CITI-SENSE

Development of Sensor-based Citizens' Observatory Community for improving the quality of life in Cities

Project summary

November 2016

http://co.citi-sense.eu

Overview

Environment and air in urban public spaces, climate change in cities and indoor environment especially in schools, concern and engage most of us. Often, we may feel that information is not sufficient, and data may vary significantly in quantity, quality and accessibility. Accordingly, the practice of co-decision on urban and environmental matters often falls short on involving those who are directly affected.

CITI-SENSE explores ways how to increase the involvement of the public in environmental decisions, both directly and through provision of citizen-collected data. The main objective is to develop technology enabled "Citizens' Observatories" to empower citizens and citizens' groups:

- to contribute to and participate in environmental governance;
- to support and influence community and policy priorities and the associated decision making;
- to contribute to European and global monitoring initiatives.

The project teams in the nine participating cities (Barcelona, Belgrade, Edinburg, Haifa, Ljubljana, Oslo, Ostrava, Vienna and Vitoria-Gasteiz) explored together with the citizens the information needs and the technological options to be used. As a result, the to date largest sensor network was made operational, with 324 air quality sensor units installed in the participating cities. A number of additional sensor devices were also tested and improved.

The information flows from sensors to users and new methods for visualisation of the air quality information were developed and implemented. One of these is an air quality map that can be developed for almost any city where sufficient number of sensor devices are in place.

We engaged a large number of citizens in testing and using our technologies. Through participation of schools, pupils were able to develop their own environmental projects, expanding on our technological solutions in the process.

We aimed to meeting the needs of the end users using a number of approaches. We investigated the knowledge and attitudes to air pollution and environmental quality, and we also collected plentiful feedback from the public regarding their perception of air quality. The CityAir app that allows to share subjective assessment of outdoor air quality, is freely available for Android and iOS. During the project, it was downloaded by more than 1,200 users around the world and used for collecting air quality perceptions of their localities. This app will continue to be available also after the end of the project.

All our results, including information on sensing technologies, communication solutions, various codes employed for the communication platforms and for end user products, methods including questionnaires, and scientific publications as well as materials for the end users are already freely available on our web page http://co.citi-sense.eu.

By Citizens' Observatories we mean communities of diverse users that will share technological solutions, information products and services, and community participatory governance methods.

CITI-SENSE in numbers

We set up Citizens' Observatories across the nine participating cities and we worked together with citizens in order to demonstrate that they can play a role in collecting environmental data, and to engage them on local environmental issues. In eight cities, Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Oslo, Ostrava and Vienna, we addressed outdoor air quality. In Oslo, Belgrade, Edinburgh and Ljubljana we collaborated with schools. And in Vitoria-Gasteiz we examined the personal comfort in public spaces. Over the four years we connected:

1,200 CityAir App users with 2,036 reported perceptions

324 air sensors units in the network

327 volunteers using portable sensors

1,530 answers to the questionnaires and evaluation reports

3 universities, 7 secondary schools,17 elementary schools, 54 Kindergardens, 9 tenants associations

And we collected more than 9 million observation during the last year of the project only.

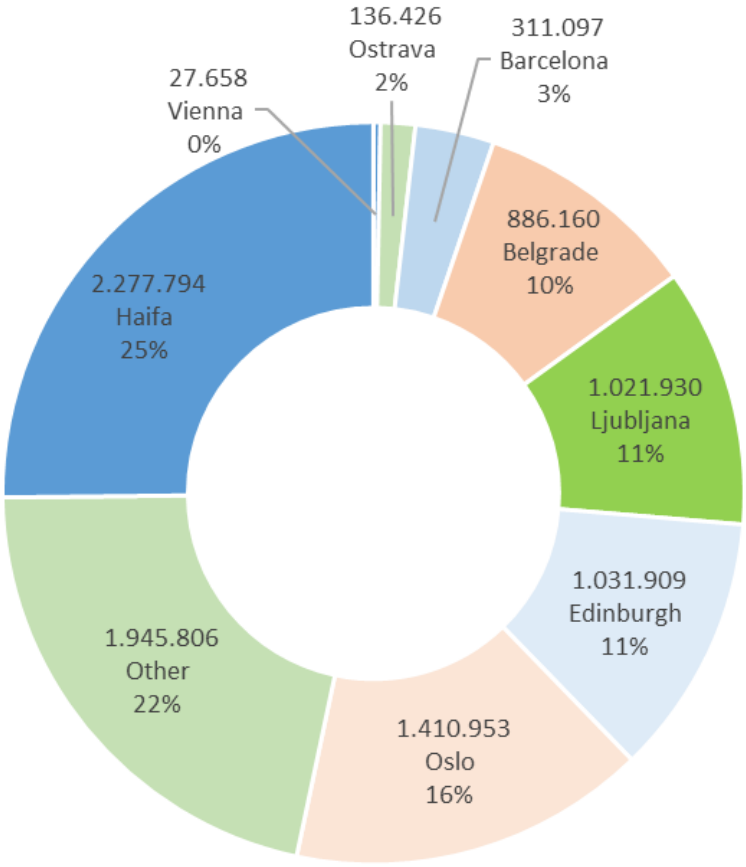

Figure 1. Data collected across the pilot cities the measurements came from the fixed and static sensors.

Methodologies

The methodology used in CITI-SENSE combined both technological development and citizens' participation. This required a collaboration across the following four elements: (i) sensor technologies; (ii) information and communication technologies; (iii) information products and services; and (iv) citizen involvement. This is illustrated in Figure 2 where we see that all methodological developments (in blue boxes) feed to engagement of citizens as well as to the environmental knowledge domain (using Standards for Geospatial Data and Services).

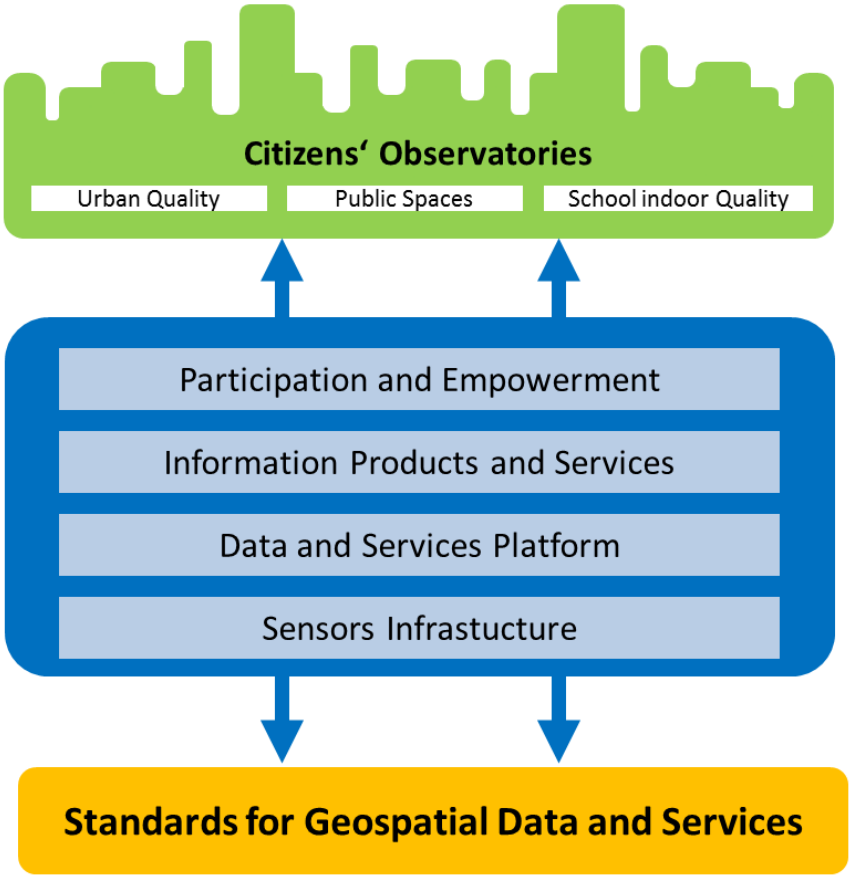

Figure 2. A schematic diagram of elements of the project.

The timeline of the project was divided into four main phases, each including a number of loops allowing us to reflect feedbacks. This led to a cyclical development of the methods and technologies, at each cycle collecting input from the users within the consortium, and the volunteers involved in the project.

Phase 1: Prototype and pilot phase for selected sensors and locations

Phase 2: Evaluation of pilot studies

Phase 3: Full implementation for all sensors and locations

Phase 4: Finalization and dissemination

Tools and services

The project relied heavily on technological developments, employing different tools. Some of the technologies were already available; they were further developed and adjusted. Other solutions were designed specifically for the project. The complete set of tools and services is available from the Citizens Observatory Toolbox (COT) where it can be reused by other cities in the future. The COT contains the following:

Figure 3. Technological elements involved in the implementation of the Citizen's Observatories concept.

Monitoring and sensor platforms

We tested and improved several sensors and sensor platforms and deployed selected ones on large scale. In Vitoria-Gasteiz, we used sensing tools developed by Tecnalia that monitor and assess noise and thermal comfort of public spaces. In the other eight cities, we deployed the Ateknea LEO personal platforms with electrochemical sensors for measuring gases (NO, NO_2 and O_3), and the Environmental Instruments AQMesh static sensor platform that can measure gases (NO, NO_2, NO_x, O_3, CO, $SO_{2)}$, particles (PM_1, $PM_{2.5}$, PM_{10}), relative humidity, pod temperature, atmospheric pressure and noise. In schools, we deployed the Atmospheric Sensors indoor unit for gases and particulate matter, and the Obeo Radon sensor.

In order to provide a complete end-to-end solution following the concepts used in the Internet of Things domain, we developed data flow tools that allow connecting the proprietary data solutions of the sensor platform providers to a central system with dedicated routines for data processing (including potentially quality control). APIs and other tools were used for user end near-real-time visualisations, and for data downloads. We also provided data to e.g., hackatons and to students who developed their own apps.

Environmental perception surveys

We developed three surveys to map knowledge and get feedback from users, on outdoor air quality perception, on indoor air quality in schools and on environmental quality in public spaces, for distribution as web or smartphone applications.

Mobile apps

Six mobile applications (CityAir App, SENSE-IT-NOW, Sense City Air App, ExpoAPP, SensorLog, SensAPP Gateway) were developed for air quality and environmental reporting. They allow to collect citizens' perceptions, or they are linked with the sensors and used to communicate measurements.

The CivicFlow platform integrated results from campaigns, and visualized the data using location and time-based analytics.

Widgets

We developed a set of reusable graphical components/widgets that could be easily configured for and deployed in various kinds of end user decision making applications and platforms. They can visualize on maps real-time data coming from a number of heterogeneous sources, and provide charts and plots tailored for web portals and mobile devices.

Data

We developed tools for users to browse and download data from the CITI-SENSE Observatories in schools and in cities.

Web portals

Each Citizen's Observatory used a local web portal as a main information hub in local language. These portals can be accessed from the central web portal of the project, http://co.citi-sense.eu.

Citizen Participation

The CITI-SENSE communication model was formed as an open dialogue among scientists, technology providers and citizens (including teachers, civil servants) with the aim to learn from each other's experience and perception and to enable co-operative planning. The cyclical development of the citizens' observatory is illustrated in Figure 4. The Citizens' observatory acts as the "mediator" or facilitator of these developments and allows evaluation of concepts and continuous improvement. Parallel development of enabling technologies, scientific methods and user interactions is essential for its success.

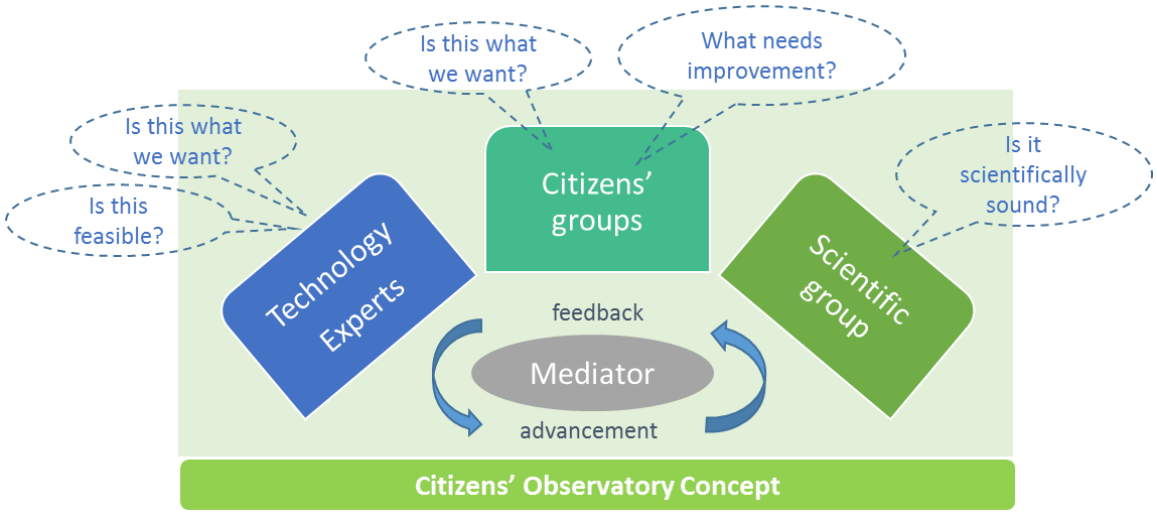

Figure 4. The Citizens' Observatories concept

In CITI-SENSE, we chose a participation method that went beyond a simple collection of data/information. We wanted to give citizens (stakeholders) a voice, to be able to engage with local decision makers in environmental problem solving in the local society.

The CITI-SENSE engagement process consisted of three main parts: preparation, participation and evaluation.

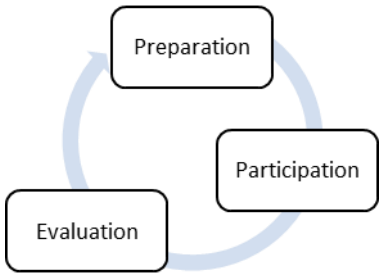

Figure 5. The three phases enabling citizen participation

Citizen Participation

1. Preparatory phase

The preparatory phase refers to the project design. It involves the following aspects:

a. Composition of a balanced **project team**

b. **Context analysis** of the issues, location, decisions to be made and clarification of the purpose of the participation process

c. **Stakeholder analysis**, including stakeholder identification, definition of their character and attitudes and the relationships between different stakeholder groups

d. **Engagement plan** including expectation management

e. Choice of **participation methods** on the basis of the stakeholder analysis

f. **Planning the process**: action and communication plan

g. **Recruitment of participants**

2. Participatory phase

This phase is the practical part of a project. In this phase, we applied the participatory methods that we developed in the preparation phase. In CITI-SENSE, we used the following participatory methods:

Survey with open questions: Questionnaires can reach a broad audience, obtaining both qualitative and quantitative information.

Interviews: Interviews are very valuable to obtain more detailed information about a certain issue than a questionnaire. This method can also be used in the evaluation phase.

Focus groups: In a focus group, a group of 6-8 people is asked about their perceptions or opinions towards a product, service or concept. This method is valuable for the design of a project or for evaluation purposes.

Perception monitoring: People's subjective perceptions can also be an interesting method in participative activities. Through questionnaires or mobile applications, participants can report their personal experiences in certain situations, places or about certain topics. Here, the participants can be engaged in the design of the questionnaire, app, web site, etc and also participate through their answers/collected information.

Co-design/ Co-creation: Co-design or co-creation activities are crucial tools not only for participation but also for empowerment activities/projects. Involving the participants in this active way will make them feel more connected to the project, since they have been part of developing it, and the results will be more acceptable to the participants. In addition, you will receive feedback and viewpoints from other perspectives, which can also be very enriching. It is generally recognized that the quality of design increases if the participants' interests are considered in the design process.

3. Evaluation

Evaluation provides feedback necessary to adapt the project methods in all steps of the process, so that the goals can be achieved. The evaluation process needs to be planned and built into the project cycle. An interim evaluation should be carried out after each important step or milestone. In this way, the activities can be monitored, improved and reevaluated. An end-evaluation of the field studies allows to measure the outcomes and impacts. In the CITI-SENSE project, we executed both an internal and external evaluation, involving project members and the participants in each location.

Lessons Learned

A project can always be seen as a learning process, and it is important that the lessons derived are not lost. Many of these are not new or ground-breaking but prove to be essential for success of any project that aims to provide value to its stakeholders, such as the public.

The first key message is **“to match expectations”**. A successful project needs to understand well what actors both within and outside the project (citizens, local authorities or other interested parties, but also the project partners) expect from the project, and what motivates their involvement. A continuous dialogue on how these expectations match what the project will deliver, and what are the technology options, is necessary.

An important aspect in projects involving citizens and aiming to serve them is to engage with people from the very beginning. Maximizing the use of feedback from real-world users is a main component that defines success. Knowing the users’ interests, preferences and abilities will lead to **solutions fit for purpose** and should always be valued in the design and implementation phases. The leading question that has to be answered in the citizens participation process is "What's in it for me?", what the project will give back and why one should be interested to join. This requires understanding of the audience, who is it for and who will respond to it. After the initial engagement, **ongoing motivation** is crucial for the success of the project and its sustainability.

The experience with technology did not always bring the anticipated outcomes. The lack of maturity of low cost sensors, the **user unfriendliness**, the electronics competence was critical for the project development and time consuming to make things work. Another big part of the technology was the **data quality** that can seriously undermine the whole project as people required firmer information to "be empowered" and act. The **simplicity** in tools, sensors and other means of interaction proved to be a key element to facilitate and engage people to return in those tools. On the other hand, the project itself moved the sensor technology forward and updated existing tools. And when things did not go as planned, creativity and teamwork led to desired results by using other means for engagement, data collection and other methods/tools.

Even though the project was comprised by a big number of partners, the teamwork and collaboration functioned well. The interdisciplinary team worked in most cases in favour of the project objectives and goals; however, there is available room for improvements in **transparency, communication, information sharing, and time efficiency**.

Overall, people within and outside of the consortium acquired a better understanding on environmental monitoring and air quality issues in cities. More technical oriented people recognised the value of the social science and the efforts to truly engage people. Cooperation between scientists with different background was at some points time-consuming and a bit frustrating, but more importantly very rewarding for individuals and the project as whole.

On the next pages, we share some practical lessons learned we believe can be useful to those who want to start their own citizens science project on environmental monitoring.

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LESSONS LEARNED
Making use of technology

Findings	Our Advice
A small number of well-trained partners can support a large number of units in the field.	Focus on the problems you are trying to solve, not on the solution you develop.
Communication and sharing information builds trust and understanding.	Set clear goals: What will be the final output? What are you asking citizens to do / take notice of? Are you speaking their language? Is it realistic / appropriate for citizens to be directly involved? What is the budget and timeframe for each activity? Is the activity relevant?
	Focus first on the community aspects. This helps on all stages of your project, and ensures its sustainability.
	Understand policy issues at stake.
When the work involves technology development, delays and other bad things always happen.	Ensure that you have all four skills: • Expertise to engage with the stakeholders / the public • Technology Development: sensor/ node technology and communications/ cloud storage • Technology implementation: on-site deployment, training, maintenance and local validation skills • Data analysis, visualization and social impact reporting competence
Homogeneity between field trials facilitate all procedures.	Involve community experts along with technologists. Solving complex issues requires multi-disciplinary approach complemented by involving the public.
	Make plans for what to do if technology is delayed or does not function as intended.
True collaboration is a must - all need to feel they are both, contributors and benefactors.	Give feedback on every aspect of the project, use it for continuous improvement.
	Document as much as possible - it may be useful later on.
	Common protocols that respect local specificities are much preferable to local protocols with common aspects.

The CITI-SENSE project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 308524.

LESSONS LEARNED
Engaging with citizens and schools

Findings

Engaging citizens is a complex process, often little understood.

People that are personally affected show most interest/are more motivated to engage.

Young people are iteresed and willing to work on environmen tal health issues - it is fun, motivating and productive.

The technology is often easy to be deployed by citizens. But there is very little information about the properties of the data it generates.

Quality control and assurance or calibration are not common steps a person takes for devices of daily use.

The lack of information on data quality restricts the use of the data.

Making space for creativity will enhance engagement.

Our Advice

- Focus first on the community aspect. It facilitates all stages and ensures the sustainability of the project.
- Make the project transparent and provide volunteers regularly with feedback/data/information.
- Share with users plans and interim results, and challenges.
- Engage with public authorities.
- Print material (newsletters or reports) are of great value. Social media can be useful to facilitate the communication with your volunteers. But don't forget communication in person - talking to people is crucial to build trust.
- Face to face feedback is a good way to understand stakeholders better and to build the connections further.
- Address the previous negative experiences of the stakeholders with low cost sensor technology; such experience makes it challenging to see potential benefits.
- Design public activities with at least the same care as you plan the technology deployment. This is the most important determinant of your success. Correcting errors in stakeholder engagement proves harder than finding other technologies.
- Explain uncertainty elements to users along with the equipment strengths and limitations.
- Work with schools? Respect the school plans! Schools' time schedules are very busy, adjust your activities to fit them - not the other way round.
- Take the time to understand teachers and pupils needs, wishes and constraints.
- Be ready for any questions when working with primary school children.
- The more your collaborators and stakeholders are involved in design and planning, the higher the chance that they will stay.
- Get acquainted with the people's language and culture. You can only win their trust when you understand their thinking and talking.
- You have to know what you want to communicate with whom and what are their preferences; the choice of a communication tool comes only after that.
- Use easy language. This will facilitate people's understanding of what is happening and what you want from them.

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LESSONS LEARNED
Generating data with low cost air quality sensors

Findings

Low cost sensors are here to stay and will continue to advance their capabilities. But, we do not always have a clear idea (yet) how best to take advantage of them.

Co-location of different instruments can give you a very useful insight in the repeatability of measurements - even if you are only comparing several instruments of the same kind. If you can compare to "reference instruments" it would also give you information how close your measurement is to the “true” value.

Laboratory results do not transfer directly to field results for air quality sensors.

Technologies have to be easy to use and possible to integrate in the volunteers' everyday life.

Our Advice

- Get the technology working before you try to engage the public to use it.
- A smartphone app needs to give the users something of value in return. If not, it will never be used.
- Capturing good requirements before system design helps creating a system that is useful to the end users.
- Knowing user scenarios helps database and schema design.
- Keep things simple in particular when it comes to technology and when you engage general public.
- Validate your equipment prior to deployment and have a clear idea about how fit for purpose it is.
- Communicate clearly the capabilities of the technology, manage the expectations.
- Be aware that numbers provided by any instrument can and should be questioned. Think about what you can do to improve your knowledge of data quality.
- Do not despair if data is not as accurate or reliable as you expect - it almost never is. Even "unreliable data" can be very valuable - all depends on how it is used.

http://co.citi-sense.eu

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The Consortium

The CITI-SENSE Consortium consists of 30 partner institutions:

NILU	NILU Norwegian Institute for Air Research (Project Coordinator)	NO
PVDH	Peter van den Hazel	NL
NAAF	Norwegian Asthma and Allergy Association	NO
Technion	Technion - Israel Institute of Technology	IL
CVUT	Czech Technical University	CZ
QU	Queensland University of Technology	AU
AirBase	AirBase Systems Ltd	IL/ DE
ATEKNEA	Ateknea Solutions Catalonia S.A.	ES
GAC	GAC Spol SRO	CZ
IOM	Institute of Occupational Medicine	UK
IBATUZ	Iritziak Batuz	ES
S&C	Sensing & Control Systems SL	ES
Alphasense	Alphasense Limited	UK
UBIMET	UBIMET GmbH	AT
U-Hopper	U-Hopper SRL	IT
CREAL/ISGlobal	Institute for Global Health	ES
IEM	Institute of Experimental Medicine, Academy of Sciences of the Czech Republic	CZ
VINCA	Vinca Institute of Nuclear Sciences	RS
JSI	Jozef Stefan Institute	SI
SINTEF	Stiftelsen SINTEF	NO
TECNALIA	Fundacion Tecnalia Research & Innovation	ES
KICT	Korea Institute of Civil Engineering and Building Technology	KR
UCAM	University of Cambridge	UK
DNET	DunavNet doo Novi Sad	RS
Snowflake	Snowflake Software Limited	UK
Geotech	Geotechnical Instruments UK Ltd	UK
Obeo	Obeo AS	NO
VLAGEW/ INBO	Research Institute for Nature and Forest - Scientific Institute of the Flemish Government	BE
Saltlux	Saltlux Incorporated	KR
EI	Environmental Instruments Limited	UK