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BE SEI | Wiseair

Executive summary

The SEI Bioengineering project was born from a clear challenge: to find an application on the market of an innovative technology studied within the IIT, the microbial fuel cell (MFC). Microbial Fuel Cell is an electrochemical system able to generate electricity from the oxidation of organic matter present into natural environments, such as in particular plants' soil. Despite its innovation potential, the technical limitations of such technology (above all the extremely low achievable power rate) still obstruct attempts to get it out of research centres and universities.

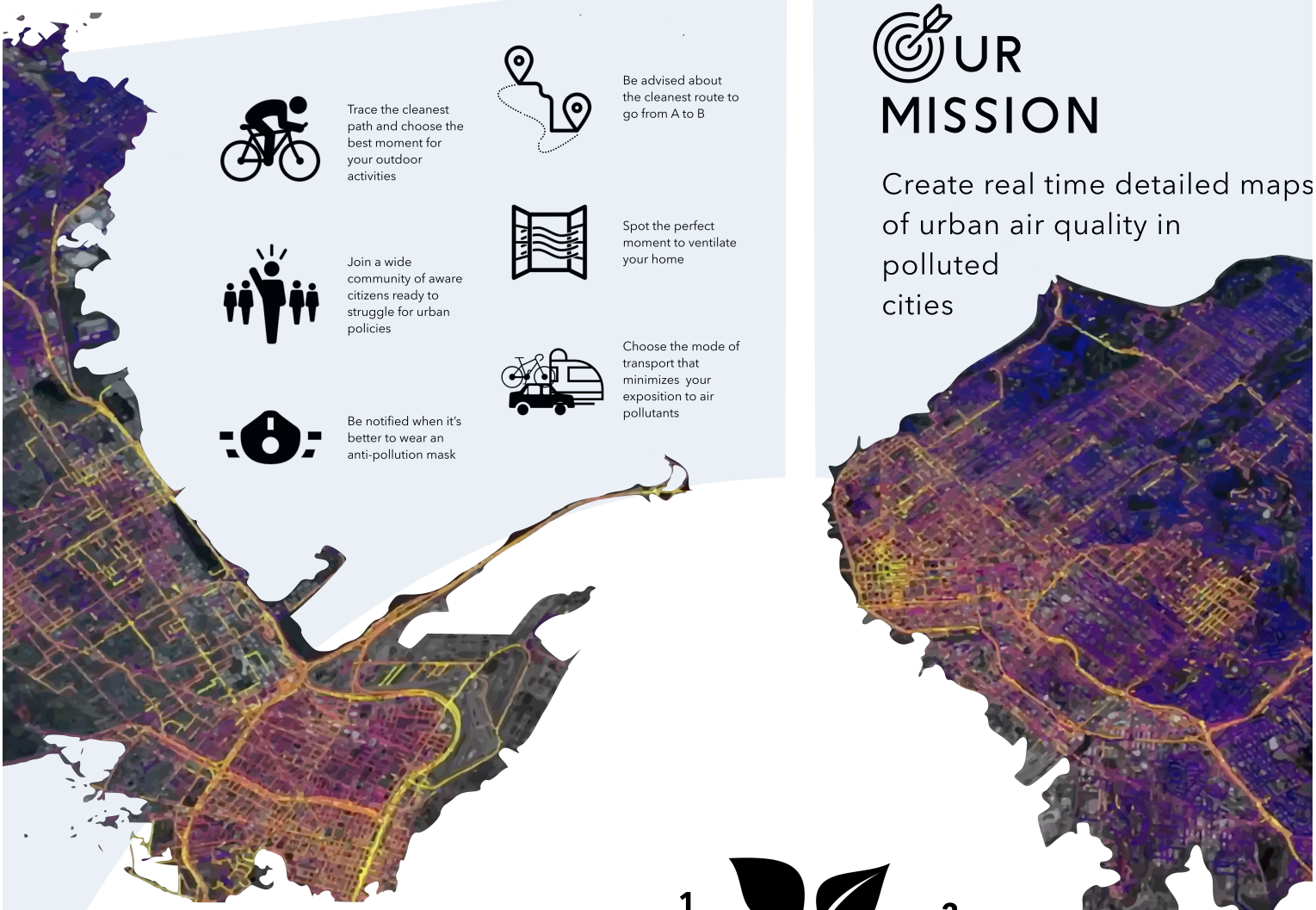
After a long phase of research and ideation, we decided to overcome the limits by leveraging the strengths of technology: (i) the ability to produce energy (albeit little) in a natural and continuous way (ii) the possibility to integrate technology into a familiar and design object like a balcony plant pot. This is how Arianna is born. Arianna is an IoT balcony pot, that exploits the energy produced by an integrated MFC to power an air quality sensor hidden inside.

Arianna was our way of applying MFCs to one of the biggest problems facing cities today: urban air pollution. Taking advantage of the technology, we invented a stand-alone sensor, which requires no network connections or batteries, and is presented as an object close to the end user.

From this idea was born a first prototype and then a real company called Wiseair. Today, Wiseair's mission is to create hyperlocal maps of air quality, giving urban communities of problem-sensitive citizens the opportunity to participate in the construction of capillary monitoring infrastructures by simply placing a vase on their balcony. The data collected by hundreds of Ariannas distributed in our cities will be the starting point to find the most effective solutions in the fight against pollution, promote them and certify their impact.

Key Words

Microbial Fuel Cells, Air Quality, Wireless Sensor Network, IoT, Smart Cities



Trace the cleanest path and choose the best moment for your outdoor activities

Be advised about the cleanest route to go from A to B

Join a wide community of aware citizens ready to struggle for urban policies

Spot the perfect moment to ventilate your home

Choose the mode of transport that minimizes your exposition to air pollutants

Be notified when it's better to wear an anti-pollution mask

OUR MISSION

Create real time detailed maps of urban air quality in polluted cities

HOW

Sunlight is naturally converted into chemical energy **1**

The biochemical integrated system turns excess chemical energy into electricity **2**

The electrical current produced by the system is used to power an AQ sensor **3**

The measured data are wirelessly sent to an user device **4**

The data from all the users are gathered in a dense urban data network **5**

This network allows to always have a detailed urban air quality map in your pocket! **6**

Project description written by the Principal Academic Tutor

The project involves the development of the application of Microbial Fuel Cells (MFC) for the power supply of sensors with application in the field of air monitoring. Microbial Fuel Cells are a technology designed to allow the exploitation of the exoelectronic activity of bacteria for power and energy production. Energy production takes place directly using fuels which are naturally present in the soil and related with the plant metabolism: these systems are therefore able to produce energy by working in direct contact with the roots of the plants. The idea of the team is to exploit this energy produced for the supply, operation and data transmission of a sensor system for monitoring air quality (in particular, particulate matter). The main focus of the project is product development, with a view to evolving the MFC system towards a real application able to penetrate the market and create value.

Team description by skill

The project team is composed of six engineering students with highly heterogeneous skills, both in the IT and in the industrial domain:

Fulvio Bambusi is a Computer Engineering student at Politecnico di Milano specialised in Big Data and software development.

Paolo Barbato is an Energy Engineering student at Politecnico di Milano specialised in renewable energy and system modelling.

Mateus dos Reis Barone is a Management Engineering student at Politecnico di Torino specialised in supply chain management and project management.

Carlo Alberto Gaetaniello is an Energy Engineering student at Politecnico di Milano specialised in energy management and efficiency.

Giulio Matarazzo is a Chemical Engineering student at Politecnico di Torino specialised in innovation processes design and oil & gas plant design.

Bernardita Stitic is a Electronic Engineering student at Politecnico di Torino specialised in microcontrollers and circuit design.

The whole team is characterised by a strong attitude towards entrepreneurship and innovation combined with solid scientific and technical skills.

Goal

Microbial Fuells Cells, with a TRL between 3 and 4 (Moro, et al., 2017), is still an immature technology for which further applied research must be carried out to overcome many technical limitations. Nevertheless, in such an early stage of development, a recognized and specific need is required capable of fostering its diffusion and industrial development and of attracting public and private stakeholders and investors.

In such a context, the project focuses on the following two main objectives:

- **Demonstrate the feasibility** of electricity generation from plants with MFC technology by developing a small-scale working prototype;

- **Find and innovative and market-ready business idea** leveraging on the potentialities of MFCs to push the technology out of the labs while solving an actual problem.

Understanding the problem

There are several technical limitations that make MFCs not competitive with other incumbent technologies. The first one is represented by the **low conversion yield** of the organic matter, which typically lies between 1% and 3%. In addition to that, the lack of any relevant real-world use case has significantly hindered the industrial development of the technology, which now is only studied and tested in lab-scale systems built for purely academic purposes. The low **reliability** and **stability** of these systems and their **high cost** are the main obstacles that, combined with the low energy output, challenged the team throughout the entire search for a viable solution.

Setup and Testing of the bio-electrochemical system at the ChiLab (research centre of the IIT)

Presentation of the project at the Party for Planet event in Milan

Exploring the opportunities

In the initial phases of the project we focused on a long research and classification work to understand what were the main applications currently feasible for Microbial Fuel Cell. The main ones we found were:

Access to electricity in remote areas. Thanks to MFC technology used as an energy harvesting technique, we are able to produce electric energy from many renewable and largely available sources of organic matters like human and animals' wastes, soil, water etc. .

Autonomous sensors. It is forecasted that autonomous sensors will replace battery-powered sensors in the next few years. In this context, due to their capability of continuously generating electric energy on-site, MFCs are a good potential candidate to overcome the old battery-centred paradigm and move towards the new concept of self-powered sensor.

The design phase was conducted with the idea of finding an application that could overcome the limits of the Microbial Fuel Call, leveraging instead the strengths. For years, attempts were made to find industrial applications for MFCs, such as energy production, but with poor results because the technology is still too immature and offers poor performance. We have therefore decided to focus instead on the energy harvesting sector and on the possibility of using the energy produced by the MFC to power autonomous sensors that require low consumption. We have produced more than 60 ideas, classifying them based on two main parameters: **value to the customer** and **effort**. Thanks to this analysis, we find a great potential in applying MFC in the field of air pollution monitoring

Generating a solution

In order to drive the design of our product we investigated the features that customers appreciate and evaluate the most.

We identified three main properties: **low maintenance**, **data intensity** and **aesthetic value**. Via the case study of smart citizens, we discovered that users perceive the maintenance of sensors as a low value-added activity, hence are not eager to perform it. On the other hand, the market of air quality data is expanding, and so it is vital that the the product produces a reliable stream of information.

Finally, in order to easily penetrate the market and spread in our cities, the pot must be extremely appealing to the consumers. We decided to enforce this property by leveraging two different strategies. First, we gave our sensor a familiar and friendly appearance. Moreover, we created a community to motivate and encourage our customers and to promote debate on the theme of air quality.

As far as the low maintenance is concerned, we designed the circuit to be autonomous from the energy point of view, and we enabled wireless transmission of data so as minimize the need of user intervention. Wireless, real time transmission of data does also address the requirement of high data intensity.

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