less driven by technology-based products and are sceptical about climate change, will make up the **laggards**, the last group of users to try or adopt something new.

Nevertheless, in order to deliver the course to a wider group of users, its reach should go beyond the project's website and the early adopters who are already involved in the project. This approach requires that the project attempts to partner with global MOOC platforms like Coursera, FutureLearn, and other European-based MOOC platforms to improve its MOOC's reach and significantly increase the number of enrollments. This will not only enhance and facilitate the exploitation of the MOOC, but will also ensure its viability and sustainability after the end of the project, even if platforms like Coursera will aim to monetise the course. In this case, the intellectual property of the course will be shared between partners of the project and the MOOC platform. As a **commercial exploitation**, this shared property and its monetisation by a third-party will only sustain and bolster the viability of the product after the end of the project, despite the non-profit nature of the COMPAIR project; taking into account that MOOC platforms can do minimum monetisation by asking learners to pay an affordable price for the e-certificate.

Such commercial exploitation will inherently support the **societal** and the **academic/scientific** exploitation of COMPAIR's MOOC. The wider the reach of the platform, the more non-profit organisations and NGOs, activists, and trainers will tend to use and recommend it. To boost the MOOC's visibility and thought leadership amongst the sustainable development community, project partners may raise awareness of the product amongst their network through the project's social media outlets, newsletters, and marketing emails. Memoranda of understanding (MOUs)

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[2] Morris, Tom (2022) "Green consumerism: who cares about the environment?", Global Web Index, 19 April, accessed at https://blog.gwi.com/trends/green-consumerism/, 27 August 2022.

[3] Lendvai, Marietta, Kovacs, Ildiko, Balazs, Bence and Beke Judit (2022) "Health and Environment Conscious Consumer Attitudes: Generation Z Segment Personas According to the LOHAS Model", Social Sciences 11: 1-18.

[4] https://blogs.oracle.com/startup/post/teenpreneurs-disrupt

[5] Getzproject.eu: https://getzproject.eu/wp-content/uploads/2021/07/Educating-and-Engaging-Generation-Z-Beth-Burgess.pdf

may also be signed with a number of local academic institutions and training centres (profit or non-profit) that are interested in climate change and citizen science to adopt the MOOC and promote it amongst their networks as a shared priority between them and COMPAIR project partners.

COMPAIR may also hold a launch conference for the MOOC, where partners can invite relevant organisations and development actors in their networks, to know more about the MOOC and exploit its strengths and advantages over other available courses on air quality monitoring. Another effective tactic would be participating in European conferences on climate change and the environment to introduce the MOOC and highlight its competitive edge over other learning courses.

Ultimately, trainers and NGOs will learn more about the project, understand the significance of air quality in our daily lives and vice versa, and start using the MOOC as best practice in their workshops and capacity building programmes. Furthermore, the MOOC can help inspire new air quality monitoring and measurements methodologies, researches, projects, and urban experimental designs in academia.

At the **policy-level**, the MOOC can help inform and inspire policies, procedures, and initiatives led by policy strategists, co-creation experts, relevant governmental departments such as the Education Department in Sofia, and different cities and regions. Furthermore, it will encourage them to set up citizen-science sensor experiments, adopt similar models, and further validate and support the concept of citizen science in different scientific, social, and environmental issues. To ensure an effective exploitation, project partners shall share the product with policy-level stakeholders, present the benefits and uniqueness of the MOOC, and potentially, develop policy briefs and recommendations that advocate for the concept of citizen science as an effective citizen engagement model to tackle environmental challenges, in addition to the significance of developing MOOCs to upskill citizen scientists in different areas of expertise.

A general overview of a competitive and potentially exploitable outline of the training course that would appeal to different target audiences, would cover these areas.

Introduction to air pollution, outdoor air quality, types of air pollutants, and their adverse environmental and health impacts would highlight why air pollution is everyone’s concern, and why it’s important to act now. There is no need to provide excessive content on different types of air pollutants as other courses already offer ample information on the subject.

Understanding Carbon Footprint would cover different sources of air pollution and how citizens’ behaviour can lower or increase air pollution. In this chapter, students would learn how to use COMPAIR’s CO2 calculator to measure their carbon emissions and how to decrease them by changing daily habits. This topic will not only promote COMPAIR’s technical tool, but will also help raise awareness and encourage people to take action.

Why Citizen Science? would stress the role of citizen science in improving air quality and stimulating behavioural change on an individual and community levels.

Understanding Air Pollution Data here trainees, students, or scientists should be able to see real citizen data on air quality and the level of pollution in pilot cities (Flanders, Berlin, Athens, Sofia, Plovdiv). Ideally, they will be able to access COMPAIR data maps and the AR visualisation app as this can aid their understanding of the subject.

Assemble Your Sensor is a guided visual demonstration of how to assemble and operate a low-cost sensor device, whether it's for traffic monitoring or air quality monitoring.

Collect and Analyse Data is technical training and demonstration of what tools and methods to use to make sense of collected data, in addition to coming up with actionable recommendations.

Citizen Science-Policy Interface a complete guide on how to turn recommendations into policy briefs, as well as other advocacy tactics that can be utilised to inform policy and support evidence-based decision making. This topic will be most relevant to those working in advocacy and policy and would like to learn more about influencing urban planning and environmental policies in their cities to advocate for cleaner air and more engaged citizens.

Finally, COMPAIR's MOOC doesn't have to be long. 10-15 hours of study time, spread across several weeks/modules, would suffice.

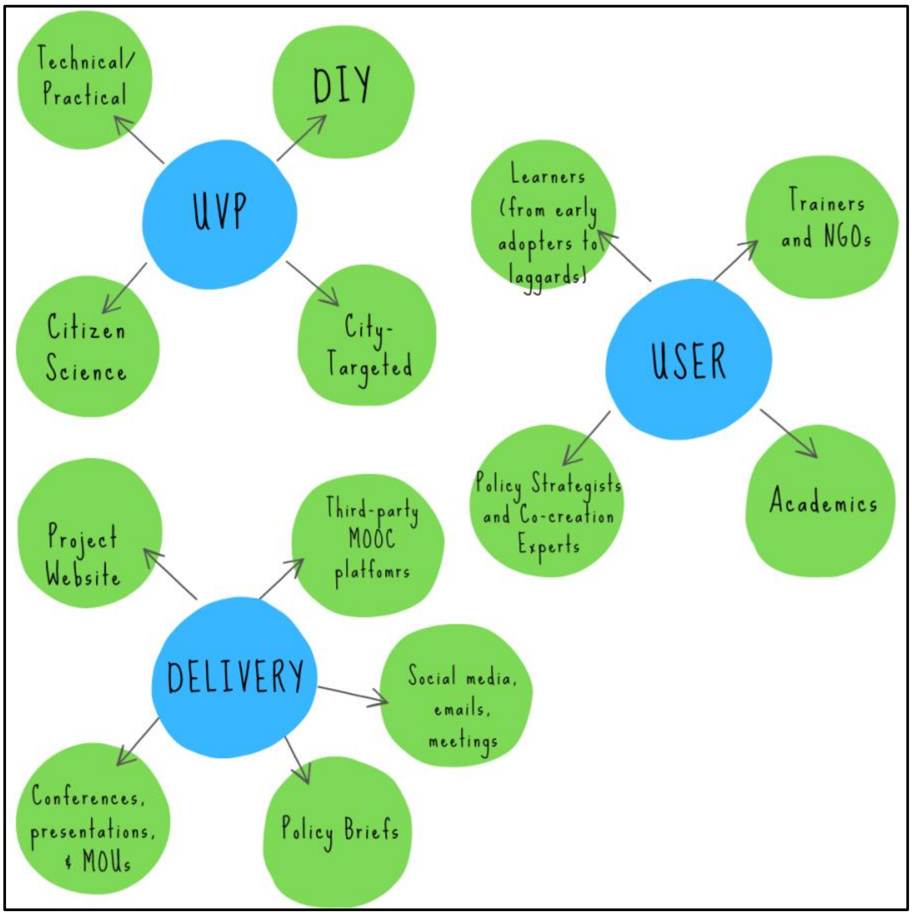

Figure 3. Exploitation Pathways for the MOOC

Citizen Science Data Visualisations

COMPAIR will use two platforms to display citizen science data. One is essentially a geospatial map of air quality obtained mainly, but not exclusively, from SODAQ devices, another is a dashboard with 2D graphics that displays processed Telraam data. The air quality map is called a Policy Monitoring Dashboard (PMD). It is being built from scratch by COMPAIR, but is connected to third party platforms (Telraam, SODAQ) which provide traffic and air quality data, and to the air quality platform, which integrates and calibrates air quality data from the above, plus reference stations. More detailed overview of the platform will be provided in D4.1 Solution Architecture Report, due in October 2022.

The platform for traffic monitoring, on the other hand, will be provided by Telraam as part of their existing solution. Basically each Telraam user who has a sensor at home will be able to access the dashboard to see processed results as simple charts. So it's not surprising that the main development effort, at the time of writing this deliverable, went towards PMD. To support this ongoing activity - and also because market review identified considerably more air quality maps than traffic visualisations from citizens' data - we will focus on PMD in this section.

Due to the non-profit nature of the project and the limited budget for dissemination and marketing, **the early adopters** of the platform are most likely to be citizen scientists involved in the project, members of the community and network of the project's local partners, and policymakers. The **early majority** who are more likely to start using the platform next are citizen scientists, academics, researchers, NGOs, and project managers involved in other EU projects that have pilots in the same cities. Joining them at a later date will be the **late majority** comprising private-sector entities, families, green/climate activists, and journalists.

Stakeholders in the three categories (early adopters, early majority, late majority) have different needs and will want to use PMD for different reasons.

Private-sector enterprises, **transport companies, data analytics, consulting and research agencies** would prefer to see the platform as an open-source tool that can be easily integrated into their products, and then further developed to suit customer/B2B needs, and well-utilised to inform their business decisions. **Governmental agencies and other non-profit organisations** will be keen PMD users as long as they see it as a credible, citizen-led source of air quality data.

The dashboard can be exploited by both private and public entities to add customised services, features, functionalities, amendments, and policy simulations to COMPAIR's dashboard to better meet the needs of their customers or beneficiaries.

For example, a charity organisation aiming to reduce emissions of the manufacturing industry, or a research agency commissioned to study the impact of manufacturing, may work with citizen scientists and use the same dashboard and even sensors to be able to see how fast air pollution spreads from an industrial park or factory to the nearest household/residential area. Another example would be a startup in the sports industry that may integrate COMPAIR's data map with its multisport mobile application to help users identify the healthiest routes/roads to take based on air quality and/or traffic data.

Further use cases include processing and analysing data to develop content on air quality in the form of whitepapers, reports, articles, news, blogs, and social media posts, which will ultimately promote the role of the enterprise and show its expertise and thought leadership in the area of environmental sustainability and climate change.

Exploitation by this group is best stimulated through high-reach, low-cost tools such as news articles and posts on social media, as well as by attending relevant events that specialise in the same topics as COMPAIR.

Families, athletes, and youth (GenZers and millenials) can use the platform to inform their personal decisions, such as which parks and play areas to spend time at, which roads to run or bike at, which hiking trails to take, which shopping areas to visit, or which neighbourhoods to live at. To enable these target groups to exploit PMD, mobile access, modern design and appealing graphics, user-friendliness, and integration with high-tech gadgets should guide our development efforts in the months to come. Younger generations and athletes specifically are used to high-tech products that are connected to the internet and mobile to provide them with real-time data on their behaviour and personal choices.

Climate or environmental journalists, bloggers, activists, and non-profit organisations can use PMD data to advocate for social and environmental causes, and at the same time, serve as product ambassadors by recommending it for personal use to parents, athletes, and youngsters through online endorsements and word of mouth.

Exploitation by this group is best stimulated by pitching articles to environmental/green journalists, commissioning bloggers and activists to spread the word as influencers, and publishing compelling content on PMD and its different uses on the project's website and social media.

Academic researchers, scholars, and research students in air quality, transportation, urban design, and citizen science can exploit PMD by relying on it as a credible source of empirical evidence and trustworthy reference in their studies. To enable that exploitation, COMPAIR should reach out to respective departments at key local universities to promote the product amongst researchers, scholars, and lecturers. Representatives from each partner organisation may hold a short seminar/webinar in at least one local university to introduce PMD and highlight its importance for research on climate change, air quality, and other related issues. For a more effective exploitation and visual analytics, researchers may want to integrate COMPAIR's data with that of other platforms to reach a bigger sample and increase generalisability of findings.

A wide range of **developers, programmers, and data scientists** can exploit PMD to design new products and applications for air quality and/or traffic monitoring, or at least add new features and technologies using artificial intelligence and augmented reality. Some may have a need to develop new traffic simulation models for sustainable mobility and urban planning.

Exploitation by this target group is best stimulated by partnering with other projects that target information and communications technology (ICT) professionals, entrepreneurs, and innovators. In this case, COMPAIR's platform can be presented as an open source solution for environmental entrepreneurs and startups, something they can use to create new innovative products and services for air quality management, urban planning, and citizen science. This can be as well considered a commercial exploitation that enhances the viability of the platform in the long term as long as entrepreneurs are exploiting it to develop and fundraise for new products. At the same time, it can be seen as a policy-oriented exploitation if COMPAIR partners with a public-private partnership project, where cities or governmental bodies present their environmental challenges to the ICT and entrepreneurship community, who on the other hand, can use PMD to produce insights and come up with new products.

Policymakers, city officials, and civil servants need to be able to compare collected data with EU standards and integrate data from different sources for an effective exploitation of PMD. COMPAIR's citizen science data could be exploited for a variety of purposes. They can use it to monitor and assess the performance of the air quality programme implemented in Sofia, to predict air quality in Berlin by applying artificial intelligence models, to combine multiple sensors under one API for a more open and interoperable data on air quality, to inform mobility plan for Adlershof (Berlin) for a road construction project, to implement and monitor sustainable urban mobility plan in each targeted city/region, specifically in Sofia and Flanders, or to implement and study the performance of low-emission zones in Sofia.

Exploitation by this group is best stimulated through a) private advocacy efforts, b) policy briefs based on the interpretation of historic and real-time data, c) public advocacy through robust and consistent relations with local media, and d) participation in conferences and events on climate change, Green Deal, air pollution, environmental sustainability, and related topics.

We would like to conclude this part by listing features that PMD should have in order to match competing solutions that were reviewed as part of market analysis. These features are formulated as things a user should be able to do on PMD if they are to choose PMD over third party platforms, or at least consider it to be on par with them. These include ability to

- Inspect air pollution in real time to evaluate current situation
- View historical data on air quality to draw comparisons and study the impact of other variables (e.g. weather) on pollution levels
- Compare data between two or more cities to evaluate performance of local policies and other drivers of change
- Compare local situation against EU standards to see if there are any deviations from recommended limits
- Locate sensors on the map to know the exact location of the measurement
- Select type of sensor to understand its contribution e.g. length of service, amount of data provided, owner (individual, public organisation, business)
- Measure distance from air pollution emission sources to a measurement location in order to study the time needed for pollution to spread from each emissions source
- Overlay citizen science data with data from official monitoring stations to see if results for the same area are the same or different (in case of the latter - why?)
- Switch between different languages English, Flemish, German, Greek, Bulgarian
- Share and export buttons to enable easy download and dissemination of map results
- Offer simple analytical and data processing functionalities. Also, advanced forms of visualisation (such as heat maps) could be attractive to stakeholders

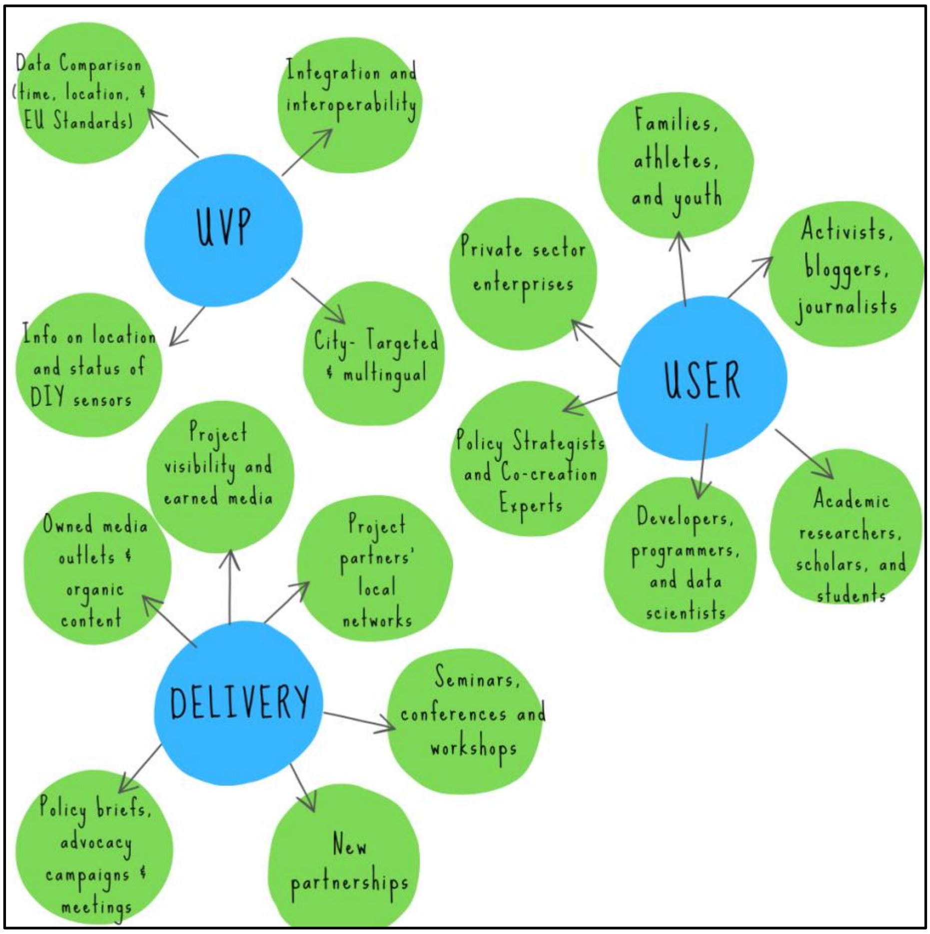

Figure 4. Exploitation Pathways for Citizen Science Data Visualisations

CO2 Calculator

Broadly speaking, the main users of the calculator are likely to be the same as for PMD, namely citizen scientists contributing data to the project, community members, project's local partners, and policy makers (**early adopters**); academics, researchers, NGOs, project managers and citizen scientists from other projects (**early majority**); private-sector entities, families, athletes, climate activists, and journalists (**late majority**). But specific stakeholders in these categories have different needs and will want to use the CO2 Calculator for different reasons, as described below.

Private-sector enterprises, mainly those interested in developing green solutions or targeting environmentally conscious customers, could be interested in customising the calculator based on their customers' or beneficiaries needs, introducing new features or upgrading existing ones, or using it as an open-source solution to integrate it into other products. For example, a consulting agency that supports manufacturing SMEs can customise the dashboard so that their clients (factories) can calculate their carbon footprint and try different scenarios to find a thriving balance between their revenue forecasts and the environmental boundaries that they should not exceed for legal, societal, and ethical reasons. These enterprises might also be non-profit or governmental, and need to customise and build more features in the platform to exploit it in their running projects or fundraise for future projects. This group can be engaged through a mix of social media activity and physical networking at events that attract business representatives.

Environmentally-aware citizens, organisations and youth (GenZers and millenials) can use the platform to understand their carbon footprint and the consequences of their choices on air quality in cities. They can use the calculator for their own personal growth and environmental awareness, as well as to experiment with different actions and get more involved in local climate action. Exploitation by this group of users can be stimulated and accelerated by enhancing the calculator's accessibility and compatibility with different devices, for instance smartphones where users can note down their daily use of home appliances or consumption of food, to calculate their carbon footprint and receive recommendations on how to improve their behaviour. The most effective delivery method to reach the target audience is through connecting with **climate activists, bloggers, NGOs, and journalists** who are keen to use and recommend the calculator to their followers.

ICT researchers can exploit the CO2 Calculator by running further research and investigation on the feasibility of such dashboards in informing public policy and the benefits of engaging citizens in policy making. **Academic lecturers** can also use it to explain to students the main sources of carbon emissions and how everyday behaviour can be changed to improve air quality. The simulation tool can specifically be well-exploited by **local universities** to train students in environmental studies, urban planning, and public policy on how to use different behavioural scenarios to formulate citizen-led policies and predict short term and long-term impact. Direct communications is the most effective tool to reach and partner with a number of local universities that might see the calculator as a useful learning tool for students and academic staff alike.

ICT Researchers and developers can exploit the CO2 Calculator by developing its features further or by customising it to study other sectors (e.g. public health) and environmental challenges (e.g. water pollution) based on the citizens' choices, predicted behaviour, and responses to policies. In the case of public health, a similar dashboard can assist public health researchers and policymakers in recommending and formulating policies by predicting citizens' behaviour during a pandemic. Similar to PMD, an effective mechanism to engage developers is through innovation and entrepreneurship projects that inspire their beneficiaries to produce similar tools or offer the calculator as a customisable, open-source solution for the ICT and entrepreneurial community, and allow them to exploit it as they see fit.

For **policymakers, urban planners and city officials**, the calculator is first and foremost a tool for predicting citizens' behaviour, understanding their willingness to change behaviour, studying citizens' responses to different policies and policy targets, and experimenting with different behavioural scenarios that can be pursued to achieve local policy objectives. COMPAIR should directly communicate with policymakers and city officials to explain the features of the calculator and its significance to building a culture that nurtures civic engagement and evidence-based decision making.

If our CO2 calculator is to appeal to these stakeholders, it should, at a minimum, have the same functionalities as competing solutions. In particular, it should

- Cover the main five sources of CO2 emissions i.e. household energy consumption, transportation, air travel, food consumption, and waste management
- Calculate results per domain and compare it with the average for a city, region, country

- Offer multilingual support, be free of charge, and open to the public

Ideally, however, our tool will offer more, for instance by covering more domains, by including intelligent simulations that answer questions like by how much would my CO2 footprint decrease if I use a car only three instead of five days a week? Or what is the impact of ridesharing, recycling, replacing electrical appliances with more energy-efficient ones, or eating less meat?

Our review showed that there aren't many tools that allow citizens to provide feedback on what actions they will take, change or perform to contribute to the achievement of a policy target, and how feasible they think these targets are. This feature, if implemented, will differentiate our calculator from others by turning into a two-way communication platform that would allow policy makers to get a quick and dirty estimate of how many residents are ready for change, and what its overall impact might be on a city and the environment.

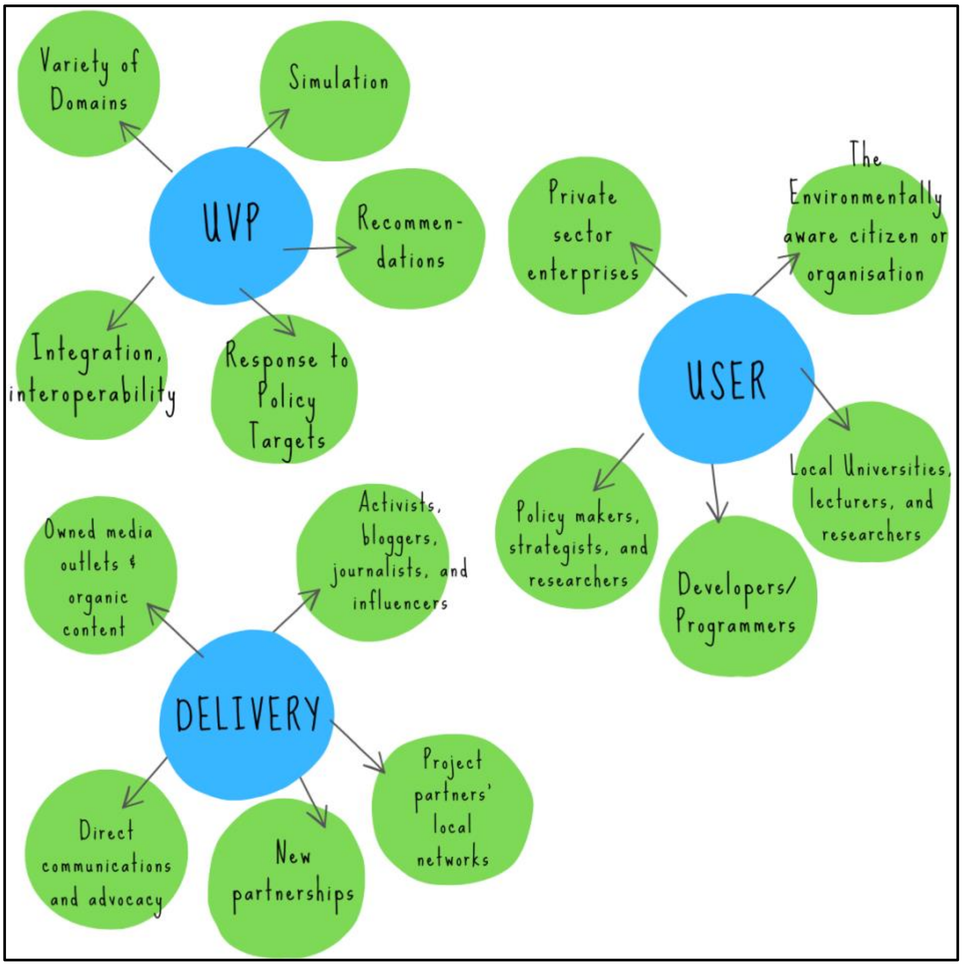

Figure 5. Exploitation Pathways for the CO2 Calculator

DEVA (AR) Application

The first group to use the app (**early adopters**), next to project partners, will be citizen scientists involved in the project, and local networks of experts, activists, and researchers that follow the project. This initial community will grow as the app becomes more popular, to form the **early majority** comprising new citizens and organisations not necessarily connected to the consortium. Constant dissemination and extensive media exposure will result in the app being downloaded thousands of times on App Store and Google Play, by the general public, and specifically by climate activists, environmentally conscious citizens, and youth (the **late majority**).

As the market for this particular tool is small, we can only speculate at this stage about specific stakeholders and their interest in using the app.

Commercial exploitation: Gaming industry and companies working on Metaverse may use the same visualisation technique to enhance virtual reality. While there are several AR apps that visualise air quality data, there are no solutions that do the same with traffic data. What COMPAIR is doing is very novel and potentially groundbreaking.

Societal exploitation: Citizens passionate about the environment, climate activists, influencers and opinion leaders may see the app as a simple yet powerful tool for exploring air quality in their surroundings; if satisfied with the results, they will recommend the app to others via word of mouth or social media. In a long-term perspective, the AR app may be used by the wider public to investigate environmental conditions in an easy and appealing way with the aim to change behaviour.

Academic/scientific exploitation: Academic professionals and lecturers might be looking for new technologies to offer a new learning experience to students, so AR has great potential to improve education and learning in a university setting, but also in schools. Young people tend to engage better with educational content that is presented in new, visually appealing ways. DEVA app may therefore provide additional motivation for students to learn and be curious about the world around them.

Technical exploitation: Developers of smart city applications may want to combine several AR use cases (e.g. air quality, cultural heritage, urban planning) in a single solution, so they will be testing different integration approaches to create a one-stop-shop app for residents and tourists. Interoperability standards used in the DEVA app may eventually become industry standards in complex solutions combining IoT, data visualisation, and mixed reality technologies.

Policy-oriented exploitation: Local community departments may be keen to promote the app in a bid to improve civic participation in communities that are not very active in democratic life of a city. The app can be endorsed by a local authority to encourage more people to explore their city/surroundings. Feedback can then be solicited through an in-app survey to collect people's concerns and recommendations for improvement.

As shown by the market analysis, there aren't many AR applications for air quality. Still, from the handful of apps we were able to find and review, we can draw some conclusions about features that users expect from such apps. These include:

- Providing information in the **national language**, in our case Flemish, German, Greek, and Bulgarian
- Giving users access to the application through both iOS and Android operating systems, and ensuring the interface design is **responsive** to all screen sizes

- Displaying complex, often massive amounts of air quality data from different sources in one application, through a **user-friendly** and visually-appealing interface
- Depicting air pollution using **one clear visualisation method** e.g. either floating particles or emojis, not both
- Linking app to the **real-time data** from available sources (e.g. citizen science, government) so that people can assess threat to their health based on where they are at a particular moment in time

To spread the message about DEVA app to the widest possible audience, a range of tactics and channels can be considered:

- SEO-friendly content that makes proper use of titles, description, keywords, and tags
- COMPAIR's social media to announce app's launch and send periodic reminders
- App ambassadors, such as activists, environmentalists, and opinion leaders who used the app, like the results, and are keen to recommend it to others
- News articles and press releases targeting journalists who write about tech and environment
- Events where live demos can be organised at the stand or as part of a workshop

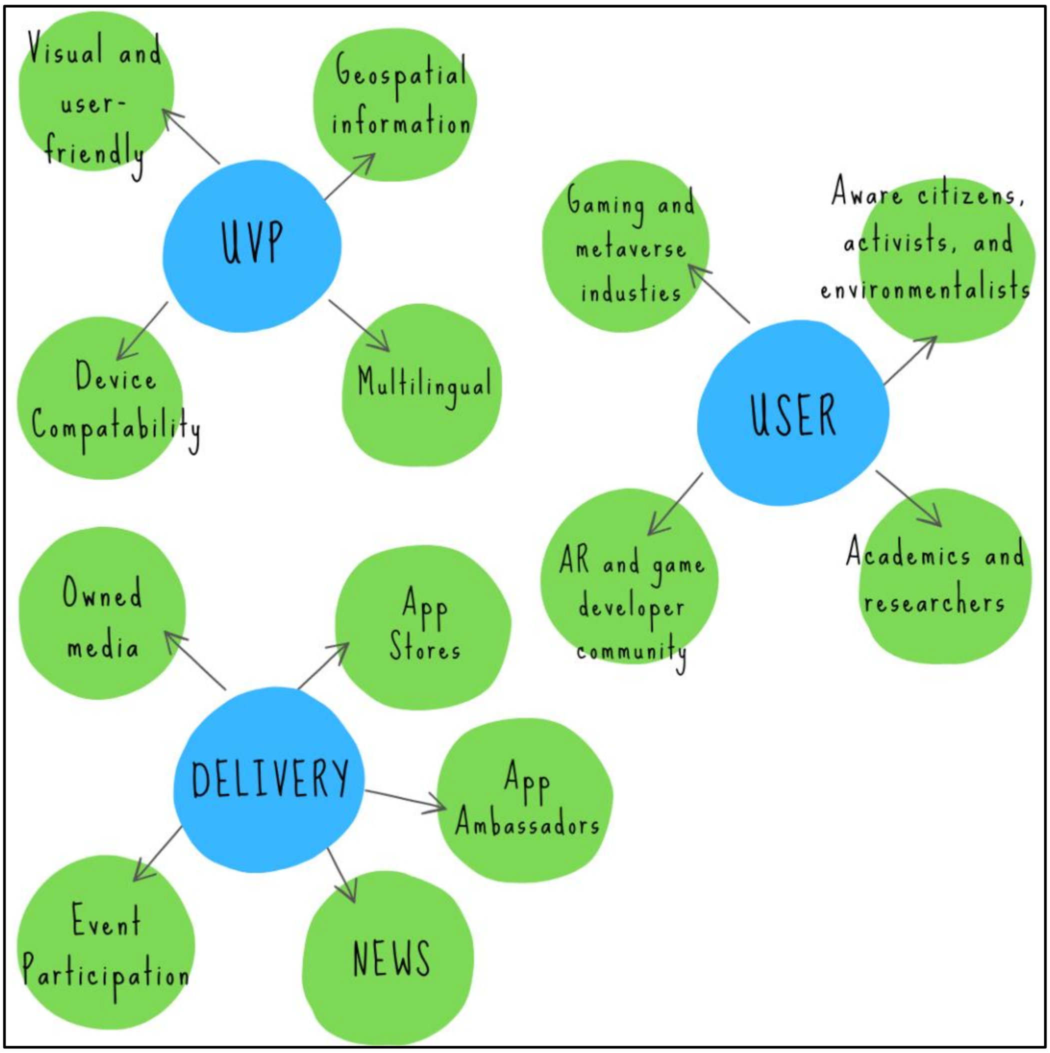

Figure 6. Exploitation Pathways for the DEVA application

Conclusion

Draft exploitation plan is the first of three deliverables that are meant to tackle one of the most difficult questions in EU projects: how to ensure long-term sustainability? To try and answer it, we must look beyond the funding period, when COMPAIR is no longer around in its current form (a consortium of 15 partners), but exists primarily through its tangible and intangible results.

Sustainability can therefore be conceived as post-project existence of COMPAIR ideas, deliverables and know-how that immediate beneficiaries and the wider public use to achieve their goals. Some of them can be commercial, some policy related. Some may be technical, some scientific or societal. The nature of the exploitation is not so important. What matters is that results are continuously exploited by stakeholders for their own benefit, to help others, or both.

Not all results are equal in terms of impact. Some carry more weight, others less. The question of sustainability then comes down to which results have the biggest influence on engagement, behavioural change, and policy making - three priority areas in which COMPAIR wants to make a difference. Identification, development and enhancement of key exploitable results, or KERs, that have a significant bearing on these areas, is a process that was set in motion by this deliverable and that is set to continue until the end of the project.

First attempt to define initial KERs happened at an interactive workshop with project partners. MOOC and citizen science data (from SODAQ and Telraam devices) topped the ranking table and so made it to the KER list.

We then wanted to see who else is offering similar products and whether there are some lessons to be learned from competitors. So we conducted a market analysis looking at i) MOOCs on air quality and ii) projects offering citizen science data on traffic and air quality, either as raw data or visualisations of some kind. We added to the review two more apps - CO2 calculators and AR apps for air quality. These apps didn’t get a lot of votes at the workshop, but because our technical teams are currently working on them, we thought some recommendations based on competitors' strengths and weaknesses might come in handy in the current development phase, or later.

There are many MOOCs on air quality and quite a few EU funded citizen science projects produced one as a deliverable. But there are no MOOCs, at least we couldn't find one, that would comprehensively cover citizen science and air quality monitoring in a single course. This gives COMPAIR a real chance to fill a gap in the market and stand out from the crowd with a unique product offering. In the advanced exploitation plan, we will elaborate which platform we not only want but can use for our MOOC. edX and Coursera are certainly more prestigious but harder to access for low-profile content creators, for whom Open Learn Create or TalentLMS might be easier alternatives. Other issues to address include certificate cost, learning time, and completion requirements.

We found more than 20 platforms that provide citizen science data on traffic and/or air quality for some or all COMPAIR pilot cities. The majority of air quality maps, for example, offer real-time data and API access, often through integration with Sensor.Community, and cover the same pollutants COMPAIR will be measuring (PM, NO2). We learned a lot from competitors in terms of features that users are expecting to see on such platforms e.g. combination of historic and real-time data, ability to compare two or more cities, to measure distance from pollution emissions source to measurement location. Technical partners would be well-advised to consider them as they develop the Policy Monitoring Dashboard, which is our contribution to the growing, and somewhat crowded, citizen science data visualisations market.

The CO2 calculator market is equally crowded. We studied 16 tools developed by NGOs, private companies, social enterprises, and projects of different kinds. There are other examples that we simply didn't have time to review, so the total number of available solutions is well in excess of 20. To stand any chance of competing in this market, we should, at the very least, provide the same features that others are offering and, ideally, a lot more. This includes more domains for CO2 estimation, more intelligent simulations that tell people how exactly planned changes would benefit them and the environment, and more opportunities for users to provide feedback, which can later be aggregated to assess citizens' willingness to change, and what the overall impact of this action might be on a wider scale.

AR applications that visualise air pollution are not new, but it seems to be a fledgling field, with only a handful of apps available on various platforms at present. The four ones that we found include a mix of finished products, beta versions, and early prototypes, which means that the scope of our investigation was rather limited. Still, based on the market review, we were able to draw some conclusions about features that users like and don't like in this kind of applications. These are distilled as recommendations for the technical team to be considered in the current development phase. The main ones relate to language support, a single visualisation method to enhance clarity, and display of real-time data for a quick assessment of personal exposure.

As PMD, CO2 calculator and DEVA app are currently being developed, the precise contribution of different partners to the final solution is not fully known. However this information is needed to develop a sound IPR strategy, not least because IPRs will determine who can use the result, on what basis, for how long et cetera. We plan to cover these in the next edition of the exploitation plan as the tools should be ready or close to completion by then.

In addition, future editions will cover steps needed to

- Augment the product offering (relevant concepts and tactics to consider include market penetration, product extension and diversification, and identified augmentation paths)
- Better evaluate the level of maturity and size of competition (SWOT analysis)
- Identify features, benefits and adoption barriers (perceived as important by potential customers)
- Achieve scalability, replicability, competitive advantage and key differentiators of each KER
- Cover costs for sustaining KERs post-project e.g. maintenance of technical apps
- Monitor the impact of KERs after the project, perhaps by establishing a monitoring committee