Participatory Design of Scenarios for Future Service Implementation
The Case of Smart Campus Project: ICT based Services for Energy Efficiency

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Abstract: Energy efficiency in public buildings is a fundamental goal for both public and private institutions. Its achievement depends on different factors such as the policy of the institutions but also the behaviour of the buildings users and the selections and availability of integrated technologies and monitoring systems. All these elements require the coordinated activity of many stakeholders with common goals and shared vision of the desired solutions, able to take into account needs and constrains of all the people involved. The paper describes the participatory design process applied in the Italian pilot of Smart Campus EU project to design ICT based services scenarios to reduce energy consumption in university campus buildings. It describes the scenarios' development process and discusses the results obtained and the positive implications of having the stakeholders involved right from the context research phase. This process is more and more used in Service Design projects in order to increase the possibilities of success for the following prototyping and on field implementation of the solutions. The paper is a contribution to the practice of participatory design of complex services.

1 INTRODUCTION

Reducing energy consumption is a major challenge nowadays and this is especially important in cities where the majority of the world population is currently living and where more and more people will concentrate in the next decades. Moving from the first attempt to agree a common understanding of the concept of sustainable development at global level, reported by the Brundtland Commission in the late 80's, the movement towards sustainability has done important steps forward in the last years. The European Union recently adopted the Energy and Climate Package (http://ec.europa.eu/clima/policies/package/), a set of legislation and directives that aim to ensure the European Union (EU) meets the set climate and energy targets for 2020. On this basis the EU member states have committed to the 20/20/20 goals reducing greenhouse gas emissions by 20% from 1990 levels, increasing the use of energy from renewable sources by 20%, and improving energy efficiency by 20%.

In order to reach these targets, the building sector is a key area. This sector is a big consumer of energy and has on the other hand a great potential for interventions aimed at reducing its consumption. This is mostly true considering buildings used for services, where different activities are performed and where common policies and interventions can significantly reduce energy waste.

Improving energy efficiency in public buildings is a challenge since it depends on many factors, such as external climate conditions, structure and materials of the building itself and activities carried out. The users' behaviour towards the use of energy is also a key factor to be considered, since everybody has a different perception and sensitiveness towards the use and value of energy. Indeed the way people use Heating, Ventilation and Air Conditioning (HVAC), lighting and appliances has a great impact on a building's energy consumption.

2 SMART CAMPUS PROJECT AS A TESTING ENVIRONMENT

"Smart Campus. Building User-Learning Interaction for Energy Efficiency" (Smart Campus) (http://greensmartcampus.eu) is a European project funded by the Competitiveness and Innovation Framework Programme 2007-2013, with the aim of

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achieving a 20% reduction in energy consumption in public buildings, through the development and installation of ICT based services at pilot buildings in four European universities. These services will be integrated with the energy management systems present in the pilot buildings and provide guidance that will lead to user behavior transformation towards more energy efficient practices. The possibility to actively interact, in a dynamic way, with the buildings energy management systems, gives users the possibility to control the environmental conditions of their workspaces in a way that until now has not been possible, becoming aware of their energy consumption habits in the process. At the same time the energy management systems learn and adapt to specific user routines. This way the users learn how to better use the spaces of the buildings thanks to the installation of sensors and technologies allowing them to interact directly with the surrounding environment.

The project is carried out in four pilot locations in the partner-country campuses (Italy, Portugal, Finland and Sweden) and actively involves students, professors and university staff in the development of the field activities. The aim of the pilots is to work on the criticalities observed and to reduce the energy consumption by enabling a mutual learning process between the building and its users and to facilitate the application of the same solutions to other university campuses.

3 DESIGNING SERVICES WITH A PARTICIPATORY APPROACH

Service Design is a relatively young discipline that moves from different traditions such as design for sustainability, interaction design and business sciences (Manzini, 1993); (Pacenti, 1998); (Mager, 2004=; (Meroni and Sangiorgi, 2011). Especially following the 'interaction paradigm', explored by Pacenti, the perspective assumed to design a service is the one of the user, detecting all the points where he/she gets in touch with the service during his/her journey across it. All these "touchpoints" are the elements (products, communication elements and processes) that need to be designed in order to assure the best experience and results in its use.

Before getting to the full design of all these interaction elements, especially when dealing with complex solutions involving many stakeholders, project scenarios are defined, aiming at creating a shared vision taking into account their different needs and behaviors. This is mostly true when the stakeholders and final users become active players in the solution development and in its adoption.

In the last decade the approaches to deal with services projects has changes significantly (Sanders and Stappers, 2008). In fact the perspective assumed by the User Centre Design method that looks at the users as "object" to be observed in their use of a service or product has been slowly changed. In the Human Centred Design concept proposed by IDEO (http://www.ideo.com) or in the Community Centred Design approached used by Meroni and the POLIMI Desis Lab group when dealing with social innovation initiatives (Meroni, 2008); (Cantù et al., 2012), the users become "subject" in the project development process, becoming active players in the detection of the problems and in the design of the solutions they will be using. Even if the user remains at the center of the project this is a radical change in its role, transforming him/her in co-designer of the future solution.

This new perspective has significant implications in the way designers work. In the Design discipline tradition the designer was the inventor, the creative person with a technical and cultural knowledge supporting the creation of a new product for the market. When dealing with services, characterized by intangibility, heterogeneity, inseparability and perishability (Lovelock and Gummesson, 2004), the user experience become the key for the success of the service solution. This, as a consequence, brought the attention on the users perspective in the design process and required service designers to become 'facilitator' in involving them in the early phase of the solution design. In this process the users are involved in collaborative activities where designers support their participation to with face to face meetings, workshops and specifically designed tools and format.

Looking at recent service design research projects (e.g. *Feeding Milan. Energies for change* project, MedeaLab's *living labs* in Malmo, *Life 2.0* EU project) it is possible to recognize that the people involved into the development process are not just final users of the services. In fact to develop an innovative service, entirely self-sustainable after designers work ends, it is important to involve the potential stakeholders right from the first phase of context analysis and scenarios' definition. This allows local actors to have voice, raising their needs and pointing out their potential role in the future solution (Cantù and Rizzo, 2012).

From a design perspective the theoretical

reference used for discussion in this paper is Participatory Design (PD). This is an approach that is used in all the design process moving from the collaborative definition of the project scenarios to the service idea - the concept - and continues with its testing and implementation together with the stakeholders, and concludes with the service ready to be used.

In order to develop this process, the methodology adopted in the Smart Campus project pertains to PD as defined by the Scandinavian school (Ehn, 2008); (Bjögvinsson et al., 2010); (Emilson et al., 2011). The authors look at PD as a movement "from designing "things" (objects) to designing Things (socio-material assemblies)" and they argue that "this movement involves not only the challenges of engaging stakeholders as designers in the design process, as in "traditional" Participatory Design (i.e., envisioning "use before actual use," for example, through prototyping), but also the challenges of designing beyond the specific project and toward future stakeholders as designers (in other words, supporting ways to "design after design", i.e. after the conclusion of the design process for the specific project). And they see this movement "as one from "projecting" to one of "infrastructuring" design activities" (Bjögvinsson et al., 2012, p.102).

As previously mentioned this means that the work of designers in this process ranges from engaging non-designers in envisioning and co-designing future service ideas, to involving potential stakeholders in the process, aligning their interests and empowering them to create self-sustainable services after the end of the design project.

In the Smart Campus project PD is applied right from the beginning with the aim of co-creating the digital services scenarios with the users and decision makers at local scale, thus ensuring higher sustainability of the solutions and better user requirement identification. This will be eventually translates into higher success rate of behavior transformation and long term adoption of the proposed solution.

This paper aims at giving a contribution to the design practice in the field of PD, describing the outcomes of the Smart Campus project scenarios' definition, whose effective sustainability will be verified with the conclusion of the EU project.

4 PARTICIPATORY DESIGN OF SERVICE SCENARIOS AT POLITECNICO DI MILANO PILOT

Milan pilot is located in the campus Leonardo of Politecnico di Milano. Inaugurated in 1927, over the course of the decades the campus has been expanded to encompass new campuses and given rise to a real and genuine university quarter commonly dubbed "Città Studi" (City of Studies). Specifically the pilot will be implemented in one of the biggest building of the Leonardo Campus: "La Nave" (The Ship). This is structured in two main functional areas: the classrooms used by the students and professors and the department rooms. This building was selected as it is one of the most representative for its double function, offering at the same time the opportunity to interact with a wide range of different users; moreover it is already equipped with technologies that collect data on costs of operation, maintenance, surfaces, volumes and consumptions and it has a significant potential in terms of reduction of energy consumption.

This paper describes the participatory process that defined how different kinds of users behave in the spaces of the pilot building with good and bad performances in term of energy consumption. Moreover it reflects on how these information were collaboratively transformed into future ICT services and solutions aimed at reducing energy consumption in the building.

The work was structured the same way in all the country-partner pilots, conducting a context analysis to define:

- Personas and "as is" scenarios
- "To be" scenarios and pilots requirements

Personas is a tool that represents a stereotypical description of the main classes of users that will be involved in the project and that will benefit from the pilots implementation in terms of behavioural changes towards a more efficient use of energy in the universities pilots buildings. "As is" scenarios are short storytelling describing the main situations where bad behaviours of the building users generate high energy consumption. From these tools "to be" scenarios are generated describing future situation where ICT based services support the users in having more energy efficient behaviour and where energy is saved due to partially automated systems. This work concludes with the definition of the users requirements to build the Intelligent Energy

Management System supporting the new services in all the pilots.

The following paragraphs will describe how the main stakeholders and professionals were involved right from the initial phases of the project, describing their role and collective contribution to the development of the services to be. The "to be" scenarios, jointly with the elicited users requirements, will be used in the second phase of the project as the starting point for the pilot real implementation.

4.1 Collaborative Design of "As Is" Scenarios: Users, Spaces and Problems Setting

In Milan the people involved in the design of the project scenarios were both users and more in general stakeholders of the Politecnico system. Here below a short description of each actor involved is provided, jointly with its main role in the process:

a) *Politecnico di Milano institution.* The university was involved right from the initial phase related to the writing of the proposal and was constantly updated during the development of the research project. Polimi participated to the selection of the building for the pilot project thanks to its knowledge in terms of energy management of the entire system and gave its endorsement and support. The objective of the Smart Campus project is in fact in line with the university policies in terms of reduction of energy consumption.

b) *Students.* The research team conducted a set of activities in parallel with the students from the *Urban Planning Studio* and *Interaction Design for PSSD Course* in the School of Architecture and the School of Design. The courses activities carried out focused on users' observation and interviews, adopting an ethnographic approach to investigate how people behave in the pilot spaces and allowed to bring the peculiar students perspective as users of the building in the project (table 1).

The work done during the courses, permitted to: highlight different classes of users described then as personas; describe the areas of the building with the major energy loss; detect the bad behaviours of students and professors; develop initial service ideas to overcome the problems detected.

c) *Professors.* Professors were involved through interviews and informal discussions. They contributed to highlight the current use of the offices spaces, not visible to the students, raising the awareness of the improper use of the energy in those spaces and outlining possible solutions.

Table 1: Tools used for context analysis in Milan pilot.

Tool	Description of the tool in use	Duration and frequency	Technologies/ Materials	Profile of the participants	Main results
FIELD OBSERVATION	- Observation of the users of the building during the interaction in different time of the day (classes hours, group work, breaks) - Visit of the building and the heating management spaces with the Polimi technicians	December 2012	Photos, notes	Students, professors, Polimi's technicians	- Critical behaviors causing excessive energy consumption - building's heating and lighting infrastructures
INTERVIEWS	Interviews with students and professors regarding their perception on the quality of the lighting and heating in the building Interviews with technicians and the chief of the heating management offices' responsible	December 2012 (students and professors) January-February 2013 (technicians and administrative)	Face to face interviews	Mainly students and professor	Discrepancy between the negative effect of a specific behavior and its perception by the users Users are not aware of the characteristic of the building and its infrastructure.
SURVEYS	Both multiple choices and open questions to collect specific information and unexpected inputs	December 2013	Face to face	Students	Information regarding the use of the spaces, usability issues and the perceived efficiency of the building.

From the first analysis on the consumption monitoring system and from the on-field observation with the energy managers and the students, a first mapping of the pilot over-consumption areas and the users' most significant negative behaviours has been drawn, eliciting spaces for a significant improvement in the energy efficiency management. The pilot areas where the main critical behaviors were detected are the classrooms, both during the lectures and during the group study, corridors, where the students have brakes during the day and professors' offices, where it happens that heating and lighting systems are turned on even when the rooms are not used.

From these problems, and using the personas generated, a set of "as is" scenarios, similar to the one reported in table 2, were generated.

4.2 Defining "To Be" Scenarios for Future Implementation

"As is" scenarios were used to define the energy managers perspective and were then translated into "to be" scenarios (table 2). This process was possible thanks to a joint work with managers and technicians who supported the pilot designing the system architecture, including sensors and logics.

d) *Energy Managers.* The energy managers of the building were key actors to be involved to understand the effective impact of the observed bad behaviours on the energy consumption. They

supported the data collection of the building performances and the understanding of the logics behind them.

e) *Technicians and app developers.* Professionals out of the Politecnico system participated to collective workshops and individual meetings and gave support in translating the users (students and professors) point of view into technical requirements and features needed from the system to solve the problems emerged. Properly supported by the research team, especially service designers, they actively collaborate to the definition of the "to be" scenarios, merging the description of the future solutions from the point of view of the users and the one of the other stakeholders.

"To be" scenarios have been detailed during a local workshop following these steps:

1. Analysis of all the materials and data collected during the context observation (personas and scenarios);
2. Elaboration, on the basis of the results of the step 1 of ideas of possible solutions for the users represented by the personas and for the problems represented by the "as is" scenarios;
3. Design of "to be" be scenarios as suggestions for energy saving solutions in the pilots building and service ideas and functionalities on which to build up the Smart Campus pilots requirements.

Table 2: Example of the evolution from "as is" scenario to "to be" scenario (taken from Smart Campus project deliverable 2.2).

AS IS SCENARIO 1: Working home having a room in the Politecnico.	**Technical description**	**TO BE SCENARIO 5: 3 temperature levels in the faculty rooms**
Main character: Alessandro, a FULL professor at the Politecnico di Milano **Secondary characters**: Students and colleagues Alessandro is a Full professor in Planning at the Politecnico of Milano, school of architecture. He has a studio in la Nave building one of the most famous Politecnico buildings since it was designed by a famous Italian architect. He likes very much that space but he doesn't come there often, only one or twice per week when he needs to meet his students or some colleagues with which he carries on projects. In fact Alessandro lives out of Milano in the surroundings and he prefers do not travel during the week but to stay home, for this reason his computer in the office is always on. In this way he can access it remotely for every files he might need. The only thing that he feels not comfortable with his office is the control of the heat during winter-time as well as that of the air conditioning in summer. In fact his office is equipped with a fan coil that has a hand based control system. The problem that Alessandro sees is that if he turns off the fan coil his office is always cold in winter and hot in summer. To solve that problem Alessandro always leaves the fan coil on.	The rooms of teachers have problems related to their orientation North or South. The rooms facing north have very little lighting and require artificial light constantly. The rooms facing south have a strong radiative load, which requires the constant use of curtains on the windows. The rooms are heated by forced air systems (fan coils on the floor or channelled vents with supply and return); the temperature is regulated by means of a room thermostat. The use of metal channelled vents to distribute hot air in the rooms is the most critical, because the hot air tends to stratify on top and to be short-circuited by the pick-up duct, often too close to the outlet nozzle. Furthermore, the air flow is often oversized, so those who frequent the rooms often "play" with the thermostat turning the plant "on" or "off" even in very short times, which is the index of a really bad plant management	The regulating system has three temperature levels: - 14°C, minimum temperature of the room (during an extended absence of people); - 16°C, medium temperature of the room (when there are no people in the space); - 20°C, higher temperature of the room (when there are people using the space). People presence is controlled by a presence sensor or, preferably, by the professor, researcher or PhD candidate who have the right to access by interacting with the APP. When someone enters the room the fancoil starts reaching the 20 °C temperature. When the sensor does not detect presence in the room the temperature tend to reach the 16 °C, (under this level the fancoil turn on again to prevent an excessive temperature reduction). If the professor knows that the room will be not used for an extended arch of time he can access the APP and indicate the period in which the room will be not used so to allow an extra saving of energy. In this case the room will be not heated up to the reaching of the lowest level of 14 °C.

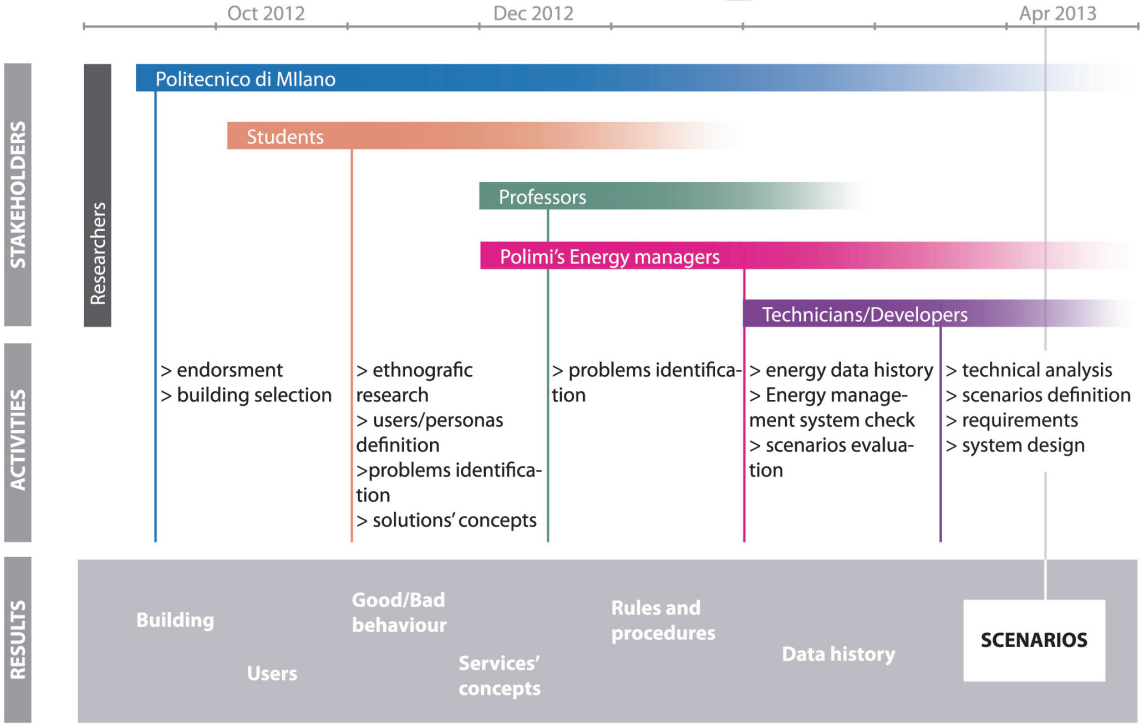

Figure 1: The participatory design process.

The dialogue and work done with the technicians moreover permitted to foreseen the effective impact of the solution further evaluating the 5 scenarios generated. The latter were translated into users, systems and functional requirements by other project partners and will be then implemented for the piloting phase in the classrooms, corridors and offices.

4.3 Main Achievements

All the 5 actors aforementioned (a-e) were involved in the design process as they represent different perspective on the project that needed to be taken into account for the development of effective solutions. The activities done by the research group through the repeated interactions with them led to the collection of the following information that were finally translated in the scenarios "to be" (figure 1):

- the detection of the building for the pilot project;
- the main users typologies involved;
- the everyday practices that users conduct in the pilots sites that mostly affect energy consumption/saving in the building;
- the rules and procedures applied by Politecnico di Milano to regulate the use of the building with respect to energy consumption/saving;
- the historical data on energy consumption of the building;

As a synthesis of the contextual research process 3 main things were outlined within the scenarios:

1) ICT based services for students and professors aiming at User Behaviour Transformation towards a more energy efficient use of the building spaces;
2) Automated solutions to save energy depending on the users behaviours;
3) Interfaces for energy consumption monitoring and management;

5 STAKEHOLDERS PARTICIPATION IN SERVICE SCENARIOS DESIGN

Energy efficiency in public buildings is a fundamental goal for both public and private institutions. Despite that its achievement depends on different factors such as the policy of the institutions but also the behaviour of the buildings users and the selections and availability of integrated technologies and monitoring systems. All these elements require the coordinated activity of many stakeholders with common goals and shared vision of the desired solutions, that are able to take into account needs and constrains of all the people involved.

In the Smart Campus project these conditions clearly emerged right from the fist phases of work, where the dialogue with the Politecnico institution started. As the project evolved it emerged the need to involve new actors in order to set the condition to create the "socio-material assemblies" argued by the PD Scandinavian school.

Moving from these considerations the research group decided to start working with the students in order to have a bottom-up perspective on the uses' behaviour in the spaces, to discuss them later on with the professors, energy managers and the institution. The definition of a set of bad habits (i.e. causing excessive energy consumption) by the students, and the generation of draft service ideas to solve them, were used as material to start involving professors in the research. The latter supported the understanding of the classrooms use but also became slowly aware of their bad behaviour in the offices spaces as well contributing to define new areas for intervention. This process started the engagement in the project of the professors more committed to the topic, preparing their participation to the following piloting phase. On the other hand the continuous dialogue with the energy managers of the university permitted to have a direct feedback on the emerging ideas, letting the researchers evaluate their effective feasibility.

The participation of all the actors mentioned and the co-design workshops and activities carried out allowed to have a holistic perspective on the problems in order to define well-articulated, innovative and realistic design. In the definition of the "to be" scenarios the designers work was to collect and integrate feedbacks, insights and suggestions from all the people involved, merging the knowledge provided by technical partners with the users perspective.

In this first phase of the Smart Campus project the idea was to "projecting", preparing the ground for future involvement of local actors in the following "design after design" process, that is the "infrastructuring" work where all the elements to implement the solution need to be included and where the "alignment" of their interest is the basis to create a partnership to run the solution in the future.

6 CONCLUSIONS

The paper discusses the process of building scenarios for ICT based services with the collaboration of users and stakeholders. This approach raise more and more interest both in public and private sector in order to develop effective solutions really adopted by the users. This holistic perspective to contexts analysis and problems detection is more and more used by Service Design to develop projects aimed at solving real problems and producing more sustainable solutions. In this field traditional tools used for research are adapted and re-designed to meet the need of involving individuals or groups into a co-generation process, supporting the inclusion of non-designers into the design process but also aligning the interest of potential stakeholders in the solution implementation.

Moving from the experience achieved in previous projects, and taking into account the Smart Campus scenario building work, it appears evident the need to start right from the beginning to include potential users and stakeholders in this process. We can refer at the process of Service Design as divided in two parts: the design of the service concept and its prototyping and real implementation with local stakeholders. In both the phases, when the service concept needs to be defined and when the future ownership of the solutions generated is not yet determined, PD approach seems to significantly increase the possibility of success for the service to be.

PD is promising to develop services with the highest level of acceptance and adoption by their users and promoters. Nevertheless the experience achieved up to date indicates that in high complex condition involving different stakeholders on relevant topics, such as energy consumption, the success of the service can not be certain.

The work done so far in Smart Campus to collaboratively build the project scenario will be the basis for the follow up of the project. Here designers' work will focus on the development of the services concepts, defining the detail of the users' journey through the service and which will be the touchpoints used to interact with the system. Then a strong effort will be addressed to the 'alignment' of the stakeholders' interests during the piloting and prototyping of the solutions, designing-after-design (Bjögvinsson, Ehn & Hillgren 2012).

This paper is a contribution on how services' scenarios can be designed using PD. The future outcoms of the alignment and prototyping phase will integrate the results achieved, verifying the effectiveness of the PD approach towards the implementation of the services to be.

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