D6.1 Engagement strategy for hackAIR community involvement

WP6 – Engagement strategies for user participation

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Executive summary

The overall objective of work package 6, task 1 (WP6, T1) is to develop an effective strategy for promoting the adoption and usage of the hackAIR platform. This deliverable, D6.1, aims to outline this strategy to sustain the engagement of multiple stakeholders and user groups with an interest in air quality information and/or who are especially affected by poor air quality to make use of the hackAIR platform and the tools provided.

From an extensive literature review, this deliverable explored the practice of citizen science, forms of participation and motivations for participation. Citizen science emerged in the late 1990s as a response to the growing relevance of non-expert knowledge, particularly through voluntary collection of data. As a growing source of concern, air pollution has been found to trigger a sense of social collectivism, an important characteristic of collective motivations. Local contexts, community building and action-oriented projects are effective ways to tap into such motivations. A curiosity of specific and familiar locations for air quality represents the main motivations for users to participate. In addition, exploratory motivations were also aimed at challenging the system functions and accuracy for collecting air pollution data. User motivations and expectations changed as their familiarity with the interface grew. Gamification might appeal to millennials and prove effective in motivating citizen scientists in certain target groups, but it runs the risk of deterring or demotivating users in higher age ranges, as well as those who are interested in high-level or structural change.

The hackAIR project mapped existing and previous air quality citizen science projects across Europe, and identified projects suitable for gathering lessons learned via qualitative interview. The collected data highlight the importance of non-academic stakeholders as agents for communication and engagement. Campaign-based gamification can prove successful in establishing urgency in local contexts. Other important engagement principles include establishing local connections, providing frequent and personalised feedback, and committing resources to training experts as well as users. Common engagement barriers for air pollution projects include issues in the data contribution, science communication, technical project limitations, scaling and the critical nature of distributed sensors.

A multi-country user survey was distributed in Norway and Germany, with the purpose of gauging awareness and behaviour, as well as exploring engagement and recruitment tactics for the hackAIR project. The survey received 372 total valid responses: 261 responses were completed in German (70.2%), 47 in Norwegian (12.6%) and 64 in English (17.2%) respectively. Overall, findings demonstrate the **motivating effect of attribution and recognition on users;** main user motivators are: i) recognition and attribution at the individual level (Highest), ii) interlinkages with other projects, iii) campaigns and initiatives, and iv) physical and social workshops that target policy debates and experiential learning. **Most people (89.4%) were interested in either viewing real-time information about air pollution around them or measuring air pollution (68.1%). 1 in 5 respondents were interested in gamification badges and levelling;** participants aged 50 years or above are significantly less interested in this feature (5.4%). **The main barriers for participating in hackAIR are: time (70%+), air quality monitoring knowledge (32.1%), hackAIR knowledge (31.8%) and tech skills (26.8%). From 308 respondents, 92 (28.9%) were not interested in hackAIR.**

Across pilots, differences can be identified through the hackAIR survey. The Norwegian sample can be characterised by their **greater interest in gamification and application-based measurements** (73.5%), **strong preference for viewing real-time information** (93%) **and significant time-constraints** (83%). The **German** sample did differ to some degree; **respondents prioritise workshops for policy making and DIY, have a stronger interest in building sensors and receiving information to reduce individual contributions.** A significantly larger portion of the German sample was **concerned about the skills and knowledge required to understand and measure air pollution.**

The final chapter of this deliverable brings together the lessons learned from literature, interviews and a user survey and is dedicated to the hackAIR engagement strategy, tactics and principles that will underpin hackAIR for the duration of the project. This engagement strategy uses the 7Es (Bambust, 2015) – a Belgian coined but UK (Defra) inspired engagement model – to frame and situate specific tactics based on their expected goal. The 7E model comprises a set

of 'leverage points', the sum of which are expected to allow for an integrated and highly practical approach to engagement. Each tactic includes a general description, envisaged target audience or group, and expected goals.

- ***Online tactics include:*** *tips of the day personalised recommendations, in-app gamification module, feedback on citizen science data quality, active and responsive social media presence, storytelling and updated list of hackAIR events.*
- ***Offline tactics comprise*** *workshops, measurement campaigns, active and responsive pilot presences, a series of awareness raising tactics, photo contests and social events, and ambassador and leadership tactics.*
- ***Engagement in hackAIR is supported*** *by physical points of contact in each pilot, modified FAQs, an operational version of 'ask an expert' and a series of sensor DIY support features.*

From October 2017, pilots begin actively recruiting, engaging and supporting users, a significant step in connecting the hackAIR platform to pilot communities. Recruitment will remain relatively limited and in a **semi-closed nature** at first, before broadening in 2018 as platform functions are iterated and finalised. When recruiting users, this strategy should ensure that the language and expected goals of the hackAIR project are paired with not only specific target groups, but also the maturity of the platform. Both pilots are encouraged to establish actors of influence across **all target groups** for offline engagement activities. This can be achieved by recruiting through ambassadors/intermediaries. Select participants who can play an 'intermediary' role, and think of these actors as bridging agents between core target groups. During phase 3 (2018), hackAIR pilots will broaden their approach and encourage participation from other citizens, such as non-environmentally aware users, elderly populations and children. As an engagement tactic, we suggest the co-ordination and execution of one large scale (250+ users) measurement campaign across the duration of the project.

Given that hackAIR aims to focus on engagement that is not stimulated by financial or other material rewards, the acknowledgement of the efforts of citizens will prove pivotal in sustaining motivations. Intrinsic incentives can be considered in order to recruit participants for workshops, however it is advisable that these are connected directly to hackAIR. **Incentives can include:** opportunities to keep or win sensors, co-authorship on a written output, recognition of ambassadors, validating official air pollution sources, relevant accessories, custom sensor casings or discounts for group sensing.

This engagement strategy will stand as an extension to the principles of digital social innovation by encouraging the generation and understanding of open data, through open hardware solutions with an interest in supporting open science outputs. Pilot partners are therefore advised to: 1) create connections with existing events and source agents of change, 2) tailor events and respective communication to different age groups and skill levels, 3) focus on building capacities and 4) prioritise physical spaces for experimentation. Central to the success of hackAIR in sustaining engagement will be the ability to provide feedback to users about their data. This will be done through three mediums: offline feedback at workshops and events; online feedback through both the application and online channels and; when necessary, directly delivered by experts.

The hackAIR engagement strategy has clear connections with parallel deliverables and work packages in WP6, WP7 and WP8. It integrates activities and the timeplan from the hackAIR pilot plan (D7.1, M20) and the plan for hackAIR workshop tours (D8.5, M20), in order to produce one complete overview moving forward. Offline and online tactics in this deliverable inform the behaviour change interventions outlined in D6.2: Behavioural change techniques for hackAIR community (M20). Ambassador tactics will be applied and expanded in pilot locations using the social media monitoring tool, as established in D6.3: Social media monitoring tools for assessment and support of engagement (M20). Finally, the tactics outlined in the engagement strategy will also be assessed in WP7 as a part of our ongoing monitoring and evaluation strategy (M20, M26 & M36).

1 Introduction

1.1 Deliverable information

The overall objective of work package 6, task 1 (WP6, T1) is to develop an effective strategy for promoting the adoption and usage of the hackAIR platform. To this end, deliverable 6.1 (D6.1) will create engagement strategies for encouraging the involvement of stakeholders and user groups with an interest in air quality information and/or who are especially affected by poor air quality to make use of the hackAIR platform, as well as maintaining the engagement and interest of already active hackAIR members (and finally, encouraging changes in their behaviour towards air quality (T6.2).

As the first activity in WP6, a precise engagement plan for hackAIR platform users will be written. To do this, VUB conducted a literature review on engaging people in citizen science initiatives; interviewed domain experts to learn from their experience from the field and; conducted a survey to gather information on the current air quality awareness of citizens. The findings from these methods have then been moulded in close collaboration with the participating partners and considering the specifics of the pilot localities. The engagement strategy will be monitored locally with small communities after which they will be implemented in the pilots (BUND, NILU). This iterative process will help us test the strategies and collect qualitative data before piloting, which will inform the further enhancement of the engagement strategies and behavioural change techniques.

1.2 Research purpose

In deliverable 6.1, the focus is twofold. Firstly, this deliverable aims to outline a generic strategy for engaging multiple stakeholders and user groups with an interest in air quality information and/or who are especially affected by poor air quality to make use of the hackAIR platform and the tools provided. Secondly, the goal is to maintain the engagement of the users on the hackAIR platform and support the activities on the platform. This overall strategy therefore serves to inform the engagement activities to be implemented in two different pilots in 2017. In order to define an effective engagement strategy, this deliverable uses broad research questions as building blocks to broaden and deepen hackAIR's understanding of citizen engagement, particularly in the context of citizen science targeting air pollution. These guiding research questions are as follows:

- *How can current concepts that exist inform hackAIR's understanding of engagement?*
- *Which lessons can be learned when developing a tailored engagement strategy for hackAIR?*
- *What is the engagement strategy for hackAIR?*

The first section of this document corresponds with concepts relevant to participation and engagement. Moreover, we explore the different factors to keep in mind when defining an engagement strategy, and provide an overview of recruitment and engagement tactics that will influence pilot specific engagement strategies in hackAIR. In part II, we advanced the scholarly understanding of engagement and citizen science by collecting data via primary sources of data. These include self-assessments from pilots, practical insights via project analysis, in-depth lessons learned from domain experts and extensive user insights via a multi-country user survey.

1.3 Structure

Figure 1 below overviews the timing and flow of D6.1. This figure combines the deliverable objectives: 1) collecting central theories and concepts, 2) mapping and analysing previous cases, and 3) connecting insights from experts, potential users and pilot partners for application in hackAIR.

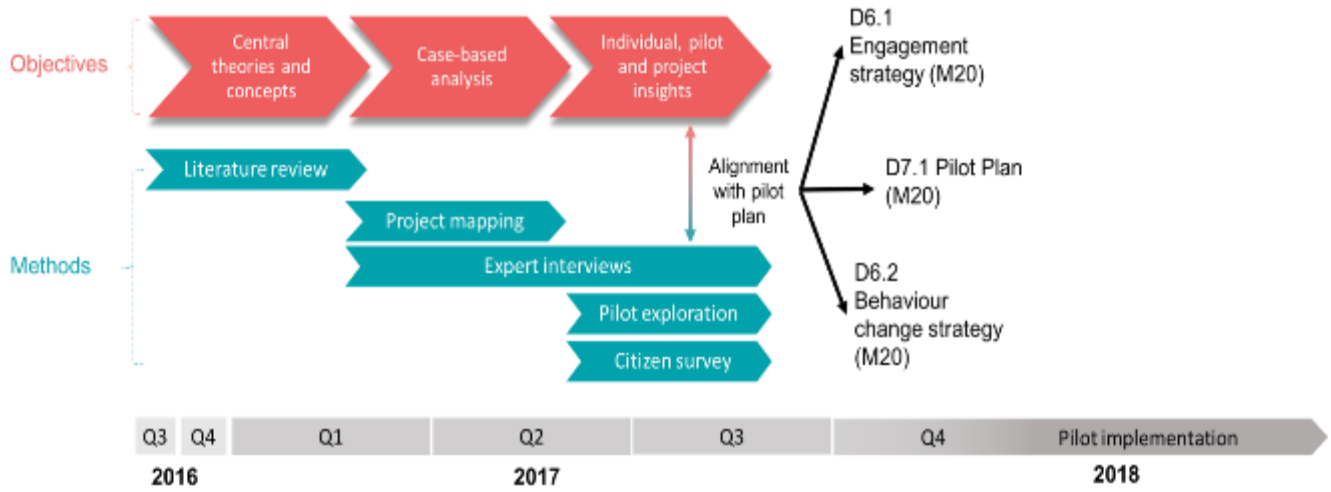

Figure 1: Visual overview of timing, objectives and methods for Work Package 6

Chapter 2 focuses on the following research question: How can current concepts that exist inform hackAIR's understanding of engagement. Therefore, as a first step, this chapter explores the theories and concepts that underpin engagement. It will present theories that are applied not only in the context of air pollution and citizen science, but also those from farther afield. Chapter two will introduce central themes related to engagement: participation, engagement in science, citizen science.

Chapter 3 explores the motivations, barriers, communication and opportunities to engagement from citizen science projects. The hackAIR platform includes a gamification layer that will provide a game-like service to various parts of the application in order for them to allow end users to gather points, earn badges or rewards as well as provide leaderboards, reputation systems and other user engagement elements. Therefore, attention is paid to motivational factors of gamification in previous studies.

Chapter 4 describes the methodology and subsequent results from an analysis of previous projects with a focus on air pollution and citizen science. This chapter discusses the refinement of criteria for expert interviews, the core focus of this section. Lessons learned were retrieved from qualitative interviews with experts in the field of air quality. General trends are established in the field of air pollution and touch upon user engagement, aspects for behaviour, communication and the role of actors in respective projects.

Chapter 5 outlines the methodology and results from a qualitative survey, which was designed and distributed to generate insights related to engagement and behaviour for the hackAIR project. The primary target group of this survey is potential users in both pilot locations.

Following the integration of different sources of literature (chapter 2-3), practical lessons learned (chapter 4) and user perspectives (chapter 5) across topics such as air pollution, citizen science and citizen engagement, chapter 6 comprises the hackAIR engagement strategy, including the tactics, principles and timeplan that will underpin the hackAIR project.

2 Citizens engagement in science

Barney (2016) defines engagement as the "interactive and iterative processes of deliberation among citizens and between citizens and government officials with the purpose of contributing meaningfully to specific public policy decisions in a transparent and accountable way". In such a context, engagement draws parallels with notions of participation and participatory democracy, as a condition to consider in the pursuit of more transparent collaborative government-citizen relations. However, when extended towards participation and the generation of knowledge and local-decision making, Poliakoff and Webb (2007) offer a wider understanding of citizen engagement as one in which communication occurs outside of the "ivory tower". This type refers to more recent scientific endeavours that move beyond those led by experts with specialist knowledge, and towards science that is more participatory in nature.

Research by Powell and Colin (2008) in the context of science and technology suggests that processes of engagement are by no means homogenous, but rather occur along a continuum. For example, broad engagement in science draws parallels with the work of Arnstein (1969); informing large public communities of a specific technology or scientific practice, more as a form of consultation rather than collaboration. Towards the other end of the spectrum, the integration of citizens into the scientific process stresses the need to strengthen individual capacities, as a way to enhance both confidence and efficacy levels. In addition to these different types of engagement, the authors identify multiple recommendations to overcome typical barriers for engagement. For example, by integrating mechanisms to initiate engagement into spaces of academia government, they touch upon broader processes of institutionalisation that can foster citizen engagement in science and policy. Such mechanisms should balance short term and long-term objectives, blend face-to-face and virtual interactions, encourage deliberation and dialogue between different stakeholders, adhere to principles of transparency and trust, facilitate citizen involvement in project goals. Scientists and researchers must be flexible and reflexive in their role, and willing to adapt to the outcomes from within the engagement process. A systematic and explicit learning process should support citizens in strengthening their competencies and capacities, particularly in a way what fosters their contribution to political and academic contexts. Likewise, similar affordances should be made for scientists, further enhancing their role as communicators and facilitators in engaging citizens in science. When applied in the context of hackAIR, these considerations shape our understanding of citizen engagement as one involving bidirectional communication flows, with an overarching common vision and connected to a social mission. Furthermore, they offer an entry point into citizen science as a practice that is underpinned by several of the points related to citizen engagement mentioned above.

2.1 Participation

2.1.1 Origins and developments

Over the last 50 years, participation has emerged as an essential property in decision-making processes. Approaches to encourage participation claim that as a democratic right, the involvement of all stakeholders 'at the table' can ultimately improve the decisions made towards a common cause. The development and application of the term can be traced broadly in the latter half of the 20th century, however it was the global movement to prioritise sustainable development that sparked the normative value placed in participation, as well as a demand in approaches that could 'guarantee' participation. The debate around involvement of multiple stakeholders does however happen to include unsuccessful attempts and ineffective settings, as well as participatory processes that fail to address environmental challenges. The seemingly ever present need for participation has therefore also resulted in a loaded, often misused and theoretically fuzzy idea of public discourse (Reed, 2008). Despite the conflation of participation, promise has been shown in the efforts of academia and practice to understand, distinguish and classify the diverse ways in which

different stakeholders can interact. By doing so, it is becoming more possible to choose participatory processes based on their merit before use, as well as to assess or classify the subsequent outcomes.

As one of the most prominent classifications of participation, Arnstein (1969, Figure 2) uses a ladder progression to explore the "rungs" through which participation can be exercised. Varying from "manipulation" (lowest rung) to "active engagement" (highest rung), Arnstein regards participation as a reflection of power that is contested between citizens and powerholders; this is explicit in her analysis and can be traced to the terms used to differentiate different levels of participation. With degrees of participation moving beyond tokenism (informing, consultation, placation) and towards citizen power (partnership, delegated power, citizen control), the hierarchical nature of the ladder implies that higher rungs lead to approaches that are more empowering. Furthermore, it offers a simplistic understanding of the often-contested nature of participation and the divergent interests that occur, both of which reinforce dominant practices and marginalize incompatible viewpoints.

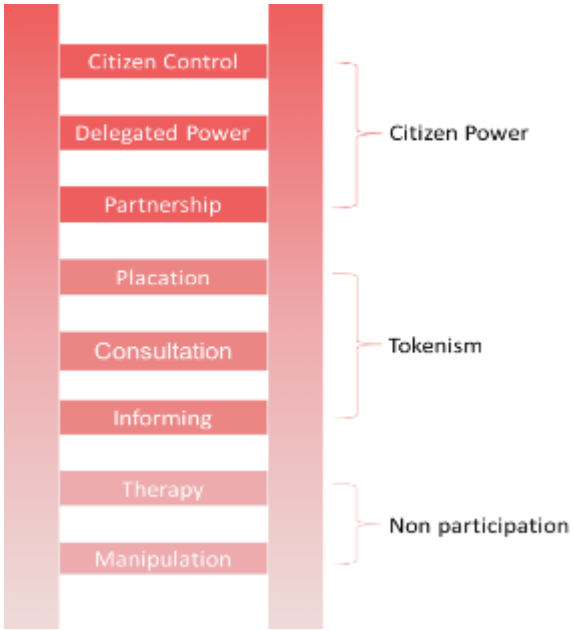

Figure 2: Ladder of participation. Source: Arnstein (1969)

2.1.2 Classifying participation

Although Arnstein's heuristic remains an enduring metaphor across both academic and participatory circles, it has also led to considerable debate and faced scrutiny (Collins & Ison, 2009). As somewhat simplistic and visual, it is arguably a far from complete representation of participation as a manifestation of power. In fact, as a linear approach, the ladder fails to pinpoint any reciprocity between citizens and powerholder and does not recognise the heterogeneous dynamics that occur even within powerholders and citizens. Nor does it differentiate the mechanisms that can possibly facilitate or impede participation at different levels, or the specific settings through which they can occur. Collins and Ison (2009) further argue that the approach suggests a "race to the top", conveying a participatory process as a struggle between oppressed citizens at the bottom, and bodies that are attempting to reserve power at the top. In reality and for various reasons however, different degrees of power do transpire, and citizens often have different expectations of participation.

Degrees of participation represent only one way to investigate involvement. Some have attempted to include the surrounding context, objectives of stakeholders and capacities of different actors. Moreover, participation can be considered either in a formative or summative manner; as a condition to develop participatory methods, or investigated after an event has occurred (Reed, 2008). Likewise, its level of enquiry can occur either on the fundamental or applied. For example, participation might be considered a normative, fundamental right in a democratic society, or an instrumental property of decision making.

Heller, Price, Reinharz, Riger, and Wandersman (1984) refer to citizen participation as "a process in which individuals take part in decision making in the institutions, programs and environments that affect them" (p. 339). In the context of public involvement in science and technology policy, Rowe and Frewer (2000) suggest that participation is a characteristic of several modes of engagement, each of which have varying communication flows. For example, lower levels of public involvement can be characterised by unidirectional flows of information from the expert to the citizen. In general, they find that bidirectional communication, dialogue and citizen-driven approaches are consistent with

higher levels of public involvement. Along this line and in the context of science/policy divides, engagement is widely accepted as a fundamental step towards fostering broad participatory processes. Through a grounded theory analysis of the multiple conceptualisations of participation, Reed (2008) identified 8 principles of participation. These have been summarised below in Table 1:

8 key features of best practice participation	Is this relevant to hackAIR?
Stakeholder participation needs to be underpinned by a philosophy that emphasises empowerment, equity, trust and learning	**Yes**; enhanced understanding of participation is a core quality of citizen-science initiatives, and hackAIR as a citizen's observatory with an emphasis on behaviour change
Where relevant, stakeholder participation should be considered as early as possible and throughout the process	**Yes**, considered a fundamental requirement of the hackAIR project (demonstrated in co-creation)
Relevant stakeholders need to be analysed and represented systematically	Yes, through user needs analysis, clearly defined target groups, expert interviews and pilot cities
Clear objectives for the participatory process need to be agreed among stakeholders at the outset	**Yes**
Methods should be selected and tailored to the decision-making context, considering the objectives, type of participants and appropriate level of engagement	**Yes**
Highly skilled facilitation is essential	**This is dependent on the capacities of each partner,** as pilot coordinators will facilitate strategies
Local and scientific knowledges should be integrated	Yes, pilot cases offer a site to include and integrate local knowledge – science is integrated in technology
Participation needs to be institutionalised	Yes, reflected in BUND's broad outreach strategies and administrative structure

Table 1: Key features for participation in the context of hackAIR. Adapted from Reed (2008)

Participation as a concept remains relatively abstract in practical and academic circles. Nevertheless, important lessons can be drawn from the above literature, particularly when refining notions of participation that are central to citizen science as a practice, and those that influence the multiple methods of engagement to be used in pilot projects in both Germany and Norway.

2.2 Citizen science

2.2.1 Origins and defining elements

With an established tradition in Ornithology and Astronomy, and examples traced back to the early 20th century, participation between volunteers and experts might not necessarily be nascent (Bonney et al. 2009; Geoghegan et al. 2016). The term 'citizen science' however emerged in the late 1990's as a response to the growing relevance of non-expert knowledge, particularly through voluntary collection of data (UWE, 2013). On a broad level, it represents the ever-expanding set of projects and initiatives within which citizens are involved in science, and can be attribute to the engagement of millions of citizens across the globe (Bonney et al. 2009). Haklay (2015) attributes this ongoing emergence of citizen science to multiple societal and technological developments, such as increased literacy and education levels, the advent of ubiquitous ICT, and the combination of increased wealth and extended life expectancies.

Citizen science not only considers citizens as fundamental in the process of scientific inquiry, but represents a broad praxis that values inclusive and participatory principles, particularly when engaging with local issues of environmental resource management. This is evident in Kruger and Shannon's definition: "citizen science is the process whereby citizens are involved in science as researchers". In order to remain comparable to classical research, citizen science typically aims to gather robust and valid data that can contribute to research on different levels (Geoghegan et al. 2016).

2.2.2 Classifying citizen science

Alongside the increase in citizen science across disciplines, multiple attempts have been made to develop a 'typology' that can help in discerning commonalties and differences. One broad distinction can be made between digital and non-digital citizen science. Shum et al. (2012) ties the recent growth of citizen science projects that attempt to collectively investigate or understand environmental issues, with the widespread use of ICT technologies that can support and enable greater and diverse forms of participation. For example, digital citizen science relies on volunteer participation through web platforms (Nov, Arazy & Anderson 2011). Likewise, the term "citizen cyberscience" marks a departure from traditional pseudo-amateur scientific endeavours, and towards web-enabled and dependent science platforms (Shum et al. 2012).

Other researchers have appraised citizen science based on the various contribution of volunteers and scientists in the scientific process. Generally, volunteers can contribute to scientific projects as: 1*) **Collectors** of data for a pre-determined research problem, 2) **Collaborators** in analysis and/or dissemination, in addition to data collection or 3) **Co-creators** of research project, alongside researchers, through multiple stages* (Bonney et al. 2009). Shum et al (2012) present a contribution to this debate, classifying citizen science into different levels of democratisation available. Projects are framed based on their levels of both participation and engagement, in the hope of both locating and progressing current practices within a 'participatory paradigm' of intelligence. As such, the levels proposed – Crowdsourcing, Distributed intelligence, Participatory science and Extreme citizen science - crossover with those of Bonney et al. (2009), but with the addition of a fully integrated scientific endeavour. Table 2 combines both classifications with typical steps associated in a research project.

Bonney et al. (2009)	Shum et al. (2012)	Project and citizen role
Contributory projects	Citizens as sensors	Research-driven data collection
		Pre-determined research plans
Collaborative projects	Citizens as basic interpreters	Volunteered, basic interpretation of data
		Active involvement in some analysis, assisted
Co-created projects	Participatory science	Project typically related to community concern
		Citizens involved in problem definition and data collection
	Extreme Citizen science	Citizen involvement in all stages
		Scientists as facilitators
		Citizens exert control over project adjustments

Table 2: Categorisations of citizen science. Adapted from Bonney et al (2009) and Shum et al (2012)

Traditional and more common citizen science projects tend to fall under contributory projects, which is historically marked by initiatives that monitor biodiversity or water, typically expert led, and dominated by data collection, recording species and data submission ((Bonney et al., 2009; Geoghegan et al., 2016). In fact, such activities have long

been performed by amateurs and volunteers prior to the use of terms such as scientist (University of West England, 2013). Earlier forms of citizen involvement were tightly tied to, and influenced by the norms and practices that came to define science at a respective time. In that sense, citizen science was initially less about reframing the roles of central figures of the overall scientific method i.e. the scientist, and more about citizen engagement as a way to extend the realm of traditional science.

Both contributory projects and citizens as sensors overlap as they represent the majority of projects under the citizen science moniker that include voluntary research within the confines of a pre-defined research plan. Project framing and analysis remaining largely reliant on the specialist knowledge of the expert, where the citizen input for data collection can facilitate a network-based approach with potentially multiple sources of data. A more recent strand of this project has emerged and is supported by the ubiquitous nature of sensor technology found in mobile phones and other mobile variants (Arribas-Bel, 2014; University of the West of England, 2013). By supporting citizens as basic interpreters, the Introduction of basic training can foster the use of cognitive capacities within collaborative projects (Bonney et al 2009). Participatory science leverages social currency, which can attract more attention and improve willingness to contribute to more "grounded" problems.

Fundamentally, co-created projects tend to retain one quality - that non-scientists have the right to engage in, and contribute towards, all stages of the project. This is exemplified by Wiggins & Crowston (2011), who argue that aspects of control are helpful in setting apart science 'for the people' and 'by the people'. In this sense, these categorisations approach citizen science less as a struggle between experts and citizens – as is the case in Arnstein's ladder of participation – and more as a diverse mix of research, NGO and citizen contributions. Neither suggests that citizens actively prefer to, and have the capacity to, become involved in extreme citizen science. In fact, empirical evidence from Geoghegan et al (2016) and Shum et al (2014) highlight that the relationship between researchers and citizens is far from straightforward. Furthermore, these typologies do not suggest (at least directly) a normative aspect to evaluate citizen science projects. For example, co-created projects are not without barriers and restrictions, and in certain cases might prove more problematic to conduct in comparison to citizens as collaborators projects. Depending on the size and scale of citizen science projects, multiple roles can be identified and have been outlined below in Table 3 (Haklay, 2015). In projects of smaller size and with less resources, it is likely that one stakeholder can assume multiple roles or merge responsibilities.

Role	Description	Engagement
Project Manager	Coordinates between scientists, developers, community members, and other organisations that are involved in the project, ensuring that the project progresses as expected	Front-end
Scientist	Provides the scientific support to the project and help in designing the methodology, ensuring that information is of good quality.	Front-end
Community Manager	Manages the communication with participants, promotes the project on various social media, and provides updates through such channels.	Front-end
Science Communicator	Prepares the scientific information that will be shared to participants and answers questions in a language that is accessible to a wider public audience.	Interface
Community Scientist	Provides training to participants to ensure that the methodology is well understood and information in data sheets, apps, and website is understood by participants. The community scientist can also help in framing the local problem as a research question that will be integrated into the project.	Interface
Software Developer	Supports the development of apps and web-based data collection systems. Develops the main project website, linking it with various social media, email lists, etc.	Back-end
Data Manager	Maintains the information that is provided by participants. Uses appropriate procedures to ensure the quality of the information. Ensures that the data is protected and shared appropriately.	Back-end

User Interaction Experience Specialist	Ensures that apps, websites, and data collection forms are easy and enjoyable to use and assists in evaluating the levels of engagement in various media and the usability of digital tools.	Back-end
Graphics and Information Designer	Ensures that the project information is presented in a consistent way across printed and digital media, and provides advice	Back-end

Table 3: Possible roles in a citizen science project. Source: Haklay (2015)

By moving away from contributory projects and towards collaborative or co-created project, bi-directional communication between citizens and scientists begins to emerge. Scientists transition to facilitators and support citizens in a scientific process across all stages. Haklay (2015) stresses that such a transition should not signify the demise of expert knowledge in science. Rather, it emphases the growing importance in trust between scientists and non-scientists when collaborating in citizen science projects.

2.2.3 Expanding opportunities and emergent fields

Recent citizen science in the context of environmental monitoring has emerged as a broad, dynamic and ever-evolving set of practices whereby citizens can now engage with, contribute towards and direct multiple processes of scientific enquiry. This is reflected by strands that 1) are oriented towards sustainability challenges across a multitude of scales, 2) integrate numerous forms of disruptive technologies, often in the hands of citizens, 3) harness crowdsourced and collective intelligence and 4) foster ownership of both project processes and the central technologies involved. ICT-enabled citizen science has created new ways to collect and analyse data related to environmental resources. The integration of multiple sensors into smartphones (GPS, Accelerometer etc) has enabled remote or rural communities to partake in participatory sensing opportunities that are directly related to local concerns. E.G. Galaxy zoo, citizen observatories such as Citi-Sense[1]. Projects such as Galaxy Zoo[2] and Geo-Wiki[3] are examples of the way that citizen science is harnessing digital platforms, often increasing the scale, velocity and scope of user-generated content in an unprecedented fashion.

Moreover, legislative frameworks encourage the development of new ways to foster citizen engagement across both science and policy. Citizen observatories – initiatives that enable the collection and integration of citizen-generated data – represent one particular way to connect science to policy through participation (Liu, Kobernus, Broday, & Bartonova, 2014). These observatories adopt a citizen science approach by relying on both objective and subjective sources of data. Observations vary across contexts in addressing sustainability challenges, with current examples ranging from biodiversity monitoring, air pollution sensing and flood risk management (UWE, 2013). Likewise, often located at sites in response to a particular local concern, 'community science' represents a discrete form of community engagement. This community can operate at different scales; Haklay (2015) traces this trend to the local/ neighbourhood level, whereas Wiggins and Crowston (2011) propose both physical and virtual communities of concern. Projects typically carry social currency alongside specific and contingent needs and as such, are often associated with environmental justice of local resource management concerns (Bonney et al. 2012). Notable local examples include Mapping for Change's Lambeth Air Quality Monitoring campaign[4] and Making Sense's Urban Air Q project[5].

[1] http://www.citi-sense.eu/
[2] https://www.galaxyzoo.org/
[3] https://www.geo-wiki.org/
[4] http://love.lambeth.gov.uk/love-lambeth-air/
[5] http://www.ams-institute.org/solution/urbanairq/

Via a comprehensive investigation into the emergence of citizen science, Geoghegan et al (2016) found that citizen science projects are converging around 8 principles:

- *Widening participation in science;*
- *Recognising benefits of participation to citizen;*
- *Leading to measurable academic output and/or being used by citizens;*
- *Harnessing emotional attachments to particular subjects;*
- *Carrying out activities across a range of skills levels;*
- *Sharing data between experts (paid and voluntary);*
- *Prioritising science over engagement;*
- *Talking about 'science' only without separating citizen science and traditional science.*

2.2.4 Common criticisms and stumbling blocks

Despite its apparent worth in participatory research, citizen science is not without its challenges. Namely, these can occur on the level of the process, the practice and the output. Citizen science initiatives are often constrained by the voluntary contributions of citizens, a majority of whom have different skill levels and expectations to contribute (Haklay, 2015). Secondly, projects can be limited by their ability to both involve and engage citizens over the course of a research project. In fact, engagement interacts with citizen science in two different contexts: 1) as a specific scientific practice that requires the engagement of citizens directly as citizen scientists and 2) as a mode of engaging citizens in advancing their role in local decision making (Conrad & Hilchey, 2011).

On the level of the practice, participation in citizen science can be both a clear strength and a central weakness. As is common for participatory processes, bringing together different perspectives can suffer from communication delays and barriers. Clashes are frequent amongst scientists and between different stakeholders. For example, when explaining core concepts, establishing a solid methodological design or communicating results to broader audiences (Geoghegan et al. 2016). In the same way as larger systems, inequalities exist when bringing together heterogeneous groups of people to participate in research. These weaknesses can be social, such as the input of marginalised stakeholder groups; structural, such as the involvement of an authoritative administration or group; capacity-based, such as the digital/analytical skills of citizens and policy-makers; or organisational, such as the time and resources needed for the input of other stakeholders in citizen science.

In the context of digital science, digital literacy skills remain a crucial and often overlooked challenge in sustained participation. Therefore, often considered an inherently positive quality, participation across the board brings with it unique challenges associated to power. Given these disparities in participation, citizen science projects often experience challenges with managing the expectations of different stakeholders, agreeing on a common vision and attracting different demographics. For example, the archetypal citizen scientist remains a white male most likely to be in the age range 55 – 64 (Geoghegan et al. 2016). Furthermore, these practices often require scientists to be flexible, communicative and reflexive.

2.2.5 Introducing motivations for citizen science

Despite the wealth of citizen science opportunities taking place across the globe, the new and innovative technologies that are enabling robust data about environmental issues, and the multiple stages of citizen input that are both required and encouraged, little is known about the motivations for citizens to engage in air pollution projects (Geoghegan et al., 2016). That does not mean that air pollution is not being investigated through citizen science to some extent; in fact, the rise of citizen's observatories (Liu, Kobernus, Broday, & Bartonova, 2014) and urban participatory sensing initiatives (Balestrini, Ladera, Pólvora, & Nascimento, n.d.; Kanhere, 2013) seem to suggest the

contrary. Therefore, no practice warrants a detailed inquiry into the specific determinants and drivers that impact the 'citizen' more than a project such as hackAIR.

As a next step, this paper draws upon multiple sources to investigate the motivations of citizens when participating in citizen science projects. By definition and to various degrees, citizen science directly relies on the voluntary contributions of interested or motivated citizens. Although it seems reasonable to assume that a motivated citizen is more likely to partake in related initiatives, there are multiple different factors at play which can influence this decision. For this reason, hackAIR will explore the extent to which different demographics and skill sets, of which there are many, have the same expectation for the goals, process and outputs that accompany citizen science. These considerations are necessary to shape an engagement strategy, a collective awareness platform and a citizen science project, informed by findings from previous projects, and supported by the input of volunteers that wish to engage in citizen science.

3 Motivations for citizen science

As argued by Geoghegan et al. (2016) until this point empirical research into the motivations and determinants of participation remains elusive. This is even more lacking in citizen science as a specific practice that will, in all cases, rely on the engagement of non-professionals. Moreover, this understanding must also reflect the changing and ever-evolving nature of citizen science, including variants such as digital science, citizen's observatories and online platforms. Essentially, an understanding of motivations will influence initial participation, achieve sustained participation and enhance the quality of the outputs in any prospective citizen science project.

3.1 Motivations

Rotman et al. (2012) investigated the motivations of participants in a variety of ecological citizen science projects and divided these into: (i) Egoism, (ii) Collectivism, (iii) Altruism and (iv) Principlism. Often cited and replicated in other citizen science initiatives, Geoghegan et al (2016) argue that **altruism** – a value related to welfare and the selfless quality of volunteers in the collection, analysis and/or problem framing – is a **prominent motivation for citizens involved in biological or wildlife monitoring**. For example, a majority of volunteers wanted to contribute to the welfare of wildlife, or more for the value of actual participation. Concerns and motivation were less spatially bound, and more specifically related to a general cause (Brabham, 2012). Nov, Arazy and Anderson (2011) have explored citizens' motivation for participating in a citizen science project. They identified six motivations that have an effect on citizens' participation in citizen science projects (see Figure 3). In their model, the authors classify two reward motive factors: reputation benefits and social interaction benefits. Nov, Arazy and Anderson (2011) find that collective and intrinsic motivations have the highest impact on participation. Reward motives, on the other hand, have the lowest impact on participation.

Collective motives: The importance attributed to the project's goals

Norm-oriented motives: Expectations regarding the reactions of important others, such as friends, family or colleagues

Collective identification: Identification with the group, collaborative vision, goals or approach

Intrinsic motives: Interest in and enjoyment of participating in a particular project or initiative

Reward motives: **Reputation and social interaction benefits.** Benefits such as gaining reputation, material or personal reward.

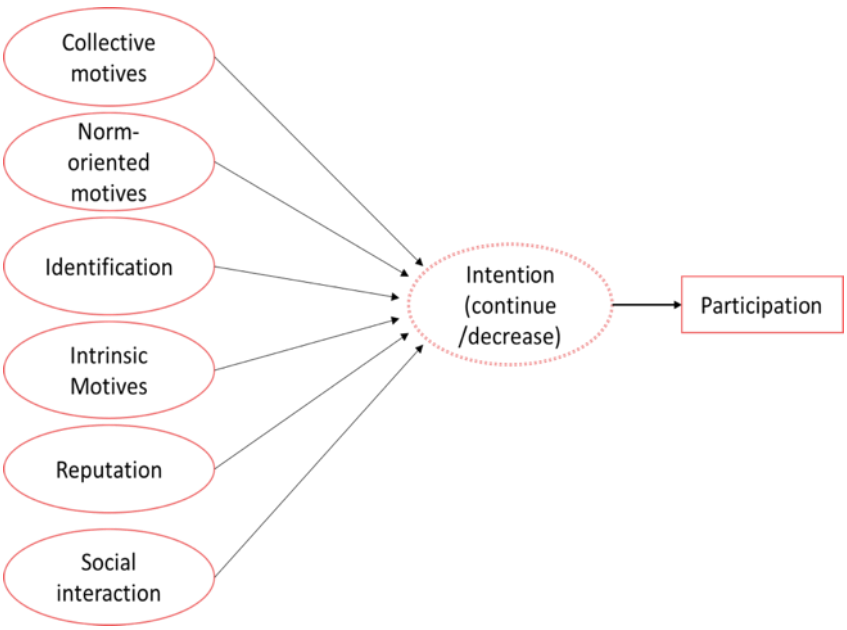

Figure 3: Citizens' motivations for participation. Source: Nov, Arazy and Anderson (2011) with description (left)

Other research has also drawn parallels with the typology developed by Nov, Arazy and Anderson (2011). In the context of crowdsourcing applications, Brabham (2012) identified multiple common motivators for participating, which can be seen in Table 4. Furthermore, the research aimed to combine the location of the motivation (intrinsic or extrinsic), derived from Self-Determination Theory, with certain triggers that underpin motivation (rational, norm-based and

affective). Of course, the prioritisation of certain factors is not homogenous across projects or domains. For example, in the context of digital platforms that are embedded within a participatory culture, some distinctions have been made to understand the motivations of citizens. In the context of social media, motivations can be reinforced by the active consumption of their content by peers for example. Often regarded as peer-influenced feedback loops (Wu, Wilkinson, and Huberman), through which motivation is driven by attention by others, or where the social interaction of the site motivates users to contribute and participate (Brabham, 2012*).*

Motives	Category
To advance one's career	Extrinsic, rational
To be recognised by peers	Extrinsic, rational and norm-based
To contribute to a collaborative effort	Intrinsic and extrinsic, norms-based
To have fun	Intrinsic, affective
To learn new skills and knowledge	Intrinsic and extrinsic, rational
To express oneself	Intrinsic, affective

Table 4: Citizen Science motivations and categories. Source: Adapted from Brabham (2012)

In the context of online mapping project Tomnad, volunteer feedback suggests that motivational factors also relate to the expected impact of their contribution. Alongside the motivation to help others, equating their contribution with either a tangible impact and with regards to a particular social mission remains important. This can take the form of data, however might also result in other impacts (Baruch, May & Yu 2016). Furthermore, volunteers also pinpointed the urgency associated with the Tomnad campaign as a determining motivator for involvement. The Galaxy Zoo project comprised over 250,000 registered volunteers, all of which engaged in the online process of classifying and categorising images of Galaxies based on multiple characteristics. As a citizen science platform that, through multiple fora, fostered public deliberation and ultimately progressed collaborative digital research in its field, Galaxy Zoo attracted volunteers for numerous reasons. Through a survey of 800+ respondents, Raddick et al (2009) discerned 12 main motivators for participation in the project (Table 5).

Motive	Example
Contribute	I am excited to contribute to original scientific research
Learning	I find the site and forums helpful in learning about astronomy
Discovery	I can look at galaxies that few people have seen before
Community	I can meet other people with similar interests
Teaching	I find Galaxy Zoo to be a useful resource for teaching other people
Beauty	I enjoy looking at the beautiful galaxy images
Fun	I had a lot of fun categorising the galaxies
Vastness	I am amazed by the vast scale of the universe
Helping	I am happy to help
Zoo	I am interested in the Galaxy Zoo project
Astronomy	I am interested in astronomy
Science	I am interested in science

Table 5: Galaxy Zoo motivations and examples. Source: Adapted from Raddick et al (2009)

Although robust research into the motivations of volunteers involved in pre-existing or current air quality campaigns remains lacking, some findings have been established. The SecondNose campaign[6] represents one of the few projects related to air pollution, through which air pollution could be collected in real-time and visualised through both an API and web based platform. Through the collection of survey data from 80 volunteers, the study highlights that, in the context of motivation:

- *Curiosity of specific and familiar locations for air quality represent the main motivations for users to participate*
- *In addition, exploratory motivations were also aimed at challenging the system functions and accuracy for collecting pollution data*
- *User motivations and expectations changed as their familiarity with the interface grew.*

3.2 Motivations for initial and continued participation

Following from the findings of Rotman et al (2012), there are multiple moments of motivation for citizen participation in a citizen science project: the initial decision to participate and the moment the citizen decides to continue to participate. The impact of motivations on engagement is at its most malleable during these two moments. This cyclical approach to both citizens and scientists can be seen in Figure 4.

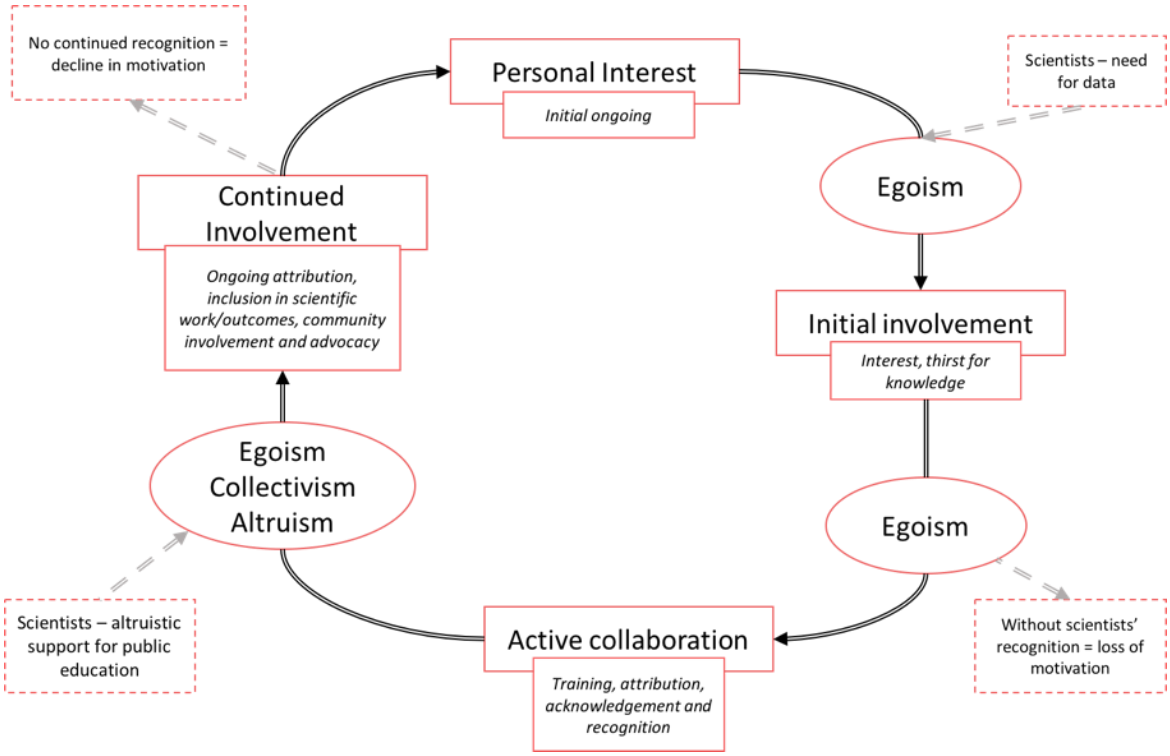

Figure 4: Engagement cycle of citizens and scientists in citizen science projects. Source: Rotman et al (2012)

Rotman et al. (2012) identify '**egoism'** as a main motivation for initial participation; that is, that citizens have an intrinsic desire for their needs to be satisfied through the pursuit of a project. Egoistic motivators can include knowledge or experience expansion, and fulfilment from an enjoyable activity (intrinsic motives). As the project or process progresses in time, citizens enter a period of reflection and reassessment; it is at this moment when they decide

[6] Findings from Leonardi et al., (2014) relate to the SecondNose air quality monitoring campaign in Trento, Italy: http://dl.acm.org/citation.cfm?id=2670273&dl=ACM&coll=DL&CFID=962905796&CFTOKEN=88013747

whether to continue to participate, and thus shift from initial participation to continued participation. Whilst for initial participations self-directed motivations are important, continued participation is influenced by other motives, such as collective interest and altruism.

When compared with qualitative findings from a more in-depth study of motivational factors from citizen science, Rotman et al. (2014) identified emergent trends that occurred between initial and sustained participation (Table 6). Whilst initial motivations for participation remained largely driven by egoism (personal interest, self-promotion, self-efficacy), the collectivist culture of one case study had impacted initial participation through the growth of a "social responsibility" in the context of environmental resource management. Acknowledge and gratification, identified previously as motivational variables in the context of crowdsourced platforms and participatory cultures, must occur to some extent to encourage long-lasting participation in project.

Timing	Motive	Related concepts	Potential Participants
Initial	Personal interest	Enjoyment, interest, ancillary hobbies, leisure, interest in nature	Individuals with ample time to spare or a very specific interest in nature; families, all ages
	Self-promotion	Reputation building, social advancement, future employment	Individuals wanting to advance themselves (Students, young adults)
	Self-efficacy	Affecting scientific work, belonging to the scientific community	Educated individuals; relatively older adults
	Social responsibility	Conservation, pride, national and local dependency	Individuals affected by local culture and education; relatively young adults
Sustained	Trust	Data quality, skills, value, time, leadership roles	Experienced volunteers looking for close relationships with scientists
	Common goals	Communication, updates, structured protocols	Volunteers looking to deepen their relationships with scientists
	Acknowledgement	Recognition, attribution, value	All volunteers
	Mentorship	Training, closeness, empowerment	Volunteers who wanted to become deeply involved in the project

Table 6: Motive, concepts and participants in citizen science. Source: Rotman et al (2014)

West and Pateman (2015) offer a broader understanding of the influences that underpin participation in citizen science, and the various stages that accompany such a process (see Figure 5). Participation is divided into a decision-making model, progressing firstly to initial, and then sustained participation. The participation process is influenced at all stages by both by dispositional factors (demographics, personal traits) and project organisation factors. Furthermore, the opportunity for individuals to decide over participation is driven by the awareness of an opportunity.

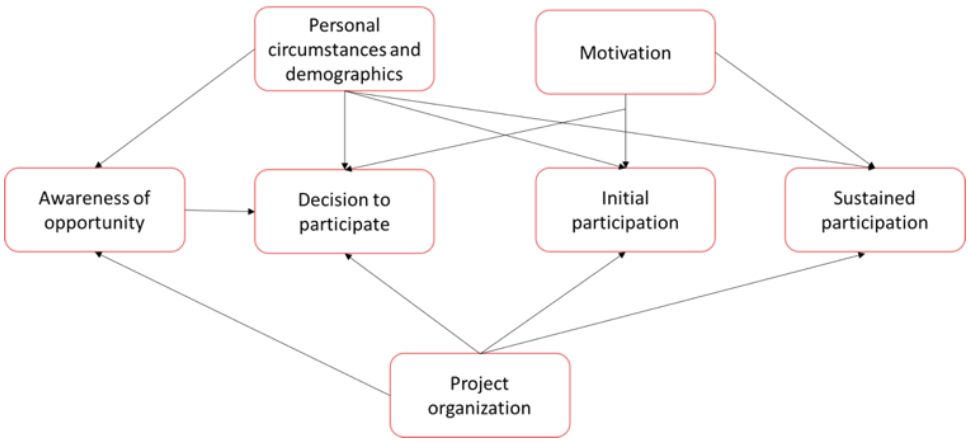

Figure 5: Model of influence for participation in citizen science. Source: West and Pateman (2015)

3.3 Barriers to participation

Alongside the multiple findings regarding motivations of participants when engaging in citizen science projects, certain factors can undermine or weaken impacts on engagement. Not only this, but so-called barriers to motivation can amplify other challenges faced by projects that rely on dense networks which comprise thousands or tens of thousands of volunteers. Table 7 lists a number of prominent delimiting factors that volunteers felt had an adverse impact on their participation in citizen science projects. Furthermore, these factors are split into those that had a main influence for citizens when initially participating, and others which limited their participation over a sustained period of time.

Barrier	Timing	Reference
Technical limitations of app	First time	Bowser et al (2013)
Inaccessible language on interface	First time	Bowser et al (2013)
Lack of awareness raising	First time	Geoghegan et al (2016)
Time Commitments for volunteers	Sustained	Rotman et al (2014)
Technology availability and usability	Sustained	Rotman et al (2014)
Lack of attention towards training and feedback	Sustained	Rotman et al (2014) Baruch, May & Yu (2016)
Different expectations and reality in terms of technology	Sustained	Rotman et al (2014)
Complex/burdensome online reporting systems	Sustained	Rotman et al (2014)
Complex communication	Sustained	Rotman et al (2014)
Difficult data contribution process	Sustained	Rotman et al (2014) Baruch, May & Yu (2016)
Contribution not translated into impact	Sustained	Rotman et al (2014) Baruch, May & Yu (2016)
Project organisation of campaign	Sustained	Geoghegan et al (2016)
Inconvenient app	Sustained	Bowser et al (2013)
Excessive feeling of competition	Sustained	Baruch, May & Yu (2016)
limited engagement between volunteers and organisers	Sustained	Baruch, May & Yu (2016)
Limited feedback on quality of data	Sustained	Baruch, May & Yu (2016)
Limited information on ongoing or similar campaign	Sustained	Baruch, May & Yu (2016)
Risk of awareness with technology	Sustained	Haklay (2015)
Communication of data	Sustained	(Leonardi et al., 2014)
Technical limitations of sensor	Sustained	(Leonardi et al., 2014)
Lack of awareness about correct sensor use	Sustained	(Leonardi et al., 2014)

Table 7: Barriers to motivation based on citizen science projects

These barriers are diverse and vary across projects, contexts and participants. Yet, some trends can also be established. For example, an absence of capacities for education, feedback and training can limit not only the motivation of participants to continue engagement, but also their skill-base and ability to do so. When introducing prototypes into citizen science projects, poorly designed interfaces can dissuade citizens from continuing with data collection or a range of interactions. This can however be mediated by a communication strategy that focuses on creating trusted testing phases so that citizens are informed of the current stage of development, and the specific goals of each phase.

Furthermore, barriers and enablers can be both organisational and dispositional. In a similar fashion, enabling and limiting factors can be seen in Table 8.

Encourages ◄► Discourages		
Organisational		
Immediate, specific and interpretable; detailed, local/individual, accessible data; explains usefulness of participants records	**Feedback**	Slow or late feedback; not saying thank you or acknowledging receipt of data
Online, updated websites, online forums, newsletters, social media. Offline: meetings in person, printed newsletters	**Communication**	Bombarding participants; one-way communication only; Inaccessible
Dedicated website with research findings; highlighting bigger picture and contributions; sharing that data made a difference	**Impacts and outputs**	Incomprehensible
Training sessions, skill development, feeling prepared	**Training/education**	Left feeling unprepared
Knowing their interests, what people love, feeling valued/useful	**Knowing your participants**	Feelings of being used
Measure benefits/impacts on participant's terms	**Participant benefits**	Too focused on stakeholder benefits
Good advertising, people have heard of project	**Awareness**	Unaware that citizen science is an activity
Well-organised	**Organisation**	Disorganised
Able to move from passive to more active role	**Participation career**	Few opportunities to progress within the project
	Dispositional	
Satisfied	**Motivation**	Unsatisfied
Access to resources	**Funding**	Not enough money to travel to sites or access technology
Accommodate diverse personal barriers through tailored project	**Personal circumstances**	Already over-committed; weather; inflexible employer; health; inclination; family commitments, bureaucracy; age; lack of time
Becomes about being in the company of others	**Enthusiasm**	Little opportunity to share interest
Meeting like-minded people	**Networking and social factors**	Doing activity alone; no opportunities to meet people (even if only occasionally or online)
More time spent participating, likely to continue	**Length of time**	One-off involvement (although not always)

Table 8: Enabling and limiting factors for participation in citizen science. Source: Geoghegan et al (2016)

3.4 Motivations towards technology

When designing a digital platform, accompanied by a companion application and integrating data collected through low-cost sensors, technological acceptance must be considered during multiple stages. This is even more pertinent for the development of hackAIR, which incorporates multiple interconnected technical components throughout the testing period.

Although relatively underexplored in literature, there are instances where models have been developed to understand participant motivations in citizen science, with an appreciation of the growing significance of technological acceptance (Nov, Arazy, & Anderson, 2011). Coinciding with the proliferation of platforms that harness collective intelligence is the movement towards low cost and DIY sensors, and the ever-emerging strand of citizen science that promotes collective awareness through citizen's observatories. User adoption towards these new and diverse initiatives, most of which contain digital interfaces or online components, will crosscut any promise of long-term change and sustained engagement. Aspects and hopes of scale are even more dependent upon, amongst other things, the relatively uneven nature of digital innovation that can be witnessed across as little as one generation, largely driven by the advent of the digital era from the 1990s.

Rogers (2003, Table 9) can prove useful as a point of reference for informing and advancing discussions surrounding technical acceptance and the diffusion of innovation. Fundamentally, it can be argued that the success of hackAIR as a citizen science project, leveraging various voluntary contributions from engaged communities, is dependent on the degree to which citizens will accept and adopt innovative services. Rogers defines diffusion as 'the process by which an innovation is communicated through certain channels over time among the members of a social society'. According to the DOI theory, the rate of diffusion is affected by an innovation's **relative advantage, complexity, compatibility, trial-ability and observability**. Further, Rogers segments adoption as determined by 5 main categories of users. Table 9 outlines these categories, in addition to their roles for diffusion and characteristics.

Category	Role	Characteristics
Innovator	Willing to **experience new ideas**.	Thus, they should be **prepared to cope** with unprofitable and unsuccessful innovations, and a certain level of uncertainty about the innovation.
		Innovators are the **gatekeepers bringing the innovation in from outside of the system.**
Early Adopter	More likely to hold **leadership** roles in the social system	Attitudes toward innovations are more important than other groups.
		Their subjective evaluations about the innovation reach other members of the social system through the interpersonal networks.
		Other members rely on their advice or information about the innovation
Early Majority	**Good interaction with other members of social system**; do not have leadership role of early adopters.	Adopts the innovation just before the other half of their peers adopt.
		Deliberate in adopting an innovation and they are neither the first nor the last to adopt.
Late Majority	One-third of all members of the social system **who wait until most of their peers adopt the innovation**	Although they are sceptical about the innovation and its outcomes, economic necessity and peer pressure may lead them to the adoption of the innovation.
		Interpersonal networks of close peers should persuade the late majority to adopt it
Laggard	Hold the traditional view and are more sceptical about innovations than the late majority.	Because of the limited resources and the lack of awareness-knowledge of innovations, they first want to make sure that an innovation works before they adopt.

Table 9: Roles of 'adopters' in diffusion of technology. Source: Rogers (2003)

3.4.1 Communication

As can be seen in the preceding sections, the importance of communication in citizen science cannot be underestimated. It is a sub-function of project organisation and crucial at various stages – initially in order to present hackAIR as a project, to appeal to multiple target groups, and to present information in a way that can enhance engagement over project durations and beyond. Geoghegan et al (2016) found that communication between stakeholders carried the following advantages:

- *Keeping participants in touch with the project*
- *Offering participants local, personal and quick feedback*
- *Sharing intellectually interesting content*
- *Opportunity for face-to-face feedback offering a personal touch/link with the project*
- *Able to share what the data is telling participants*
- *Able to treat people as social creatures (e.g. it's not a club, but there can be interaction)*
- *Target individual requirements (e.g. daily for some, others not bothered)*
- *Sharing how data is used in scientific papers to communicate what their data is able to do and*
- *Educate participants by sharing top tips, what to look for, advice, answers to letters*

Communication must be aligned with the target groups of the pilot cities and to the needs of specific volunteers. A multifaceted approach to communication as a core aspect of an engagement strategy crosscuts all aspects of the hackAIR project (input, resources, data collection, analysis, results, evaluation). For example, in the context of results: *"communicating raw factual conclusions, sterile numeric tables, and lone graphs and visualisations often resonates poorly with audiences, falling flat and leading people to invest their limited attention elsewhere. Moreover, presenting isolated information fails to effectively contextualize it within the reality that we hope to change" (*Shum et al, 2012, p.135).

3.4.2 Gamification

A popular definition of gamification is provided by Deterding et al. (2011). Accordingly, gamification entails the "use of elements of games in non-game contexts" and is concerned with gamefulness, gameful interaction, and gameful design (p. 10). Specifically, the refer to gamification as the use (rather than the extension) of:

- *Design (rather than game-based technology or other game- related practices)*
- *Elements (rather than full-fledged games)*
- *Characteristic for games (rather than play or playfulness)*
- *In non-game contexts (regardless of specific usage intentions, contexts, or media of implementation).*

Gamified applications are thus inherently different from whole games (including serious games) or more playful design, in the sense of toys. Gamification aims to appeal to the hedonist in users. Despite this, gamification also enable non-hedonic, i.e. utilitarian potentially non-enjoyable tasks, which however might be socially or environmentally desirable, to become more enjoyable. In other words, intrinsic motivation, i.e. the wish to perform activities for the sake of it are promoted for tasks which would usually require extrinsic motivations, i.e. motivation from outside to achieve certain valued outcomes (Ryan & Deci, 2000).

Gamification is therefore more complex than "adding points and badges on top of a system (Thiel, Reisinger, Röderer, & Fröhlich, 2016, p. 35). Rather, it is rather the process of balancing utilitarian and hedonic benefits (Hamari and Koivisto, 2015). In this context, design thinking is important when creating gamification in order to stimulate user participation. Detering et al. (2011, Table 10) provide a comprehensive overview of the levels on which such a game design can take place. The authors differentiate between design patterns, mechanics, general principles, models, and methods. These include design patterns such as a smooth player journey, creating balance between challenge and skills, and the designing of the set-up as a full experience are essential.[7] Game-mechanics such as competition, mastery, scarcity and discovery can then be applied to make the game attractive (e.g., Chou, 2013).

Level	Description	Example

[7] http://gamifyforthewin.com

Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badges, leaderboards, levels
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	MDA; challenge, fantasy, curiosity; game design atoms; CEGE
Game design methods	Game design-specific practices and processes	Playtesting, play-centric design, value conscious game design

Table 10: Levels of game design according to abstraction. Source: Detering et al (2011)

However, as the authors note, the description of game elements varies significantly in literature. While there seems to exist a general agreement of basing frameworks on the concept of intrinsic and extrinsic motivation, depending on the theoretical focus of the framework, the elements listed might differ (see also Seaborn & Fels, 2015). Aparcio et al. (2012) connect the intrinsic factors competence, autonomy, and relatedness in the context of gamification with a list of game elements. Accordingly, autonomy is realised through profiles, avatars, macros, configurable interface, alternative activities, privacy control, and notification control. The need to feel competent can be addressed via positive feedback, optimal challenge, progressive information, intuitive controls, points, levels, leaderboards. Finally, relatedness can be created by considering the creation of groups, messages, blogs, connection to social networks and the provision of chats.

Blohm and Leimeister (2013) start from the perspective of game design and aim to create so called "gamified service bundles": Starting from a specific usage objective, these are translated into game design elements which are then compiled in the gamified services, which should active certain user motivates and thus stimulate consumption. The motives include hereby not only self-determination, but also intellectual curiosity, achievement, social recognition, social exchange and cognitive stimulation. The authors list hereby two kinds of game design element: game mechanics and game dynamics. The mechanics are the actual building blocks for the design of the game, while the dynamics describe their effect (see Table 11).

Game-design elements		Motives
Mechanics	**Dynamics**	
Documentation of behaviour	Exploration	Intellectual curiosity
Scoring systems, badges, trophies	Collection	Achievement
Rankings	Competition	Social recognition
Ranks, levels, reputation points	Acquisition of status	-
Group tasks	Collaboration	Social exchange
Time pressure, tasks, quests	Challenge	Cognitive stimulation
Avatars, virtual worlds, virtual trade	Development/organisation	Self-determination

Table 11: overview of game elements. Source: Blohm and Leimeister (2013)

In the end, as Seaborn & Fels (2015) emphasise, most gamification-specific frameworks were developed in isolation and "there is, as yet, no evidence of their completeness; these frameworks need to be applied in order to determine

their applicability and convergence." Hence the overview of Thiel et al. (2016) proves to be useful here. The authors provide a comprehensive overview of the most commonly used elements in gamification approaches. Commonly identified elements for gamification include achievement, points, status, expression, feedback, personalisation, challenge, competition, and time constraint (see Table 12).

Classifier	Elements	Description
Achievement	e.g., badges	A mechanism to show the user his or her progress and achievements within the system
Points	-	Users can earn virtual points that in some cases can be used to redeem physical artefacts.
Status	e.g., levels	In contrast to points in leaderboards, the underlying mechanic that aims to motivate is the strive for recognition by others and findings one's place in a community.
Expression		e.g., spaces for creativity
Feedback	e.g., notifications	Where used, these spaces for open creativity/creation are usually the main component of the system.
Personalisation	e.g., profiles, avatars	The system provides the user with additional information, hints or gives encouraging statements.
Challenge	e.g., missions, quests	The system offers a space that contains information about the specific user or can be modified by the user.
Competition	e.g., leaderboards, high score lists	The system or other users ask the user to perform a certain activity under predefined conditions.
Time constraint	e.g., due dates, countdowns	Competition does not necessarily connect to rivalry, but can also be neutral comparison.

Table 12: Overview of game elements. Source: Thiel et al (2016)

3.4.3 The potential of gamification for citizen science

As Thiel et al. (2016) emphasise, gamification can contribute to participation by providing a means to engage and educate individuals in a novel way. Indeed, as Geoghegan, et al (2016) outline, with the increasing use of online platforms for citizen science platforms, gamification is being embedded into an increasing number of projects to stimulate participation.

Gamification is popular in the context of topics as diverse as education (e.g. Foster et al., 2012), health (e.g. Rose et al., 2013), sustainability (e.g. Liu et al., 2011), research (e.g. Rap & Marcengo 2012), crowdsourcing (e.g. Mason et al., 2012) or marketing (e.g. Downes-Le Guin et al, 2012). A common application of gamification in citizen science is in the context of citizens as data collectors. Giving an example, the Geograph.org.uk engages citizens to map remote areas in the United Kingdom. Participants compete via the numbers of uploaded images. Likewise, the Citizens' Network for the Observation of Marine BiodivERsity (COMBER) project in Greece reached out to local diving clubs to monitor biodiversity in a marine environment (Haklay, 2015).

Prestopnik and Crowston (2012a) provide an important contribution to this strand of research by differentiating generally between "task gamification" and "game taskification". The former concept refers to adding game elements to a needed task to foster the completion by making it more enjoyable. As an example, the authors describe the tool Happy Moths which was created by scientists for taxonomy purposes. Users are required to identify moths according to pictures, with "the happy moth" used to evaluate their performance. However, users also achieve scores for their

long-term involvement, leader boards, and high scores to promote competition. This also helps to evaluate the quality of the users' work (see also Prestopnik & Crowston 2012b). The latter concept, game taskification, refers to building a game with tasks elements. The authors use the example of Forgotten Island. The game features a full story-driven gaming world, namely an island that the user must build and explore. The classification of insects is hereby only a means to collect game money for equipment and game items for the game. As Prestopnik and Crowston (2012a, 2012b) outline, task gamification is simpler to realize in the context of citizen science as it less time and resource intensive. Nevertheless, game taskification has immense potential for user involvement. Crowston & Prestopnik (2013) demonstrate that in both cases, competitive features of the game and the prospect of contributing to science highly motivated users to participate, even above the required benchmark. This finding is also echoed in the work of Cooper et al. (2010) and Curtis (2015), who highlight that in some cases the motivations of participants stem from the competitive features; for others however, the contribution to science is at the forefront (West et al. 2015).

Gamification does have some limitations, both in theory and in practice. Conceptually, these include the incoherence of definitions, the use of theoretical foundations, lacking empirical investigation and long-term studies (Seaborn & Fels, 2015). Thus, as Murphy (2015) outlines, the application of gamification for citizen science can still be regarded as requiring significant research. In the application domain, gamification runs the risk of actually demotivating users to participate if their performance is evaluated (Massung et al. 2013). Personal profiles of users can be decisive in the success of gamification in citizen science (Bowser et al. (2013). While millennials might be attracted to game elements such as earning badges and peer competition motivating, and elaborations offered in response to open-ended survey questions, older users have shown to be less interested in game features. Participants who identified as amateur scientists do not typically embrace highly game-like interfaces, as their interest lies in contributing to science and the public good.

3.5 Relevance for hackAIR

Until this point, scholarly understandings of citizen science motivations largely draw on experiences from the context of biodiversity and wildlife monitoring, owing to the sheer number of examples in comparison to other fields. This is no more common that in the context of air pollution, where projects are increasingly springing up, each of which have varying goals respectively. From the more established literature identified above, it is possible to distil some lessons that are transferable to hackAIR on a general level.

3.5.1 Motivations to participation

It can be understood that citizens enter stages where they re-adjust their expectations and motivations to participate. This occurs initially when deciding to join in a project, but then moves forward with more sustained participation. Accordingly, any impact on the engagements strategies and the planning and design of citizen science initiatives must Identify the moments of 'initial participation' and 'continued participation' in order to know which motivations to address at the right time.

Generally, and given the importance of collective motives in the context of air pollution, it is important to clearly communicate the project goals and achievements to their volunteers and interested citizens. Citizens should feel that their contribution is valued. Newman et al. (2012) refer to these distinctions as a defining factor in the 'motivation' and 'retention' of participants. Expectations of project and volunteer output have a clear impact on sustained engagement – justifying a need to **translate their contribution into tangible results**, or **to acknowledge their contributions**. This finding is supported by Geoghegan et al (2016), who found that feedback, communication, the feeling of having made a useful contribution either through their participation or data.

There are potential ways to connect acknowledgement mechanisms with the impact of participation, including: (i) communicating the science behind the project, (ii) providing progress updates, (iii) the presence of a personal contributions page and (iv) benchmarking relative performance related to others (Iacovides et al. 2013). Furthermore, lessons can be drawn from Leonardi et al., (2014), who found fundamental differences between the motivations of volunteers for initial and long-term participation. This is evident in the shift away from curiosity about the accuracy of sensors and relevance to their own habits and everyday locations, and towards the need to cross-check 'subjective sensing' with more accurate or precise readings.

Additionally, two potential incentives for continued participation were identified in an online survey by Geoghegan et al (2016): (1) **skills development**, and (2) **feedback and communication.** When translating a general engagement strategy into tailored settings, there is a need to understand dispositional factors and motivations of citizens, as they will directly underpin the strategies for each pilot. It is clear that very few have investigated lessons learned, particularly in the context of motivations and engagement of citizens, in projects related to citizen science and air pollution. Therefore, these findings **justify the design of expert interviews and a retrospective analysis**, so that lessons can be derived from projects that, whilst operating at different levels (European, National, Regional), can be defined based on their focus on citizen science and air pollution. Furthermore, they **justify the design of a user survey** that can gauge factors that will impact participation for citizens in specific pilot locations (Chapter 5).

3.5.2 Gamification in hackAIR

As discussed in 3.4.2, gamification is a personal matter in several respects. First, it is not applicable to every group, and must not be considered a quick-win feature. Its applicability depends on the demographics and self-understanding of the group. Second, and as a result, gamification will only work effectively if it is personalised and considers participants' wishes and needs. At this point, it is worth noting gamification requirements that emerged from the hackAIR co-creation process in 2016[8].

R	Actions	Included in final app
R20	Game-elements should give users recognition for their contributions to the platform and as such create an incentive to keep on contributing.	x
R21	A point-based reward system should be integrated ("people want to win").	x
R22	A public ranking should be included to display user gathered points and their status compared to others.	
R23	Users should be able to compare their status/ranking with others near them or with 'friends' who also use the platform.	x
R24	Based on the level of engagement with the platform, the gaming tasks should become more complex.	x
R25	Rewards should be fine-tuned: a user should receive more points if the measurement is really relevant, i.e. new place or real-time instead of uploaded in the evening.	-
R26	Users should be able to 'unlock' badges for gathering a certain amount of points or for certain contributions. Badges are displayed on the profile of the user.	x

Table 13: Gamification requirements (R) from user needs. Source: hackAIR D2.4

Based on the literature review above, and in tandem with the above co-creation findings surrounding gamification, hackAIR will adopt an approach that:

[8] See D2.4: Report on co-creation of services for comprehensive methodology and findings.

- *Introduces users to hackAIR application*
- *Provides an on-boarding process which*
- *Allows users to familiarize with the interface and core functionalities*
- *Introduces advanced functionality*
- *Supports habits of checking air quality in user surroundings.*
- *Strengthens the commitment of improving air quality of user surroundings*
- *Provides tips of how to improve the user health in relation with air quality.*

Various features will be embedded, including: **Role play, Missions, Tip of the day, Points, Levels, Badges and Push notifications.** For a full overview of the tailored gamification strategy developed for hackAIR, see D5.2: 1st version of integrated and tested hackAIR open platform.

3.6 Lessons learned

Chapter 2 explored literature concerning citizen's engagement in science and the various strands of citizen science that are now present in our society. Given the centrality of user participation in citizen science, chapter 3 investigated empirical research touching upon motivations for participation, communication and gamification. These chapters comprise part one of D6.1. Following these sections, several insights can be outlined:

Participation and citizen science
• *On a broader level, pilot cities must remain attentive to power dynamics that might either be implicit or explicit in hackAIR (Gender, inequality, age, digital divide, the voice of the activist)* • *hackAIR warrants a move beyond "participation as power", and must recognise that for a multitude of reasons, disparities do exist on access to participation, expectations within user profiles and across different target groups* • *It is important to reflect on and actively challenge the power held as a scientist, and the flexibility required to facilitate citizen science* • *Based on both conceptual and empirical literature, the degree and quality of expertise with facilitation directly contributes towards the quality of participation. Furthermore, this can also have implications for sustained engagement, which is often considered a core challenge in participatory methods.*
Motivations and participation
• *Air pollution has been found to trigger a sense of social collectivism, an important characteristic of collective motivations. Local contexts, community building and action-oriented projects are effective ways to tap into such motivations* • *Curiosity of specific and familiar locations for air quality represent the main motivations for users to participate. In addition, exploratory motivations were also aimed at challenging the system functions and accuracy for collecting pollution data. User motivations and expectations changed as their familiarity with the interface grew* • *Various barriers exist to participating in citizen science project. These can appear on the level of the results, the tools involved, feedback and training, outcomes and impact, organisational characteristics, communication, technological status and dispositional factors* • *Gamification might appeal to millennials and prove effective in shaping motivation for citizen science in certain target groups, but research has shown that across all demographics gamification does not stand as a holistic solution for user participation. Furthermore, if isolated from other activities, it runs the risk of deterring or demotivating users in higher age ranges, as well as those who are interesting in high-level or structural change.*

The next two chapters are now dedicated to the collection and generation of new data surrounding air pollution citizen science projects. Various sources of data will be collected and analysed, including expert interviews and experiences and a dedicated user survey distributed in 2017. These chapters then conclude with an engagement strategy output that will be both adopted by pilot partners, and interlinked with the pilot plans of WP7 and the communication strategy outlined in WP8.

4 Project mapping and expert interviews

In addition to a literature review (CH2-3), pilot profiles (Annex 1) and project mapping (Annex 2), the hackAIR project conducted qualitative interviews with experts in the field of air quality. Given the new and fragmented findings for citizen science projects that target air pollution, and the emerging role of technology as an enabler, the goal of these interviews was to discern a set of consolidated lessons learned. Furthermore, both enablers and barriers were considered, with a clear focus on the engagement of citizens and users.

As a first step in defining projects and experts for interview, a three-phased systematic approach was used to map and analyze projects in the field of air pollution. Firstly, Table 14 displays four search strings that were entered in Scopus database to retrieve a core empirical base.

Keywords	Results
"Citizen Science" AND "Air Quality"	N = 25
"Participatory" AND "Air"	N = 425
"Citizen Science" AND "Air Pollution"	N = 25
"Citizen Science" AND "Air"	N = 67

Table 14: Search strings used for collection of projects relevant to hackAIR.

4.1 Project mapping

Upon completion, the abstract of each paper was reviewed with the following criteria: 1) Does this paper touch upon citizen science and air pollution? 2) Does this paper have an explicit approach to citizen participation? Additionally, Google scholar and a snowball approach using existing literature (both grey & peer-reviewed) were used to extend the list of projects for analysis. This process generated 30 projects for analysis. All projects began between the years 2006 and 2017, with all apart from seven occurring in a European context. An excerpt of findings can be found below in Table 15, and a full overview of projects with broad parameters can be found in Annex 2.

Project name	Systematic engagement strategy	Explicit beh change strategy	Feedback to citizens	Continuous feedback to citizens via ICT	Personalised ICT feedback	Gamification via ICT	Non-ICT Gamification
Meet je Stad	yes	no	yes	unknown	unknown	no	no
Second Nose	unknown	no	unknown	yes	no	no	no
APIC	yes	yes	yes	no	unknown	yes	yes
Love Lambeth Air	yes	no	yes	no	unknown	no	no
Science in the city	yes	no	yes	yes	unknown	unknown	unknown

Table 15: Case analysis summary based on engagement parameters

4.2 Interview methodology

Following project mapping, additional criteria were applied to identify projects suitable for qualitative interviews. These were as follows: *Technology* – the project must involve technology for data collection, aggregation or communication; *Citizen engagement* – Citizens must be involved in at least one stage of the project; *ICT* – a web platform or companion app must be available. When applied, these criteria yielded six core projects for investigation: 1) EveryAware APIC, 2) Urban AirQ, 3) CITI-Sense, 4) iSPEX, 5) SecondNose and 6) ClairCity. Given its focus on co-creation and local level air pollution, a supplementary interview was conducted with an expert from iMinds Living Labs

with respect to the CityZen project. More information about interviewees can be found in Table 12 below. Additionally, a descriptive overview of each associated project can be found in Annex 4.

Project	Expert	Is ICT involved?	Technology?	Interview date
UrbanAirQ	Gijs Boerwinkel	X	Fixed NO2 and PM Sensor, Real Time data platform	April 13th, 2017
Clair City	Dr Enda Hayes	X	Black Carbon Sensor, Web-based game, Web-data portal, Mobile Application	April 21st, 2017
CITI-SENSE	Sonja Grossberndt	X	Monitoring toolkits, web & mobile application	April 26th, 2017
iSPEX	Dr Frans Snik	X	Attachable iSPEX, Mobile and Web Application	April 28th, 2018
Second Nose	Chiara Leonardi	X	Mobile CO & No sensor, Web and Mobile application	April 28th, 2017
iMinds Living Labs (CityZen)	Bas Baccarne	X	Web application	March 18th, 2017
Everyaware: APIC	Dr Alina Sirbu	X	Mobile PM sensor, Web and Mobile Application, Web Game	May 8th, 2017

Table 16: Interviewee and criteria information for expert interviews

Given the various goals of the hackAIR project, the decision was made to apply the above criteria to generate a set of diverse yet relevant projects for qualitative interview. In doing so, each project and their associated interview would generate findings that ranged from local to national implementation, from citizen as data collector to extreme citizen science, from engagement through gamification to engagement through community involvement. Despite this diversity, 5/7 of the cases either directly or indirectly associate with EU-Funded projects. This quality of transnational co-operation and multi-city piloting, both of which necessitate distributed roles and responsibilities, ensure that conclusions are pertinent for hackAIR. Skype interviews with seven key actors of these projects were conducted between April 18th and May 9th, 2017. Interviews followed a flexible tone and a fluid structure, focusing on broad themes rather than a more rigid approach. All interviews were between 45-60 minutes in length, were recorded with consent from interviewees, and were fully transcribed.

Subsequently, transcriptions were sent to interviewees for confirmation, in order to eliminate potential biases and misinterpretations that might have occurred. Comprehensive transcripts were then analysed with the use of qualitative analysis software MAXQDA. Qualitative codes were derived from key parameters in the scientific field related to engagement, and were deliberately treated in relation to other sources of data, such as project deliverables, official reports and peer-reviewed research. Coded text varied relatively in length, but was never limited to individual words. Rather, phrases and sentences were used to effectively connect qualitative insights to the context in which they were generated. Finally, the analysis of findings from qualitative interviews was corroborated with the general trends uncovered in the systematic project mapping. The following section will delineate preliminary insights from this process.

4.3 Interview findings

Based on the analysis of findings, interlinked with general trends of systematic project mapping, several mechanisms emerged at the interface between air pollution, project participation and knowledge production. In summary, common mechanisms include: 1) Scale, 2) User-involvement and co-creation, 3) Multiple facets of communication, and 4) Linkages between user motivation and aspects of behaviour.

4.3.1 Scale

Findings suggest that scale is a central determinant to the process of citizens' engagement. Interestingly, the introduction of ICT technologies is often heralded as catalyst in the expansion of citizen science initiatives. Investigated projects utilize ICT in different ways, ranging from solely data access to more complex forms of data contribution. Projects such as iSPEX and EveryAware achieved unprecedented quantities of user-generated data during their period, whereas Urban AirQ deliberately focuses on an acute, local air pollution issue. Both approaches have discrete advantages and limitations, and as such, interact differently with aspects of scale. Scaling represents processes of replication and diffusion of innovation across spatial, temporal or institutional scales. iSPEX achieved critical mass in terms of data collection, but the institutional and technical capacities of the project created a challenging environment to replicate the project beyond iSPEX EU. As affirmed by Frans Snik, the lead researcher in the iSPEX project *"The iSPEX reached a scope where we had to transition to a more professional, operational state than a university could support"*. The Urban AirQ project remained at a confined spatial scale, creating a managed environment for the engagement of citizens. In fact, spatial scale was the largest determinant in Urban AirQ; *"We knew that topic of air quality was urgent to citizens [in Valkenburgerstraat], and we invited people from this street to come to the kick-off meeting"* – Gijs, Waag Society.

4.3.2 Co-creation

Co-creation is rapidly gaining traction as a broad concept that potentially confronts the often-exclusive nature of digital innovation. It represents a set of practices that facilitate the rapid collection and integration of qualitative insights into innovation processes. In terms of benefits, co-creation processes fuse multiple forms of knowledge, ranging from technical to environmental expertise. Furthermore, it is underpinned by the assertion that all citizens have the right to, and are able to, contribute towards innovation processes (Sanders, 2002). A majority of the mapped projects (20/35) do not explicitly engage in any co-creation process. It is quite common that digital services and solutions are designed in contexts that exclude user participation until the beginning of the testing period. This results in a situation where the needs of users, who are invariably the envisioned adopters, are often assumed during development.

Importantly, co-creation activities offer spaces to participation that are currently still lacking in the context of air pollution. This trend is also emphasised by the broader assertion that, in citizen science research, user roles are typically consigned to data collection (Geoghegan et al. 2016). Projects mapped in this project largely mirror this assertion, with some notable exceptions. SecondNose facilitated a co-creation process that directly fed into interface and application development. Due to funding issues however, this process was cut short before completion. Urban AirQ developed an engagement strategy that integrated co-creation at the stage of ideation and problem development. This ultimately led to a research design that was developed by, and owned by, non-experts.

Whilst not explicitly linked to co-creation but rather participation in science, CITI-SENSE encouraged the integration of subjective sensing, perceptions of air quality and alternative interpretations of air pollution. All of these projects, in different ways, suggest that steps are being taken in the field of air pollution to move beyond traditional forms of knowledge and practice. This sentiment is encapsulated by Frans Snik, who states that "*I still firmly believe that the next big breakthrough in terms of citizen science, outside Astronomy and classification, will be with respect to air pollution*".

4.3.3 Communication

Findings suggest that communication interacts with citizens' engagement on multiple different levels. Firstly, ICT communications create digital avenues for projects to directly communicate with various stakeholders. For example,

for Urban AirQ and CITI-SENSE, users and other citizens were directly able to access data measurements using web or companion applications. Second Nose and EveryAware APIC both used mobile sensors, which were dependent on a smartphone to send and communicate collected measurements. iSPEX stands out as a unique example in the field of air pollution to this point; the use and analysis of mobile images as proxies for outdoor air pollution.

Multiple project insights suggested the importance of non-academic stakeholders as agents for communication and engagement. This was evident in different city campaigns as part of the EveryAware project; *"It is important to have people that are experts in engagement working alongside engineers. We could see a clear difference in the number of citizens interested in Turin (without), and the amount of people in London (with). It is not easy to communicate with users, and we need to test the technology well without giving it away"* - Alina Sirbu, a computer scientist in EveryAware. In projects including EveryAware and Urban AirQ, separate non-state and non-academia actors were responsible in prominent aspects of user engagement.

Qualitative insights suggest that currently, academic institutions often assume roles that extend beyond traditional research. These operate at different levels, from the level of a university that can transfer knowledge towards other partners, to a researcher with expertise in science communication to engage directly with citizens and users. Indeed, projects indicated that users respond positively to a visible presence from academia, particularly for processes such as data quality, acknowledgement of contributions, translating input into impact, and offering support.

Projects differed in terms of their identification of target groups. Generally, however, and given the largely researcher-heavy orientation of citizen science, target groups such as universities and schools were considered strategic options for engagement. This is evident in projects such as AirBezen (from mapping, see Annex 2), EveryAware and CITI-SENSE. In the context of CITISENSE, children were identified for two reasons: 1) they represent a demographic that is commonly considered the most vulnerable to outdoor air pollution, partly due to their prolonged exposure outdoors. Secondly, they offer an avenue to resonate with parents, which can prove effective in fostering new ways of thinking and any results behaviour change about air pollution.

4.3.4 Motivations and Behaviour Change

As established in literature, there are multiple motivations of users engaging in citizen science. Project mapping highlights that, in the context of air pollution and enabling technologies, research into the relationship between user motivations and behaviour remains empirically new. Interview findings, complemented by academic contributions, do offer insights into user motivations and behaviours. One such example suggests that as a problem area, air pollution does trigger a form of social collective motivation. These sources suggest that identified motivations for users of air pollution sensors are incredibly diverse, ranging from curiosity, interest in contributing to science and interest in local pollution, to using data to inform policy-making and encourage new forms of governance.

For example, the EveryAware project demonstrates that, in the context of air pollution, campaign-based gamification proved successful in establishing urgency in local contexts. Interestingly, behavioural research conducted as part of the project actually found that, rather than leading to increased avoidance of pollution hotspots, users were drawn to high-pollution areas due to their motivation in contributing to science, and curiosity in the accuracy of the sensors (Sirbu et al., 2016). Drawing parallels with other strands of citizen science research, gamification is questionable as a long-term solution for all users in the context of pro-environmental behaviour (Geoghegan et al., 2016). Furthermore, lessons can be drawn from Leonardi et al (2014), who identify fundamental differences between the motivations of volunteers for initial and long-term participation in the SecondNose project. This is evident in the shift away from curiosity about the accuracy of sensors and relevance to their own habits and everyday locations, and towards the need to cross-check 'subjective sensing' with more accurate or precise readings.

4.4 Challenges in engagement

As mentioned in chapters two and three, processes of participation are often seen as a way to legitimize marginalised voices, balance a wealth of interests and deepen the involvement of citizens in decision-making processes. Taking place at the interface between policy and science, they encompass a level of societal interaction that is increasingly deemed necessary for the achievement of sustainable urban development. As is the case with participation in the urban realm, citizen's involvement in science and policy does not materialize easily, is too often initiated with hidden intentions and might not lead to desired outcomes. Therefore, it is crucial to understand the design of participatory processes, as well as central bottlenecks that arise along the way in the pursuit of 'good participation'.

In addition to the success factors and central principles uncovered from interviews, it is equally necessary to consider the barriers and hurdles that comparable air pollution projects have been presented with. Balancing both positive and negative outcomes could help hackAIR to recognise limitations that are likely to occur over the next 16 months. In addition, it could also allow partners to identify organisational, practical and motivational shortcomings in hackAIR, as well as potential corrective actions or solutions. All project interviewees were asked to identify and discuss two central challenges from their project that impacted their ability to engage users. Table 17 below shows a categorisation of these factors.

Challenge	Description	Relevance
Critical nature of low-cost sensors	Particularly when collaborating with public health experts Technical limitations forcing products and project to be positioned in a different way	Criticism of self-measurement expected
User issues for data contribution	Issues with syncing Dependent on project partner	Direct impact on user motivations
Project limitations	Experts working in isolation at pilots Important to connect product/service to value Adaptive organisational approach	Main motivation for user to participate
Communicating user and project outcomes	Taking into account expectations of different user groups Communicating delays and disruptions to service Unevenness in science communication	Relevant for individual or organisational target groups, as well as public service providers
Achieving 'critical mass'	Representative participation and reaching out to unaware users Supporting partners without experience in engagement Centrality of communications strategy	Crucial to engage citizens unaware about air pollution, or their contributions

Table 17: Challenges encountered in interviewed air pollution projects

Encouragingly, several actions and lessons were mentioned that interviewees felt projects them in overcoming barriers to participation and their general engagement strategy. For example, iSPEX and Urban AirQ emphasised the value placed in appealing to local concerns, particularly in areas where citizens have pre-existing complaints or concerns about air pollution. EveryAware APIC identified combining experts in engagement with engineers at pilot locations as a success factor; this had a marked difference across locations.

4.5 Lessons learned

General lessons learned
Do not build from scratch - Pilots should explore existing connections, networks, partners, projects, societies, rather than relying on completely new circles. NILU will be doing this by connecting with schools in a similar fashion to the CITI-SENSE project. BUND will engage the existing federal structure of their organisation, as well as working with existing initiatives and sub-projects
Move beyond comfort – Given the fact that NILU is a research centre, and BUND is an environmental organisation, it is expected that both pilots will have different qualities. This also means that there are aspects of the hackAIR that might bring new responsibilities or task. These interviews highlight the value of influential and community figures, expert support, science communication and interactive learning to engaging citizens in measuring and understanding air pollution
Expert training is as important as user training – As a potential solution to the above point, be aware of the capacities of each pilot. Ensuring that pilot partners are comfortable with the technical components of the hackAIR platform and can take a front-facing role in each city will go a long way in building trust with users
Frequent results and progress updates - During the engagement strategy, both pilot partners and consortium partners should prioritise responsive support and personalised feedback. These are crucial in sustaining the motivation of users in citizen science projects
Campaign-based gamification can be effective, but is not a total solution - Face-to-face contact is as vital as offline events
Local geographical/political/cultural context can establish urgency and responsibility – Considering local initiatives is a way of building a community presence, involving users in research design and data analysis, and attracting 'groups of interests'. It is also an effective way to use hackAIR to develop knowledge on local concerns and air-pollution perspectives.

5 User Survey

Between May and July 2017, a quantitative survey was designed and distributed to generate insights related to engagement and behaviour for the hackAIR project. The primary target group of this survey is potential users in both pilot locations. During these months, the VUB coordinated with pilot partners NILU and BUND in order to tailor, design and translate the survey. Moreover, pilot partners were encouraged and assisted in aligning communication channels for distribution. The hackAIR user survey served multiple purposes, including:

- *Determining the awareness of participants on topics related to air pollution*
- *Recruitment & segmentation of the potential hackAIR users to define engagement strategies*
- *Identifying possibilities for behavioural change (changing knowledge, beliefs, behaviour)*

5.1 Survey content

The hackAIR user survey was first designed in English using the research and experience service Qualtrics[9] and then translated into Norwegian and German for pilot distribution. VUB was responsible for the overall survey design, and iterated this design with feedback from other consortium partners. VUB also coordinated with NILU and BUND respectively in order to ensure consistent and tailored translations across all languages. In order to fulfil the objectives outlined above, the user survey content was divided into several thematic blocks: Introduction, 2) Knowledge and awareness about air pollution, 3) Perceptions of local air quality, 4) Engagement features on hackAIR platform, 5) Intention to use & 6) General respondent information. In total, these sections comprised 21 questions and predominantly followed a flat design logic.

In two instances, branched design was used to redirect respondents to questions based on their response i.e. You selected that you live in a city, town or village. Please provide the name: _____. The survey combined multiple styles of questioning, in order to gather varied responses and ensure a user-friendly experience for respondents. Predominantly closed questions were included, as well as Likert scales to enable quantitative analysis of certain themes. In other instances, open question fields and text boxes were encouraged to generate emergent responses from users. This option has the potential to allow unexpected patterns to arise, as well as user-centric feedback that can be taken into account in the subsequent engagement strategy.

5.2 Distribution

In June 2017, the hackAIR survey was officially launched and distributed to collected user insights regarding air pollution, engagement, intention to use and aspects of behaviour. In total, three anonymous distribution links were generated; one for each language (ENG, DE, NO). Project partners were encouraged to distribute the survey within their departments, amongst professional contacts, as well as to promote the survey within their respective target groups. As can be seen in Table 18, pilot roles in promoting the survey were complemented by communication via hackAIR channels. All partners distributed via personal emails, dedicated Facebook posts and social media.

Channel	Pilot level		Project level
Website post	NILU	Bund	hackAIR
Facebook post	X	X	X
Twitter post	-	X	X

[9] https://www.qualtrics.com/

E-mail mailing list	X	X	X
Personal E-mail	X	X	X
Co-creation participants	X	X	-

Table 18: Distribution overview for hackAIR survey

BUND and hackAIR posted distribution links via twitter posts. Given their prior involvement in the WP2 co-creation activities, pilot partners were encouraged to reach out to the co-creation participants that participated in workshops in Berlin and Oslo in 2016. Therefore, the survey targeted Norway and Germany as primary target locations, and Netherlands, Belgium and Greece as secondary locations. In the subsequent sections, we will outline the results of this survey for questions related to air pollution, engagement and intention to use; D6.2: Behavioural change techniques for hackAIR community will outline responses from questions which targeted behaviour, values and change. All questions for the survey can be found in Annex 5.

5.3 Survey responses

Table 19 briefly outlines the main figures regarding the hackAIR survey. The survey was launched and closed exactly one month apart, and generated 372 responses that were included in any subsequent analysis.

Survey launch:	14:00 Monday June 26th 2017
Survey closed:	17:00 July 26th 2017
Total valid responses	372
Total completed responses	321
Included responses (50%+ completion)	51
Total Norwegian survey responses	47
Total German survey responses	261
Total English survey responses	64

Table 19: Response overview for hackAIR survey

Given that the survey was both distributed via an anonymous link and contained optional questions, the survey also generated incomplete survey responses. In total, 65 responses were considered partial i.e. below 50% of questions were not completed, and were removed from the data results. Additionally, 51 survey responses contain partial responses that comprised more than 50% of the overall survey design, and were therefore included in the total survey results for analysis. 261 responses were completed in German (70.2%), 47 in Norwegian (12.6%) and 64 in English (17.2%) respectively. It is not entirely unexpected that responses were mostly in German, given the membership base and community of interest within BUND. Norwegian responses did however produce less responses that envisioned. One possible explanation for this could be that the core target group of students (high school+) are currently on summer vacations, which significantly reduces the sample success. It is difficult to estimate the overall success of the survey, due to its online nature and reliance on digital communication channels. In the next sections, general patterns amongst the full survey will be outlined, before beginning with pilot-specific results.

5.3.1 Socio-demographic profile

In this sub-section, general demographic patterns across survey responses will be briefly discussed, utilising education and age categories. Table 20 provides a cross tabulation of these categories across all responses.

		Age in years								
		Under 15	15-20	21-30	31 - 40	41 - 50	51 - 60	61-70	70+	Total
Highest level of education	Less than secondary school	0	1	6	4	14	7	2	3	37
	Secondary school	0	8	13	12	11	11	1	2	58
	Bachelor degree	0	0	22	12	5	4	1	1	45
	Master Degree	0	0	36	45	30	8	3	0	122
	Doctoral degree or higher	0	0	1	9	8	9	2	0	29
	Professional degree	0	0	3	7	1	5	4	0	20
	Other	0	0	1	2	3	4	0	0	10
	Total	0	9	82	91	72	48	13	6	321

Table 20: Crosstab presenting sample respondent age and education profiles. N=321

In total, 91/321 (28.3%) of all responses were aged between 31 and 40 years old, representing the largest age category. With regards to education, 122/321 (38%) repondents were educated to master's level. Broadly, a majority of respondents were between 21 years and 50 years old and were educated to a master's level. These three age ranges comprise 35% of the total sample response. Only 9 respondents were aged between 15 and 20 years old, highlighting the fact that the hackAIR survey was unsuccessful in targeting school children as expected. 51 respondents did not complete this question.

In addition to age and level of education, settlement was investigated as a parameter of relevance for hackAIR. Given that both pilots will be based in large cities in their respective countries, as well as the fact that all pilot partners are located either in or close to large metropolitan areas, it is unsurprising that a signification portion of respondents live either in or on the outskirts of a city (205/321; 63.9%). Approximately one in the three respondents did state that they live in either a town or a city. Figure 6 compares all responses amongst respondents.

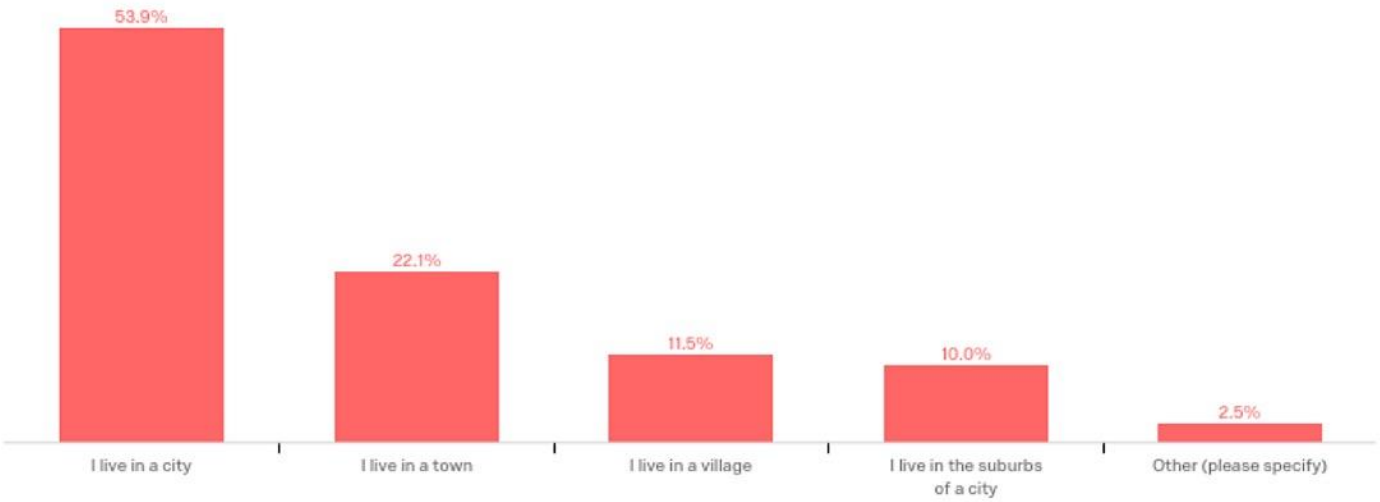

Figure 6: Bar chart illustrating settlement size of total sample. N= 321

5.3.2 hackAIR platform features and functions

Of particular interest for hackAIR is the validating the added value of the hackAIR platform and various features amongst users. Responses from this survey, visualised below in Figure 7, offered a first quantitative glimpse into the potential interest from users in Norway and Germany in these various tools. From 329 responses, 294 (89.4%) people were interested in viewing real-time information about air pollution around them. This feature will be embedded into

the hackAIR application and web app, and is enabled through the fusion mapping of heterogeneous air pollution data sources.

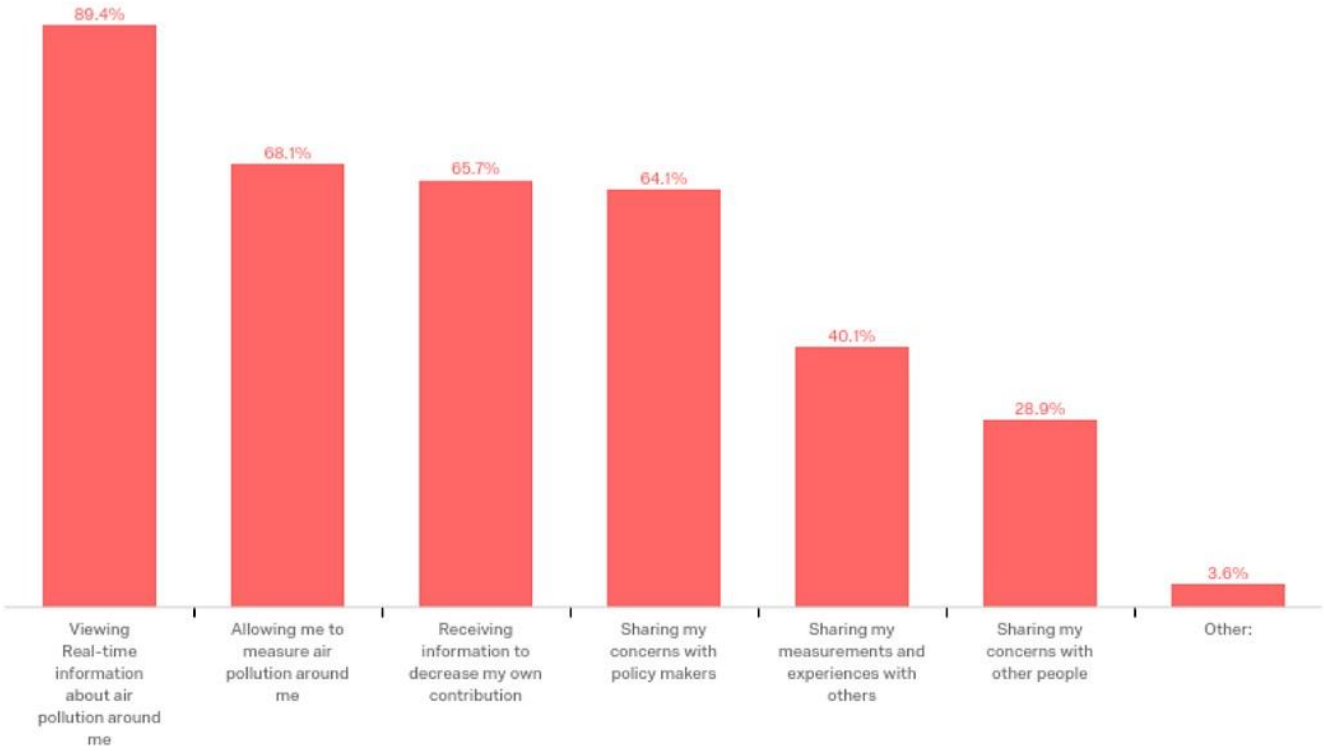

Figure 7: Bar chart displaying hackAIR platform functions and features of interest. N=329

Encouragingly, 224/329 (68.1%) of the sample registered interest in measuring air pollution in their surrounding area. This represents the second most favoured feature offered within the project. The persuasive component of hackAIR, comprising the gamification engine in the mobile application, tips of the day and personalised recommendation, appealed to 216/329 respondents (65.7%). This response rate is comparable with the ability to share concerns with policy makers (211/329; 64.1%), an activity which will be fostered through mutual learning workshops and hackAIR pilots as citizen's observatories. Less appealing however was the option to share measurements and experiences with other hackAIR users (132/321 40.1%), or with others in general (95/321; 28.9%). The former will be encouraged through the community feature on the hackAIR app, through offline workshops in pilot cities, and partially in the forums on the hackAIR website. Despite the comparably low response rate for general sharing of data, almost 1/3 of all respondents does offer promise for more creative forms of data sharing. These could include the photo safari's and other notions of data journalism, both of which are currently being explored in hackAIR. The following text responses for hackAIR features were input under the "other" option:

- *Impact on daily health*
- *Collecting points as in Treeday. This is motivating when you can collect points (coins). You can then see how much a particular action really saves (e.g walk instead of car, or bike instead of car etc.)*
- *Direct reference of fixed measuring stations*
- *Having mobile phone measured data to download*
- *The ability to anonymously share data with others*
- *Being able to access and reuse raw data*
- *Pressure on politics and industry. One cannot always burden the citizens with prohibitions and personal restrictions*

5.3.3 Measuring air pollution

This sub-section builds upon one specific feature presented in 5.2.2 "allowing me to measure air pollution around me" (see Figure 8). Of the 224 responses interested in measuring air pollution in total, the use of hackAIR DIY sensors as measurement tools appealed to the largest relative share with 137 (61.2%). Simple non-electric sensors received the second most amount of selections, with 130/224 (58%). In contrast, under 1 in 2 respondents seemed attracted to the hackAIR measurement feature that will be embedded into the mobile application (105/224; 47.5%).

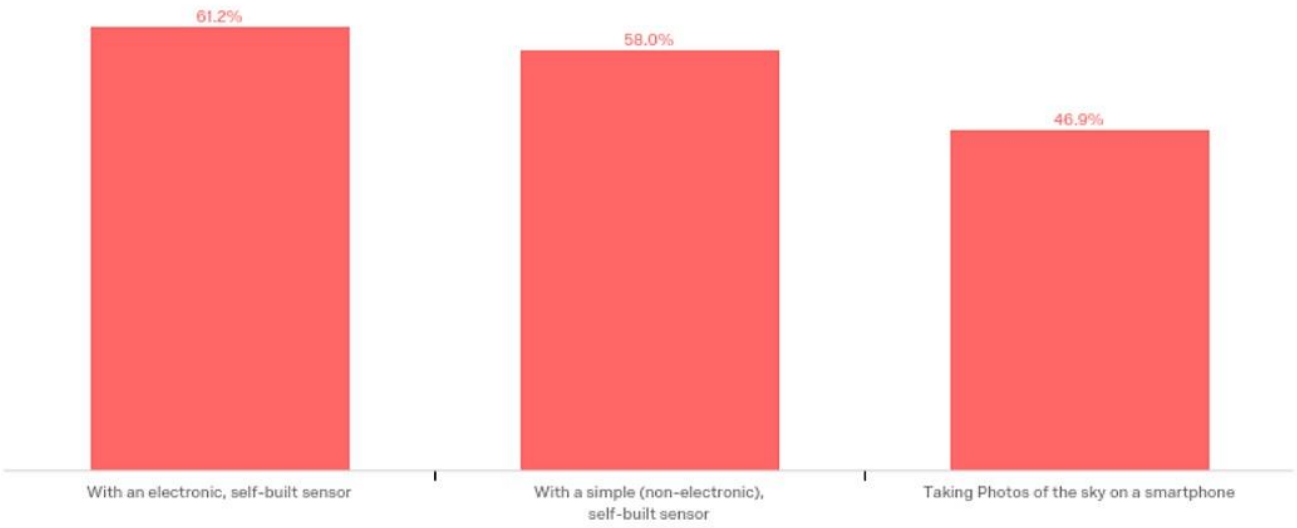

Figure 8: Bar chart showing respondent priorities in measuring air pollution. N=224

5.3.4 Engagement with hackAIR

As investigated in the preceding chapters, there are a multitude of mechanisms that can be effective in both engaging citizens to participate in citizen science projects, and in encouraging prolonged participation in the project. Figure 9 highlights prioritised mechanisms and activities that respondents feel could foster sustained participation in hackAIR. In summary, predominant engagement mechanisms suggest that motivational factors for hackAIR are i) recognition and attribution at the individual level, ii) interlinkages with other projects, iii) campaigns and initiatives, and iv) physical and social workshops that target policy debates and experiential learning.

Interestingly, the process of feedback from experts on contributions in hackAIR triggered a response from more than half of responses (154/292; 52.7%). This finding reinforces the findings from chapter 3 above, demonstrating the motivating effect that attribution and recognition can have on citizen scientists. Moreover, it highlights the complementary role of experts and associate forms of knowledge in citizen science initiatives such as hackAIR. This finding goes beyond recognition from volunteers or project coordinators of hackAIR, and strengthens the need of interaction between scientists and volunteers in the upcoming pilots. Furthermore, it suggests that feedback should not only be on the level of the project i.e how individual input was part of a collective movement, but also at the level of the user I.e how individual contributions improve data density at the local level, or the implications of individual data.

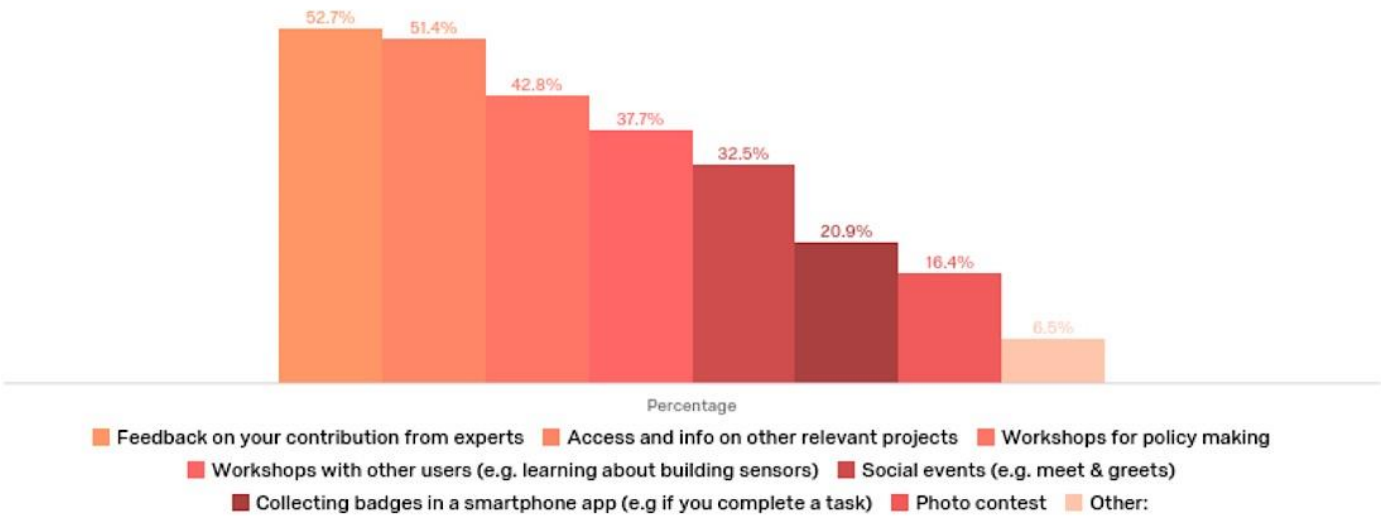

Figure 9: Graduated bar chart comparing engagement activities across total sample. N=292

Workshops for both policy making (125/292; 42.8%) and with other users e.g. learning about building sensors (110/292; 37.7%) attained the third and fourth highest number of responses. These workshops generated comparable results with social events such as meet and greets. Collecting badges in the hackAIR app – a feature within the gamification profile – was considered an effective engagement mechanism by only 1 in 5 respondents (61/292; 20.9%). Interestingly, when compared with the age categories of respondents, the distribution of collecting badges does suggest that such gamification features are not considered motivating factors for older users. For example, 42 of those 61 that selected badges (68.9% of this range), were aged between 21 – 40 years old. This is in stark contrast to the 3 responses in total attributed to the age ranges 50 years old and upwards. In fact, when extended to include all mechanisms for potential users aged above 50 years old, collecting badges was selected by just 5.4% of this segment (3/57). Rather, older respondents seem more likely to engage with hackAIR over sustained periods of time if they have access to related projects (33/57; 57.9%), receive feedback from experts (27/57; 47.4%) and are able to connect to policy (21/57; 36.8%).

Several additional responses were gathered, some of which referred closely to the activities included above. Four text responses related to hackAIR as an open data platform, the potential appeal of multi-functional mapping and analysis, and the its ability to allow multiple queries on one interface. Two responses regard citizen-centred policy outputs as a motivational factor. Extrinsic motivators and incentives were also mentioned twice, which included coupons to emission-free products and monetary incentives. Likewise, demo sessions appeared as a text input once respectively, as did a potential impact of hackAIR on regulating wood burning and grilling.

5.3.5 Barriers to participation

Figure 10 provides an overview of the most frequently noted barriers to participation. Based on the total sample of 302, time constraints appear as the most frequent barrier to participation in hackAIR (217/302; 71/9%). This is an unsurprising outcome, and remains a common caveat to citizen science projects that rely on the voluntary contributions of non-scientists, as they often require an investment of personal time. A lack of knowledge around air quality monitoring emerged as the second most common concern (97/32.1%), alongside lacking information about the project (96/302; 31.8%). The latter figure could relate to the fact that until this point, communication of hackAIR has largely taken place outside of pilot locations. Hence the distributed survey might be the first real introduction to hackAIR for a signification portion of the total sample. As such, it is reasonable to assume that a lack of knowledge

about hackAIR at this moment is a short-term barrier to participation. In the coming months, ongoing engagement efforts, the pilot implementation plan and the broader communication strategy of hackAIR should reconcile project awareness as a barrier to participation.

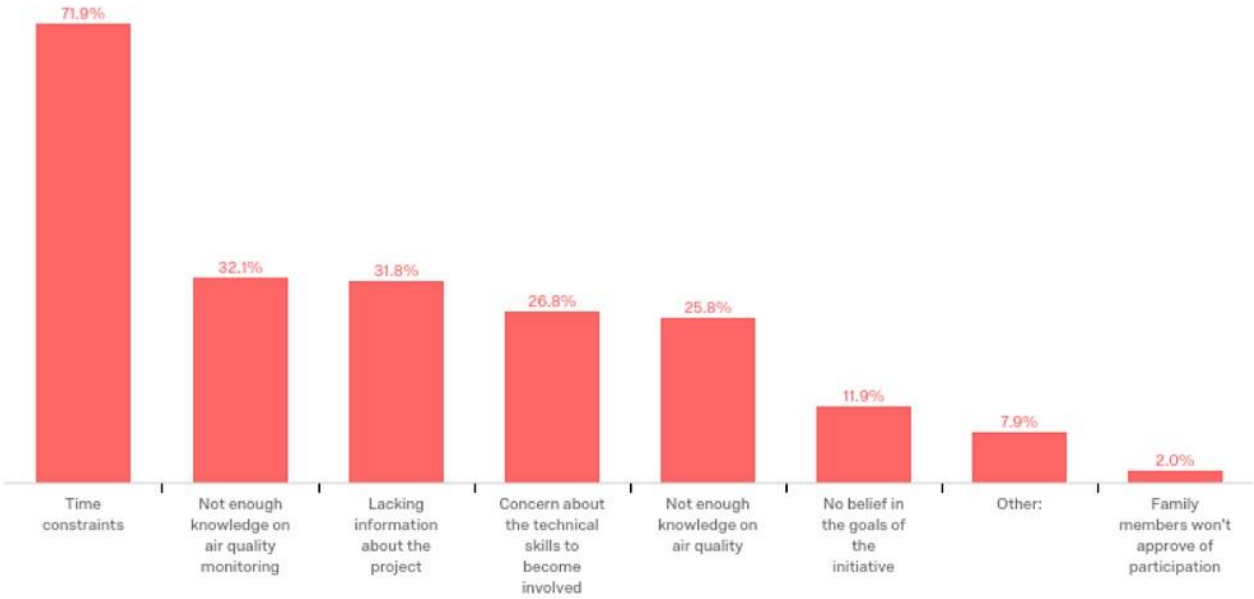

Figure 10: Bar chart illustrating barriers to participation for total sample. N=302

Just over one in four respondents regard the technical requirements of hackAIR as a potential stumbling block (81/302; 26.8%), a similar total to those with perceived gaps in knowledge about air quality as a phenomenon (78/302; 25.8%). Just over one in ten respondents stated that at this moment, they do not believe in the goals of hackAIR. Moreover, 8% of all respondents entered an additional text response in the "other" field. These included:

- *Data privacy and personal privacy concerns*
- *Fear that this obligation affects my private life due to the effort / time requirement health condition*
- *Financial investments*
- *Health concerns*
- *Doubt whether there are no more efficient and reliable methods*
- *Concerns about the change that can be made with such project*
- *Unreliable sensor data undermining how meaningful the findings are*
- *The belief that such initiatives should be based on open data*
- *Misuse of the information and results*

5.3.6 Future contact

With a response total of 308, the final section will present future contact as a proxy indicator for intention to use the hackAIR platform in any of its capacities. As seen in Figure 11, 48.7% of respondents indicated their intention to participate in hackAIR (152/308) directly in the future. 40% of respondents (125/308) also held an interest in participating through their respective local partners in pilot locations. A group of 92 respondents did however state they would not be interested in participating in hackAIR in the future.

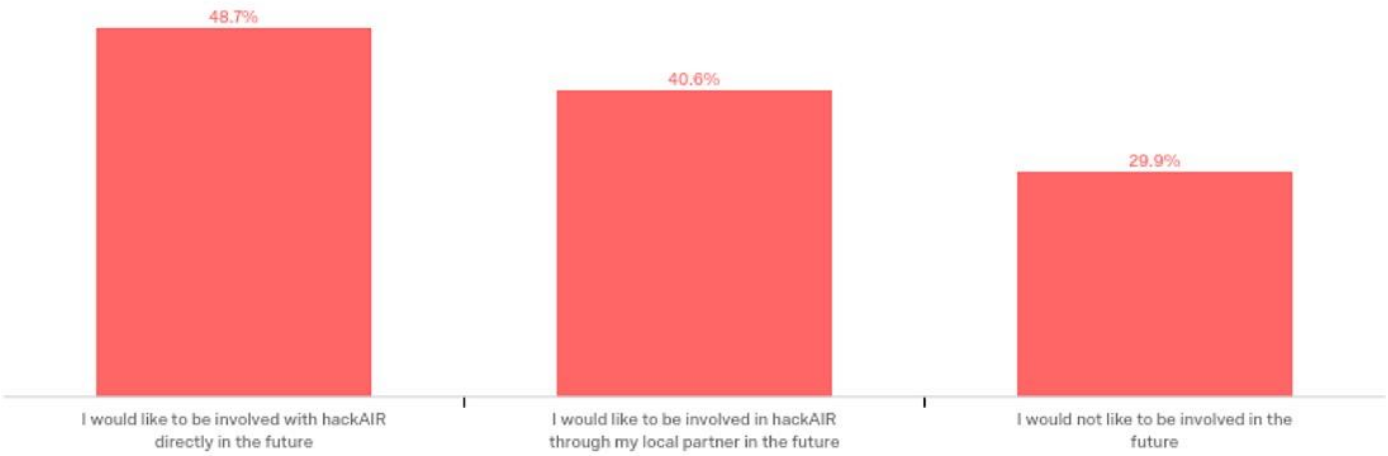

Figure 11: Bar chart comparing intention to stay involved with hackAIR in the future. N=308

Sub-chapter 5.4 will now zoom in on Norwegian and German responses in order to derive some pilot-specific insights from hackAIR survey. The section will direct less attention to responses that largely mirror the general patterns uncovered in the analysis. Rather, pilot specific patterns will be outlined and discussed that can be valuable for NILU and BUND in the ongoing pilot plans.

5.4 Pilot-specific survey responses

5.4.1 Socio-demographic profile

Table 21 compares age against education categories for both Norway and Germany side-by-side. Socio-demographically, both Norwegian and German responses largely align with the general trends identified above.

		Age in years								
		Under 15	15-20	21-30	31 - 40	41 - 50	51 - 60	61-70	70+	Total
Highest level of education	Lower than secondary school	0	0	0	0	0	0	0	0	0
	Secondary school	0	1	0	2	0	1	0	0	4
	Bachelor degree	0	0	1	3	1	2	1	0	8
	Masters Degree	0	0	8	8	7	2	0	0	25
	Doctoral degree or higher	0	0	0	0	1	3	1	0	5
	Professional degree	0	0	0	0	0	2	0	0	2
	Other	0	0	0	0	0	0	0	0	0
	Total	0	1	9	13	9	10	2	0	44

		Age in years								
		Under 15	15-20	21-30	31 - 40	41 - 50	51 - 60	61-70	70+	Total
Highest level of education	Lower than secondary school	0	1	6	4	14	7	2	3	37
	Secondary school	0	7	13	9	9	10	1	2	51
	Bachelor degree	0	0	18	6	4	2	0	1	31
	Masters Degree	0	0	15	22	19	6	3	0	65
	Doctoral degree or higher	0	0	0	2	3	4	1	0	10
	Professional degree	0	0	3	7	1	2	4	0	17
	Other	0	0	1	2	3	4	0	0	10
	Total	0	8	56	52	53	35	11	6	221

Table 21: Crosstab presenting respondent age and education profiles in Norway (left) and Germany (right).

Master's level respondents between the age of 31-40 represent the largest segment. Between the age of 21-40 however, the distribution of master's level students varies between location however. A higher quantity of bachelor's students responded in that age range in Germany (18/221; 8.4%)) than compared to Norway (1/44; 2.3%), both in relative and absolute terms. Moreover, age and education distributions were more spread in Germany. This is evident in the fact that 53.8% (119/221) of German respondents were educated until at least bachelors level, a significant variance from 20% (9/44) experienced in the Norwegian segment. A reason for this could be that survey distributions were based largely on professional and outreach networks. As a research institute, NILU is naturally connected to a population of research-oriented citizens educated to at least master's level. BUND on the other hand, with a formal institutional structure and activities for all age ranges, generated outreach to a broader age and education range for the hackAIR survey.

5.4.2 hackAIR platform features and functions

Table 22 outlines and compares respondent interest in the various functions and features of the hackAIR platform Generally speaking, both pilot countries share a similar pattern to that of the total sample.

		Norway		Germany	
		Percentage of responses	Choice Count	Percentage of responses	Choice count
Feature	Viewing Real-time information about air pollution around me	93.3%	42	88.2%	201
	Sharing my measurements and experiences with others	35.6%	16	34.2%	78
	Sharing my concerns with policy makers	51.1%	23	66.2%	151
	Sharing my concerns with other people	11.1%	5	28.5%	65
	Receiving information to decrease my own contribution	53.3%	24	69.3%	158
	Other:	2.2%	1	4.4%	10
	Allowing me to measure air pollution around me	75.6%	34	63.2%	144
	Total		45		228

Table 22: Crosstab comparing respondent interest in hackAIR features in Norway (left) and Germany (right).

This includes a significant interest in both viewing real time information about air pollution (Norway=93.3% of sample; Germany=88.2% of sample) and measuring air pollution in the surrounding area (Norway=75.6% of sample; Germany=63.2% of sample). Despite this alignment, German respondents registered more interest in receiving information about reducing individual contributions, and sharing concerns with policy makers. This indicates that pilot implementation efforts by BUND should ensure there is adequate focus on awareness and individual action, as well as linking with policy formulation.

5.4.3 Measuring air pollution

As we begin to explore the specific feature presented in 5.4.2 “allowing me to measure air pollution around me”, German and Norwegian respondents importantly suggest that the measurement interests amongst target groups for each pilot differ significantly. This is evident in Table 23, which highlights that the particulate estimation feature within the hackAIR platform was considered an option by 73.5% of all Norwegian respondents; this proportion of responses varies significantly from the German sample (31.9%). Conversely 63.2% of German respondents selected the simple, non-electronic self-built sensor, as opposed to 35.3% of the Norwegian sample.

		Norway		Germany	
		Percentage of responses	Count	Percentage of responses	Count
Measurement option	With a simple (non-electronic), self-built sensor	35.3%	12	63.2%	91
	With an electronic, self-built sensor	52.9%	18	60.4%	87

	Taking Photos of the sky on a smartphone	73.5%	25	31.9%	46
	Total		34		144

Table 23: Crosstab comparing measurement options of choice in Norway (left) and Germany (right).

These findings highlight the growing momentum of self-built sensors and the maker movement in Germany, through initiatives such as Luftdaten.info and others. Furthermore, they emphasise the need for accessible and user-friendly support resources to ensure that motivated citizens are able to assemble tools, generate data and draw conclusions surrounding air pollution in their respective areas.

5.4.4 Engagement with hackAIR

Pilot responses in Table 24 highlight differing expectations when presented with a selection of activities that aim to engage citizens to participate in hackAIR. Although both pilots prioritise access to other project and feedback on contributions from experts, the German sample is distinguishable due to the emphasis placed on workshops in comparison to Norway. This is demonstrated by response rates of 34.2% (67/196) for workshops with users and 46.94% (92/196) workshops for policy making in Germany, both of which are significantly higher than the Norwegian sample (23.8%/10 and 19.1%/8 out of 42 responses respectively). Of interest, however, is the fact that 28.6% (12/42) of respondents in Norway in collecting badges, possible through the hackAIR application.

		Norway		Germany	
		Percentage of responses	Choice Count	Percentage of responses	Choice Count
Engagement mechanism	Access and info on other relevant projects	61.9%	26	52.0%	102
	Feedback on your contribution from experts	50.0%	21	53.1%	104
	Collecting badges in a smartphone app (e.g. if you complete a task)	28.6%	12	17.4%	34
	Social events (e.g. meet & greets)	26.2%	11	29.6%	58
	Workshops with other users (e.g. learning about building sensors)	23.8%	10	34.2%	67
	Workshops for policy making	19.1%	8	46.9%	92
	Photo contest	16.7%	7	12.8%	25
	Other:	11.9%	5	6.6%	13
	Total		42		196

Table 24: Crosstab engagement mechanisms of choice in Norway (left) and Germany (right).

5.4.5 Barriers to participation

As is common in the practice of citizen science, time constraints represent the central barrier to participation in both locations (see Table 25). A significantly larger proportion of respondents in Norway (82.9%; 34/41) considered this as a barrier when compared to responses from Germany (67.8%; 141/208). Interestingly, this question also indicates that respondents in Germany are more concerned about the technical skills involved in the project (28.9%;60/208), lacking knowledge about both air quality (29.3%; 61/208) and associated monitoring (35.6%; 74/208) than in Norway. The findings suggest that broader efforts must be taken into account when attempting to overcome barriers in the German pilot, given the diversity of concerns discussed.

		Norway		Germany	
		Percentage of responses	Choice Count	Percentage of responses	Choice Count
Barrier	Time constraints	82.9%	34	67.8%	141
	Lacking information about the project	24.4%	10	37.5%	78
	Concern about the technical skills to become involved	22.0%	9	28.9%	60
	Not enough knowledge on air quality monitoring	12.2%	5	35.6%	74
	Other:	9.8%	4	8.1%	17
	Not enough knowledge on air quality	7.3%	3	29.3%	61
	No belief in the goals of the initiative	7.3%	3	13.9%	29
	Family members won't approve of participation	0,0%	0	2.9%	6
	Total		41		208

Table 25: Crosstab comparing barriers to participation in Norway (left) and Germany (right).

As mentioned above, raising awareness about the hackAIR project is a clear way to mediate lacking information. Similar efforts however should be made to raise awareness about air quality and its discontents, as well about approaches that can be taken to measure air quality. Given the interest from the German sample in participating in workshops, physical settings will be of utmost importance for the transfer of knowledge about these issues, and can certainly be combined to overcome challenges related to both awareness and technical capacities. Due to the relatively small sample, it is difficult to draw conclusions from Norwegian barriers other than those related to time. Having said that, roughly one in four respondents were concerned about both information about the project (24.4%; 10/41) and the technical skills to become involved (22%; 9/41). Physical demonstrations and awareness events are possible settings where potential users can reflect on and potentially test the skills required to become involved in the project. Likewise, acting on the larger interest in the mobile application might also mean focusing on photo safaris and platform-related engagement (run through, workshops).

5.4.6 Future contact

Responses related to future contact (see Table 26) can be considered promising in general; a majority of responses across both pilots indicate that there is considerable intention to remain involved in the hackAIR project in the future.

		Norway		Germany	
		Percentage of responses	Choice Count	Percentage of responses	Choice Count
Intention to participate	I would like to be involved with hackAIR directly in the future	35.7%	15	44.8%	94
	I would like to be involved in hackAIR through my local partner in the future	47.6%	20	41.9%	88
	I would not like to be involved in the future	33.3%	14	33.8%	71
	Total	42			210

Table 26: Crosstab comparing intention to participate in Norway (left) and Germany (right).

The presence of a local partner had a favourable impact on responses, with relatively evenly weighted rates in both Norway (47.6%) and Germany (41.9%). One in 3 respondents at both locations did however indicate that they would not like to be involved in the hackAIR project in the future. When other questions are factored into account, it seems reasonable to assume that tactics can reduce this number in practice by:

- *Overcoming challenges related to **time** through digital participation and timely communication*
- *Overcoming challenges related to **awareness about hackAIR** through awareness events and broad dissemination for pilots*
- *Overcoming challenges related to **awareness about air pollution** through an informative hackAIR website, awareness raising events about air pollution and measurement campaigns*
- *Overcoming challenges related to **awareness and skills about air pollution monitoring** through accessible support manuals, demonstrations and physical workshops and promotion of the hackAIR mobile application as a bridging solution.*

5.5 Lessons learned from survey

General lessons learned
• *In total, 91/321 (28.3%) of all responses were aged between 31 and 40 years old, representing the largest age category* • *With regards to education, 122/321 (38%) repondents were educated to master's level. Broadly, a majority of respondents were between 21 years and 50 years old and were educated to a master's level* • *Most (89.4%) people were interested in viewing real-time information about air pollution around them and measuring (68.1%)* • *137/224 interested in DIY sensors; 105/224 interested in smartphone app* • *Findings demonstrate the motivating effect that attribution and recognition can have on users* • *Main motivators are: i) recognition and attribution at the individual level (Highest), ii) interlinkages with other projects, iii) campaigns and initiatives, and iv) physical and social workshops that target policy debates and experiential learning* • *1 in 5 interested in gamification badges and levelling; 50+ are significantly less interested than rest (5.4%)* • *Barriers: Time (70%+), AirQ monitoring knowledge (32.1%), hackAIR knowledge (31.8%), tech skills (26.8%),* • *92/308 (28.9%) not interested in hackAIR.*

Norwegian pilot
• *Master's degree & 21 – 40yrs old were core respondents in Norwegian survey. Minimal input from Bachelors level or below* • *Strong interest in real-time info (93%) and measuring air pollution in surrounding area (75%). Just over ½ interested in either receiving info to reduce impact (53%) or sharing concerns with policy (51%) – both lower than total sample* • *Significant interest in estimating air pollution through sky-depicting images (73.5% from total interested in measuring). Just over ½ interested in DIY sensor (53%)* • *62% of respondents selected access and info on other projects – only 19% selected workshops for policy making (far below sample response). 1 In 2 want feedback from experts* • *83% regard time as a central barrier to participation in hackAIR. Respondents largely unconcerned about knowledge on AirQ monitoring or AirQ. 2nd Main concern is lacking information about project.*

German Pilot
• *Relatively even demographic distribution in BUND Survey* • *Almost 70% of respondents interested in either receiving information about reducing individual steps or sharing concerns with policy makers* **= focus in pilot should be on connecting to local policy, and individual contributions** • *German responses represent a growing interest in maker movement. Therefore,* **sensor related resources will be central to German pilot** • *Badges and gamification are low on list of engagement mechanisms that interest respondents. Rather, interest lies in access on other projects, feedback from experts, and workshops for policy making* • *Just over 1/3 respondents are concerns about the knowledge required for AirQ monitoring; at this point, 37.5% consider their lack of knowledge about hackAIR to be a barrier to participation*

6 Engagement strategy

Following the collection of empirical sources (Chapter 2 and 3), pilot profiles (Annex 1), practical experiences (Chapter 4) and user perspectives (Chapter 5) across topics such as air pollution, citizen science and citizen engagement, this chapter documents the engagement strategy, tactics and accompanying principles that will underpin the hackAIR.

Firstly, this chapter will outline and justify the tactics selected for inclusion in the hackAIR engagement strategy. Each tactic will include a general description, envisaged target audience or group, and expected goals. Secondly, the hackAIR engagement strategy will present information and guidelines on central principles to be considered alongside tactics. These principles have been chosen based on their empirical significance (i.e. reoccurrence across empirical literature, expert interviews and user survey); it is therefore our belief that they are likely to have impacts for the success of the subsequent hackAIR activities. There is a degree of flexibility for both pilots, to ensure that the engagement strategy can be tailored to the capacities and resources of both NILU and BUND. Therefore, this strategy should be considered as a set of building blocks, both from the perspective of specific activities, and also influencing factors. Finally, the hackAIR engagement strategy will include guidance on communication, as well as the pilot plan timeline for the remainder of 2017/2018. These three parts ensure an empirically grounded engagement strategy, with a clear connection to existing communication and pilot plans in hackAIR.

This engagement strategy uses the 7Es (Bambust, 2015) – a Belgian coined but UK (Defra) inspired engagement model – to frame and situate specific tactics based on their expected goal. The 7E model comprises a set of 'leverage points', the sum of which are expected to allow for an integrated and highly practical approach to engagement. As such, each 'E' represents one of seven categories that can be used to group existing tactics, or construct new ones from scratch. Moreover, the interventions are expected to target multiple different levels of interaction, and as such can also be grouped based on their impact on user motivations, their expected support function and the potential to provide experience to users about an action. As alluded to above, the 7E model extended Defra's 4E model (in red) by introducing three new categories (indicated by dashed border): Enthuse, Enlighten and Experience.

Enable – lower the barriers by making the action possible in an easy, supportive, adaptable way

Engage – show the social support; show that a group of people is behind the endeavour and get people involved: if they can do it, I can do it too (collective motivation)

Encourage – show the potential benefit and reward (extrinsic motivation)

Exemplify – proof that you mean it by acting as an example and sharing responsibility, e.g. taking measures, policy and regulations, work with ambassadors

Enthuse – create enthusiasm, make people enthusiastic by making it personal to them (intrinsic motivation)

Enlighten – provide information, clarification and knowledge on the issue/behaviour

Experience – let people experience behaviour in a positive way and see that they made a good choice: social events

In the following sub-chapters, the hackAIR engagement strategy is presented. The strategy is split up into three parts:

- *Online engagement tactics (subchapter 6.1)*
- *Offline engagement tactics (subchapter 6.2)*
- *Supporting engagement (subchapter 6.3)*
- *Engagement principles for initial and continued participation (subchapter 6.4)*

6.1 Online engagement tactics

The strategy begins by outlining online engagement tactics available for the hackAIR project. Online engagement tactics include features or functions available to users on the hackAIR platform, as well as accompanying interventions that will be applied by hackAIR partners. The online tactics are therefore geared towards providing both general and personalised information to users about air quality, encouraging participation via gamification, providing feedback on user contributions, an overarching online presence by the project and a connection to offline activities and other pilots. Therefore, the tactics outlined will include: 1) Tips of the day and personalised recommendations, 2) gamification, 3) feedback on citizen science quality data, 4) active and responsive social media presence and 5) updated list of events.

6.1.1 Tips of the day[10] and personalised recommendations

Description	When a citizen opens the hackAIR app on Wednesday, the first things s/he sees is a pop-up screen with a tip of the day. At the end of the message a link is provided that leads the citizen to more scientific information/research on the topic that is discussed in the Tip of the day. If the citizen does not want to receive Tips anymore s/he is able to turn off 'tips of the day' in settings
Material/ communication needed	List of tips (as many tips as the apps will be used) in ENG, NO, DE Weekly launch of tip in the hackAIR app
Target group	hackAIR user[11]: basic users, especially users with a low level of awareness around air quality
Size target group	All app users, size does not matter
Expected outcome	Enlighten Encourage
Timing	Every Wednesday during usage of the app
Frequency	Weekly
Engagement type	Continuous engagement
Phase	Phase 2 (launch & test)

As discussed in D6.2: Behavioural change techniques for hackAIR community and D4.2: Semantic integration and reasoning of environmental data, tips of the day and personalised recommendations were developed in order to better inform citizens about: 1) general facts/guidelines that lead to proven reduction of an individuals emitted pollutants in

[10] For the tactics 'tips of the day', A/B testing will be executed as part of a behavioural change experiment in 2018. For more information, see D6.2: Behavioural change techniques for hackAIR community.
[11] hackAIR users refer to the types of end-users as defined in D2.2

the atmosphere, and 2) existing air quality conditions and accompanying actions which can be taken in order to avoid hazardous effects to their health. Depending on the characteristics entered by a user of the hackAIR application – via their user profile – and the pre-determined air quality index in their surrounding area, personalised recommendations will be sent via the mobile interface.

Personalised recommendation	
Description	In the general settings, a user of hackAIR app can, when setting up his/her account, define to be interested in information related to 1) respirational problems 2) pregnancy 3) outdoor sports 4) toddlers, … If so, the citizen will get personalised recommendations based on his/her interests.
Material/ communication needed	List of recommendations that will change depending on personal profile Personalisation module in the hackAIR app Launch of personalised recommendations on the hackAIR platform Define pre-determined air quality index
Target group	hackAIR user: basic users Demographic profile: people with health problems, people with a higher health risk related to air pollution.
Size of the target group	All app users, size does not matter
Expected outcome	Enlighten Encourage
Timing	Depends on the pre-determined air quality index
Frequency	Depends on the pre-determined air quality index
Engagement type	Continuous engagement
Phase	Phase 2 (launch & test)

6.1.2 Gamification module[12]

Description	When a user starts using the hackAIR application s/he can activate the gamification feature in the profile or can be invited to participate in the hackAIR game. Once s/he launched the game feature s/he gets embedded in a gamification experience during the different phases of usage of the hackAIR application[13]

[12] For the tactics 'gamification module, A/B testing will be executed as part of a behavioural change experiment in 2018. For more information, see D6.2: Behavioural change techniques for hackAIR community.

[13] See D5.2: 1st version of integrated and tested hackAIR open platform, where the gamification strategy is described in detail.

Material/ communication needed	Gamification engine Explanation on game in FAQ
Target group	hackAIR user: basic users, students Demographic profile: youngster
Size of the target group	All app users, size does not matter
Expected outcome	Enable Encourage
Timing	At pace of the user
Frequency	At pace of the user
Engagement type	Continuous engagement
Phase	Phase 2 (launch & test)

6.1.3 Feedback on citizen science data quality

Description	A citizen who uploads data to the platform (environmental data gathered via DIY sensors or uploaded pictures) gets informed on the quality of the data s/he provides and the value of the data for optimising the data fusion map.
Material/ communication needed	In the FAQ, it should be explained how the quality and value of the data is defined. Feedback mechanism on data level (e.g. number of stars)
Target group	hackAIR user: basic users, teachers, environmentalists, media Demographic profile: all hackAIR users
Size of the target group	All app users, size does not matter
Expected outcome	Enlighten Encourage
Timing	Every time a user uploads data
Frequency	Every time a user uploads data
Engagement type	Continuous engagement

Phase	Phase 2 (launch & test)

During the first two months of the hackAIR launch phase, there is an opportunity to introduce personal feedback to users via direct contact (either mail or message). This mechanism has been emphasised in literature, by expert interviewees and by a majority of respondents in the hackAIR survey, and cannot be stressed enough. Furthermore, it can serve as a way to start a conversation about the potential of an "ask an expert" support function. In terms of support, it is important to respond to participants **as soon as possible** in the event of a complication, as they might lose interest and motivation when they are in the field and cannot proceed with the measurement. Therefore, we encourage, to avoid missing expectations, to test feedback times during the testing period. This can ensure that pilots can adapt to increasing demand/learning curves during a trusted testing period.

6.1.4 Active and responsive social media presence

Description	The social media accounts of hackAIR should tweet or post on a frequent basis about the outcomes of the pilot implementation periods. Furthermore, the tweets and posts should go hand in hand with the other types of engagement tactics, e.g. when organising a workshop, this can be posted on this account. The storytelling (see next tactic) can provide a lot of content for social media presence Online channels are important to provide feedback about hackAIR. Such feedback can include: 1) *frequent updates on hackAIR progress, 2) frequent progress on specific workshops or other offline events, 3) information about upcoming or related events, 4) generating interest about measurement campaigns, 5) communicating results on a specific day (aggregated, place specific, high density, high/low pollution area), 6) sharing user-generated data, 7) approaching common challenges/concerns from users*
Material/ communication needed	Input from pilot partners with results and conclusions from the pilot implementation periods. The material also needs to be translated to German and Norwegian. *Cues and/or prompts* are central here, and include blog posts, newsletters, fact sheets about the different ways potential users can participate in hackAIR, as well as showing the results of the air quality monitoring campaigns
Target groups	hackAIR users: all hackAIR users
Size of the target group	hackAIR social network + pilots' social media networks
Expected outcome	Enthuse Experience
Timing	Continuous
Frequency	At least once every two weeks (more frequent presence in the lead up to, during, and directly after events)
Engagement type	Continuous engagement

Phase	All phases of the pilot implementation periods

6.1.5 Storytelling

Description	Multiple options are currently under discussion to promote storytelling and exchanging of experiences across pilot locations. The use of narratives/user testimonials as part of the hackAIR communication strategy gives substance to differing degrees of participation across pilot locations. By tracking and making the very stories and experiences of citizens involved in hackAIR visible, the goal is to focus on the human aspects of participatory sensing.
Material/ communication needed	Possible to develop stories for either pilot or project contexts. Therefore, important that pilot partners (NILU/BUND) collaborate with ON:SUBJECT in the event of translation into English. Pilots would also be responsible for collecting impressions from users during workshops, that can be used to develop narrative.
Target group	All hackAIR users
Size of the target group	Dependent on specific workshops; possible to create group or individual narratives
Expected outcome	Enlighten Exemplify
Timing	As a result of offline participation tactics
Frequency	To be decided
Engagement type	Continuous engagement
Phase	Tested in Phase 2, extended in phase 3

A second outcome could mean that users of the hackAIR platform are able to exchange stories across pilot locations and countries. In doing so, hackAIR narratives from users can potentially combine social and technical elements of the project, shedding further light on significant spatial, cultural or temporal trends in air pollution. Currently, several developments will ensure that time and resources are dedicated to storytelling during hackAIR pilots:

- *Storytelling is included as a topic of interest for updated hackAIR communication strategy*
- *ON:SUBJECT will encourage NILU and BUND to collect hackAIR narratives. This can be done either in person at workshops, or digitally via the hackAIR application. These stories can then be displayed on both pilot and general hackAIR channels*
- *hackAIR is currently exploring collaboration with public broadcasters and others, who are interesting in integrating user-generated data from the hackAIR platform into their own environmental database. This approach therefore has the potential to contribute to the development of 'data journalism'.*

6.1.6 Updated list of events

Description	In the coming months, the hackAIR platform will not only include related events and activities of affiliated projects. The hackAIR website will integrate the schedules of hackAIR workshops at all pilot locations, so that hackAIR's offline activities are as accessible as possible for citizens and interested parties.
Material/ communication needed	Updated list of events from pilot partners should be sent to ON:SUBJECT for the website to be updated. Current activity timetables are available in D7.1: Pilot Plan
Target group	Pilot locations, target groups identified for workshops. Awareness raising activities are targeted towards broader demographics (non-environmentally aware, elderly, parents)
Size of the target group	Dependent on specific events and workshops
Expected outcome	Enlighten
Timing	This should be available on website. In additional, calls for interest can be sent out at least one week before workshops or offline activities take place. See communication guidelines for workshops in D8.5: Plan for hackAIR workshop tour
Frequency	Before each offline event (min. 2 weeks in advance)
Engagement type	Initial engagement
Phase	Beginning in phase 2, and continuing across all phases

6.2 Offline engagement tactics

In the following subchapter, the strategy outlines the offline engagement tactics. These tactics are designed to be implemented in physical pilot setting, offering the opportunity for citizens to directly participate in the hackAIR project. They also target settings where citizens can socialize, learn and experience hackAIR as an innovation, complementing the online engagement tactics mentioned above in subchapter 6.1. The following tactics will be discussed: 1) workshops, 2) measurement campaigns, 3) active and responsive pilot presence, 4) awareness raising tactics, 5) photo contests and social events and 6) ambassadors and leadership tactics.

6.2.1 Workshops[14]

Description[15]	A large proportion of planned offline engagement will take place through the combination of **workshops across both pilots.** The goal of these activities will be to reach a large community of interested citizens to build awareness about the project, its benefits and results, as well as to engage citizens, local air quality advocates, end users and members of organisations working on air quality. The workshops mostly have the objective to get familiar with hackAIR and to start using the different tools.
Material/ communication needed	Instant feedback from users, opportunities for media coverage and a hands-on approach to either technology or data comprise the material/communication outputs of the workshops
Target group	Target groups identified in Table 27. These include basic users, advanced users, and multiple demographics. It is recommended that pilots also organise workshops with a specific target group to have a diverse audience, and to adjust the learning pace to the demographics of the citizens. For instance, one workshop can be dedicated to only children; one workshop can be dedicated to parents of young children, etc. Pilots should guarantee that they recruit a good mix of audiences as identified in D2.2: User and technical requirement analysis, and as validated in annex 1: pilot profiling template (2017).
Size of the target group	Dependent on specific workshops – usually between 15 – 30 for each event
Expected outcome	Experience, Enlighten, Engage
Timing	This should be available on website. In additional, calls for interest can be sent out at least one week before workshops or offline activities take place. See communication guidelines for workshops in D8.5: plan for hackAIR workshop tours.
Frequency	Offline events should take place in each phase, and have been scattered accordingly
Engagement type	Initial engagement
Phase	Beginning in phase 2 (Norway), but predominantly in Phase 3

6.2.1.1 Workshop modules and timeplan

In order to increase participation, multiple workshop modules have been developed and will be offered to citizens at various stages at hackAIR pilots. These include:

[14] The tactic 'workshops' will be used to execute a behavioural change experiment in 2018. For more information, see D6.2: Behavioural change techniques for hackAIR community.
[15] For detailed information about workshops, please see D8.5: plan for hackAIR workshop tours.

- *Introduction to air quality and citizen science*
- *Introduction to the hackAIR platform – demonstration and presentation of the hackAIR platform in interactive sessions*
- *Building your own sensing device – experiential workshops that allows potential users to collectively build and test a sensor from scratch*
- *Photo safari - Walking or biking tour around the city while taking pictures of the sky. It is recommended there that the research design is chosen by the participants, as to identify perceived hotspots of air pollution in the city*
- *Making sense of data – a workshop module that will target the generating knowledge regarding data interpretation of results*
- *Air quality policy dialogue – bringing together local policymakers and influential stakeholders, discussing the role of hackAIR and pilots in bridging policy concern (Important to note that organising mutual learning workshops require preparation and time to frame a discussion that will be appealing to decisions makers and users alike).*

Preparation for workshops will begin in September and October 2017 (see Table 27), according to the preparation plan outlined in D8.5: Plan for hackAIR workshop tour, and aim to target the following numbers:

Pilot	Activity	When	Target audience	No. users
Norway	Workshop	Oct-Dec 2017	Technical high school students in Oslo	20
	Workshop	Nov-Dec 2017	Students and professionals at Oslo and Akershus University College for Applied Sciences (HIOA)	20
	Workshop	Jan-Mar 2018	Norwegian Asthma and Allergy association (NAAF) and Friends of the Earth in Norway	30
	Workshop	April-June 2018	Target at environmental professionals and pro-environmental citizens at Oslo Science Park	30
Germany	Workshop	Oct-Dec 2017	In collaboration with federal state offices & regional groups	60
	Extra workshops	Oct-Dec 2017	Workshops for specific groups (working groups on transport/air quality, BUNDjugend)	30
Total expected participants from workshops				190

Table 27: Planned workshops in both Norway and Germany across pilot periods

6.2.1.2 Workshop feedback

Feedback can be offered during and after workshops. These allow pilot partners to assist and support users in desired activities, at a stage when curiosity will be a main motivator. Furthermore, it is crucial that users experiencing challenges can be encouraged at early stages in hackAIR. It is ideal if feedback about data is communicated **by a domain expert during workshops**, and feedback about the hackAIR platform is **relayed by pilot partners.** Hence, pilot partners should source stakeholders that can offer **physical support** for introduction to air quality/citizen science, building sensors and analytics/results workshops.

6.2.2 Measurement campaigns

Description	It is recommended that both pilots explore the potential of crowdsourced measurement campaigns. A measurement campaign can be a one-day activity or a longer time period in which citizens are asked to upload as many contributions as possible to the hackAIR platform, around a specific outlined task (e.g. measure the air quality during New Year's Eve, measure the air quality at the start of winter, etc.) These campaigns are important to stimulate participation in hackAIR at the local level. Based on previous experiences, a locally developed campaign seems more applicable to the vision of hackAIR as a citizen science project. It is encouraged that pilots both involve potential users in more than just data collection, and involve a wide range of potential users in hackAIR. Depending on size, the organisational requirements must be taken into account when promoting a large-scale event (250+ users). These include time for designing clear tasks, sufficient guiding materials, media-coverage in the lead up, potential partners and local campaigners, and the resources needed to offer feedback
Material/ communication needed	Important to communicate with domain experts in advance so that expert knowledge can be included in the campaigns. Crucial to communicate the date, place and goals of the campaign in advance, including the measurement period (one day, one week etc). This can be integrated into pilot and project social media (hackAIR Facebook/Twitter/Instagram). Also, it is important to consider incentives. For data density, what will stimulate users? Possible incentives that can be rewarded are: *co-authorship as a data collector, opportunity to design a local campaign or feedback session afterwards*
Target group	**Dependent on campaign:** communities of concern**,** DIY and maker movement**,** school children, potential for diverse user profiles
Size of the target group	Dependent on specific campaign. If the goal is data density, scale is key. Therefore, as many users as possible should be mobilised (50 – 400+)
Expected outcome	Experience, Enlighten, Engage
Timing	The measurement campaigns should be marked as an event on the web app of hackAIR.
Frequency	Offline events should take place in each phase, and have been scattered accordingly.
Engagement type	Initial engagement
Phase	Begin exploring in phase 2 for winter 2017, but predominantly taking place in phase 3

6.2.2.1 Exploring measurement campaigns

During the launch period, pilots shall identify potential sites/themes for coordinated measuring for the end of 2017 (Phase III). These could include most polluted areas, congested junctions, popular places etc, or:

- *Co-ordinated campaign in one city, site, street - Urban AirQ stands out as a successful example of a local level intervention related to air pollution, and showed the potential of community led sensing. Therefore, pilot partners should research the most polluted or topics streets in their respective regions. This can also include prominent sites in Berlin or Norway, such as primary roads or intersections, or areas well known for their levels of congestion. Such a campaign would target both environmentally aware and unaware citizens alike, as proximity to air pollution offers a broad distribution of demographics and awareness levels*
- *Comparative campaign across sites - Comparative sites appeal to users interested in generating and comparing diverse data about AQ*
- *Comparative against official sources (challenge the expert/station) - Challenging official sources or reference points would appeal to hackers or DIY enthusiasts, as well as environmentally aware citizens. In order to develop a campaign against official sources, pilot partners will require an overview of the specific sites and measurements of fixed reference points at their locations. Conversely other researchers or environmentally aware citizens could employ hackAIR sensors to target spatial gaps or "blind spots" in their respective areas*
- *Winter campaign - The winter period of 2017 represents a potentially crucial season for the hackAIR project, largely due to the topical and visible nature of local air pollution in urban environments. For this reason, it is encouraged that pilots begin thinking about potential scenarios and campaigns for data collection for the end of 2017/beginning of 2018. Both pilots have discussed the possibility of a joint measurement campaign on New Year's Eve, using sensors to estimate air pollution from fireworks displays.*

6.2.2.2 Campaign requirements and schedule

- *Identify theme of interest, scope, time period, potential stakeholders (see Table 28 for timing)*
- *Mobilize around local actors or groups (street or neighbourhood groups, DIY groups, informal meetups). This is an opportunity to introduce hackAIR and technical components, and discuss the opportunities offered. Explain in broad terms the goal of this campaign, and explore group interests. Be flexible – it might be more effective if a local group or partner is involved in the organisation*
- *Organise a meet and greet or introductory event for users interested in physical sensors, and also for those interested in using the hackAIR application. Encourage a local expert to join in the meeting, in order to discuss topics like air pollution, environmental behaviour or the hackAIR component*
- *Pilots must decide whether to involve users in research design (i.e. Urban AirQ), or as data gatherers (i.e. iSPEX)*

Time	Objective
Sep-Nov 2017	Pilots must identify and prioritise potential sites/themes for campaigns in 2018
Dec 2017	Potential for first measurement campaign (winter measurements)
Jan-Mar 2018	At least one small campaign (50 – 100 users) carried out
Apr-Sep 2018	At least one small campaigns (50 – 100 users) and one large scale campaign (250+ users)

Table 28: Measurement campaign timeplan

Based on the previous experiences, a locally developed campaign seems more applicable to the vision of hackAIR as a citizen science project. It is encouraged that pilots both involve potential users in more than just data collection, and involve a wide range of potential users in hackAIR. One way to do this would be to develop a feedback session or results event. Alongside a representative from BUND/NILU, or with a local expert, this event will provide the

acknowledgement and recognition that users require. Given the different profiles and capacities of BUND and NILU, the qualifying criteria for campaigns will include resources, time and sensor performance.

6.2.2.3 Campaign feedback

As demonstrated by the Urban AirQ project, expert feedback can also be effective after a measurement event or campaign in pilot cities finishes. This took the form of a wrap up results session, where participants were invited to find out about the results of their measurements by a dedicated expert in the field. Therefore, we recommend that if a measurement campaign is initiated:

- *Plan a wrap-up or feedback session with respondents in person* ***AND/OR***
- *Communicate a timeplan of the results for participants in the campaign (either via email or through the platform)* ***AND/OR***
- *Publish dedicated campaign results to promote acknowledgement of user actions* ***AND/OR***
- *Integrate campaign or measurement results into newsletters and social media posts.*

6.2.3 Active and responsive pilot presence

Description	It is important that, from phase 2 onwards, pilots are responsive to questions from participants, and to provide support where necessary. This may require that they have an open channel of communication with technical partners (i.e. via a mailing list) so that they can respond in time to technical requests.
Material/ communication needed	After each physical activity, personally thank participants either via mailing list, individual email (preferred, with the assistance of a template) or other means. This is also an opportunity to suggest follow-up events, encourage users to navigate to the hackAIR platform, or to **download** the hackAIR application. Provide training materials and videos.
Target group	All hackAIR users at pilot locations
Size of the target group	Participants from all offline events
Expected outcome	Exemplify, enable, encourage
Timing	Maintain a responsive presence before, during and after workshops
Frequency	Driven by events
Engagement type	Continuous engagement
Phase	Phase 2 (test and launch)

6.2.4 Awareness raising tactics

Description	In addition to workshops and measurement campaigns, other engagement tactics are suggested to increase the awareness of hackAIR Norway and Germany. Ad-hoc demonstrations, meetings and appearances from pilot partners can all be considered under this category appearances (e.g. on seminars,

	conferences, or other organised events about the environment). The goal of this tactic is to raise the awareness of hackAIR as an initiative, as well as the possibilities at each pilot location for estimating air pollution. Therefore, these tactics can also be recruitment tools for appealing to new participants, or new avenues to promote the project.
Material/ communication needed	Local promotional materials can be brought along, such as brochures, postcards, leaflets in Norwegian or German. Sensors might be effective in quickly highlighting the data that can be generated by citizens, as well as an understanding of results. A sign-up or subscribe list should be available.
Target group	Broad participation groups, including participants outside of target groups. **Of particular interest are unaware citizens, either about air pollution, sensing or hackAIR**
Size of the target group	This can range from school settings, lectures, civil organisations or policy makers.
Expected outcome	Enlighten, enable, enthuse
Timing	Awareness raising tactics should begin after the platform is fully functional
Frequency	Can form part of recruitment tactics that pilots have in place (see D7.1: Pilot Plan)
Engagement type	Mostly initial, but also sustained engagement
Phase	Phase 3

6.2.5 Photo contests and social events

Description	The goal of photo contests and social events is to let citizen's experience behaviour in a positive way and experience hackAIR in a fun and enjoyable way.
Material/ communication needed	Promotional material, venue, materials during content. Incentive or prize for social contest, as well as a topic or theme to build event around.
Target group	Schools, and younger target groups
Size of the target group	Size does not matter
Expected outcome	Engage, enable, exemplify, experience
Timing	No consistent timing - at least one photo contest in both pilots by end 2018
Frequency	Sporadic
Engagement type	Initial engagement
Phase	Phase 3

6.2.6 Ambassadors and leadership tactics

Description	An ambassador is a participant in the hackAIR project that is an early adopter in the first stage. An ambassador mostly likely has a high level of awareness, and already takes current actions to reduce the individual source of air pollution. Ambassadors can link to both the platform functions (skills-based) or to the engagement activities (network-based) in Germany and Norway. By also making these figures visible (through a t-shirt, token or in-app badge), ambassadors become users or figures that can be approached by other individuals and create trust between citizens and the technologies available in hackAIR. Through the social media monitoring tools influential users can be identified, who are already part of the hackAIR network or who are not yet. In respect to the engagement strategy in WP6, pilot coordinators and local communication managers, in collaboration with CERTH, will rerun the processes to identify ambassadors on a regular basis (once per quarter).
Material/ communication needed	Encourage and recruit ambassadors at pilots during workshops. Sign-up sheet and training materials are important, as is an identifier to make ambassador invisible (badge, title, shirt, social media mention). Possible to also pin-point ambassador organisations
Target group	Organisations such as: Environmental organisations, DIY communities Individuals such as: DIY builders, Students, experts, Citizens with respiratory issues, pro-environmental citizens
Size of the target group	This could be at individual or organisational level. Recruit at least one ambassador per workshop and offline event
Expected outcome	Exemplify, Enable
Timing	Identify quick learners/enthusiasts at workshop and group settings
Frequency	Driven by events
Engagement type	Continuous engagement
Phase	Beginning phase 2 (test and launch)

Given the uneven nature of technology acceptance and diffusion of innovation, bridging agents such as ambassadors serve multiple purposes. For example, they connect new and curious participants to the tools available (either physically or digitally), have a physical presence at events and activities, and become sources of knowledge at the community level. Moreover, they are often one of the first adopters of a product or service, representing an important user-base whose views are particularly important to unsure or sceptical users. Both pilots have discussed the possibility of encouraging skill transfer via ambassadors. Given the school-oriented nature of NILU's recruitment plans, classroom settings enable group learning in this very way. BUND is currently exploring possibilities to cater for differing base skills and learning styles amongst potential users.

6.3 Supporting engagement

The hackAIR survey and expert interviews highlight the importance of citizens that are able to access knowledge related to both air pollution, hackAIR technical components and interpretations of any generated knowledge. As a result, the hackAIR team first began to explore the possibility of multiple support functions in 2017. Currently, these functions are undergoing iteration and, in the coming months, will become available for all pilot co-ordinators, partner organisations and users. This sub-chapter outlines the various support functions that have been agreed upon, and which will ultimately be available for the hackAIR platform: Single point-of-contact (SPOC), modified FAQ, ask an expert, sensor DIY support.

6.3.1 Single point-of-contact (SPOC)

Description	As we are dealing with participants that may be in field performing measurements on the hackAIR app or hardware sensors, it is essential to have a dedicated contact person available for technical issues that might be encountered. This is particularly important for the later phases of pilots, and therefore pilots must ensure that a feedback process can be initiated and tested in the earlier phases (for instance, pilot should ensure that they respond within a reasonable timeframe perceived by users).
Material/ communication needed	Physical point of contact should be agreed on and communicated for each pilot. This should be done through social media, and also in person whenever possible. Pilots must also give feedback to users during the testing process, in order to support participation at the beginning of the project. This can be supported during offline events and at other demonstrations
Target group	Available for all users at pilot locations
Expected outcome	Enlighten, Exemplify, Enable
Timing	Continuous (online)
Frequency	After every user request
Engagement type	Continuous Engagement
Phase	All phases

6.3.2 Modified FAQs

Description	Pilot coordinators have developed an initial overview of questions for the hackAIR FAQ feature. These questions will be iterated both by consortium partners, and based on the feedback from pilot partners during internal testing. Such feedback can then be translated into a user-friendly FAQ feature on the platform. Building upon the feedback gained during testing, the frequently asked questions should include

	updated information about air pollution, the hackAIR components (DIY sensors, mobile app) and generated data
Material/ communication needed	FAQs can be translated into pilot languages (NO, DE & ENG)
Target group	All hackAIR users - FAQs will have several categories
Expected outcome	Enlighten
Timing	Available continuously
Frequency	At the disposal of users
Engagement type	Both initial and continuous engagement
Phase	Iterated in phase 2, and modified across all phases

6.3.3 Operational version of ask an expert

Description	This feature will enable direct user enquiries about technical or domain-specific concerns. As participant motivation moves from initial curiosity to fine grained information about the results generated by hackAIR users, "ask an expert" allows for bi-directional support
Material/ communication needed	Ongoing discussions with consortium partners will determine which format this feature will take – one option could be in the form of an online helpdesk. Offering a channel for input with users has been proven to not only support new volunteers in experiencing the hackAIR platform smoothly, but to also foster sustained engagement for users at multiple stages.
Target group	Generally, available for all participants that have an interest in expert knowledge. Target groups that are generating data, either via sensors or mobile application. Also, other participants interested in data interpretation/analysis
Expected outcome	Exemplify, Enlighten
Timing	At the request of users, but also possible to promote more during measurement campaigns etc
Frequency	Ongoing discussion about whether this will be an event-driven or continuous feature
Engagement type	Initial and continuous engagement
Phase	Phase 3

6.3.4 Sensor DIY support

Description	Initially planned as one video demonstrating the assembly process for DIY hackAIR sensors, the decision has been made to develop a series of short videos for each specific air pollution sensor. Assembly videos will cover the hackAIR home sensor (Arduino), hackAIR mobile sensor (PSoC) and hackAIR cardboard sensor (COTS). Having said that, the capturing and distribution of videos during hackAIR and phase does not need to be constrained to one official video. During each workshop and offline activity, photographs, time-lapses or videos can effectively be integrated alongside posts or status updates as part of the ongoing social media presence for hackAIR. Furthermore, these events can be used to create testimonials and user videos during sensor assembly and data gathering
Material/ communication needed	Set of videos on sensor assembly FAQ on sensor assembly most common made mistakes Online support desk for sensor assembly Written online manual for sensor assembly If recorded in English, pilot partners might need to consider either voice-over or subtitles as a way to make videos more accessible for their participants
Target group	hackAIR user: expert participants, members of DIY communities, students Demographic profile: caters for all types of users and demographics
Expected outcome	Enlighten, Encourage
Timing	Should be publicly available for all users in final version on the hackAIR website
Frequency	Available during demonstration sessions and workshops, or online at all times
Engagement type	Continuous engagement
Phase	End phase 2, beginning phase 3

ON:SUBJECT are currently preparing to record videos in Greece. Given the technical skills and knowledge of components that will be required to successfully assemble hackAIR sensors, there is a need to strike a balance between understandable information that still grasps the process in a realistic manner. Therefore, the decision was made to use language for **DIY enthusiasts and pro-environmental citizens**, both of whom are expected to possess a basic understanding of the technical components.

6.3.5 Engagement tactics overview

Table 29 provides an overview of all engagement and support tactics in conjunction to the 7E principles, highlighting the role of each tactic in targeting user motivations, behaviours and ongoing support.

Tactic type		Tactic suggested
Motivations	Enthuse	Active and responsive social media presence

		Promotional materials Awareness raising tactics
	Encourage	Gamification module Feedback on citizen science quality
	Engage	Tips of the day Personalised recommendations hackAIR workshops Photo contests and social events Measurement campaigns
Support	Enlighten	Updated list of hackAIR events Storytelling
	Exemplify	Ambassador and leadership tactics
	Enable	Single point-of-contact (SPOC) Sensor DIY support User manuals Operational version of ask an expert Modified FAQs
Action and behaviour	Experience	hackAIR workshops Photo contests and social events

Table 29: hackAIR engagement tactics grouped based on 7E's

6.4 Engagement principles for initial and continued participation

The following paragraphs present the tactics for recruiting, establishing and incentivising potential hackAIR participants, either offline or online. The rule of thumb is that we would like to have a mix of environmentally aware citizens, and non-environmentally aware citizens. Recruitment outside of agreed pilot communities will be essential to strike this balance.

6.4.1 Recruitment

This section will, taking into account the next stages of the pilot plan and the respective location-specific findings, outline guidelines for recruiting users to the hackAIR platform. From September 2017, pilots begin actively recruiting, engaging and supporting users, a significant step in connecting the hackAIR platform to pilot communities. Recruitment will remain relatively limited and in a semi-closed nature at first; given that hackAIR can at that point still be considered

in a developmental phase, the overall engagement threshold has been set between 50 and 100 citizens. A small group of citizens within the networks of hackAIR and at pilot locations should be targeted in order to, through the testing of platform functions, gain feedback on different technical elements. These elements include the mobile application and functions, and all DIY sensors. System performance and usability information will be gathered in a systematic way, which will be translated into corrective actions that can then be acted upon before each ensuing phase. At this time, recruitment tactics should focus on encouraging the engagement of future users, as well as assessing hackAIR support functions in real-life settings.

It is important to ensure that the language and expected goals of the hackAIR project are paired with not only specific target groups, but also the maturity of the platform. For example, positioning the platform as a "launch test" for September & October 2017 is an effective way to minimize expectations during this period. At this stage, recruitment strategies should focus less on users likely to have an interest in a mature and tested platform (pro-environmental organisations, makers to some extent also) and more on users who are less likely to be deterred by bugs or issues in this stage (school groups, researchers, professional contacts/circle). Essentially, the goal here should be to reduce the likelihood of user dropout at early stages – trusted and closed testing serves this purpose. Moving into phase three with a mature platform, we suggest to recruit participants in the following ways:

- *Participants can be selected either on a street-based, region-based or hotspot-based approach. This tactic can be effective for recruiting small-scale panels and for establishing a 'community of interest' around the topic of air quality in a local neighbourhood (with potential benefits for measurement campaigns)*
- *After identifying the location, the next step is to get in contact with neighbourhood figures and groups. These contacts can play an 'ambassador' role for the hackAIR project, and can connect users and volunteers with more participants*
- *Given the findings that air pollution can evoke a form of collectivism which in turn triggers intrinsic motivations, technical testing should be targeted towards users who have an interest in developing skills, exploring technology and experiential learning. As such, 'groups of interest' might include affiliated researchers, supporting experts, students or DIY enthusiasts*
- *When the hackAIR platform remains in a testing stage, recruitment should avoid citizens who are motivated primarily by political change, as well as those with respiratory diseases. DIY hackers present a path to test the support manuals and FAQ questions that are currently in development.*

6.4.1.1 Incentivisation

Given that hackAIR aims to focus on engagement that is not stimulated by financial or other material rewards, the acknowledgement of the efforts of people is pivotal in sustaining motivations. Intrinsic incentives can be considered in order to recruit participants for workshops, however it is advisable that these are connected directly to hackAIR. Such incentives could include:

- *When recruiting for a measurement campaign, allow users to keep sensors after the measurement period is over*
- *When recruiting for a measurement campaign, offer an opportunity to co-author in the analysis/output. This could range from peer reviewed journal (researchers), a manual (DIY enthusiasts) or factsheets/infographics (environmental/other organisations)*
- *The project will highlight the work of ambassadors in newsletters and social media posts*
- *"Challenge the expert" themed events incentivise users to not only gather data that can be compared against official sources, but that might have practical impacts on the measurement of air pollution at the local level (reducing spatial gaps).*

Alternatively, some extrinsic incentives could be considered, under the condition that they are aligned with either the domain focus (air pollution) or the level (individual action). Examples of such material rewards include:

- *Particulate matter filters/masks for air pollution*
- *Customised/limited edition sensor casings*
- *A free/assembled hackAIR sensor*[16]

One possible way to encourage group-learning would be to provide sensors to individuals during the testing phase under the condition that they engage at least 5 other users during their learning process. This learning process can occur simultaneously (co-learning), or when the initial user has already experimented with technology. Likewise, this can include interaction with multiple or various functions (platform, sensor, application, social media monitoring tool). Furthermore, use this approach as a way to validate the ease-of-access of the hackAIR support manuals. Test co-learning approach in closed user environment in at least one setting per pilot during Phase II. If successful, scale up alongside full pilot launch in late 2017.

6.4.2 Broadening recruitment

Several additional steps CAN be taken in order to prepare for achieving effective recruitment. These include targeting group focal points and bridging actors in each pilot. Pilots should consider: *who are the community leaders, school actors, environmental organisations or political actors that are of interest for hackAIR?* Again, physical contact should be stressed here. To ensure that engagement targets are achieved across both pilots, it is encouraged that additional efforts are made to reach users outside the existing structures and networks. This can be achieved by organising meetings and presentations to increase awareness about hackAIR at an organisational level. When available, pilots must be willing and prepared to demonstrate the platform in person (with a Wi-Fi or data connection) or through in-app walkthroughs at various locations, as well as showcasing sensors available within the project.

[16] BUND is currently exploring the option to *purchase sensor components in bulk.* This would allow the German pilot to take advantage of one-time delivery fees and economies of scale. These savings will then be balanced by reduced prices or one-time discounts for participants in during the pilot phase.

In line with more ambitious engagement targets in 2018, the hackAIR engagement strategy will begin to adopt a broad and active recruitment strategy in order to achieve targets upwards of 500-1000 users. By this point, the hackAIR platform should be fully operational. This will encompass technical components – hackAIR sensors at optimal accuracy and performance, the hackAIR platform and all accompanying support functions. Furthermore, this platform will be available for all target groups. Both pilots must establish actors of influence across all target groups for offline engagement activities. This can be achieved by recruiting through ambassadors/intermediaries. Select participants who can play an 'intermediary' role, and think of these actors as bridging agents between core target groups. Such ambassadors could include, for example:

- *The school principal or a school teacher to contact students*
- *A director of a science museum / park to contact families*
- *A representative of a committee or a citizen association to contact environmentally aware citizens*
- *A caregiver for contacting patients with allergies, or asthma*
- *A kindergarten for reaching out to children and families*
- *A HR manager or other responsible for the corporate social responsibility programme of a company to reach out to commuters*

As awareness about the hackAIR project increases, we would encourage a broader recruitment strategy which begins to encompass other target groups (parents, elderly residents, other organisations). These groups, as well as others, represent those users more likely to refuse adoption of technology in the early stages. Hence, they are more likely to become involved if the hackAIR platform has generated a sufficient level of awareness. In addition to the aforementioned target groups at each location, several guidelines have been included in order to achieve broad participation. These include:

- *Create connections with existing events and source agents of change - organise events outside of rigid institutions (i.e. public spaces, cultural events, makerspaces, NGOs, meetups)*
- *Tailor events and respective communication to different age groups and skill levels - use tactile props for creativity, take advantage of visual and audial mediums, and ensure both online and offline presences*
- *Focus on building capacities (public demonstrations, interactive testing, low fidelity testing) - overcome crosscutting barriers – gender, literacy and participation, work with enabling institutions (NGOs, social entrepreneurs, civil society groups)*
- *Prioritise physical spaces for experimentation during the project - consider hackathons, data jams and measurement campaigns as ways to support offline presences and encourage heterogeneous target groups. Survey results demonstrate that physical settings and events are central to maintaining engagement with users. These events will be discussed at the hackAIR consortium meeting in October 2017.*

6.4.2.1 Managing expectations

Given the ambitious objectives of hackAIR, as well as its focus on collective awareness in the context of sustainability, it is important to consider that differing and sometimes contrasting expectations might be present at pilot locations. These will take place on the level of project goals, technical outputs and expected impact. For example, members of the maker movement are more likely *to* be motivated *by the opportunity to construct and self-assemble sensors using single parts*. Researchers are more likely to have an interest in *the results and potential impact of the sensors.* Whilst

target groups such as asthma associations and pro-environmental organisations might share some similar motivations, with overlapping interests of users, such groups also bring with them a *need for results, knowledge and, ultimately, action.* Differences in the expectations of users are not only interesting from a research perspective, but will undeniably have a role to play in the success of recruitment tactics employed. Likewise, it is a factor which remains sensitive to the language used and opportunities positioned by hackAIR. At the beginning of each workshop or physical session, it is encouraged that pilot partners explore the expectations for users explicitly. This can then form the basis for defining expected session outputs i.e. be able to record data by the end of the DIY workshop. Table 30 combines the tactics enclosed above in D6.1, as well as workshop updated from D8.5: Plan for hackAIR workshop tour, and activities from D7.1: Pilot plan to produce a synthesised engagement strategy.

6.5 Engagement strategy plotted on pilot timeline

Phase	Timing	Targets	Online tactics	Offline tactics	Recruitment
2	Sep – Oct 17	50-100 users	Gamification module Tips of the day Personalised recommendations Use of social media for results from workshops Updated website and list of events	Ambassador and leadership tactics **2 Oslo workshops: high school** **Prep for Germany workshops** Preparation of offline materials Offline version of FAQs/manual SPOC	**Mostly closed** Based on location Focus on bridging actors Target users interested in testing technologies – schools, previous participants, internal networks
3	Nov 17 – Mar 18	500-1000 users	**All of the above +** Active social media presence using testimonials & user videos Storytelling Feedback on data contributions Modified FAQ section Support videos should be available online and for pilots Ask an expert	**All of the above +** Awareness raising tactics **Oslo workshops Dec 2017**: College x 2 **Oslo workshops Mar 2018:** NAAF & FotE German workshops beginning end 2017 Photo contests and social events Measurement campaigns end 2017 (winter campaigns/fireworks)	Broad & active **All of the above +** Demonstrate platform in person Each target group should be targeted during this phase **Actors of influence** should be established across all target groups Additional segments targeted: parents, elderly
4	Apr – Oct 18	8000 users	**All of the above +** Comprehensive support functions for up scaled pilot	**All of the above +** Co-ordination and execution of one large scale (500 users+) measurement campaign **Norway Workshops**: Environmental professionals and pro-environmental citizens at Oslo Science Park **Germany Workshops:** Possibly air quality and citizen science workshop bringing together stakeholders in Germany	**Active & ongoing** Large scale measurement campaign to attract large and diverse users
5	Nov – Dec 18	10000 users	Evaluation and impact assessment of participatory activities, support functions and recruitment strategy		

Table 30: hackAIR engagement strategy

7 Conclusion

This deliverable outlined a strategy to sustain the engagement of multiple stakeholders and user groups with an interest in air quality information and/or who are especially affected by poor air quality to make use of the hackAIR platform and the tools provided. It is designed so that pilots take this strategy as a baseline for moving forward with pilot implementation. Therefore, it can be revised and updated in the progressing months, for re-use in respective intermediate (D7.4, M26) and end-evaluation deliverables (D7.7, M36). Over the next several months, this strategy will be iterated in line with pilot timelines, as well as partner and technical developments. In addition, VUB will remain involved in several capacities for the development and evaluation of the hackAIR project:

- *The VUB team will remain involved in the hackAIR pilot plans, in order to monitor the application of the hackAIR engagement strategy. Not least, they will develop a parallel agenda to introduce behavioural change interventions in 2018, as disclosed in D6.2: Behavioural change techniques for hackAIR community.*
- *The VUB team will co-ordinate with hackAIR partners to broaden data collection to pilot locations and other locations. The survey will therefore be opened to a broader audience, outside of pre-defined target groups.*
- *The VUB team will distil the hackAIR survey results as a written output. Ongoing discussions are also taking place about whether or not the hackAIR engagement strategy will be condensed into a fact sheet or infographic for pilots to implement in their pilot plan.*
- *The VUB team will consolidate results from Chapter 4-5, as well as from Annex 3-5, into a peer-reviewed output for publication.*
- *In collaboration with NILU, BUND and ON:SUBJECT, the VUB team will form a pilot action group and establish regular contact during pilot plans in order to monitor the success of engagement activities.*

Moreover, hackAIR engagement tactics will become the basis for behavioural change interventions set to take place in 2018.

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Annexes

Annex 1: Pilot profiling template

In April 2017, a template was designed and distributed to hackAIR pilot partners in preparation for the development of the engagement strategy. The aim of this document was to establish an engagement profile prior to the piloting phase of hackAIR. In this exercise, pilots were asked describe their current and future communication channels, target groups that they wish to engage, existing networks and previous project experiences with engaging citizens. The collected responses can be found below, and were used to compliment the engagement strategy of D6.1 by integrating pilot specifics into account.

Norway Pilot

Target groups and pilot goals

Target Group		Reason
Citizens with respiratory issues	X	We have set up network with these four groups from previous projects. These four groups are interested in air quality related issues due to different reasons, and are expected to be involved in the pilot in Norway.
Pro-environmental citizens	X	
Environmental organisations	X	
Other experts and academics	X	

Organisation/ network	Audience	Do you already have contact? (Yes/No)	Access?
Friend of the Earth in Norway	Members	Yes	Via us at NILU
Universities and research institutes in Norway	Students, researchers and experts/professionals in the environmental science fields	Yes	Via us at NILU
Norwegian Asthma and Allergy Association	Members	Yes	Via us at NILU
Pro-environmental citizens	Those who are interested in air quality related issues	Yes (Two co-creation workshop participants and those showed their interest via our social media pages)	Via us at NILU

What do you envision as the role of the "scientist" within your organisation for your specific pilot?
For us at NILU, we will do data collection, research framing and communication of results. Communication to citizens can be split between broad communication from our communication manager Christine F Solbakken, and local pilot-specific communication by our pilot coordinator Hai-Ying Liu and co-leader Sonja Grossberndt.

What do you envision as the role of the "citizen" within your organisation for your specific pilot?
Participants as a human sensor (data collection through sensors, and mobile app)
Participants will be encouraged to communicate and disseminate results
Participants as users (of data, of results, of services)

Recruitment and Engagement

While a communication channel for recruitment focuses on establishing first time contact with a participant, a communication channel for engagement focuses on keeping both new and existing participants motivated and concerned about the project.

Channel	Recruitment		Engagement	
	Currently using this channel:	Aim to use this channel for hackAIR	Currently using this channel:	Aim to use this channel for hackAIR
Organisation website	X		X	
Organisation Facebook	X		X	
Organisation Instagram				
Organisation twitter	X			
Organisation blog				
E-mail (1 to 1)	X		X	
Email / mailing lists (1 to many)	X		X	
Online newsletter				
Paper newsletter				
Community meetings	X		X	
The hackAIR project website		X		X
hackAIR Twitter		X		X
hackAIR Facebook		X		X
hackAIR Instagram				
hackAIR Twitter				
hackAIR blog				
hackAIR Email (1 to many)		X		X
Conferences of hackAIR		X		X
Workshops of hackAIR		X		X

Previous Project/campaign	Information	Role in engagement
Case study in Oslo, EU FP7 project CITI-SENSE	We have collected data from 64 static AQ monitoring platforms, 32 portable AQ sensor packs, more than 300 replies from an online AQ perception questionnaire and more than 300 reports from a mobile application on personal AQ perception.	Coordinator

Can you name two main positive engagement outcomes you have achieved from the above projects or campaigns?

Outcome 1: Set up networking with Oslo municipality, schools and kindergartens.

Outcome 2: We developed a high temporal-spatial air quality map of Oslo.

Can you name two main challenges or barriers during engagement that you have experienced from the above projects or campaigns?

Challenge 1: to maintain those participants (motivation)

Challenge 2: the quality of the portable sensors (sensitivity and stability) - the premature standard of the AQ sensors has made public engagement – much less empowerment – quite challenging.

Has your organisation been involved in projects or campaigns that have had an explicit behaviour change strategy? (as a goal, or a process):

Yes, and in a project with a focus on air pollution; for high school students in Oslo pilot within EU FP7 CITI-SENSE project. This included two rounds of a questionnaire survey – at the beginning (before students were involved) and the end of the projects (after the students being involved).

Germany Pilot

Target groups and pilot goals

Target Group		Reason
Pro-environmental citizens	X	As an environmental organisation, our strength is to work with environmentally interested people. This is where our core group and membership base lies. Furthermore, in Germany there is a quite active DIY-scene currently working on this issue. We hope to have close collaboration with them. This is needed because the hardware sensors will mostly appeal to technology interested people.
DIY builders	X	
Environmental organisations	X	
DIY communities	X	

Organisation/ network	Target group	Do you already have contact? (Yes/No)	How will we access this network?

BUND e.V.	Bund members	Our membership base, overall 500.000, but much less than that are active	Through regional group contacts, newsletters, activist relations.
Luftdaten.info	Already active measurement sensors	Yes, but unsure if they see benefit in hackAIR	Make a proposal to organisers for collaboration, tbc.
General public	Random Interested groups	No	By going public, press release, larger newsletters of organisation, feature of citizen science

The membership base of BUND is large and heterogeneous. It is rather difficult to put a stamp on it in terms of certain criteria.

What do you envision as the role of the "scientist" within your organisation for your specific pilot?

We have discussed the role of scientists (or experts) before but have not decided how to do that exactly. The bottom line is: citizen science works if participants have the feeling that they are doing science. A scientist helps with that.

What do you envision as the role of the "citizen" within your organisation for your specific pilot?

Helping science, working for transparency, showing a problem and experience for themselves. Making it visible.

Recruitment and Engagement

Channel	Recruitment		Engagement	
	I am currently using this channel	I aim to use this channel for hackAIR	I am currently using this channel	I aim to use this channel for hackAIR
Organisation website	X	X	X	X
Organisation Facebook	X	X	X	X
Organisation Instagram				
Organisation twitter	X	X		
Organisation blog				
E-mail (1 to 1)	X	X	X	X
Email / mailing lists (1 to many)	X	X	X	X
Online newsletter	X	X	X	X
Paper newsletter	X	X		
Community meetings	X	X		X
Other channels (please fill in):				
The hackAIR project website				X

hackAIR Twitter hackAIR Facebook hackAIR Instagram hackAIR Twitter hackAIR blog hackAIR Email (1 to many) Conferences of hackAIR Workshops of hackAIR Other channels (please fill in):	X	X	X	X

Can you name two main challenges or barriers during engagement that you have experienced from the above projects or campaigns?

Firstly, the timing of pilot phases might mean that it is difficult to get numbers in advance of a functional platform. We need to make sure that we mobilize before the winter period as this will be our only winter phase. Secondly, the potential complexity of the DIY sensors pose a challenge for us at Bund. The Luftdaten.info sensors and platform seem to be a competing service to hackAIR – from our experience, it was quite hard to assemble their sensors using the assembly manual. Therefore, the way in which we communicate the sensor assembly will be both a challenge, and an opportunity to gain an advantage over other similar initiatives.

Annex 2: Extended excerpt of air quality citizen science project mapping

Project name	Project start	Project end	Weeks of testing	Project Goal: Awareness (societal knowledge)	Project Goal: Data collection (expert knowledge)	Project Goal: Data Visualisation	Project Goal: Policy impact	Project Goal: Citizen Participation	Project Goal: DIY Sensing	Project Goal: Behaviour Change	budget/resources	Status today	Location - City 1
ExpAIR Project	2013	2016	4	yes	yes	yes	probably	yes	no	yes	N/A	still running	Brussels, BE
AirBezen 2014	2014	2014	8	yes	yes	probably	probably	yes	no	no	N/A	ended	Antwerp, BE
AIRbezen live on BorgerRio!	2015	2015	0,15	yes	yes	yes	probably	yes	no	probably	N/A	ended	Antwerp, BE
AirBezen@School	2015	2015	5	yes	yes	yes	probably	yes	no	probably	N/A	ended	Antwerp, BE
AirBezen EastFlanders	2017	-	-	yes	yes	yes	probably	yes	no	probably	N/A	still running	Antwerp, BE
MakingSense: Science for Change	2014	2017	-	probably	unknown	unknown	yes	yes	yes	no	n/a	still running	Phristina, KO
MakingSense: UrbanAirQ	2016	2016	6	yes	yes	no	no	yes	no	no	n/a	passive running	Amsterdam, NL
CurieuzeNeuzen	2016	2016	4	yes	yes	yes	probably	yes	yes	no	n/a	ended	Antwerp, BE
iSPEX NL (2013)	2013	2013	0,5	no	yes	no	no	yes	no	no	n/a	ended	Nationwide, NL
ISPEX EU (2015)	2015	2015	6	no	yes	no	no	yes	no	no	100.000	ended	Athens, GR
Discover-AQ	2011	2015		yes	yes	yes	no	yes	no	no	-	ended	Houston, USA
Discover-AQ Houston	2013	2013	3	yes	yes	yes	no	yes	no	no	-	ended	Houston, USA
Discover-AQ Denver	2014	2014	4	yes	yes	yes	no	yes	no	no	-	ended	Denver, USA
Meet je Stad	2015		-	yes	yes	yes	probably	yes	yes	no	-	still running	Amersfoort, NL
AirQuality Egg (2012)	2012	2012	-	yes	yes	yes	probably	yes	yes	no	-	passive running	NY, USA
Second Nose	2013	2014	33	yes	yes		no	no	no	no	-	ended	Trento, IT
APIC	2012	2014	4	yes	yes	yes	no	yes	no	no	650.000	passive running	Antwerp, BE
Love Lambeth Air	2016	2017	31	yes	yes	yes	yes	yes	no	no	-	still running	Lambeth, EN
Science in the city; monitoring air quality in the Barbican	2013	2014	12	yes	yes	yes	yes	yes	no	yes	-	-	London, EN
Mapping for change - Citizen Science Used to Map Community Air Quality	-	-	4	yes	yes	yes	yes	yes	no	yes	-	-	London, EN
Pepys Air Quality	2011	2011	-	yes	yes	yes	yes	yes	no	no	-	ended	Deptford, London
Cleaner Air 4 Communities	2013	2015	-	yes	yes	yes	yes	yes	no	yes	£50,000 funding	ended	London, EN
Cityzen	2014	2014	-	yes	yes	yes	yes	yes	-	-	-	-	Antwerp, BE
AirWalk	2013	2013	-	probably	yes	yes	probably	yes	-	-	-	-	London, EN
CitizenSense Pollution Sensing / Frackbox	2013	2016	unknown	no	yes	yes	unknown	yes	no	no	1.500.000€	still running	Pennsylvania, USA
CitizenSense project	2013	2017	unknown	no	yes	yes	unknown	yes	no	no	1.500.000€	still running	Pennsylvania, USA
City Wardens Antwerp	2012	2016	52	no	yes	yes	unknown	yes	no	no	unknown	ended	Antwerp, BE
AeroFlex mobile measurements	-	2012	unknown	no	yes	yes	unknown	yes	no	no	unknown	unknown	Antwerp, BE
Amsterdam Smart Citizens Lab	2015	2015	unknown	no	yes	no	yes	yes	yes	no	unknown	still running	Amsterdam, NL
Citi-Sense	2012	2016	unknown	yes	yes	no	probably	yes	no	probably	715.000	ended	Oslo, NO
AirProject	2006	unknown	unknown	yes	yes	yes	unknown	yes	no	no	unknown	unknown	NY, USA
AirCasting	-		unknown	yes	yes	yes	yes	yes	no	no	unknown	still running	Seattle, USA

Annex 3: Interview topic list for expert interviews

Section A: General Project Information

1. Can you tell me a bit about the general aims and ambitions of your project?
2. More specifically, can you explain a bit about the role of yourself and your organisation in the project?
3. Could you describe how community engagement fitted within your strategy?

Section B: Broad engagement

4. It would be great if you could tell me a bit about the process that your project took towards narrowing and defining target groups?
5. Likewise, could you describe how your engagement process was influenced by the different technologies involved in your project?
6. Could you tell me a bit about the roles and responsibilities of project partners in implementing the engagement strategy?

Section C: Characteristics of engagement

7. Could you explain a bit how your engagement strategy was tailored to reflect multiple stages of engagement?
8. Who was responsible for the communication of materials towards target groups for initial selection? This can be both via online/offline activities
9. Furthermore, throughout your project were there any periods where corrective actions needed to be taken, or when you needed to adapt to changing circumstances?

Section D: Engagement mechanisms

10. Could you tell me a bit about how your project provided feedback to the local community of their contribution?
11. How were results relayed towards citizens in the local area? And by whom?
12. Did your project think it was important to provide recognition to citizens engaged in the project?
13. Was there a gamification or reward component to your project? How were incentives considered to keep citizens engaged and motivated?

Section E: Moving Forward

14. If you could pinpoint two main challenges that your project experienced that are directly related to engaging users for your project, what would they be?
15. What advice would you give to other projects that can help then in approaching an engagement strategy?

Annex 4: Descriptive overview of interviewed projects

Urban AirQ

Urban AirQ[17] is a 2016 pilot for the EU-funded project 'Making Sense'. With a spatial focus on Valkenburgerstraat, the most polluted street in Amsterdam, the goal of Urban Air Q was to explore the possibility of combining concerned citizens, trained experts in air quality and the maker-movement into a pilot that allows citizens to measure the air quality in their street. In collaboration with GGD Amsterdam, Waag society, the KNMI, the Long Fonds, Wageningen University, and ECN Netherlands, Urban AirQ focuses on the topic of community-based air pollution sensing. Running in parallel to Pristina (Kosovo) and Barcelona (Spain), it is one of three such European pilots rolled out in the EU making sense project.

In total, 20 residents engaged in 6 weeks of testing in their local area using modified sensors from previous projects. This testing period formed on component of a strategy which included community interaction, co-creation and problem definition, and was followed by direct personal support (as can be seen in Figure 12), analysis and results from experts and discussion. With regards to ICT, citizens were able to view real-time measurements from their sensors on a basic web-application, as well as readings from their neighbours as a basic aggregated map.

Figure 12: Urban AirQ Sensor, resident in Amsterdam and Gijs, Waag Society Community Manager

As an institute which explores emerging technologies, played a central role in engagement in the Urban AirQ pilot, and has strong affiliations to Amsterdam Smart Citizen Lab, Waag Society was selected as an ideal actor for qualitative interview. As stated by Gijs Boerwinkel, community manager at Waag society, "We [at Waag Society] aim to open up technology and look behind the 'black box', so that we can try and provide innovative solutions. This is the element that helps us connect citizens to technology, and also to experts of technology and the maker movement.

[17] http://waag.org/nl/blog/urban-airq-burgers-meten-zelf-de-luchtkwaliteit-hun-buurt

ClairCity

ClairCity[18] is a recently initiated EU-project that aims to harness citizen and behaviour-centric knowledge in order to develop bottom-up policy packages in six countries across Europe. With ambitious engagement targets of 50,000 across the project, partners will use existing data already applicable across cities to drive innovative public engagement activities (illustrated in Figure 13).

ClairCity aims to build new models of urban air pollution and carbon emissions, which can support cities to identify changes that they can make for society to reduce emissions and make a positive change in peoples' lives. By allocating multiple variables related to air pollution (carbon footprint, health and concentrations) against everyday citizen behaviour, the project aims to demonstrate the interlinkages between citizen activities and the pollution that they generate. Dr. Enda Hayes, ClairCity technical director, associate professor in Air Quality and Carbon Management and Director of the Air Quality Management Resource Centre at University of the West of England, affirms that "by taking this approach, we hope to provide a better awareness of the connectivity between people's day to day lives and practices and the pollution that they generate ".

Additionally, ClairCity will appraise and evaluate the structures and processes central to governing air pollution in pilot cities, and leverage citizen-centric scenarios using various engagement tools and tactics to formulate citizen-led policy packages. Pilot locations include: Amsterdam, Netherlands; Bristol, UK; Aveiro, Portugal; Liguria, Italy; Ljubljana, Slovenia; and Sosnowiec, Poland.

Figure 13: ClairCity Illustration. Source: ClairCity Jan 2017 Newsletter

CITI-SENSE

CITI-SENSE[19] is a recently completed EU-project (2012-2016) that had been developing "Citizens Observatories" (CO) as practices to inform and empower citizens in environmental governance. In order to fulfill this ambitious goal, the project targeted the following objectives: i) raise environmental (air quality and noise) awareness in citizens, ii) raise user participation in societal environmental decisions and iii) provide feedback on the impact that citizens had in decisions. At the heart of CITI-SENSE was the development and testing of an environmental monitoring and information service (using data from portable and static air quality monitoring sensors).

[18] http://www.claircity.eu/
[19] http://www.citi-sense.eu/

The CITI-SENSE solution comprised portable air pollutant sensors and a companion application, and an environmental monitoring toolkit for public places. In Oslo, these locations were schools. Additionally, a coordinated effort was made to collect and map subjective data about air pollution in order to compliment mobile sensor data and fixed measuring stations in respective cities (see Figure 14 for Oslo case). This outcome was enabled by the CityAir App, allowing citizens to register individual perceptions and attach comments of air pollution globally. A dedicated CITI-SENSE platform map enabled multiple layer visualisations of these static, mobile, and subjective data associated with air pollution.

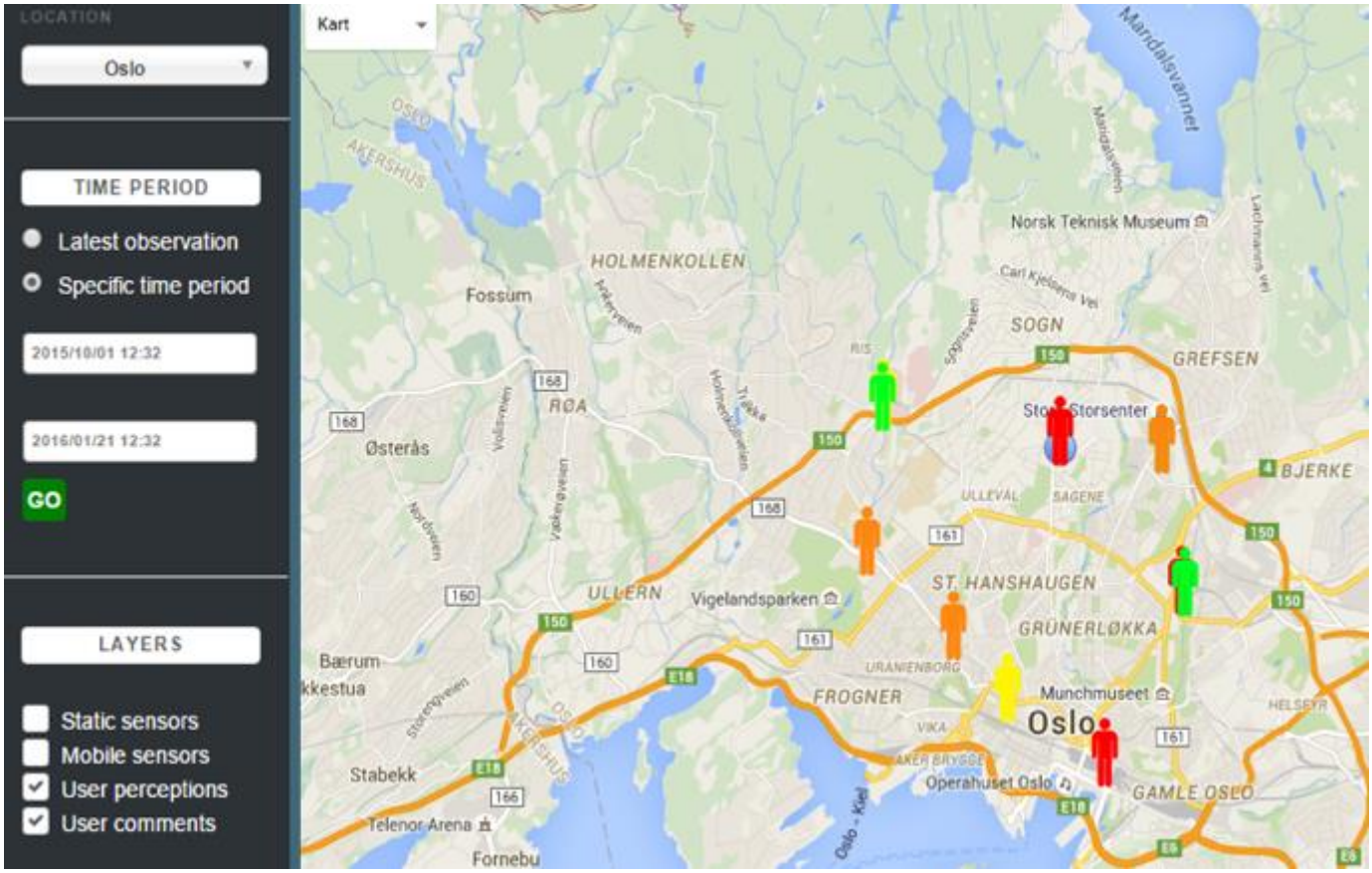

Figure 14: CITI-SENSE CityAir Application, Oslo. Source: CITI-SENSE Product Information brochure

Similar to Making Sense: Urban AirQ and ClairCity, CITI-SENSE maintained a focus on partnership building and knowledge transfer. This was operationalised by multiple case studies or 'empowerment initiatives' in European countries. These included: Barcelona, Spain; Belgrade, Serbia; Edinburgh, Scotland; Haifa, Israel'; Ljubljana, Slovenia; Oslo, Norway; Ostrava, Czech Republic and Vienna, Austria. Given the topical and spatial relevance of the Oslo case study, as well as NILU's involvement in both CITI-SENSE and hackAIR, Sonja Grossberndt was contacted as an expert interviewee.

iSPEX

The iSPEX project[20] comprised two consecutive citizen science campaigns which actively involved citizens in the scientific measurement of air pollution. With expertise in planetary science and remotely sensing aerosols, the novelty with iSPEX took the form of an inexpensive iPhone attachment and accompanying mobile application. When combined, both of these tools enabled the widespread estimation of tiny atmospheric matter concentrations in everyday surroundings through optical sensing (Figure 15). Atmospheric aerosols play an important but as-yet poorly understood role in climate and air quality, with significant impacts on environment, health, and air traffic.

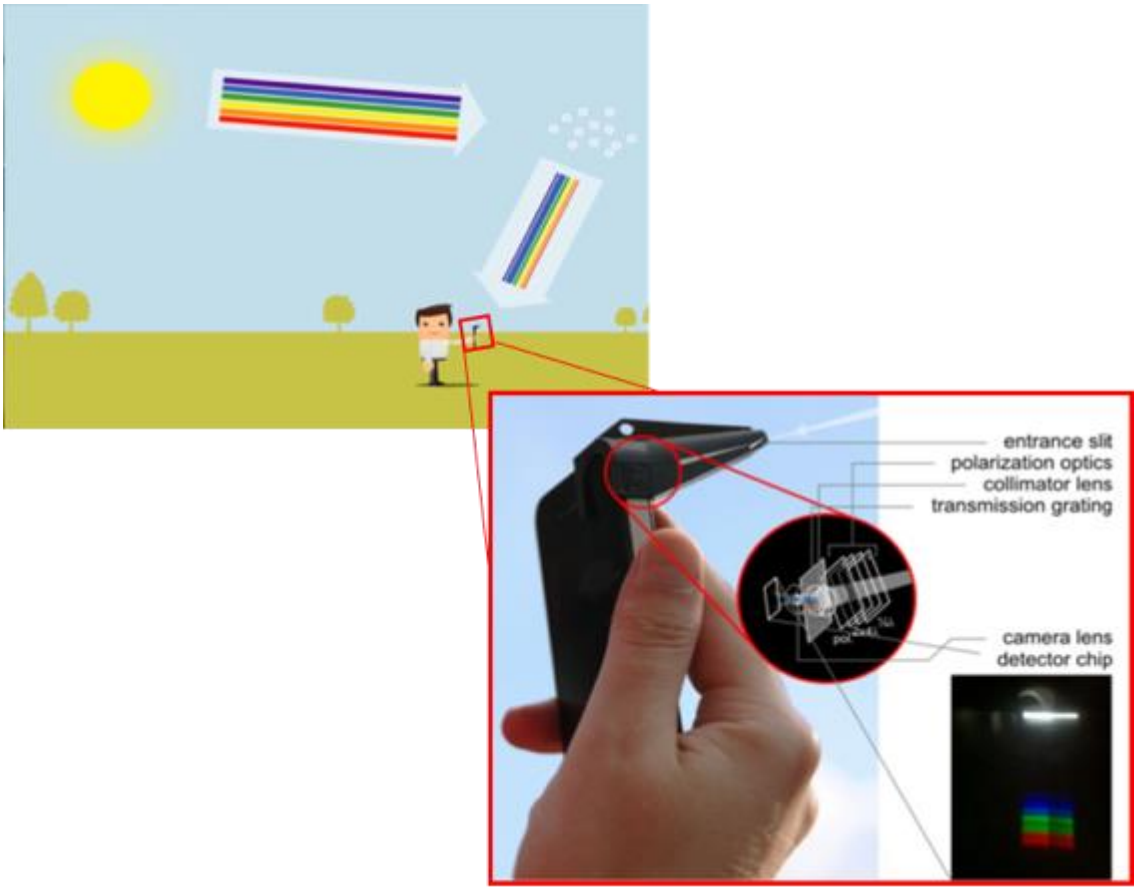

Figure 15: iSPEX Instruction video (16a) & add-on description 16b). Source: iSPEX Website.

Following a successful nationwide campaign in the Netherlands in 2013, iSPEX launched a decentralised multi-country campaign in order to scale up measurement practices and offer greater comparability across spatial and temporal scales. The iSPEX-EU campaign took place for 6 weeks in 2015, across the following cities: Athens (GR), Barcelona (ESP), Bari (IT), Belgrade (SE), Berlin (DE), Copenhagen (D), London (UK), Manchester (UK), Milan (IT) and Rome (IT).

[20] http://ispex-eu.org/

Given the use of a smartphone-enabled sensor, albeit in this case via an attachment, and the focus on widespread and dense data collection, iSPEX shares several similarities with hackAIR. The genesis of iSPEX however – A research project that rapidly gained momentum before turning into a large campaign – does differ from our approach and development. Nevertheless, the researcher-driven implementation, multi-city appeal, focus on awareness and critical mass can all be of relevance for our efforts moving forward into implementation. As one of the influential figures behind the its development, Dr. Frans Snik was interviewed regarding iSPEX in April 2017.

SecondNose

SecondNose[21] is a completed initiative (2014) that took place in Trento, a medium-sized city in Italy, and was designed to understand whether small portable devices with smartphones can become an effective way to generate and display individual environmental data. A smartphone companion app was used to collect and aggregate all air quality data points, alongside a desktop map that visualised all respective points with 5 min refresh intervals (see Figure 16). On a technical level, it was important to understand which data could be collected and generated to compliment fixed sensing stations in Trento. Particularly if these data could efficiently cover city areas to understand relative pollution in the city.

Figure 16: SecondNose solution. Source: Leonardi et al. 2016

SecondNose was one of several projects developed under Mobile Territorial Lab[22], a living lab which aimed to co-create and develop mobile services in the city. Across the duration of the project, SecondNose collected more that 30k daily data points from 80 different citizens in Trento. All citizens deliberately shared similar demographic traits (single parents with children between 0 and 10 years old). Given her role in both the implementation of SecondNose and the subsequent research, Chiara Leonardi was interviewed in April 2017.

[21] SecondNose project information here: https://goo.gl/C2X2yF
[22] https://i3.fbk.eu/projects/mobile-territorial-lab

EveryAware: Air-Probe International Challenge

The EveryAware project[23] is a recently finished EU-funded project that aimed to develop the tools and the knowledge needed to make environmental information transparent, available and easily integrated with the perceptions of people, regarded as a first-order observable. At the core of the EveryAware approach was reducing the gap between subjective and objective sources of environmental data, in order to produce actionable knowledge at the grassroots level. Therefore, the Everyaware platform was developed in order to collect and integrate these multiple sources of noise and air quality data. The platform is a modular system composed by several components: a 'SensorBox' to gather objective data about the environment in the form of particulate matter concentrations, a companion application which controlling the data acquisition and the user-experience, alongside a system that gathered, stored, analysed and visualised all associated data.

Of particular interest from the EveryAware project was the AirProbe International Challenge (APIC) – the large-scale multi-city measurement campaign driven by a web-based game – which took place in Antwerp (Belgium), Kassel (Germany), London (UK) and Turin (Italy). This campaign combined competition-based incentivisation at the city level to collect sensor-generated data on Air pollution in a way that was comparative with the perceived pollution levels of users themselves (see Figure 17).

Figure 17: APIC game interface. Source: EveryAware D6.3: Report on participation fostering activities

In this way, the EveryAware stands out as the only large scale project on air pollution that attempted to blend engagement/participation with behaviour change. Given this unique and highly relevant approach, Dr Alena Sirbu, computer scientist at University of Pisa was interviewed in May 2017.

[23] http://www.everyaware.eu/

CityZen (iMinds Living Labs)

CityZen[24] represents a SME project conducted alongside iMinds living labs, with the aim of involving residents in their city through an interactive map application for air quality. CityZen took place in the City of Antwerp, especially in 2 regions: the neighborhood around the Kerkstraat in Antwerp / Borgerhout and in the neighborhood of Neerland in Wilrijk. Following an intensive "ideation" and "co-creation phase" in spring 2014, a beta version of the interactive map application for air pollution was developed (see in Figure 18). Although the CityZen project ceased in 2015, lessons learned from the co-creation process and resulting beta can complement the findings from other interviews.

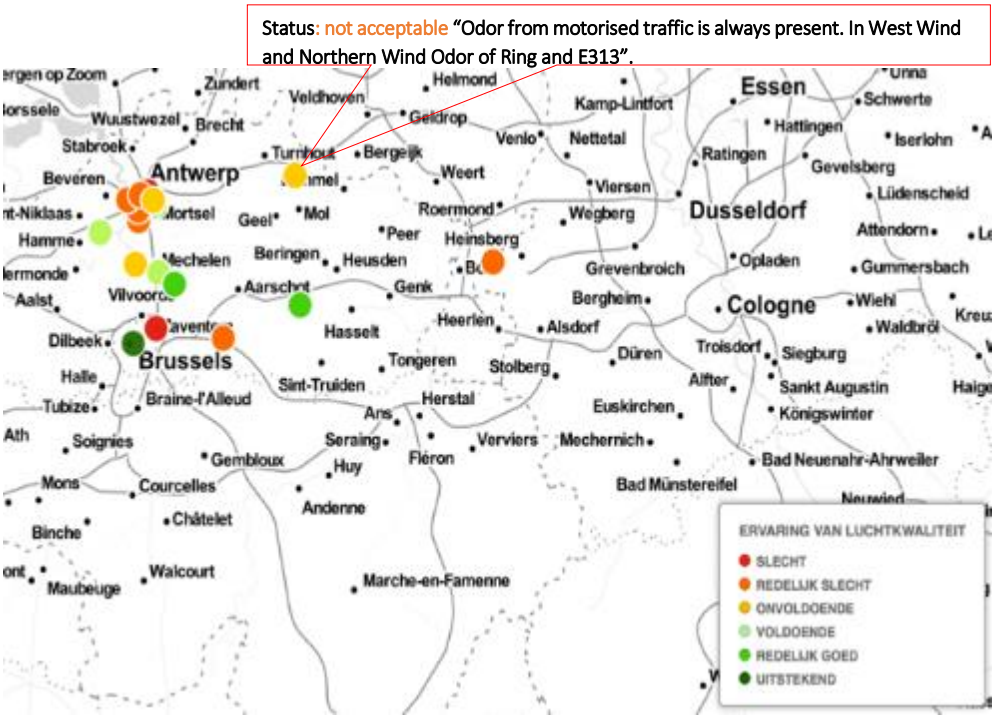

Figure 18: CityZen map. Source: nazka.be/cityzen

[24] http://nazka.be/cityzen/

Annex 5: User survey template

Q1 Thank you for agreeing to take part in our survey. We would like to find out more about your perspective and opinion on outdoor air pollution. Your personal experience is important, thus there are no wrong or right answers. Do not reflect extensively, but answer spontaneously. This survey is expected to only take a few minutes to fill in. All answers are treated anonymously and confidentially. Please click the red button below to begin.

Q2 How aware are you about causes and impacts of outdoor air pollution? (Not at all aware, slightly aware, somewhat aware, quite aware, extremely aware)

- Causes of outdoor air pollution
- Impacts of outdoor air pollution
- Individual steps that can reduce air pollution

Q3 How do you inform yourself about outdoor air pollution levels? (Select all that apply)

- Standard Media (TV, radio, newspaper) (1)
- Social media (2)
- Website (3)
- Mobile app (4)
- Personal contact (5)
- Other: (6) _____
- I do not inform myself (7)

Q4 Are you aware of any initiative that already aims to improve outdoor air pollution? (yes, no)

Q5 If Are you aware of any initiative that already aims to improve outdoor air pollution, lease tell us more about at least one of these initiatives. If you do not remember the details, just continue the survey.

- What is the name of this initiative? _____
- Which level did this initiative take place on? (Individual, neighbourhood, citywide, regional, nationwide, I do not know)
- How did you first find out about it? (Standard media, social media, website, mobile app, personal contact, other)

Q6 What motivates you to inform yourself about outdoor air pollution? (Select all that apply)

- General curiosity (1)
- I work or spend a lot of time outside (2)
- I have an existing health condition (3)
- A member of my family has a health condition (4)
- For my children (5)
- I live in a city or area with high pollution (6)
- Other: (7) _____
- No specific reason (8)

Q7 How often do you inform yourself about outdoor air pollution?

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
(1)	•	•	•	•	•

Q8 On which occasions do you inform yourself about outdoor air pollution? (Select all that apply)

- Before doing outdoor activities (1)
- Before doing outdoor activities with children (2)
- As part of my routine (3)
- Sometimes when I'm curious (4)
- During ozone, smog or weather alerts (5)
- Other: (6) _____

Q9 How clean do you think the air is around you? (1 star = very unclean, 5 stars = very clean)

_____ Neighbourhood (1)

_____ City (2)

_____ Country (3)

Q10 In your eyes, what are the three main causes of outdoor air pollution in your surrounding area?
Main causes: Traffic, emissions from industry, air pollution from other countries, burning from household activities, electricity production, emissions from agriculture, waste disposal, I do not know, Other _____

Q11 In your eyes, what are the three main effects of outdoor air pollution?
Main impacts: Health impacts, unpleasant smell, visibility loss, psychological issues, effects on nature, lower quality of life, I do not know, other _____

Q12 How do you currently combat outdoor air pollution? (Please fill in both columns)

	I currently do this		I would be interested in doing this more	
	Yes (1)	No (2)	Yes (1)	No (2)
Limiting energy usage (1)	•	•	•	•
Choosing non-polluting travel (2)	•	•	•	•
Buying eco-friendly products (3)	•	•	•	•
Limiting the burning of wood or coal (4)	•	•	•	•
Giving donations for the protection of the environment (5)	•	•	•	•
Campaigning as an individual or as part of a group (6)	•	•	•	•
Other: (7)	•	•	•	•

Q13 hackAIR will have an internet website and mobile application. Below are some features that we are working on - which of these features appeal to you? (Select all that apply)

- Viewing Real-time information about air pollution around me (1)
- Receiving information to decrease my own contribution (2)
- Allowing me to measure air pollution around me (3)
- Sharing my measurements and experiences with others (4)
- Sharing my concerns with other people (5)
- Sharing my concerns with policy makers (6)
- Other: (7) _____

Q13a You said you would like to measure air pollution around you. If these options were possible, how would you like to do this? (Select all that apply)

- Taking Photos of the sky on a smartphone (1)
- With an electronic, self-built sensor (2)
- With a simple (non-electronic), self-built sensor (3)

Q14 Which tools or activities would help you stay motivated to be part of hackAIR? (Select all that apply)

- Collecting badges in a smartphone app (e.g if you complete a task) (1)
- Social events (e.g. meet & greets) (2)
- Photo contest (3)
- Workshops with other users (e.g. learning about building sensors) (4)
- Workshops for policy making (5)
- Access and info on other relevant projects (6)
- Feedback on your contribution from experts (7)
- Other: (8) _____

Q15 Which main barriers do you think might prevent you from participating in an initiative like hackAIR? (Select all that apply)

- Time constraints (1)
- Lacking information about the project (2)
- Not enough knowledge on air quality monitoring (3)
- Family members won't approve of participation (4)
- No belief in the goals of the initiative (5)
- Concern about the technical skills to become involved (6)
- Not enough knowledge on air quality (7)
- Other: (8) _____

Q16 How old are you?

	Under 15 (1)	15-20 (2)	21-30 (3)	31 - 40 (4)	41 - 50 (5)	51 - 60 (6)	61-70 (7)	70+ (8)
Age in years (1)	•	•	•	•	•	•	•	•

Q17 What is your highest level of education?

	Less than secondary school (1)	Secondary school (2)	Bachelor degree (3)	Master's Degree (4)	Doctoral degree or higher (5)	Professional degree (6)	Other (7)
Level of education (1)	•	•	•	•	•	•	•

Q18 Where do you live?

- I live in a city (1)
- I live in the suburbs of a city (2)
- I live in a town (3)
- I live in a village (4)
- Other (please specify) (5) _____

Q18a You selected that you live in a city, town or village. Please provide the name: _____

Q19 In the next few months, hackAIR will be tested and further developed. How would you like to stay involved?

- I would like to be involved with hackAIR directly in the future (1)
- I would like to be involved in hackAIR through my local partner in the future (2)
- I would not like to be involved in the future (3)

Annex 6: Responsibilities for engagement strategy in hackAIR

		Primary Responsible	Secondary responsible
Recruitment	Broad call for participation	ON:SUBJECT (Communication)	Project management
	Citizen testimonials	ON:SUBJECT (Development)	Local pilot partner (Citizen input)
	Demonstrations	Local pilot partners (presentation)	DRAXIS (development and testing)
	National press release & media (VRT, work towards a large collection date, possibly in the winter)	Communication (ON:SUBJECT) and pilot partner	
Online tactics	Storytelling	Pilot partners (collection of experiences at workshops)	ON:SUBJECT (distribution)
	Updated list of events	Pilot partners (event updates)	ON:SUBJECT (Posting and updating)
	Active and responsive social media presence	ON:SUBJECT	Other partners for input
Offline tactics	Photo contests & social events	Informal networks (meetup, Facebook, personal contacts)	Local pilot partner
	Workshop: photo safari	Pilot Partners	Co-ordinated with ON:SUBJECT
	Standard workshop modules	Local pilot partners and external expert	Co-ordinated with ON:SUBJECT and domain expert
	Workshop build sensors	Local pilot partners	Co-ordinated with ON:SUBJECT and technical expert
	Workshop data analytics	Local pilot partners and technical expert	Co-ordinated with ON:SUBJECT and technical expert
	Workshop policy impact	Local pilot partners and domain expert	Co-ordinated with ON:SUBJECT and technical expert
	Measurement campaigns	Broad co-ordination - pilot partner to identify local issue or site. E.g. if based on fixed stations, ownership for local pilot partner to promote on local channels	Broad mobilisation across channels, and more targeted recruitment by pilot partners.
Communication	Newsletter (general hackAIR)	ON:SUBJECT (Design and distribution)	Consortium partners (input)
	Posters (Roll-out) and other promotional material	ON:SUBJECT (Design)	Translation by pilot partners
	hackAIR social media	ON:SUBJECT	Local partners for pilot channels
Support	Sensor DIY support	DRAXIS	ON:SUBJECT
	In-app walkthrough for sky pictures	DRAXIS	