CITYOPT - HOLISTIC SIMULATION AND OPTIMISATION OF ENERGY SYSTEMS IN SMART CITIES

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ABSTRACT

CITYOPT is a collaborative project supported by the European Commission through the Seventh Framework Programme (FP7). CITYOPT mission is to optimise energy systems in smart cities. The project will create a set of applications and related guidelines that support efficient planning, detailed design and operation of energy systems in urban districts.

CITYOPT develops a French case study in Nice Côte d'Azur (NCA) which focuses on optimisation scenarios related to demand response services to reinforce the continuity of service in the fragile Provence Alpes Côte d'Azur (PACA) electricity supply network. An Internet application called Community Network for Energy is developed and will be tested with 200 citizens living in Nice. Participants will be rewarded for their efforts in response to the utility's requests with CITYOPT points, a virtual currency which they can convert to support the realisation of local community projects for their city.

INTRODUCTION

The CITYOPT NCA case study takes place amid restrictions of energy use at certain times of the day due to dated electricity infrastructure. Indeed, Nice depends on a single high voltage transport line which supply electricity to the south east of France (around 5 Million inhabitants), covering in particular the densely urbanized coast from Marseille to Menton. Due to the tourism attractiveness of the region, the population can double in certain towns during summer holidays. As an answer to the recurrent problem of load demand, the French electric energy supplier EDF is forced to use thermal power plants which generate important CO2 emissions and have a high cost in terms of maintenance.

The Nice case study will develop and experiment a web-based application to encourage energy saving behaviour in a community of citizens. One of the outcomes will be the assessment of how this community responds to demand-response solicitations. 200 volunteers will be recruited to join the experiment. The only requirement to participate is to be an EDF customer equipped with the French Smart meter Linky, which is currently being rolled-out by ERDF in several neighbourhoods of the city of Nice. The smart meter is needed in the experiment for the evaluation of behaviour change and the calculation of energy savings after the solicitations.

This paper presents intermediate research results obtained on the NCA case study including the outcomes from the user research conducted with the local stakeholders, and an overview of the developed CITYOPT application and its functionalities.

ENERGY AWARENESS APPLICATIONS

Unlike most consumable goods, energy is abstract, invisible and intangible. Therefore, without tangible manifestation, the impact of different energy consuming behaviours and routines often goes unnoticed and the majority of people have low levels of energy literacy [1], while their behaviour can have a significant impact on energy use [2].

In the residential context addressed by the CITYOPT NCA case study, the information made available on domestic energy bills and meters does not support an understanding of energy use, despite many consumers exerting considerable efforts to interpret this information in a meaningful way [3]. Thus, energy is hardly visible: in most households with neither energy bills nor energy meters providing adequate tools for managing energy demand and control energy expenditures.

Social interaction within and between communities has a large effect on peoples' behaviour and the uptake and use of technologies [4] highlighting the business and environmental potential from the application of web-based business models which could be harnessed to support virtual energy efficient communities of practice [5]. However, the benefit of the energy consumer to underpin these new communities of practice must be clearly understood and communicated [6]. Given the low levels of energy literacy in the domestic context and the possibilities presented by web-based business models, it is not surprising that the design of energy awareness solutions is a growing topic for research and innovation communities. The European Commission's latest Energy Efficiency Directive [7] states that consumers have a

right to know how much energy they consume: the roll-out of smart meters will reshape supplier-customer relationships [8] and encourage further work on energy awareness solutions.

A review of existing solutions conducted in 2012 [9] identified 26 tools mapped across the following two axes: Information and Engagement / Private and Public sphere. The private sphere concerns the user's personal attitudes and behaviors in relation to the household. In a broader perspective, the public sphere concerns the patterns and behaviors that define the users and their families in relation to the values, reference points and rules of their own community. Previous research has addressed the importance of considering collective impact [10] and has also investigated the potential use of social networks for conservation [11]. The Internet application developed in CITYOPT play both on private and public spheres to maximise incentives and impact.

Serious gaming and competition are also parameters to consider in the design of energy awareness applications. An article [12] reports on two successful initiatives from U.S. energy retailers conducted in 2014 which managed to keep half of its customers engaged. This was done by carrying out a pre-rollout communications program on a gamified energy audit called "Dropoly" which provides a simple way in which people can make effective energy savings in their homes. Gift cards were offered to the 300 first families who created an account. The "game" also keeps the customer engaged by sending out constant reminders and updates via email and phone. Without these notifications, the customer will forget about the program or lose interest: *"Because, the truth is that there are those who would like to be environmentally and economically responsible but busy lifestyles can hinder good intentions"*. The business model in CITYOPT rewards active participants with CITYOPT points, a virtual currency to buy or to crowd fund energy efficient services or projects for their city. Crowd funding gives the opportunity to transform customers into investors through innovative service platforms [13]. It is a new form of social media that facilitate transfers of money to enable larger projects to find the funding they need.

NCA STAKEHOLDERS EXPECTATIONS

A user research study [14] was conducted with local users and stakeholders of the Nice case study based on the assumption that user behaviours play a crucial role in demand response scenarios. Past research elicited some common motivations and barriers for end-users to optimise energy, as stated in the previous section. However, these results should be contextualised, as cross-cultural analysis of energy usage behaviours, confirmed that they vary significantly according to several parameters, including: different climatic zones, local culture and habits, energy sources available, local legislation, etc. Understanding people's behavioural patterns in energy usage is critical in a demand response scenario, as it can elicit the conditions that will encourage people's willingness to participate in the solicitations program. For this reason, CITYOPT's research focused on the local dwellers, their current behaviours, drivers and expectations in a demand response scenario such as the one proposed in CITYOPT's NCA case study.

Moreover, engaging individuals as members of a community, rather than only as consumers of energy, is an important strategy for changing energy-related behaviours. CITYOPT's research included social aspects in the study, to evaluate the role of the communities in the local context and the weight that they could have in the NCA's case study. The following paragraphs summarise the main insights and the results of the post-research analysis:

Awareness and understanding

There is a general perception that energy is not a common topic of conversation and the people's awareness is quite low. Even informed participants are not fully aware of the risks that the region is suffering. Even though some people noticed public announcements or news on TV and local press, it did not seem to affect their behaviours.

Inaccurate mental models

People evaluate their consumption in economic terms, while the bill measures it in terms of energy quantity. Several participants have a two-rate time-of-day tariff, but they are not always aware about the fee differentiation between peak and off-peak hours. Even those who are, find it hard to remember the exact range and make mistakes about it. People have a generic idea about their consumption patterns, which is only based on their behaviours and bi-annual bills.

Familiar blackout experiences

All the participants had experienced a blackout. Most people accept these issues passively and without complaints, except when micro-interruptions damage their appliances. However, they complain about the lack of communication before, during or after these events.

Reducing vs. delaying

Except for washing machine usage, energy saving strategies focus more often on reducing general consumption (e.g. limiting usage of heating, keeping temperature low) than on avoiding peak hours. The most common practice however is to use heating when needed and try to limit temperature, duration of usage and number of rooms heated.

The art of programming

A key differentiating element in people's behaviour is the possibility/ability to program. As most washing machines can be programmed without much effort, people are keener to delay their usage to off-peak hours. Apparently the same does not apply to heating either because

programming is not available or because people find it difficult to use it and modify it when needed.

Simplified assessment of behaviours

Most people feel comfortable about their behaviours, either because they feel they are doing enough to limit their consumption, or because their bills are not too high. Asking for advice or comparing one's performance with others (e.g. friends' experiences, statistics, etc.) is not a common practice. Even those people who are more committed to energy saving (e.g. participate in experimental projects in the region), lack an accurate understanding of how different activities and appliances' usage impact their household consumption.

Need for stronger drivers

Current motivations to undertake energy efficient behaviours do not appear to be particularly strong due to convenient energy pricing and limited cultural/social pressure. Currently, the strongest drivers are: good self-perception (e.g. "feeling like a good citizen"), money saving, professional interest and sensitivity to the subject. The most appealing incentives to change behaviours in a demand response scenario are financial rewards and visibility of good practices. Some participants would also appreciate public recognition and visibility of people's effort, for example through the designation of smart neighbourhoods or communities. Reactions to community-based benefits are mixed and weaker for people with little involvement in the local community.

Community involvement

School emerged as the most promising type of community to focus on for several reasons: kids can become strong and persistent advocates of a good cause; kids are competitive and can be effectively involved in both household and school-based games and friendly competitions; schools and the education system in general were indicated as the ideal target for initiatives aimed at rewarding community-based efforts.
Participants also identified a great potential for improvement in the energy management of common holds ("co-propriétés"), especially through the owners' meetings ("syndic de copropriété"). Small towns and villages appear to be stronger cohesive social clusters than city neighbourhoods. Villagers are more open to possibilities and more interested in rewards at the local community level.

Potential barriers to adoption

Except for time rich (e.g. retired) people, checking energy consumptions is not likely to rank high in people's top priorities. Moreover, people that are professionally and socially active are overloaded by emails, especially those coming from commercial actors: emails risk being neglected and treated as spam. At the same time there is no shared interest in using social networks for energy-related content. While some people are open to it, others think that SNSs like Facebook are tools for the young generation. Several people see their variable routines (e.g. being at work) as an obstacle for responding to a request to lower their consumption at specific times. They would appreciate the possibility to delegate to EDF when they are not at home.

CITYOPT APPLICATION OVERVIEW

An Internet application called Community Network for Energy is developed. Its objective is to encourage individual actions for promoting the reduction and/or shift of power consumption at homes during peaks of consumption in the PACA region. EDF consumers use electricity primarily for heating, cooking, dish and clothes washing, and consumables operation. As a reward, the dwellers earn bonuses that will be invested in useful projects in the community to which they belong to. Such projects are for example funding of new public buildings such as schools, a school project, cultural activities, complimentary "Vélo Bleu" membership. Thus, instead of using additional and punctual energy production from thermal power plants, end-users of electricity will "learn" how to consume energy in a better way and at the same time they will benefit from these economies of scale for their community. When joining the experiment, the 200 volunteers will have at their disposal a tablet pc to access the application.

A typical user journey in the CITYOPT application is introduced in the following 6-steps tutorial:

1. Welcome to CITYOPT: a community committed to protect the environment, avoiding overconsumption and resources waste.

2. CITYOPT engages citizens through the support to local projects. Projects will address issues at the neighbourhood scale, lowering the impact on the environment.

3. Like in crowdsourcing, people can support their favourite projects. Support is given "investing" CITYOPT points in one project or more. CITYOPT points are the "currency" used to back projects up. Points are earned by CITYOPT members for their successful commitment during peak load alerts.

4. CITYOPT calls its participants to rally to avoid severe peak loads. The entire community has a common mission: reduce energy waste and respect the environment.

5. Participants set ready for an alert laying out a strategy. Choosing what will be off, decreased of shifted during an alert will allow people to gain points to be later invested in community projects.

6. CITYOPT will succeed if people will engage with each-other. Participants will receive after each peak the result on their energy savings (at the individual scale and at the community scale) based on the load curve analysis (statistical models are implemented). Moreover participants can tap into social networks to show their commitment and get others to join for a healthier environment.

Users will receive regular notifications and updates before and after every alert on their phones and email.

CONCLUSION

The CITYOPT NCA case study offers a new solution to manage the active demand of electricity and test demand-response scenarios. Demand Response offers a number of benefits to the electricity system, including increased efficiency of asset utilization, supporting greater penetration of renewables on the grid, easing capacity issues on distribution networks to facilitate further uptake of distributed generation on congested local networks, reducing the required generator margin and costs of calling on traditional reserve, including the associated environmental benefits (reduced emissions) [15].

The community Network for Energy developed and tested in CITYOPT is a new mean:

- to contribute to energy demand reduction of households through increased energy awareness;
- to contribute to time-shifted energy usage, through timely demand-response notifications;
- to enhance coherence between different energy projects/services and city planning alternatives.

The project will offer a new insight on how citizens react to the utility's request and how the community scale and crowd funding approach offered in the application act as incentives. A 12 months operational validation and test phase with the 200 volunteers will be conducted from October 2015 to September 2016. A comprehensive technical and socio-economic evaluation will be conducted and publicly documented by the end of 2016.

Acknowledgments

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