APOLLON

Using Living Lab Methodologies in the Cross-border Context for Energy Efficiency Pilots

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Abstract: The APOLLON Project (CIP–ICT–PSP No. 250516) has addressed the challenge of stimulating and measuring energy user behaviour transformation facilitated by ICT solutions to achieve an increase in energy efficiency. Cross-border pilots in four different countries were established and tested common methodologies and practices. The user-driven Living Lab methodology was implemented to achieve faster and more effective results.

1 INTRODUCTION

People's well-being, industrial competitiveness and the overall functioning of society are dependent on safe, secure, sustainable and affordable energy. The EU is committed to reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050 in the context of necessary reductions by developed countries (EC1, 2011).

Energy efficiency is at the heart of the EU’s Europe 2020 Strategy for smart, sustainable and inclusive growth and of the transition to a resource efficient economy. Energy efficiency is one of the most cost effective ways to enhance security of energy supply, and to reduce emissions of greenhouse gases and other pollutants. In many ways, energy efficiency can be seen as Europe's biggest energy resource. This is why the Union has set itself a target for 2020 of saving 20% of its primary energy consumption compared to projections, and why this objective was identified in the Commission’s Communication on Energy 2020 as a key step towards achieving our long-term energy and climate goals (EC2, 2011).

Substantial steps have been taken towards this objective – notably in the appliances and buildings markets. Nonetheless, recent Commission estimates suggest that the EU is on course to achieve only half of the 20% objective.

Improvements to the energy performance of devices used by consumers – such as appliances and smart meters – should play a greater role in monitoring and optimizing their energy consumption, allowing for possible cost savings and ensuring that consumer interests are properly taken into account in technical work on labelling, energy saving information, metering and the use of ICT. Consumers need clear, precise and up to date information on their energy consumption.

In future years the deployment of a European "smart grid" will bring about a step change in the scope for gathering and communicating information about energy supply and consumption. This information will allow consumers to save energy. Member States are obliged to roll out smart electricity meters for at least 80% of their final consumers by 2020 provided this is supported by a favourable national cost-benefit analysis.

Smart grids, meters and appliances will allow consumers to choose to permit their appliances to be activated at moments when off peak cheaper energy supply or abundant wind and solar power are available – in exchange for financial incentives. Finally, they will offer consumers the convenience and energy saving potential of turning appliances on and off remotely (Bergvall-Kåreborn et al.) (Holst, M et al., 2011).

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2 OBJECTIVES

The work developed in APOLLON in the cross-border pilots targeted the challenges in terms of Energy Efficiency which the European Union is currently facing. It has been stated that to identify and address these key challenges, an ICT-based transformation of the energy sector is needed both in production and consumption. The Energy Efficiency pilots focused on the stimulation of behavioural changes. The aim was to do this by providing real-time updates on energy consumption through Smart meters. (EC3, 2011)

The four Living Labs involved in the experiment were:

- **Botnia Living Lab (Luleå, Sweden)**: Together with Luleå Energy AB, Botnia Living Lab invited 20 households to participate in the test and evaluation of two different visualization technologies aimed at energy saving. The first technology ELIQ focuses on electricity and price while the second technology SABER can measure and visualize consumption of district heating, electricity and hot water consumption.
- **Amsterdam Living Lab (Amsterdam, Netherlands)**: The purpose of the Geuzenveld pilot was to stimulate awareness among citizens and their energy consumption patterns, to make them aware of how to improve their behaviour and thereby to actually save energy. The residents were engaged on an individual and on a collective basis. Another important objective was to gain experience with respect to the implementation of smart meters and energy feedback displays. Over 500 smart meters have been rolled out in the Geuzenveld area. Sixty residents were also issued with a display that is connected to the smart meter.
- **Aalto Living Lab (Helsinki, Finland)**: Together with the building owner and superintendent some of the most vital energy consumption points were mapped out. The building was originally chosen as an energy saving living lab because of the owner's need to mitigate the energy consumption in all the like buildings and, as the chosen building is also the headquarter for Process Vision, it was easy to start testing the different measurement solutions as the immediate vicinity provided quick response times to the needed configurations for the meters themselves. The goal of the Living Lab was to test technical solutions on the metering side, but also, and more importantly, to see how energy savings can be achieved through smart metering and user involvement, in four different use groups at the pilot building.
- **Lisbon Residential Living Lab (Lisbon, Portugal)**: The Lisbon Residential LL is located in a residential block. The purpose of the LL is to implement energy efficiency measures in private households through behavioural change, to test the effect of using smart metering technology and remote management tool software in the reduction of energy consumption and to achieving viable and profitable solutions for energy management and communication.

3 METHODOLOGY

Viewing Living Labs as an environment, several different types of Living Lab environments can exists such as, *Research Living Labs* that might focus on performing research on different aspects of the innovation process, *Corporate Living Labs* that focus on having a physical place where they invite other stakeholder (e.g. users) to co-create innovations with them, *Organizational Living Labs* where members of an organization co-creatively develop innovations, and *Intermediary Living Labs* where independent partners are invited to collaboratively innovate at a neutral arena. Due to the constant development of the concept, other types of Living Labs certainly exist. (EC3, 2011)

Figure 1: Key Components of a Living Lab.

To be able to understand what a Living Lab is, there are some components it should have. The components for a research Living Lab are ICT and Infrastructure, Management, Partners and Users, Research and Approach (see Figure 1). (EC3, 2011)

The *ICT & Infrastructure* component outlines the role that new and existing ICT technology can play to facilitate new ways of cooperating and co-creating new innovations among stakeholders. *Management* represent the ownership, organization, and policy aspects of a Living Lab, a Living Lab can be managed by e.g. consultants, companies or researchers. The Living Lab *Partners & Users* bring their own specific wealth of knowledge and expertise to the collective, helping to achieve boundary spanning knowledge transfer. *Research* symbolizes the collective learning and reflection that take place in the Living Lab, and should result in contributions to both theory and practice. Technological research partners can also provide direct access to research that can benefit the outcome of a technological innovation. Finally, *Approach* stand for methods and techniques that emerge as best practice within the Living Labs environment. (EC3, 2011)

A Living Lab can also have a specific approach to innovation. This approach is built on five key principles. These are: Value, Sustainability, Influence, Realism and Openness and these should permeate all Living Lab operations. (EC3, 2011)

In more detail, the key principles can be described as follows:

- **Value:** The notion of value and value creation in a Living Lab concerns several different aspects such as societal value, economic value, business value and consumer/user value. A Living Lab might also provide insights about how users perceive value. These insights should guide the innovation process to be able to deliver innovations that are perceived as valuable from a societal, economical, business, and a consumer perspective. A Living Lab has the opportunity to create value based on all aspects of the value term
- **Sustainability:** This key principle refers both to the viability of a Living Lab and to its responsibility to the wider community in which it operates. Focusing on the viability of the Living Lab highlights aspects such as continuous learning and development over time. Here, the research component of each Lab plays a vital role in transforming the everyday knowledge generation into models, methods and theories. Other important aspects related to the sustainability of a Living Lab is the partnership and its related networks since good cross-border collaboration, which strengthens creativity and innovation, builds on trust, and this takes time to build up. Also, in line with the general sustainability and environmental trends in society it is equally important that Living Labs also take responsibility of its environmental, social, and economic effects.
- **Influence:** A key aspect of the influence principle is to view "users" as active and competent partners and domain experts. As such their involvement and influence in innovation and development processes shaping and transforming society is essential. Equally important is to base these innovations on the needs and desires of potential users, and to realize that these users often represent a heterogeneous group. While users often are described as drivers and shapers of technology, they still very often are treated as a homogeneous and passive group that carry out activities assigned to them. Hence, one important issue that Living Labs need to manage is how to assure that participation, influence and responsibility among different partners harmonizes with each other and with the ideology of the user influence of the project.
- **Realism:** One of the cornerstones for the Living Lab approach is that innovation activities should be carried out in a realistic, natural, real life setting. Orchestrating realistic use situation and user behaviour is seen as one way to generate results that are valid for real markets in Living Lab operations. However, the aim to create and facilitate realism is an endeavour that needs to be grappled with on different levels and in correlation to different elements such as contexts, users, use situations, technologies, and partners. The principle does not separate between the physical and the online world. Instead it is argued that activities carried out in both worlds are as real and realistic to its actors.
- **Openness:** The principle of openness emphasizes that the innovation process should be as open as possible. The idea is that multiple perspectives bring power to the development process and achieve rapid progress. The openness supports the process of user-driven innovation. In a Living Lab, digital innovations are created and validated in collaborative multi-contextual empirical real-world environments. Openness is crucial for the innovation process in a Living Lab, where it is essential to gather a multitude of perspectives that might lead to faster and more successful development, new ideas and unexpected business openings in markets. However, to be able to co-operate and share in a multi-stakeholder milieu, different levels of openness between the stakeholders seems to be a requirement (Bergvall-Kåreborn et al.).

3.1 Pilot Implementation Methodology

The pilot projects ran in Living Labs localized in Amsterdam, Helsinki, Lisbon and Luleå. They operate in a very fragmented market all over Europe which raises problems and barriers that were analysed during the project. These regional differences are originated by for example: (EC3, 2011)

- Climate differences (Northern countries versus Southern countries).
- Regulatory environments. Different standards. Different levels of deregulation.
- Lack of standards and interoperability.
- Different communication and data transfer standards.
- Different behaviour and cultures.

In order to address these specific issues the Energy Efficiency experiment followed the next 5 steps: (EC3, 2011)

1. Preparation of the pilot - During this phase the Living Labs share best practices and methods for user testing. The Living Labs co-create a methodology for the Energy Efficiency domain and determine what actions to optimize the usage scenario to be implemented for the cross border pilot experiment. The common technologies and research framework to be used are agreed for the four pilots.

2. Experimental setting - The selected technologies are installed in the Pilots under a general usage scenario. This includes a network of sensors, actuators and smart meters connected to wireless interface providing real time information. Users interact with the system and behaviour transformation is carried out. The level of integration of the energy management systems and the interface with electricity utilities depends of local conditions.

3. Testing - Users are facilitated through a participative innovation process. They define their needs and the level of acceptable settings and comfort they consider adequate for their life style and expenditure. These are dependent of their culture, climate and building insulation conditions. Living Lab methodologies are used to gather the user needs and ideas. Users get familiar with the energy management systems and learn from each other. Behavioural transformation approaches are utilised.

4. Evaluation - The evaluation is done continuously and will gather information on:

- Difficulties faced with product integration due to lack of standardization and local regulatory environment (Deregulation availability of real time data, dynamic pricing, etc.);
- Difficulties with the users' culture and their surrounding environments. The setting of control parameters is dependent on the local environment;
- Results on the impact of regulatory environment, climate, culture and behaviour are compared between the different Living Labs. Methodologies and tools to gather results will be assessed to select the most effective;
- Evaluation of the benefits of using cross border methodologies for co-creating and co-testing Energy Efficiency products.

4 TECHNOLOGY DESCRIPTION

In the way of involving end-users in the living lab experiment, different levels of visibility for energy measurement were given in the different Living Labs. All four Living Labs have installed different metering solutions. Also the different metering systems are controlled by different management systems and from these management systems the measurements are shown thru different portals: (Oja et al., 2012)

- **Lisbon:** The users were provided with an easy-to-install meter that from the first minute displays energy consumption, thus the user was aware of its consumption right from the beginning. The solution envisaged for the pilot could be easily rolled out, since it was only necessary to set up a distribution list, supported by a customer service line, and the users can easily, by themselves, install the equipment.
- **Luleå**: Metering solutions from two different local vendors were installed, and both of these vendors had their own solution for showing the measured data to end users. Those users that had the KYAB solution installed could follow-up on their energy consumption through a web portal. Those end-users that had the ELIQ solution installed had the possibility to view their consumption from a home display.
- **Helsinki**: The users in were able to view the energy consumption thru an excel report that was updated hourly to the intranet site viewable to all, also they had the possibility to view the consumption thru an extranet site called eGeneris that showed the energy consumption also on hourly basis.
- **Amsterdam**: The users had access to two kinds of real time energy displays: Onzo display and the GEO display, that real-time interacted with the

smart meter and provided information on energy consumption to the user.

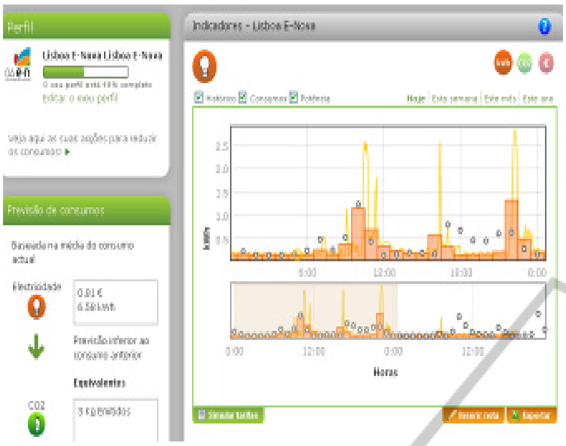

Figure 2: Energy display at Lisbon.

Figure 3: Energy display at Luleå.

5 RESULTS AND DISCUSSIONS

Within the energy efficiency experiment there has been in place during the Apollon project four different LLs in four different countries: Finland, Sweden, Netherlands and Portugal. All the four countries had a different basis for energy consumption because of the different climate conditions and what borders these conditions set for energy efficiency. Legal entities as well as national energy players set demands to mitigate energy consumption as well as lowering/shifting of consumption peaks. The Living Labs are in most part similar except for the Finland pilot that is located in a higher voltage office building when in the other Living Labs the pilot is of low-voltage metering point; namely private homes. (Oja et al., 2012)

From the four different Living Labs few key issues have risen above others in terms of user involvement and notification. The most flagrant issues in energy saving is the avenue with which the users are notified of their energy consumption and therefore are incorporated in the process of energy savings also on how to keep them engaged long-term. End users are most likely to change their consumption habits to greener ones if they have a good knowledge on what their usage has been before, what this usage means in terms of minutes and euros as well as clear objectives on what the consumption could be and with what means this could be achieved. (Oja et al., 2012)

Users demonstrate an interest at the start of ICT use and interaction, but interest tends to decrease in time if users are not engaged and challenged on regular intervals. Hence, energy efficiency information workshops are essential to raise user awareness, provided messaging and language are appropriate to the audience involved. With this in mind cross border activities are vital in sense of fresh ideas and common methodologies for interpreting the user behaviour changes. (Oja, R., et all, 2012)

The results of the co-operation can be seen in the good results in energy savings of the four living lab pilots: (Oja et al., 2012) (Gonçalves et al., 2012)

- **Helsinki**: Average 9% (increase of energy usage 4% to decrease of 24%)
- **Luleå:** Average 9% (5-12% decrease of energy usage)
- **Amsterdam**: Average 6% (4-8% decrease of energy usage)
- **Lisbon**: Average 15% (9-20% decrease of energy usage)

6 CONCLUSIONS

6.1 Cross-Border Collaboration Experiences & Evaluation

The most sustainable part of Cross-border collaboration and its evaluation is the collaboration between the Living Labs, who share most of the interests and whose strategic focus does not shift as rapidly as does the corporate side. Also, research collaboration is very much linked to most Living

Lab activities and sharing research findings add value for those partners. Public sector partners such as municipalities or regional innovation agencies are there to support and facilitate rather than to take part in the project operational side. (Launonen, P. et all, 2012)

6.2 Benefits

International cooperation benefits from exchange of experiences and lessons learnt from the partners, allowing the results of an initiative developed elsewhere to be appropriated and worked upon in other projects. This allows a convergence of resources, leveraging European-wide available assets (scientific excellence, technologies, methodologies, tools, experimental facilities, Living Labs, user communities) and avoids double work while achieving the same results. (Launonen et al., 2012)

A European level initiative can more broadly assess a wider range of topics, methodologies and technologies, count on a wider network of stakeholders and reach a far bigger audience and so prompt results on a totally different scale from those achieved if the experiments are solely conducted at the local level, which, due to a lack of economies of scale and budgetary constraints, would of necessity be deficient and incomplete. (Launonen et al., 2012)

Each pilot has its own specific target users but uses common methodologies, allowing for generalization of findings to other Living Labs. Working at the European level is complementary to city initiatives, fostering public collaboration in the form of city's cooperation to enhance impulse and build upon each city's strengths and expertise, providing also the basis for harmonization in areas where this is both essential and beneficial in advancing and initiating follow-up studies. (Launonen et al., 2012)

Benefits for Research and business are:

- Knowledge transfer
- Business matching & partnerships – SMEs and Large Enterprises
- Technology testing and validation, market and feasibility testing

6.3 Challenges

The challenge for public organizations and non-profit private entities, which seek to contribute to sustainable development by systematic and continuous improvement of the energy and environmental performance of the city is to implement a continuous improvement process involving all of the city's key stakeholders in a holistic and quantifiable way which results in a measurably better energy and environmental performance of the city. The cross-border activities consisted of several such cases, all with the purpose to test and evaluate new technologies for energy saving and behavioural change in terms of energy consumption, all striving to share experiences, methods and tools among their sites and to provide business opportunities for their SME communities. (Launonen et al., 2012)

The challenge for SME's is to take the advantage of being in permanent touch with up-to-date technologies, from different companies, in the field of energy metering, with partners from different European countries, sharing ideas and forming business alliances. The greatest challenge is the absence of a single uniform European Energy service market for consumers. There are different industry legacies, regulatory environments, standards and supporting instruments for each individual European country. (Launonen et al., 2012)

6.4 Partners in the Project

Available public funding for SMEs helps when it focuses on RDI issues close to markets, since their development cycles are very short. LLs should aim to provide 'same type services' for SMEs in each location. (Launonen et al., 2012)

In this experiment Local Authorities were municipality representatives, energy companies owned by local authorities and energy agencies. So local authorities drive the local energy policy and support local SME community for piloting. Local energy management systems are an asset in achieving local energy consumption optimization, facilitating the delivery of a balanced supply system and an optimal integration of demand storage means. The residential level created by e.g. the Lisbon pilot promotes the reshaping of energy consumption patterns by smoothing peak hours' consumption and implementing management procedures that allow transfer of consumption to off-peak hours, settling of dynamic baselines of consumption according to energy supply conditions, combining grid needs with dynamic accumulation sources and strategies that shall be addressed within the energy management arena for the installations evaluated. This methodology, commonly used at a higher level than the municipal can be easily replicated to the municipal level. (Launonen et al., 2012)

Municipal Energy agencies are the link to the energy test bed. Their unique position allows them to be the bridge between local authorities, SMEs and Universities, positioning such a consortium to be the real framework that motivates the LL methodology. Municipalities can appropriate results and draw up new policies and legislation both at the urban planning and urban management level, exploiting APOLLON results towards a more sustainable approach to the urban environment. (Launonen et al., 2012)

6.5 Research

In this experiment there were two Research Institutions as partners; Helsinki Aalto University and Luleå University of Technology. For research institutions in this experiment, the focus has been to do research on how to stimulate users to change their energy consumption behaviour by means of new technology and by means of tasks that stimulates their use of the implemented technology.

In this experiment we have been able to elaborate with methods and tools for user behaviour transformation. For instance, one aspect of the experiment has been to have done a longitudinal study with user involvement for a longer period of time. Here it has become obvious that it is difficult to involve users and to keep them engaged for several months. One way that we have tried to stimulate their engagement has been to give them assignments that they should carry out, with the objective to stimulate use transformation and adoption of the innovation and to stimulate the users to change their behaviour. By this mean, it is observed that the users do change their energy behaviour to some extent, and they do also become more knowledgeable in the area of energy saving. (Launonen et al., 2012) Another focus area has been facilitation of systemic innovations and orchestration of open innovation networks in the energy efficiency domain.

The added value for Living Labs has been the increased knowledge in the area of energy savings. This has led to new project initiatives, business models, products and services. The project initiatives will in turn increase the collaboration between partners around Europe. Another aspect of added value has been a strengthened collaboration with local SMEs who have not been involved with similar projects before. (Launonen et al., 2012)

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