YouPower – A Social App for User Engagement in Power Grids

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Abstract: The abstract should summarize the contents of the paper and should contain at least 70 and at most 200 words. The text must be set to 9-point font size.

1 INTRODUCTION

This paper presents the design of YouPower, a social smart grid platform that is designed as a means to explore the potential and challenges of supporting social participation, awareness and engagement of power gird users (`https://app.civisproject.eu`). The goal of developing such a system is to make energy visible, to inform users' energy know-how, to promote pro-environmental social norms, and to facilitate users in their day-to-day life to take energy-friendly actions together with online communities.

X The idea of linking smart grids with (online) *Social Network*s (SNs) as a joint R&D topic has recently caught much attention in media (Boslet, 2010; Chima, 2011; Erickson, 2012; Fang et al., 2013). There are many research efforts on either topics, but research on combining SNs with smart grids has just started. A number of recent works propose frameworks or approaches that interconnect smart meters (or smart homes) as SNs for energy management and sharing (Ciuciu et al., 2012; Steinheimer et al., 2012). In addition, Silva et al. (Silva et al., 2012) conducted surveys to understand user needs for energy services including SN services. Several frameworks or simulation models for demand side management and value-added web services with SN aspects have been developed (Chatzidimitriou et al., 2013; De Haan et al., 2011; Lei et al., 2012). Others have used simulation models to demonstrate the feasibility of social coordination in supply and demand (Skopik, 2014; Worm et al., 2013). Our research interest expands on the related work in that it focuses on smart grid user communities. The research is performed within the framework of the EU FP7 CIVIS project (`www.civisproject.eu`).

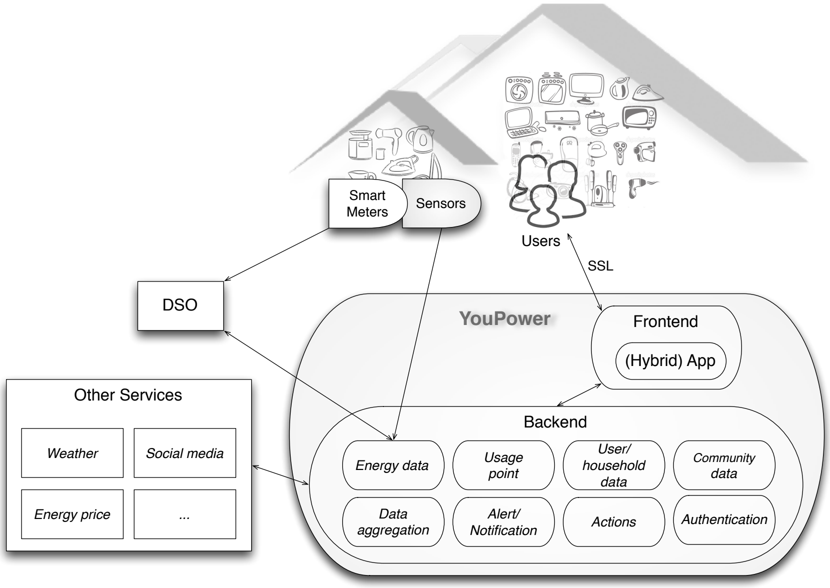
Project Context

2 STATE OF THE ART

Prior to designing YouPower, we first review existing proposals for social platforms in the context of power grids. Second, we summarize the findings about success of different consumer behavior change interventions and strategies. One of the repeatedly reported drawbacks of different solutions aiming to involve consumers is a lack of their sustained use (Edward and Jones, 2015). Iterative and lean design process that we adopt is suggested as a promising approach to tackle this problem (Schwartz et al., 2014).

Weiss et al. (Weiss et al., 2012) developed a smartphone community platform, PowerPedia. The platform works in connection with smart meters and enables users to identify and upload their own appliance-level consumption statistics. After upload, the users can compare their appliance consumption with other users. The platform was evaluated in a lab setting and the test users rated favorably social comparison features and appliance level statistics.

Community Monitor (Dillahunt and Mankoff, 2014) is a social energy app deployed on tablets



DSO (Distribution System Operators), SSL (Secure Sockets Layer)

Figure 1: YouPower system overview

that was tested in two distinct communities for 4-10 months. The app featured leaderboard, message board and shared actions ("ways to save"). The findings from the trial revealed importance of environmental, social and cultural context for the app use. For instance, the existence of common spaces for community members to interact and knowledge of other users supported the app use. On the other hand, shorter length of residence or rented apartment negatively affected the engagement. Community Monitor did not manage to engage users around the message board feature.

Petkov et al. (Petkov et al., 2011) delve more into the details of comparative feedback. Their findings confirm importance of comparisons to similar users in terms of energy consumption and neighbors. However, if the competition features are included, then the users preferred to compete with the people whom they actually know and especially with their friends.

X Considering the analytical frames and the CIVIS use cases, we chose a set of platform features and translated those into three self-contained and composable parts to be included in the CIVIS (front-end) application (hereinafter abbreviated as CIVIS app):

With peer review results and users' feedback on the design, adaptations and changes are made to suit user needs and to achieve the CIVIS research goal. In general, the application aims to enhance users' energy know-how through action suggestions that are implementable in everyday life, engage users in energy communities with understandable and actionable information and feedback, and facilitate community interaction and self-teaching by means of group discussions.

Given the time and resource constraints, the app can not be developed all-in-one cross-platform (for phones, tablets and computers). We chose to design the front-end as a mobile app. This means that the app design has layouts and user interactions that suit (small) phone screens. Western Europe has a large mobile phone internet user base[1]. Many surveys show that mobile apps have advantages such as creating deeper user engagement, easy sharing, among others[2]. This makes mobile app a good choice given the goal of the CIVIS platform. Once developed, mobile apps can also be more easily transformed to web browser versions, while the reverse is more difficult. The back-end of the CIVIS platform will remain mostly the same independent of the front-end alternatives.

[1] Between 2013 and 2017, the penetration rate of mobile phone internet users among mobile phone users will rise from 49.0% to 77.8%. See more at:http://www.emarketer.com/Article/Nearly-Half-of-Western-Europeans-Will-Use-Mobile-Web-This-Year/1010510\#sthash.AaVfsqIU.dpuf

[2] https://infomedia.com/blog/the-advantages-of-mobile-apps/, https://econsultancy.com/blog/62326-85-of-consumers-favour-apps-over-mobile-websites/

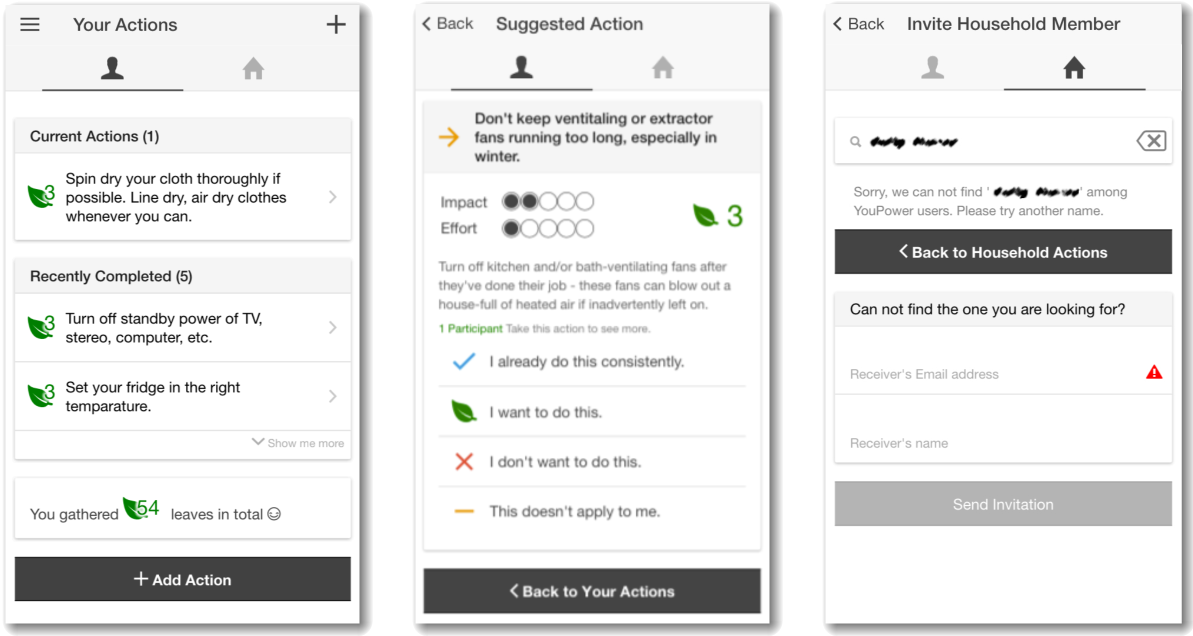


Figure 2: Action suggestion part of YouPower

3 DESIGN CONCEPT

3.1 Action Suggestions

This part of YouPower (see screenshots in Figure 2) aims to provide users easy access to practical and inexpensive suggestions (or tips) to (1) increase energy awareness, (2) inform energy know-how, and to (3) shape their long-term behaviors related to household energy consumption. We collected about 50 suggestions (`https://goo.gl/R11QdZ`) from credible sources such as national and international energy agencies and associations. There are routine actions such as “don’t keep hot water flowing when you wash your dishes by hand”, regular actions such as “defrost your fridge in x days”, and one time actions such as “install a programmable thermostat”. Each action is accompanied with a short explanation that mainly focuses on intrinsic values to target long-term sustainable behaviors, the estimated impact and entailed effort (on a scale of 1 to 5), and the information about how many users are taking the action.

Users can choose to take a few actions at a time and are suggested with a new action when one is completed. Some suggestions can be triggered by time, e.g., “defrost your fridge in x days.” In such cases, the app reminds the users of the pending actions they are interested in. When an action is completed, the user is awarded with points (displayed as *Leaves*) associated to the effort and impact level of that action. A user may also choose to abandon or reschedule an accepted action. Upon action completion and cancellation, a user is asked to give feedback. The user may “like” and “share” an action, rate the effort level of the action and give comments.

Engagement in Household and Communities To engage each member in a household, the app allows a user to add members (who are also YouPower users) to his/her household. A user can see the actions of household members, and add their actions to his/her own action list. A user can also join communities and participate in discussions to exchange their ideas and share experiences. The top actions (the ones with most participants) in a community are displayed to members to introduce social norms.

Personalization and Localization A user has a personal profile and a household profile. We allow a user to customize the display name, preferred language (English, Italian or Swedish), and to provide information about the household composition, home type and size, major appliances, etc. The information is useful for personalized action suggestions, the comparison of similar households and individuals, and can be used for research purposes. A user (at the test sites) can link YouPower to the household’s (DSO and sensors) energy data if an data account is provided. In such cases, the app customizes its content to a user’s test site: housing cooperatives content for the Swedish site and load-shifting content for the Italian site. They are discussed in the next two subsections.

Design Evaluation The design was evaluated by peer reviews, a study with 24 participants in an environmentally-oriented event in Helsinki (`https://oscedays.org/helsinki/`), and a workshop with nine participants in the Italian test site. In general, people liked the idea of receiving action suggestions. They like to see the impact of their actions and asked for easy to perform actions. The majority was interested in collaborative community actions, e.g., to save together and to donate for a common goal. Very few had interest in competition. Many expressed the opinion that monetary savings are only somewhat important to them. They were also skeptical about how much money they can actually save. They instead showed interest to learn about energy saving strategies as they are driven by more intrinsic motives. Some participants think that the others (in their neighborhood or city) do not put the same effort in energy conservation as themselves do. The YouPower approach to display other people's actions may have the potential to motivate people seeing the others' efforts. Some suggested that for those who do not have or are not comfortable with smart-phones, the app should be made available through a browser.

3.2 Housing Cooperatives

This part of YouPower (see a screenshot in Figure 3) is considered for households in the Stockholm test site. In Sweden, each apartment or house owner is a member of a housing cooperative that owns the property and annually elects a board that is in charge of the finances and maintenance of the property including making energy related decisions. Such a housing ownership concept exists in a number of EU and non-EU countries. Three main categories of features are designed for this part of YouPower: energy information about a user's own housing cooperative, energy information about other housing cooperatives, and support for communication between energy managers. Expected primary users are energy managers and board members of housing cooperatives. Secondary users are ordinary cooperative members.

Housing cooperative energy information includes comparative energy performance and the cooperative's monthly and yearly energy use, divided into heating (including hot water) and facilities electricity. Energy actions that have been taken are listed in relation with energy consumptions. A user can see when different actions, such as energy information, optimisation or investments, were previously taken and see more details about the actions. By comparing the energy use with previous periods, the user can also see the impact of the actions. In the same way that the

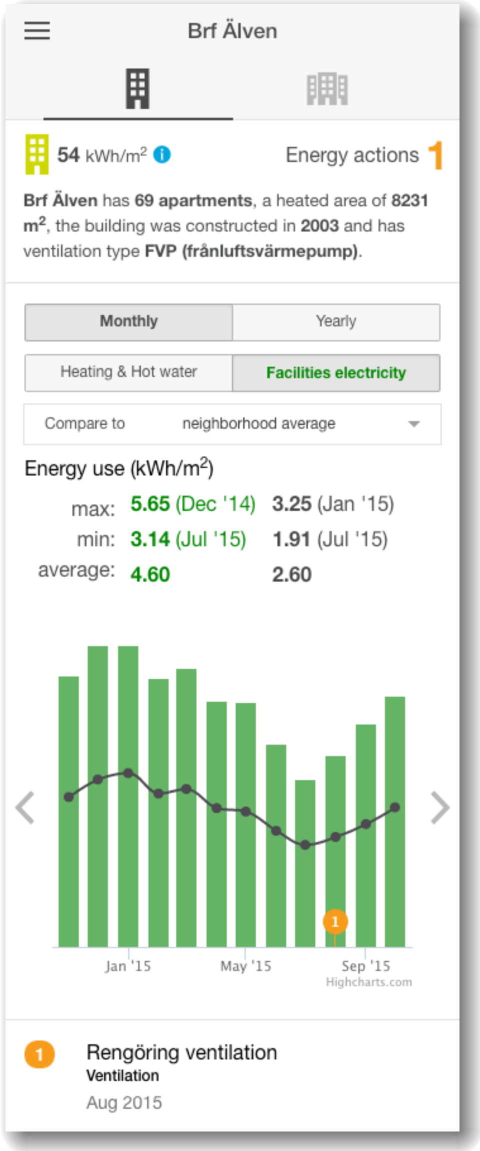


Figure 3: Housing cooperatives part of YouPower

users can view information about their own cooperatives, they can also see the energy performance and energy actions taken by other cooperatives. This allows energy managers and others who are interested to e.g. explore the effect of a neighbouring cooperative's actions on their energy use and read about how they carried out an investment and which contractor was used. To further support collaboration and knowledge exchange between housing cooperatives, there is a discussion group dedicated for energy managers. Within the group they have the possibility of creating discussion topics of their interests. In this way, the discussion of the occasional meetings with the local energy network can be extended to continue online.

Design Evaluation The design was evaluated with three energy managers and the feedback was incorporated in the design improvement of the application. The energy managers would primarily want to use the app to find housing cooperatives with similar challenges and see what actions they had taken. They also thought the app would be helpful for deciding which companies can be trusted based on what other housing cooperatives had done and what the effects were on the energy use. The energy managers doubted that other members in their cooperatives would be very interested in following the cooperative's energy use, but they thought the app might be useful for engaging members in specific questions.

3.3 Energy Data

Three different levels of energy consumption data are displayed in the app: household, appliances and community. At the household level, the current and historical consumptions are displayed. For users with production from renewable sources – many households from the two Trentino pilot sites have roof-installed PV panels – the app compares production and consumption levels with the aim to raise awareness of different prosumption patterns and to maximize self-consumption. For users with installed smart plugs, the app visualizes consumption patterns at the single appliance level. This is meant to enable users to gain a deeper understanding of the relationship between their daily actions and the resulting energy consumption. At the community level, aggregated data is displayed on the energy balance of a community. In Italy test sites, a community refers to a whole energy consortium, while in Sweden the housing cooperative a user belongs to. The aggregated monthly consumption and production levels are reported. The share of self-consumption is also reported.

Dynamic Time-of-Use Tariffing In the Trento pilot site, the main focus is to leverage load elasticity to maximize self-consumption of locally-installed Renewable Energy Sources (RESs). This means that electrical loads shall be shifted to the time of high production. In order to achieve this, the lever identified has been that of price, actuated by means of a dynamic time-of-usage tariffing scheme. A predictive engine has been designed to predict the level of production from renewables in the subsequent 72 hours. The engine, which is based on a linear prediction model, uses weather forecast data (solar radiation data) from both public and private sources (Meteotrentino `http://www.meteotrentino.it`, OpenWeatherMap `http://openweathermap.org`, Fondazione Edmund Mach `http://www.fmach.it` and US National Weather Service `http://nomads.ncep.noaa.gov`) and historical data about the production of single renewable plants provided by local energy consortia. Estimating consumption patterns based on historical data, a matching engine is designed to forecast whether there will be surplus of local productions. If so, a favorable price is offered to users as an incentive for them to move flexible loads (e.g., dishwater and washing machine) to the perspective time intervals. A higher prices will be used to discourage the use of energy-intensive appliances when local production level is low. In the app, the energy price is forecasted for the next 72 hours, divided into three-hour intervals. Each interval has a constant price.

Donation A user's contribution towards a better community energy load balance can bring about economic benefits for the electric consortia. In both Trento test sites, local generations from RESs exceed consumptions at the aggregated yearly level. Yet there is a timing mismatch so that in order to serve consumption peaks the consortia have to buy (expensive) electricity from the national energy market. At the same time, there are time periods during which production exceeds consumption so that excess energy has to be sold typically at a much lower price on the market. Thus, the local stakeholders foresee the potentials of donation programmes. Users in the Trento test sites can optionally sign up for a donation programme organized as a crowdfunding campaign. Each donation programme has a well-defined beneficiary. The app gives a description of the programme, information on the current status of the campaign, i.e., how much has been collected with respect to the goal, and plots the trend of donations.

Design Evaluation The design of the energy data visualization and comparison part has been validated incrementally with users in the Trentino site. Two focus groups and four workshops were conducted. During the focus group events, ideas about the possible functionalities were used as probes with the participants. During the workshops, practical activities were carried out with the participants in order to develop an idea of the most desirable features and then to receive evaluation feedback. One issue that emerged was the interest in the production data and the ability to maximize self-consumption. The ideas of the dynamic ToU and the donation programme were also well received.

4 MANUSCRIPT PREPARATION

Group 2. Additionally, you may wish to copy and edit the following 3 example files:

- `example.bib`
- `example.tex`
- `scitepress.eps`

4.0.1 Tables

Table 1: This caption has more than one line so it has to be justified.

Example column 1	Example column 2
Example text 1	Example text 2

4.0.2 Equations

Equations should be placed on a separate line, numbered and centered.
The numbers accorded to equations should appear in consecutive order inside each section or within the contribution, with the number enclosed in brackets and justified to the right, starting with the number 1.

Example:

$$a = b + c \tag{1}$$

4.0.3 Program Code

Program listing or program commands in text should be set in typewriter form such as Courier New.

Example of a Computer Program in Pascal:

```
Begin
    Writeln('Hello World!!');
End.
```

5 CONCLUSIONS

ACKNOWLEDGEMENTS

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