

User-centered design for smart solar-powered micro-grid communities

Leendert W. M. Wienhofen
Software Engineering,
Safety and Security
SINTEF ICT
Trondheim, Norway
Leendert.Wienhofen@sintef.no

Carmel Lindkvist
Department of Architectural Design,
History and Technology
NTNU
Trondheim, Norway
Carmel.Lindkvist@ntnu.no

Matthias Noebels
Systems and Applications
ISC Konstanz e.V.
Konstanz, Germany
matthias.noebels@isc-konstanz.de

Abstract — CoSSMic (Collaborating Smart Solar powered Micro-grids) is an EU funded project aimed at developing a system for smart management and control of solar energy. The system must be relevant to a community of end-users and other stakeholders. Two processes are described here to contribute in meeting this aim, user-centered design and lean startup product design. We describe an iterative approach to the design of the system which incorporates these two processes and the impact it has had on results.

Keywords—*Lean development; User-centered design; smart energy micro-grid; user community*

I. INTRODUCTION

When considering renewable energy sources, like solar power, people often do not directly see the benefit of their investment. On the one hand, when the sun is shining and might be producing electricity in their homes, they are at their work and cannot use that energy directly. On the other hand, when they need the energy at night (for laundry, lighting, cooling, etc.) the solar panel is no longer producing. Indeed, research has shown that while in theory houses can be self-reliant on solar panels by the amount of electricity they produce, it would require considerable (and rather expensive) storage capacity to realize this. The drive behind the CoSSMic (Collaborating Smart Solar powered Micro-grids) project is smart management and control systems in different types of buildings (for example, a mix of residential housing, industries and schools) could connect in such a way so that more renewable energy in a community could be used than is currently possible. The advantages of such a system would enable a situation where a neighbor uses the battery from an electric car to store excess energy produced from solar panels on another neighbor's roof. CoSSMic aims to develop technical tools needed to facilitate sharing of renewable energy within a community. Two feasibility studies are being conducted in Konstanz, Germany and the Province of Caserta, Italy. While both trial locations are quite different in terms of population, solar irradiation, available equipment and electrical consumption, they have been chosen because of their current

and potential solar energy consumer use on a community scale. Amongst other goals, CoSSMic investigates how to motivate people to participate in acquiring (more) renewable energy and sharing renewable energy in these communities. It is this aspect of CoSSMic which is discussed in this paper.

The next sections will describe a general overview of an iterative approach with an emphasis on user-centered design and lean startup product design. These approaches have been used to develop concepts and prototypes for CoSSMic and incorporate perspectives of potential users and stakeholders from the trial sites in Caserta and Konstanz. A critical reflection of the approach and how it impacted on results is also discussed. The paper concludes with how the approach has aided in involving user perspectives as well as building a community.

II. ITERATIVE APPROACH TO DESIGN

Central to the work of identifying CoSSMic application concepts is an iterative approach. Specific to this work, the iterative approach involves three workshops where concepts and prototypes progressively change and develop. To be successful, it is not enough to follow an iterative process where concepts and protocols are developed with end users alone but there is also a need to feedback these results to developers of the CoSSMic technology. End-users are defined in terms of those who use the hardware and software associated and developed by CoSSMic and include owners/users of schools and residential houses. Two types of stakeholders for user-centered design are considered:

- 1) Internal stakeholders: a technical group from the CoSSMic team who represent their own goals but also act as representatives for real stakeholders external to CoSSMic.
- 2) External stakeholders: a group external to the CoSSMic project but who can benefit from the results. Typically these are also the ones which would be eligible to participate in the trial.

While concepts and prototypes come from the end users, they are then integrated into the CoSSMic systems by internal stakeholders. The objective of this is to produce results that all stakeholders will use in the CoSSMic ecosystem. Stakeholders

can be the end-users, but also the electricity grid provider, manufacturers of batteries, solar panels, etc. The process can be summarized as developing technology (Make), sharing of services and applications using a marketplace (Share) and using the service and applications (Use). The technology vendors “Make” the technology, the service providers “Share” the service, while the service recipients “Use” the service. The approach relies on user-centered design and Lean Startup product design which are co-dependent but are described in two separate sections for the purposes of explanation.

III. USER-CENTERED DESIGN

User-centered design is conducted to make the system developed by the CoSSMic team relevant to the everyday lives of the end user. The idea behind user-centered design is to improve understanding of user and stakeholder roles in the development of complex systems [6, 9]. While often such an approach is viewed as ‘something nice to do but too expensive’[6], CoSSMic teams is committed to developing concepts for the systems which are co-developed with stakeholders and end-users.

In CoSSMic, user-centered design is characterized as a multi-stage problem solving process which not only requires designers to analyze and foresee how users are likely to utilize a product, but also to test the validity of their assumption habits with regard to user’s behavior in real world tests. In this section we explain the methods used to extract feedback from potential end-users of CoSSMic.

1) *Design workshops*

Design workshops were conducted with users under the utilization of co-design games to develop CoSSMic concepts. Methods include rough prototyping, experience prototype and product box. Workshops incorporated a number of communication tools to encourage ideas and discussion to flow.

Communication tools [2]

- *Tomorrow headlines* are a communication tool to facilitate a thought process to think about the impact of the project. It is based on fictional articles or advertising images published on magazines or journals that could be composed by projecting themselves in the future and trying to understand what kind of impact the service will have on the society .
- *Story board technique* is a communication tool used to facilitate the sharing of thoughts and encouraging participation in workshops. Storyboards can also explain pieces of complex processes in a quick and effective way.
- *Service image* is a unique picture which gives a snap shot of the main features of a service concept. The service images are aimed at supporting the dialogue with the stakeholders, bringing them a vision of the service. It also supports discussion around concepts, facilitating the elicitation of the prominent aspects of ideas and the comparison between them.

Workshops were used with the aim that the user would be involved in the development of the software/technology in their homes. Results were given to software and technology developers to assist in the development of parameters and concepts in CoSSMic. Therefore creating an iterative process of involving what the users want and checking how these aspirations fit with what the developed software can provide.

There were a total of five workshops although workshops are referred to as the first workshop held in Konstanz in December 2013; the second workshop which is two workshops occurred in early 2014 in Konstanz (February) and Caserta (March); the third workshop which is again two workshops occurred in March 2014 in both participating cities. The first workshop only involved project-internal participants. Researchers put themselves in the place of the CoSSMic end users and imagined what the users would want from CoSSMic. The user centered workshops held in Konstanz and Caserta involved potential users of the CoSSMic software test cases. These user-centered workshops developed and built up technological concepts and parameters developed in the first workshop.

2) *Interviews*

Interviews are conducted to identify specific needs and values which end users want from the system. An interview guide compiled questions focused on facilitating a semi-open discussion to understand user expectation from CoSSMic. Questions therefore primarily start with how, what and why, aimed in developing a focused discussion. The interviews were not conducted by experienced qualitative researchers. The interview guide outlined instructions on how to conduct the interview and provided criteria on how to prevent bias influencing the interview. The interviews were conducted after the third workshop in each city.

3) *Innovation games*

Innovation “games” were used to develop paper prototype results. In this section we briefly introduce the games and the purpose of these. The outcomes are described in the next section.

a) *Cover Story (derived from Tomorrow headlines)*

The goal of this game is to create a product vision and to write tomorrow's newspaper’s headlines. This game is inspired by Game-storming [3] and all of the examples and templates we used were taken from this book. The below is a step by step outline of how the game is conducted as an individual activity.

- Imagine the best-case scenario for the results from CoSSMic - and then take that scenario a step further
- Brainstorms – used for writing down ideas before starting the activity
- Fill out the provided templates individually
 - Cover – states the spectacular success accomplished by CoSSMic
 - Headers – reveal what the story is about

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