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Gabriele Santinelli[1*], Veronique Beillan[2], Ilaria Monteverdi[1], Isabelle Jalmain[3], Régis Decorme[4] and Marie Tatibouet[5]

1: Experientia
Via Cesare Battisti 15, 10123 Turin, Italy
e-mail: {gabriele.santinelli, ilaria.monteverdi}@experientia.com, web: http://www.experientia.com

2: EDF Recherche et DéveloppementLab Paris Saclay
7 rue G. Monge, 91120 Palaiseau, France
e-mail: veronique.beillan@edf.fr web: http://www.edf.com

3: EDF Commerce Méditerranée, Direction Collectivités, Territoires et Solidarité Méditerranée
7, rue André Allar, 13015 Marseille, France
e-mail: isabelle.jalmain@edf.fr web: http://www.edf.com

4: CSTB
290 Route des Lucioles, BP 209, 06904 Sophia Antipolis Cedex, France
e-mail: regis.decorme@cstb.fr web: http://www.cstb.fr

5: Métropole Nice Côte d'Azur
455 Prom. des Anglais, 06200 Nice, France
e-mail: marie.tatibouet@nicecotedazur.org web: http://www.nicecotedazur.org

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Abstract

The purpose of the CITYOPT Nice pilot project is to reduce domestic consumption during peak load hours, by engaging residents with demand response scenarios through a mobile app. This paper analyses the CITYOPT approach, suggesting that, when economic rewards are missing, a mix of educational activities, community involvement, social proof, and altruistic rewards could be a significant motivation for potential users. This study also explores possible positive consequences of crowdfunding campaigns to motivate participation and long-term engagement. Moreover, 8 other areas of improvement that could lead to higher user engagement were elicited during the research. Results imply that behaviour change considerably contributed to reducing the average energy consumption during the peak loads, and suggest that there is space for replication of the CITYOPT French pilot in other countries.

1. INTRODUCTION

CITYOPT is a collaborative project supported by the European Commission through the Seventh Framework Programme (FP7) under grant agreement N°608830. CITYOPT's mission is to optimise energy systems in smart cities. CITYOPT developed a French case study in the Nice Côte d'Azur (NCA) metropolis, with an energy network considered fragile [1]. During the coldest days of winter, the concurrent usage of electricity for domestic heating brings the network close to its limits. Peak electricity consumption is generally observed between 6 and 8 PM, and can be forecasted by the energy supplier 24 hours in advance. To avoid blackouts, a thermal power plant is activated during consumption peaks, but it generates significant CO2 emissions and has a high cost in terms of maintenance. Other projects with similar objectives are currently being conducted in the NCA area: EcoWatt PACA[1] and Nice Grid[2].

As part of the CITYOPT NCA demonstration, 140 local residents were provided with a tablet computer running the CITYOPT web application. This app asked them to reduce their domestic energy consumption whenever a peak in the electricity demand was forecasted. A large participation in "shaving" peak loads could permit the energy supplier to reduce the use of the backup power plant, with obvious economic and environmental benefits [2]. The cost of additional electronic equipment to control the consumption is often a strong barrier to economically sustainable business models [3]. Therefore, participants in the pilot program were already equipped with the smart meter Linky.

Due to the crucial role of consumer behaviours in demand response scenarios, the CITYOPT NCA pilot focused on studying conditions that would lead to behavioural change.

CITYOPT had several limitations, including the short time of pilot (we couldn't test long-term engagement), the relatively small number of participants, and the very specific region of the pilot. These are hard to overcome in a test pilot, nonetheless we still feel that significant results can be inferred from the pilot, and we have formulated 8 general recommendations to improve people's level of engagement and ability to understand project goals and functioning. This paper summarises the user research insights and our recommendations for improvement.

2. METHODS AND MATERIALS

2.1. The challenge of engaging people

26.8% of the energy consumption in Europe is used by households [4]. Studies on comparable houses highlighted that human behaviours can affect electricity consumption by a factor of up to five times [5] and that a reduction of up to 20% in household carbon emissions could be achieved by behavioural changes alone [6]. However, people are creatures of habit, and behaviour is very resistant to change [7], therefore research efforts should focus on stimulating end-users' interest and engagement. Previous research has identified potential

[1] EcoWatt PACA - Le bon geste énergie: www.ecowatt-paca.fr
[2] Nice Grid - Un quartier solaire intelligent: www.nicegrid.fr

enablers and barriers for user engagement in smart grid projects [8]. Enablers focus on three main factors: self-interest ("my direct benefit"), altruism (good for other people) and civic norms (I do it because others around me do it) [9].

Self-interest	**Altruism**	**Civic norms**
Learn about consumption	Support local non-profit projects	Neighbourhood comparison
Perform better than community	Avoid blackouts	Competition
Entertainment/gamification	Environmental benefits	Local anchorage
Personal interest in local projects		Conscious citizen effect
Tips and suggestions		Social recognition

Table 1. Some motivational factors driving the engagement with the CITYOPT app.

The CITYOPT app considered these enablers, particularly the factors in Table 1. Economic savings are widely considered as a main driver for people to change their energy habits [10] and are the most commonly used in research projects [11]. However, in this project the demonstration was conducted in France, with relatively low electricity cost [12]: individual economic benefit was estimated at up to €5 per year, and wouldn't constitute a strong driver. Therefore, we focused on:

- **Environmental concerns.** People with a strong personal interest in environmental causes are easier to engage in energy-saving and research projects often leverage the environmental factor [10]. 90% of CITYOPT respondents said they joined the project partly due to interest in environmental issues.
- **Educational.** People generally have little practical knowledge about electricity markets; relatively few people know what a kilo-watt hour is or how many kWhs they use each month [3]. Some energy rudiments are fundamental to engage people in demand response scenarios, but consumers appeared willing to learn more and to better understand their household consumption, as they see it as a way to save on their monthly bill. CITYOPT provided education on common domestic appliance consumption, with suggestions on how to reduce household consumption.
- **Community.** The value of social activities to change individuals' environmental behaviour is well known [13] and has the greatest likelihood of generating verifiable savings in the short-term [14]. Community involvement and social proofing (comparison and conformation) have proven to be beneficial [15][16], even without economic incentives [17]. We felt that community aspects were crucial to the success of CITYOPT, and we prioritised collective actions and achievements.
- **Local anchorage.** A sense of community belonging can significantly impact the establishing of new practices [18]. Word-of-mouth and social sharing can have more influence when a strong neighbourhood relationship exists and social comparison can be more effective. CITYOPT leverages the sense of neighbourhood belonging by solving regional electricity issues and collaborating on funding local projects.

We also hypothesized that while individual economic savings were too small to be a big incentive, an economic reward for the whole community (i.e. funding local non-profit

projects) could be an additional stimulus for engagement by leveraging altruistic values. The local projects could be voted on by the participants, by using the points received for participation in peak events (see section 2.2). The points incentives seem to work well in similar game-based energy applications [19], but motivational approaches for energy-related projects using crowdfunding are lacking in literature, suggesting this is an untried innovation.
The literature amply addresses drivers for behavioural change in demand response scenarios, but little is known about long-term engagement, and few projects have had demonstration periods long enough to address this issue [13]. It has been reported that average energy savings are usually higher for shorter studies than longer ones, though this could be due to the inability of shorter studies to capture seasonal variations in energy use [20]. However, evidence of economic savings achieved, and constant and frequent communication (e.g. newsletters, notifications, feedback, etc.) has proved to have beneficial effects on long-term engagement [21][22]. In CITYOPT we provided feedback after each peak alert, and we hypothesised that regularly changing the crowdfunded projects could refresh the participation experience by giving new added value to the participation over the long-term.

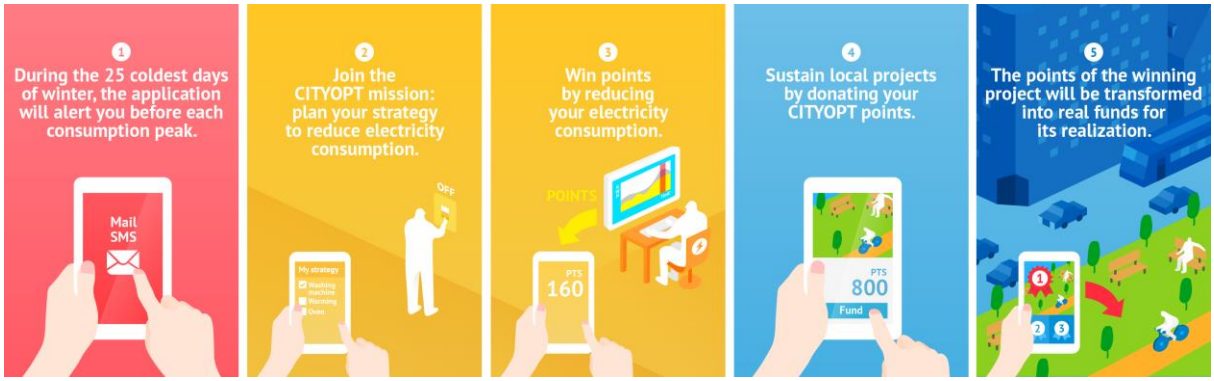

Figure 1. The CITYOPT participation process shown as a tutorial upon first use of the app. From left to right: (1) notification of upcoming peak event; (2) definition of the strategy; (3) points incentive; (4) crowdfunding of local projects; (5) funding of the winning local project.

2.2. The CITYOPT app

The concept behind the CITYOPT participation process is quite simple (see Figure 1):

(1) an SMS and/or email notification is sent 24 hours before a forecasted peak event;
(2) participants take part in missions by selecting appliances they won't use during the alert;
(3) after the peak event, points are given in accordance with observed consumption reduction;
(4) collected points can be used to fund local projects;
(5) projects that reach a certain points threshold will be funded.

The CITYOPT Nice pilot design followed the principles of user-centred (or UX) design, by involving stakeholders and end-users in all project phases through individual contextual interviews, workshops, co-design sessions, user experience testing and other participatory

activities. The CITYOPT app was developed as a web-application and has been optimised for the target tablet. Some screens of the CITYOPT app are shown in Figure 2.

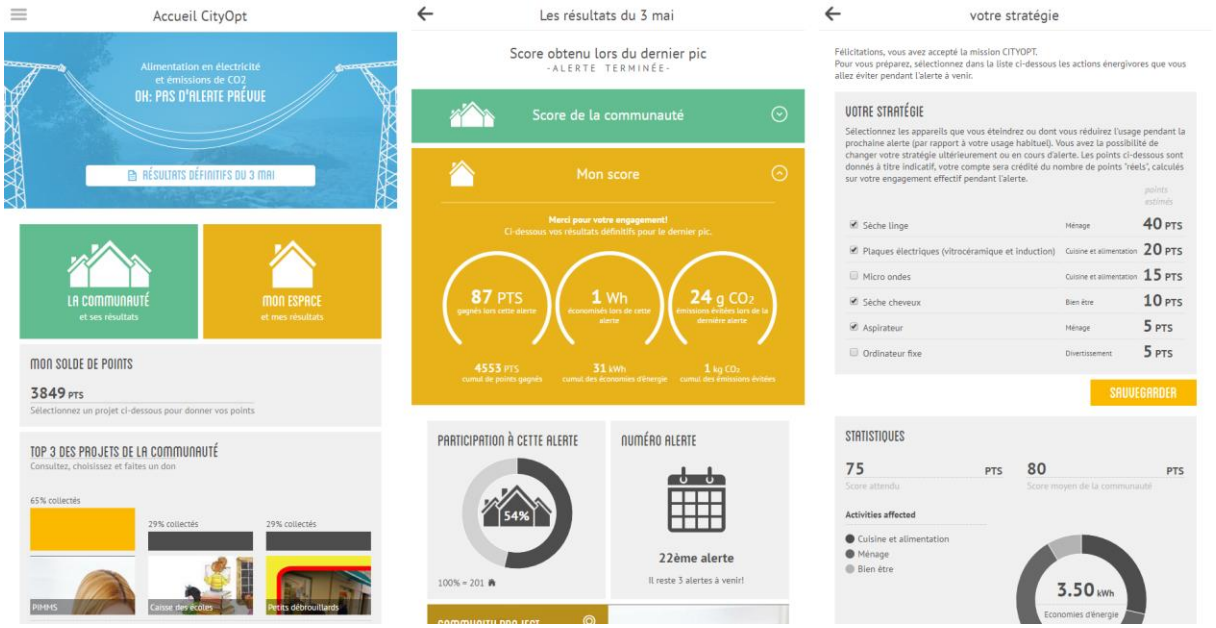

Figure 2. Three screens of the CITYOPT app. From left to right: (1) the dashboards with the status of the electricity network; (2) detailed results of the latest peak event; (3) the selection of appliances to be included in the household's strategy.

2.3. The pilot demonstration in Nice

A pilot demonstration involving 140 Nice citizens took place over a 5-month winter period. Each household was equipped with the French Linky smart meter, which measures the energy use of the apartment. To facilitate recruitment and simplify development, participants were rewarded for participation with a tablet (with the CITYOPT app preinstalled). However, no further incentives were given, making participation totally voluntary. During the demonstration participants received 25 peak alerts[3] (some generated for research only).

The results of the household energy consumption was illustrated with quantitative data (i.e. online survey with 84 respondents, application analytics and load curve analysis of the 140 households' consumption). The quantitative data was supported by qualitative research into user acceptance of the CITYOPT app. The methodology included contextual interviews and observations of app usage in participants' homes. Qualitative methods are the best way to understand motivations and drivers for participation, or explore barriers and pain points experienced. They gathered deeper insights on why people would be motivated to use the app, and if and how the app could be improved. The insights described in this paper integrate and summarise results from all of these research activities.

[3] Results presented in this paper rely on the analysis of 23 alerts out of the 25 planned during the entire demonstration.

3. RESULTS

The pilot demonstration results were encouraging: participants reacted positively and responded to the solicitations on a regular basis. During peak load, EDF registered a decrease of electricity usage equal to 300Wh per household during the winter alerts, approximately 28% less than the estimated business-as-usual average in the same time interval.
Interestingly, measured results are in line with Nice Grid results[4], which involved citizens from the same area in similar demand-response activities [24]. However, Nice Grid's approach differs because households were given financial incentives at the end of the pilot if a significant reduction in electricity consumption was registered during the peak time, making CITYOPT's results even more interesting.

Figure 3. The peak simulator provides a simplified environment to learn about domestic appliance consumption and to forecast the amount of savings/points that can be collected during a peak event.

3.1. Motivational factors

79% of respondents said they participated in the CITYOPT project due to economic benefits. 85% also cited the educational aspects: people are keen to understand more about their domestic energy consumption, to reduce their electricity bills. Interest in environmental issues also seemed to be a strong driver for 90% of respondents. Educational and economic aspects have a higher impact on young generations (100% were interested), while other factors, such as fear of blackouts seem to have a higher impact on the elderly segment (81%), probably a sign that younger segments have been less exposed to the problem in the recent past.

3.2 Participation

The general participation rate fluctuated between 73% and 83%, with 87% of households taking part in half of the peak alerts or more. Although participation in peak alert does not directly imply a reduction in energy consumption, it still identifies a high commitment

[4] The Nice Grid pilot took place in Carros, Provence, France. During the winter of 2013-2014 77% of residential customers reduced their electricity consumption between 6 and 8 PM by 22% (i.e. 400Wh/household).

towards the project's objectives.
The most common reason for not taking part in a peak alert mission was not being at home (30%), which doesn't represent an issue for the project objectives as consumption is expected to be low anyway when the apartment has no occupants. However, in 25% of the cases people forgot about the peak event. This suggests that additional unobtrusive reminders of peak events might be needed, but also confirms that a more portable app could increase participation, as people would be able to respond in real-time to the peak alert notification.

3.3 Preferred strategy and discomfort

Although people are sometimes concerned about how reducing energy consumption would impact their comfort and lifestyle [22], participating in CITYOPT missions had a low perceived discomfort: 71% felt that participation in CITYOPT missions did not cause any discomfort, while only 7% felt it generated considerable discomfort. Younger people tended to report neutral feelings on this topic (62% said the discomfort was neither low nor high) while singles living alone seems less concerned (85% responded that it was not a hassle).

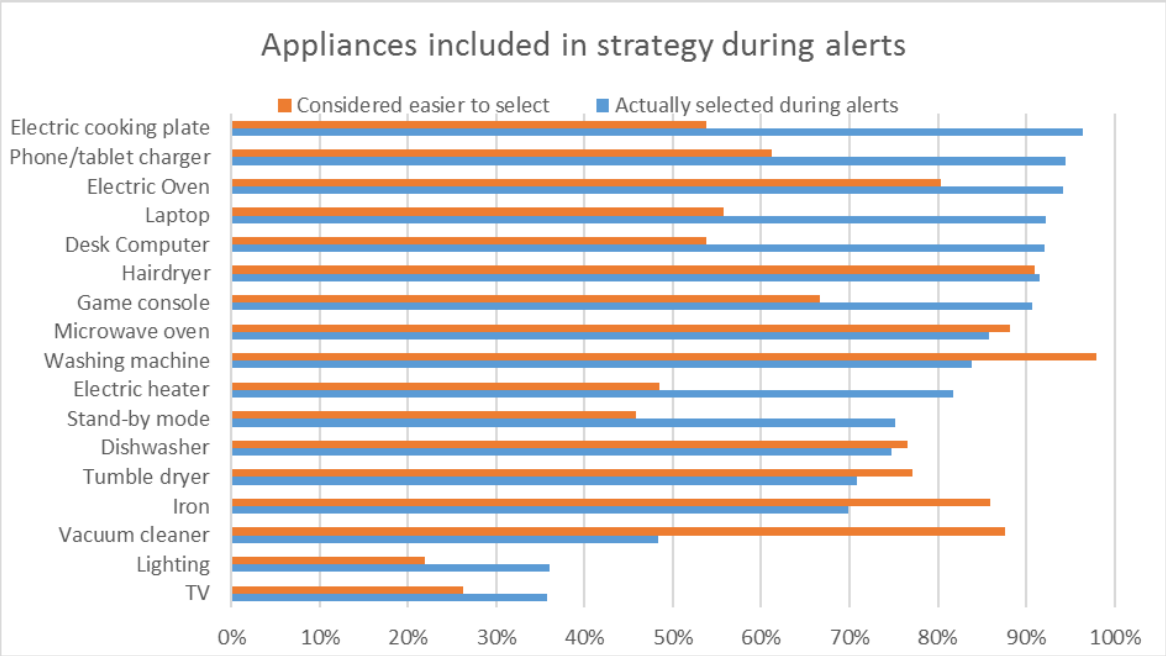

Figure 4. The list of appliances that respondents considered easier to turn-off during peak events (orange) compared with the appliances that were actually selected during alerts (blue).

This could be explained by analysing the appliances that people considered easiest to include in the strategy. Energy intensive appliances (i.e. washing machine, hair dryer, iron, dishwasher, etc.) were considered easy to include, because it is relatively easy to shift their usage to a different time of the day: they usually are not used daily and some of them can be programmed. On the contrary, turning off lights, the TV or appliances in stand-by mode requires more effort, also because these appliances are more likely to be used during the

evening and provide entertainment that is difficult to renounce (see Figure 4).
However, electric heating, which in France corresponds to about 70% of total energy consumption [25], was considered by only about half (46%) of respondents who can control it, suggesting that thermal comfort is quite a significant topic. On the other hand, 20% of respondents showed a very high commitment to the project, even going so far as to change their food habits (e.g. postpone dinner, cook in advance, eat cold meals, etc.) in order to get higher scores. The Nice Grid project reported similar results for appliances that households decided to use less during alerts [24], and this can have beneficial repercussions if we consider that home cooking can produce a peak of up to 10kW [26]. Positively, we found that the biggest change was related to energy intensive appliances, resulting in higher results with minimum effort. Instead the appliances for which people's usage was difficult to influence were those with the lowest contribution to household consumption, and therefore of lower importance.

3.4 Crowdfunding

The concept of funding community projects and non-profit organisations was highly appreciated (80% considered it a good or very good idea) and only 10% would prefer to have individual incentives only. Many participants would have liked to also fund projects directly related to the environment (56%). The young adult segment seemed less engaged by the choice of project, probably because the projects proposed targeted children, teenagers and elderly but not young adults. This shows the importance of selecting local projects to match the target audiences.
Qualitative research also confirmed interest and curiosity in the crowdfunding system, which prior to the project was only known by about half of respondents (55%), mainly adults (73%) and highly educated (63%). Contextual interviews with participants confirmed that project selection is an engaging activity per se: participant chose projects to fund for either direct or indirect reasons, e.g. relatives who benefit from some of the proposed projects.
Studies have highlighted the benefits and weaknesses of crowdfunding [27], mainly focusing on economic and entrepreneurial aspects. There are 4 main motivations to support crowdfunding campaigns: collect rewards (both tangible and intangible), help others, be part of a community, and support a cause [28]. In particular, the sense of community and connectedness, which might already be present in a community such as CITYOPT, might be increased by contributing to crowdfunding projects of interest [29].
We believe that crowdfunding, instead of funding a specific project, leverages a sense of ownership and the engaging nature of choice. The idea of active choice adds to the ownership the participants feel over the final funded project, which hypothetically could drive people to engage more in order to see their own project realised. This is as yet unproven, but could be more powerful than people simply earning points toward a pre-determined funded cause, because theoretically, they should care much more about a cause they have chosen themselves. The model we implemented seems to be a good way to inject feelings of ownership into the theme of energy consumption engagement.
Contextual interviews also suggested that crowdfunding could play a significant role for long-

term engagement. As previously mentioned, research demonstrated that providing periodical tailored communication can improve engagement in the long-term. In a similar way, periodically changing the local fundable projects could create an additional stimulus for the community of users. However, due to the short duration of the pilot, we couldn't verify this hypothesis. Moreover, non-profit organisations that benefit from CITYOPT's fundraising could become active promoters of the CITYOPT project among new segments of consumers that otherwise might be difficult to reach, enlarging the pool of active users of the application.

3.5 General recommendations

Our research highlighted 8 areas of improvement that could lead to higher user engagement with the CITYOPT app, and that can be generalised for similar demand response applications:

1. **Cause-and-effect vision.** The absence of per appliance tracking of household consumption makes it hard for participants to understand which appliance contributed more to the achievement of the result and how to improve their performance. Literature confirms the importance of feedback to reduce consumption [20] and its impact seems to increase when feedback is immediate [30]. While expensive equipment (e.g. smart-plugs) in a project like CITYOPT would not be economically sustainable, alternative ways to provide more informative feedback should be considered.
2. **Editorial communication.** People would like to know more about what happened during the peaks. It is gratifying to know they have been part of a group of people that achieved something important for the community (e.g. avoided a blackout). Providing customised, editorial content describing the peak event and how the community helped avoid bad consequences would help people to understand the tangible implications of their contribution, and consolidate their commitment to the project.
3. **Metaphors instead of numbers.** Points earned, CO2 and kWh savings are abstract numbers that don't help people to quantify their results, especially for the young segment, who are probably less acquainted with energy bills and considered post-peak reports difficult or very difficult to understand in 37% of the cases. Alternative narration methods such as comparisons and metaphors to visually quantify the results used in the peak simulator (see Figure 3) were appreciated by those who used it and have proved to have higher impact on users [31].
4. **Community effect & local anchorage.** Displaying data at the community level, rather than at the household level, encourages thinking about energy as a collective issue, and provides a sense of urgency in case of peak events [14]. Qualitative research highlighted participants' interest in the local community and in events and initiatives taking place at the local level.
5. **Comparable communities.** People want to compare their consumption and achievements with neighbours sharing similar family composition, flat characteristics, economic status and lifestyle. Feelings of competition, social comparison, or social pressure may be especially effective when important or relevant others are used as a reference group [13]. Moreover, people already careful about energy issues would see

no benefit being compared with people who aren't, as the latter would appear to have the higher scores. Although this was not completely possible in CITYOPT due to the limited number of participants, larger scale projects should always consider appropriate communities to refer to for comparisons.

6. **Household engagement.** Despite strong interest in community aspects, other household members are not always involved: 53% of respondents despite not living alone, did not share the usage of the CITYOPT app with other household members, the elderly (68%). Other household members are sometimes just passive participants, acting on instructions from the main user, or not engaging at all with the application (31%). In order to increase awareness and maximise results, the application should encourage participation from all household members, e.g. by providing tailored challenges for different family members or expressing results to appeal to different values, e.g. environmental, economic, points earned, etc.
7. **Social participation.** 91% of respondents said they had talked about CITYOPT with family, friends, colleagues or others. Large scale applications could likely benefit from social engagement. Word-of-mouth and online social networks could be an effective way to recruit new participants to join the program (39% of respondents would invite other people to join), to further motivate those who share their achievements (social sharing has been shown to lead to reduction in energy consumption [32]) and to stimulate awareness and spread the project objectives to a wider audience.
8. **Application portability.** People don’t spend a lot of time using the CITYOPT app, but they need to access it at any time and from any place, whenever a peak notification requires their response. Postponing response to a peak alert notification could easily make people forget about it — one fourth of CITYOPT participants who didn’t take part in peak events said that the cause was forgetfulness. Moreover, device preferences for the app were equally distributed among tablets (35%), smartphones (32%) and PCs/laptops (28%), suggesting that a cross-platform and cross-device application, capable of running on mobile devices as well as desktop PCs, is critical.

4. CONCLUSIONS

The CITYOPT project addresses energy savings during peak hours through demand response scenarios. Behaviour change considerably contributed to reducing the average energy consumption during the peak loads. Taking into account that the demonstration took place in a country with relatively low energy price, in a region with a specific winter characterised by warm temperatures (i.e. low electric heating usage), we are confident that replication in different economic and climatic conditions could generate even more positive outcomes.

Our research suggests that, despite people’s interest being still (mainly) focused on money savings and a desire to educate themselves about consumption, a mix of educational activities, community involvement, social proof, and altruistic rewards could be a significant driver for specific clusters of the population. For the moment, the issue of drivers is complex, and can be attributed to a combination of factors, but the crowdfunding of community-benefit projects seems to have had a positive impact on people’s involvement. The crowdfunding model, with

its element of choice, seems to have been successful in offering a sense of ownership over the outcomes. We believe that this makes it a promising direction to explore in terms of motivation, either additional to other motivations and drivers, or perhaps even on its own, in future projects aimed at a community level.

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