End User Centred Interactive Software Architecture and Design: The Creation of Communities for a Smart Energy Use

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***Abstract*--- CoSSMic (Collaborating Smart Solar powered Micro-grids) is an EU funded project. It aims to develop both hardware and software which will include an ICT system for smart management and control of generated/consumed solar energy in neighbourhood communities. The creation process of energy monitoring and controlling of Graphical User Interfaces (GUIs) is described here. User Centred Design Workshops and face to face interviews were conducted with targeted neighbourhood communities in the Province of Caserta, Italy and the City of Konstanz, Germany. These workshops initiated the first part of the creation process and resulted in paper prototypes leading to functional and partially interactive hardware and software implementations. Thus linking the user to the technical development of the system. Furthermore a dedicated focus was set on the formation and sustainability of smart energy deploying user communities.**

Keywords-- ICT (information and communication technology); GUI (graphical user interface); API (application programming interface); user centred design; user community; smart energy micro-grid; PV (photovoltaic)

I. Introduction

CoSSMic aims to develop an innovative autonomic ICT based system. The system will control the usage, production, and storage of energy. It will facilitate both peer-to-peer collaboration between micro-grids in a neighbourhood and in collaboration with the public power grid. User Centric Design is an approach used here to involve input of end users who are to use CoSSMic software. Involving end users as co-designers was identified as priority in CoSSMic. The concepts end user identified for the system would be integrated into CoSSMic software. This software would then be tested in participating user's buildings.

This co-creation process between end users and software developers was introduced in previous published work [1] but focused on the end user input. This published work described User Centred Design Workshops held in the Province of Caserta, Italy and the City of Konstanz, Germany where information input was gained from participants. Paper prototypes were developed from the workshops which were drawn on paper and literally describe functionalities of the intended ICT system to be developed by CoSSMic. The prototypes were used for discussions in other workshops with potential trial participants (i. e. the end users) for further refinement. The concepts developed in the workshops are being integrated into a functional Graphical User Interface (GUI) using CoSSMic open source software [2-5].

The general overview of the designed CoSSMic ICT architecture is shown in Figure 1.

The GUIs are intended to be run on user owned personalized handheld tablets, smart phones and/or internet connected personal computers.

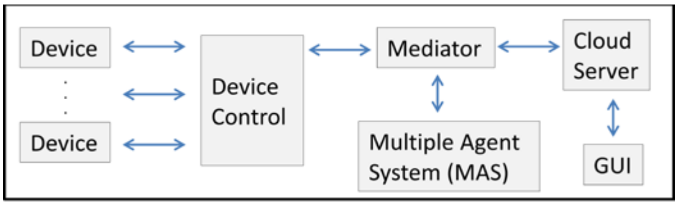

Figure 1 Overview of the CoSSMic ICT architecture. The Graphical User Interface (GUI) serves as the gate to link the users to the internet connected cloud server interactively with the CoSSMic ICT platform.

II. COMMUNITY BUILDING

Community building is a priority in CoSSMic as potential CoSSMic users can give feedback on outputs developed by the CoSSMic team. It is enabled through the approach of User Centred Design by facilitating an open forum for discussion between end users and CoSSMic software developer. The approach was conducted through workshops, face to face meetings and interviews with targeted neighbourhood communities in Caserta and Konstanz. The aim was to establish a platform for interactive information exchange on smart energy usage based on single households, industrial, public units and the wider community. The platform has resulted in interactions and close collaboration between the CoSSMic research team and potential users in Konstanz and Caserta. The process of community building has had challenges. Potential end users are voluntary in the project and their participation is time restricted. Additionally, the personal objective of the end users can conflict with the objectives of the CoSSMic project.

Continuous collaboration with end users in Konstanz and Caserta will be developed by a CoSSMic online community. Potential end users are requested to provide input on content and usability through a survey. The objective of the survey is to identify how CoSSMic can support relevant social interactions amongst users in an online community. The benefit of such a community will be a forum, where users can share their experiences of CoSSMic and gain insights from the information shared by others in the community and the CoSSMic project team. All feedback will serve as a platform for further work in the development of smart solar-powered micro-grid communities.

The trials of the CoSSMic software are expected to start in the summer 2015. The CoSSMic hardware and software is to be installed in the trial participants user households. The co-creation process on input for the design of GUIs has facilitated developing relations with and between end users and developing end-user ownership of the CoSSMic technology. One example, of, how end users benefit from being part of a CoSSMic community is illustrated in the German case. In this case, end users may comprehend that the PV system on their roof tops leads to an individual self consumption of the PV-generated electrical energy which cannot exceed the average of 20%. This is due to a time based misfit between production and consumption. The remaining 80% is fed into the local power grid which means, at present in Germany, a reimbursement to the individual end user of about 13 ct/kWh. It also leads to an ironic situation, as consumption of electrical energy from the public grid is at a cost of 26 ct/kWh from the local electricity supply company. Sharing the free 80% self produced energy inside a community such as CoSSMic with other members on demand, with an additionally integrated storage system, is likely to increase self consumption of the community to almost 100% [6-7].

III. COSSMIC USERS AND DEVICES

There are three different types of users integrated into the CoSSMic trial sites in Konstanz and Caserta, i.e. private, public and industrial users. Buildings of users differ in size, complexity, power production and consumption. At the same time there is a common ground to develop a community for smart energy use. This section firstly defines the users involved in CoSSMic and secondly defines consumption devices. The electrical vehicle is used to demonstrate a consumption and production device.

A. Users

As users we wanted to win at least ten to twelve responsible persons with their facilities for each trial site, with a preference of being already equipped with a running PV system. For the consuming devices we paid special attention that some of them are able to run with respect to their need and availability at preferred periods of time, i. e. that these devices can be regarded as so called shiftable loads.

1) Private user

Private users consist of two ensembles of six households in Konstanz and three in Caserta. They have different PV related electrical power production which is between zero and almost self-sustaining which feed also into the local power grid. And they are very different in self- and local power grid consumption.

2) Industrial user

Konstanz has four industrial users. They have a span of PV production between 4% and above 100% of their own total electrical demand. Some industrial users consume the entire energy which is produced from PV while other industrial users give away a portion of their energy production to either the local public grid or to the neighbouring consumers. To date, Caserta will not include industrial users because none were available with suitable PV installations.

3) Public user

The integrated public users mainly include schools in terms of their energy consumption and production - two in Konstanz and eight in Caserta. In addition one public swimming pool in Caserta. The swimming pool has a large PV installation providing more energy than the demand and the integrated schools in Konstanz produce an average of 28% of their electrical demand.

B. Devices

The integrated devices of managing electrical energy can be distinguished, in principle, by different main properties in terms of a consumer, a producer, or a storage unit. They also can be labelled differently as either a single running or a continuously running device. *Single running consumption devices* are, for example, dish washers, washing machines, kitchen stoves, hot water heaters, etc., which are switched on for each service run. *Continuously running consumption devices*, for example, refrigerators, freezers, air conditioners, heat pumps and electrical heaters are all driven by a set-point thermostat and a feedback loop. An electrical vehicle interestingly can be either a consumption device or once charged a producer. The production of the electrical vehicle is done when it discharges its battery during mobile service or when delivering electrical energy connected to a private local grid. But it is always a single running device.

The CoSSMic consortium has decided to use open source software called Emoncms [8]. This decision came after cross-checking against other open source available options and from a testing phase using the baseline component for storing and processing energy and sensor-monitored data on the project trial sites in Konstanz (Germany) and Caserta (Italy) [2]. The main focus is the comparison between the locally consumed and the PV produced electric energy with the demanded energy and power in the whole neighbourhood which is also supported by the public power grid. For convenience and for comparison all of these three measured values with respect to each user, i. e. their own PV production and consumption and the offered neighbourhood PV production may be displayed together and can be compared directly online.

The different software routines and programs for the GUI include an interface between the users and their integrated owner devices as well as external inputs such as weather forecast, tariffs of local power supplier, etc. These are being developed in CoSSMic and will be released as open source software.

IV. GUI and Simulations

The role of the GUI is to build the link between the users and their integrated devices (and neighbourhood and external inputs). This is done to display measured data which are continuously transferred to be included into evaluation and visualization programs. The GUI is integrated in an appliance with a user-friendly interface to enable the visualization of both, real-time information and historical data. Power changes and fluctuations within the whole neighbourhood are compared with changes and fluctuations of single systems and results are used to make subsequent adjustments.

The data will be used for computer simulations to conduct data analysis and gain information, which goes beyond the real time monitored neighbourhoods. This approach will extend the potential of the technology. Simulations of the system behaviour can be initiated and followed up directly by the GUI. The GUI helps to optimize the energy flow by the general collaboration of the trial users and their interaction in different ways. The points of system optimization are as follows:

- Load peak avoidance, peak shifting and the optimized overlay of (peaks of) PV production and (the peak) consumption which not only increases, but also optimizes through the adaption of self and community consumption. This approach goes hand in hand with a direct monetary cost minimization, but also with an indirect cost reduction, especially for future generations, as achieved through, for example, CO_2 reduction and an overall reduced need of high capacity grid installations.
- Go for direct real time energy use which minimizes the necessary storage capacity. As one example, before the energy goes into the users own storage unit, it should be proliferated to the neighbourhood.
- To show a positive effect of collective PV systems by a reduction of the total power fluctuation.
- Reduction of the energy cost as related to the degree of self consumption to improve the return of investment costs.

V. Different Inputs from the Workshop

The approach of User Centred Design involved a series of workshops where users in Konstanz and Caserta were asked to provide feedback on initial prototypes developed by researchers. For details on the sequence of workshops, please refer to [1]. The rational on including users is provided from numersous studies where residential users do not use energy saving devices as designed [9]. The composition and the background of the various user groups in the two cities led to different kinds of considerations and comments. Due to the majority of public users present during the workshops in Caserta, their suggestions were tailored at a public building use. The majority of workshop participants in Konstanz were public and industrial users, thus in Konstanz discussions and suggestions were heavily targeted for home use (from the private users side) and linked to business policies (from the industries side). The main differences emerged during the workshops seem to be related to the type of users (private, public or industries) rather than on the nationality of users, while the same kind of users share roughly the same point of view. The results of the workshops were used for the technical development of CoSSMic user interface.

The workshop comments are centred on the usability of the system. Initial feedbacks requested an interface for different types of views and for different types of users. The inputs from users of private buildings drive the prototype into the direction to be more useful for residential use, rather than for commercial or public buildings such as schools. To develop software suitable for buildings such as schools, users believed it would be useful to enable school representatives to control entire rooms instead individual devices. Hence add the functionality to configure rooms and related areas - and then to add devices to these areas. They wanted to have the possibility, to monitor the power consumption for these areas.

The public users in Caserta suggested to provide an accounting feature with different level of permission (normal users for example can set the air conditioning in their rooms but not in other rooms and similar). They wanted to have a functionality of an automatic discovery and setup of all the devices with minimum setting effort. Private users from workshops in Caserta were more focused on the economic aspect than public users. In fact they would like to see a chart that indicates the credit and debit based on the users' consumption. A booking system for energy conditions was also proposed - book in any case or book only if CoSSMic energy is available. Users in Konstanz were more focused on the energy monitoring of a house on device level, plus controlling devices. The Konstanz users would like to have a functionality to manage priorities (assigned to tasks) and have tasks with little priorities cancelled in the case of low green energy. Also the feature to decide upon whether CoSSMic would control or not control the devices would be very appreciated by this group of users.

In the final workshops in Konstanz and Caserta, built on previous workshops, control of the system was once again emphasized. Control was considered in terms of the CoSSMic project's monitoring capabilities and the aspiration of not having set limits on power but limit and control the daily energy consumption. There were also considerations based on presentations and types of information, in which users wished to ascertain from a CoSSMic system, for example the past history of the consumption of devices. There were some conflicts identified, when integrating users' views into the GUIs based on what users want and what the CoSSMic goals can achieve. For example, the users want to optimize the energy consumption of their own households while CoSSMic is focused to manage the neighbourhood energy optimization.

During the workshop other aspects not relevant to the software development emerged but they are important for consideration in implementing the software for trials. Some public users in Caserta presented concerns regarding responsibilities of the project and user participants. These concerns included the installation of components: "The tools for the measurements shall be given on loan for use?" "Who preserves these devices?" "It is possible that the system will be damaged?" "Who pays if something breaks?" These comments originate mostly from public users.

Control is a key concept which repeatedly came out of the workshops. Control of the system occurs on different levels – control of energy/power levels for devices; control of information and control of monitoring. Therefore, taking a look at the type of controls is necessary in integrating user's perspectives into CoSSMic. However, CoSSMic requires monitoring control in order to ascertain real results of energy consumption based on the software being introduced. The impact of this control needs to be balanced to reflect the reality in which users want to use the system in order to alleviate any unintentional influence CoSSMic objectives have on the results.

VI. From Requirement Driven Mock-ups to the GUI

The mock-ups and the paper prototypes produced with the workshop inputs and requirements are the starting point to create the GUIs. The GUIs provide the link for the users to monitor, control, and drive and interact with the devices which are further controlled by CoSSMic. Furthermore the GUIs provides insights to the user related to the data gathered by CoSSMIC around the weather forecast, tariffs and on energy availability and demand within the CoSSMic neighbourhood.

The baseline paper-prototype for a first workshop was created in the project together with end-users in the first phase of the lean user interface iterations, see [1]. As one resulting consequence, the next development has been designed with a more household end-user perspective in mind.

During the workshops, it was confirmed that the strongest interest from the users into the graphical interface are energy monitoring on a house and device level, plus controlling devices. The controlling of devices is a more complex topic as it intersects both the optimization of the usage of the devices in the house by CoSSMic and the control of the user experience by the end user. Overall, the controlling of the devices is affected by constraints both of the device types and of the optimizations to be performed by CoSSMic.

One of the main ideas behind CoSSMic is to have the CoSSMic system capable of triggering the operation of the devices in the time span which would lead to higher energy efficiency. Besides this automation, the users suggested that they could be interested as well in using the CoSSMic GUI to turn on and off devices more easily, like using a universal remote control. Industrial users also suggested the possibility to measure and to control entire rooms instead of individual devices. However, this would rely on the instrumenting of all the devices on the same room, which would not necessarily be feasible in most of the sites. At the same time, there would be a conflict between the different device types, existing in the rooms and their level of control. This could probably be overcome by allowing the user to link devices to rooms and/or set overriding policies. However, those features would highly increase the complexity of the GUI, at higher investments and bringing additional value to relatively few users. For that reason, a room controlling option was ruled out before deciding on the specific challenges of the control of the different types of devices.

Suggestions emerged from the user workshops on how to manage the different levels of controls (i. e. whether and how CoSSMic controls the device and whether the device should be turned on/off). These suggestions included having distinct on/offs for both enabling/disabling CoSSMic control and turning on/off the device; and having priorities linked to the controlling of the devices to allow the users preferences or maximum load limits to rule the operating behaviour of a device.

The acceptance of all the suggestions would translate into too complex requirements to match an intuitive and self-explained graphical interface. Moreover, they also led to many open questions such as: "Should the users set a priority for all devices?", "Should they be able to set those priorities each time they use the device or just once?", "Will the users understand the situations on which the non-high priority tasks could be cancelled without using much of the GUI or end-user manual for explaining each behaviour?". "Would users become disappointed in case a task is cancelled even if its priority was high?" and "Would they get confused in between turning on/off a device and disabling the CoSSMic control over a device?"

Based on the questions above, the decision to simplify the system was taken by the CoSSMic research team. The simplification led to the development of the GUI that did not inclde priorities on tasks and nor the disabling/enabling of the control of CoSSMic. To account for the user views in this area, the CoSSMic research team is planning to allow the user to specify most appropriate constraints for the CoSSMic control of the device (such as temperature ranges for heating devices, for example) which reflects the importance of the task and of executing it in a certain time, as we will explain later on. That approach is also more coherent with the mindset of delegating the control as much as possible to CoSSMic and avoiding the control of devices, when that would disrupt the user experience.

Regarding the user expectance, some devices deliver a service by the completion of a task, such as washing the dishes, vacuum cleaning the house, etc. While other devices deliver by being turned on during a specific time, such as lights, TV, etc (the latter are referred here as "specifically timed action, non fixed duration" devices). While it is possible to postpone the operation of the first type of device without affecting the user experience, you can't postpone the latter. In other words, it is acceptable for the system to assign an executing time for the dishes to be washed (as long as they are washed within a certain time duration on the day), but it is not acceptable for the system to tell the user when to watch TV. Watching TV, turning on lights and the usage of other "**specifically timed action, non fixed duration**" devices would lose their sense if performed at a time slot not decided by the user.

This means that it doesn't make sense to have CoSSMic controlling **specifically timed action, non fixed duration** devices. As a consequence of that, it was decided that those devices would not be controlled by CoSSMic, nor CoSSMic would provide a GUI to turn them on/off (as a remote control). Instead CoSSMic controls all the other types of devices, and those are controlled by user experience and expectation related constraints relevant to those devices.

Analyzing the remaining type of controllable devices and the different ways to control the user experience derived from them, the CoSSMic team decided on three categories: **single-run devices**, **continuous-run devices** for heating, cooling and air-conditioning, heat-pumps and **chargeable devices** as already mentioned in section IV.

Single-run devices basically execute their task as a single, one-step run. Those devices are determined that the user sets the earliest start and the latest finish time of the task. So for example in the case of a washing machine, the user can set the earliest start time when the clothes are loaded and the latest finish for a specific time when they should be ready washed. This same type of operation is used by dishwashers, robotic vacuum cleaners and tumble dryers.

On the other hand, **continuous-run devices** operation are not linked with an outcome for a single discrete time, but rather with obtaining and maintaining a certain state. For those devices, the user preferences are set based on a range of ambient characteristic values (such as for example a temperature or humidity level) around the desired state selected by the user. The ambient characteristics will be measured and fed back to the system to tune its control. Those devices include air conditioners, humidifiers, heat pumps, heaters, etc.

At last **chargeable devices** have internal batteries, for electrical energy storage and the system can take advantage of the energy autonomy and reserve created by the batteries to tune the charging schedule. This could be done for any chargeable battery powered device such as mobile phones, cameras, laptops, e-vehicles as bicycles, cars, scooters, lifters, etc. and stationary secondary battery modules for storage purpose only. In the CoSSMic project only e-cars and stationary battery modules are under investigation.

Finally another suggestion came mainly from the industrial users who would like to provide different access levels to different employees. They would also like different users to have different energy views. However, due to the limitation of resources it was decided to focus first to accomplish a stable and overall accepted single user GUI and later to look into a multi-user scenario. In any case, the system access will be already protected by an authentication mechanism that is offered by the underlying platform in which the GUI is being developed.

VII. The developed GUI

The result of the previously mentioned analysis of the users' suggestions resulted in revised GUI mock-ups and in an initial running first prototype. The running prototype was not yet complete and fully functional at present (April 2015) as many features depend on other back-end components which are still under development. Therefore, to describe the final GUI, we have used a mix of both mock-ups and real HTML (hypertext mark-up language).

The GUI is divided in four different parts: a main entry screen (**the Summary**), a screen to visualize the scheduling of the different devices controlled by CoSSMic (**Home Control**), a screen for configuring the devices (**Settings**) and a screen for visualizing the energy consumption and generation in the household (**History**).

The **Summary Screen** in Figure 2 provides a glance and overview of the status of the system and therefore relies heavily on the usage of displayed graphics. An overview of the current status of the household energy sourcing (i. e. the amount of consumed energy coming from the public grid, from inside CoSSMic, from the battery, the PV installation and the amount of shared energy which is going to the CoSSMic neighbourhoods or to the public grid) is represented through stacked bar chart quickly informing the user who is supplying and consuming the energy used and produced in the site. Under the stacked bar chart, there are both, a widget with the weather forecast for the day and the overview of the total energy production and consumption in the CoSSMic neighbourhood. This information can be useful for the user to estimate when a surplus of energy will be available either from their own PV installation or from the CoSSMic community. In this way, they can plan better for their own energy usage. Lastly, the accumulated energy shared with CoSSMic is also displayed on the **Summary Screen**.

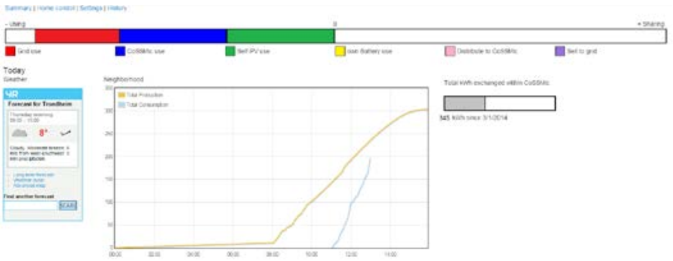

Figure 2 Summary Screen with left and further graph for total production and consumption.

The screen “**The Settings**” shows in Figure 3 the list of devices, which are connected inside the system including the devices which are not controllable such as PVs or "**specifically timed action, non fixed duration**" devices. Then, for the configurable devices, the user can select the device and configure preferences to set boundaries for how and when the CoSSMic system can turn on/off the device. As illustrated in Figure 3 single-run devices such as the tumble dryer machine are configured by setting of the earliest start time, latest start time and its program type.

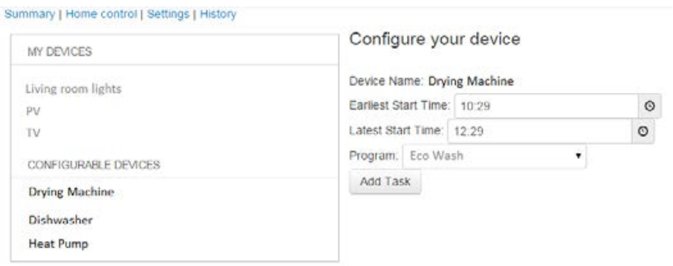

Figure 3 The Settings Screen

The setting of **continuously running devices** for heat/cool/ambient has been modelled in a similar fashion to manage central heating control systems. The user sets a range of maximum and minimum temperature for the periods when residents are at home (Standard) and for the periods where they are away (Eco). Together with that, the user defines on a weekly basis the periods of the day when the user expects to be at home and away. Such control is represented on the mock-up corresponding to Figure 4 for a heat pump set-up.

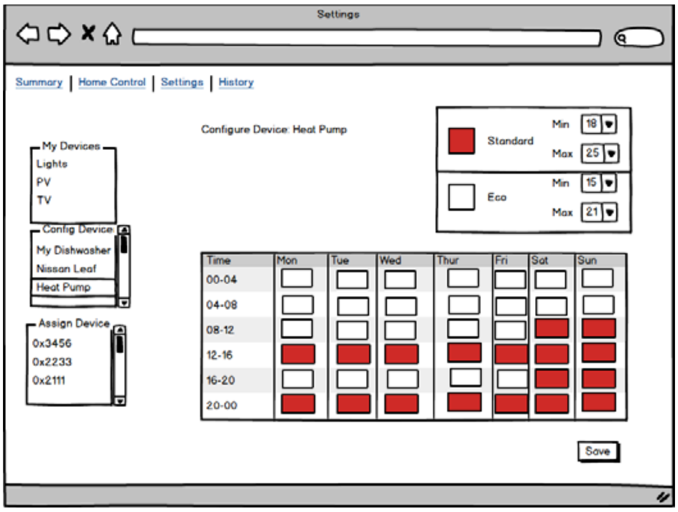

Figure 4 Heat Pump setting

The e-car and the stationary chargeable devices (secondary batteries) have been the most difficult devices to find a suitable charging configuration option. Their usage largely follows the same pattern as the "**specifically timed action, non fixed duration**" devices, however, the battery offers more flexibility for the provision and usage of electrical energy. As a result of this flexibility,it was decided to limit the configurations to: 1) setting a minimum battery level to always be charged with high priority when connected, to be able to run spontaneous errands; 2) Setting a charging percentage and a time, at the latest time the car should be charged. For example, the battery should be charged at least 70% by the beginning of the next day. Such a configuration is shown and illustrated with examples in the following Figure 5.

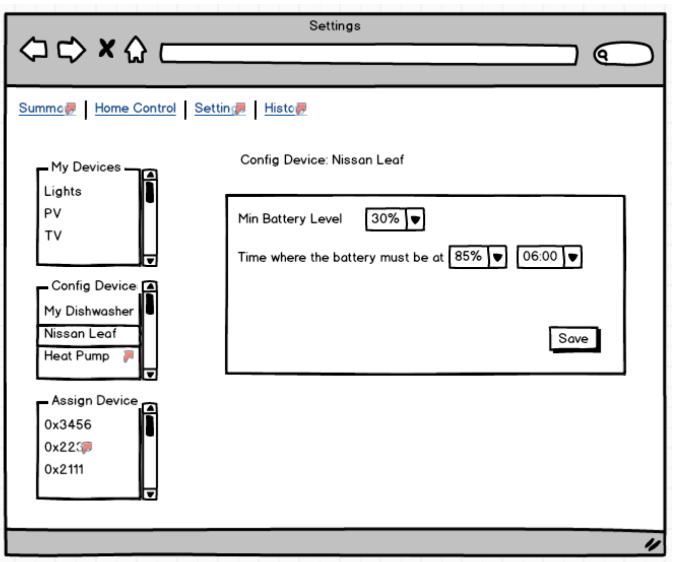

Figure 5 Settings of e-car

In order to elucidate the process of charging of an electric vehicle and its integration into the CoSSMic ICT system by online monitoring and control, one selected technical example describes the following section.

The State of Charge (SOC) of a battery must be known and the maximum charging current during the loading process alterable to control and estimate the loading profile of an Electric Vehicle (EV),. Both parameters were accessed by the integration of two system solutions, provided by manufacturers.

Charge controller

The ability to communicate to already affiliated EVs about charging privileges, as required by regulation IEC 61851-1, was made possible through the integration of a charging controller provided by Schletter GmbH (EWS-Box). The EWS-Box, through communicating over Ethernet/TCP, enables the controlling system to start and stop charging; it sets the maximum charging current and in this way, controls the current charged power. An integrated metering system enables the system to log previous charging profiles.

Manufacturers Website

Due to the mobility of EVs, the current SOC can either only be accessed, if the cars location is near authorized devices where communication is feasible or as provided over an official web-server. This server constantly communicates with the vehicles over the network provider and can be accessed by authorized devices. In our approach, the provided web- or smart phone-applications were integrated into the CoSSMic data acquisition system Emoncms, to extract the SOC of the EV. Because no official API could be provided by the manufacturer, a virtual web-browser was adapted and installed, to automatically simulate the website and the necessary authentication process. The access and authentication to this “Car-Net” website of VW though, seizes a lot of resources of the Raspberry Pi, due to a significant amount of JavaScript background processes to verify e.g. that it’s being up-to-date. This approach is ongoing for further improvements.

The overview of all tasks which should be managed by CoSSMic is listed and displayed in the “**Home Control**” screen as illustrated in Figure 6.

Summary | Home control | Settings | History

Device Name	Status	Program	Earliest Start Time	Latest Start Time
MyDrier	Not yet scheduled	eco	12:22	13:22
MyWash	Not yet scheduled	eco	18:19	19:19

Figure 6 Home Control

While the “**History Screen**” shows a stacked graph of consumption and production of energy, together with sources and destinations, and a graph with the energy consumption of the different devices in the user’s house. Both graphs can be displayed in a daily, monthly, yearly time frame and navigated in the time perspective as shown in Figure 7.

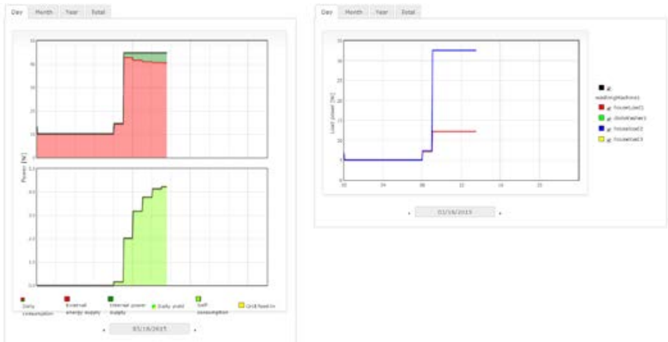

Figure 7 Graphs from History Screen on which is displayed the self consumption (left bottom), again the self consumption on top of the external energy supply (left top) and two different loads (right).

VIII. Discussion

The user-centred design process is a very valuable way of receiving real user input to a research task. The different user groups helped to map the different needs and as a result, structured the final prototype. One drawback is that not all viewpoints can be implemented for different reasons. For example, the priorities were not implemented even though it was on the "wish list", and valid arguments were given to the users about the reason for this. Furthermore, the type of home control features for "specifically timed action, non fixed duration" devices were rendered as not feasible for CoSSMic, even though the concept of home control is nice. Though the drawback of implementing all of them in the frame of the running project would simply be too large for our setup scenario.

However, the analysis of the remaining type of controllable devices gives a good grouping of functionality that does fit the CoSSMic vision.

IX. Conclusion

The approach realises graphical user interfaces (GUIs) as an interfacial link between the expectations and wishes of participants of designer users’ workshops and interviews within the project CoSSMic and the technical requirements. The set up of an ICT based system for smart management and control of generated and consumed solar energy in end user centred neighbourhood communities has been reached successfully.

The method of the empirical approach was applied. The process started with surveys of interested potential community members in workshops and with interviews and questionnaires, which were held in Caserta (Italy) and Konstanz (Germany). This was an adequate way to generate the necessary input information. In iterative feedback loops, together with the users, with special focus on community building and sustaining them for future smart energy use, the interface between the technical and the users’ requirements could be realized and established as GUIs.

The present results on community building may serve as a platform for further growth, cross linking and finally networking of “Collaborating Smart Solar-powered Micro-grid” communities. The next steps are likely to include community forums and administrative help lines to facilitate the different information exchange.

The fostered exchange of information and energy in an ICT managed and user optimised neighbourhood based electrical energy system points the direction to self-sufficiency and energy autonomy.

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