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Federal Department of the Environment, Transport, Energy and Communications DETEC

Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Division

Interim report dated 22 December 2021

SOCPOP - Social Power Plus

Empowering energy sufficiency and energy citizenship in households through co-designed app-based Community Energy Challenges

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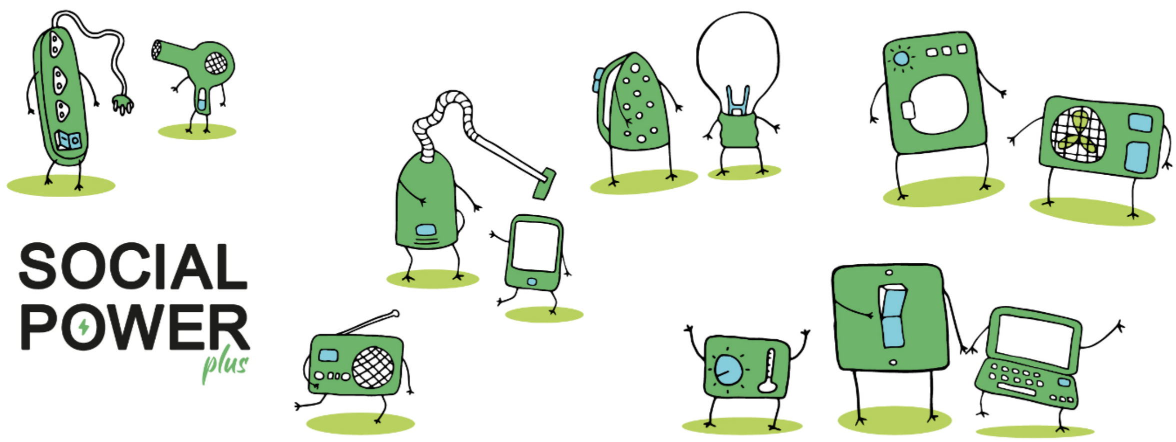

Source: ©SUPSI 2020

University of Applied Sciences and Arts
of Southern Switzerland

SUPSI

Date: 22 December 2021

Location: Bern

Publisher:
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech
CH-3003 Bern
www.bfe.admin.ch

Co-financing:
Stadtwerk Winterthur
Winterthur
www.stadtwerk.winterthur.ch

EKS AG
Schaffhausen
www.eks.ch

Technische Betriebe Will
Will
www.tb-wil.ch

Subsidy recipients:
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Zusammenfassung

Individuelles und kollektives Handeln ist ein wichtiger Faktor für den Energieverbrauch in Haushalten. Im Rahmen von Social Power Plus engagieren wir Teams von Haushalten, um sie zu sensibilisieren und Verhaltensänderungen bezüglich Suffizienz, Effizienz, und Flexibilität beim Energieverbrauch (Strom und Heizung) zu fördern. Dieser Energiesparwettbewerb wird unterstützt durch eine mobile App und eigens entwickelte nicht-intrusive Lastüberwachungsalgorithmen, die digitales Energiefeedback (stündlicher, täglicher und wöchentlicher Energieverbrauch für Heizung und Strom), Gamification (Zielsetzung und individuelle Challenges für Verhaltensänderungen, regionale Energiesparwettbewerbe) und soziale Normen (Vergleich mit ähnlichen Haushalten, Erfahrungsaustausch in der App über Energieverbrauchspraktiken) nutzen. Der Wettbewerb und die App wurden in einem Co-Creation-Prozess mit Stromkunden mitentwickelt. Der Feldtest der entwickelten Elemente wird im Jahr 2022 in drei Schweizer Regionen in einem quasi-experimentellen Rahmen mit einer Kontrollgruppe ohne App durchgeführt. Insgesamt werden rund 300 Haushalte (100 pro Region) an der dreimonatigen Social Power Plus Community Energy Challenge teilnehmen, an die sich eine neunmonatige Periode mit individuellem Energieverbrauchsfeedback und Benachrichtigungen anschließen wird. Die Ergebnisse der Intervention werden wie folgt bewertet: i) die Veränderungen des Energieverbrauchs (sowohl für Heizzwecke als auch für andere Zwecke) im Vergleich zu den historischen Basisverbräuchen im Jahr 2021, ii) die Veränderungen des berichteten Verhaltens, der Einstellungen, der persönlichen und sozialen Normen und der Selbstwirksamkeit, die durch drei Längsschnittbefragungen (vor und nach der Intervention, und ein Jahr später) gemessen werden, und iii) das Niveau der In-App-Interaktion, die direkt über die mobile App gemessen wird. Die Erkenntnisse aus diesen Aktivitäten werden in Empfehlungen und Leitlinien zusammengefasst, die die Ausweitung der Community Energy Challenge und ihrer Toolbox unterstützen, um eine breitere Wirkung zu erzielen.

Résumé

L'action individuelle et collective est un facteur important de la consommation d'énergie dans les ménages. Dans le cadre de Social Power Plus, nous engageons des équipes de ménages pour les sensibiliser et promouvoir des mesures actives de suffisance, d'efficacité et de flexibilité énergétiques (électricité et chauffage). Pour soutenir ce processus, nous avons lancé des activités de laboratoire vivant visant à co-concevoir un défi énergétique communautaire, soutenu par une application mobile et des algorithmes de surveillance de charge non intrusifs développés à cet effet, exploitant le retour d'information numérique sur l'énergie (consommation d'énergie de chauffage et de non-chauffage au niveau horaire, quotidien et hebdomadaire), la gamification (fixation d'objectifs et défis personnalisés pour le changement, concours régional d'économie d'énergie) et les normes sociales (comparaison avec des ménages similaires, partage d'expériences sur les pratiques de consommation d'énergie). Le test de terrain des éléments développés sera réalisé en 2022 dans trois régions suisses dans un cadre quasi-expérimental avec un groupe contrôle sans App. Au total, environ 300 ménages (100 par région) seront impliqués dans le défi énergétique communautaire Social Power Plus, d'une durée de trois mois, qui sera suivi d'une période de neuf mois de retour d'information et de notifications individuelles sur la consommation d'énergie au fil du temps. Les résultats de l'intervention seront évalués en prenant en compte : i) les changements dans la consommation d'énergie (à des fins de chauffage et autres) par rapport aux consommations historiques de base en 2021, ii) les changements dans le comportement, les attitudes, les normes personnelles et sociales, et l'auto-efficacité, mesurés par trois enquêtes longitudinales (avant et après l'intervention, et un ans après), et iii) le niveau d'interaction in-app mesuré directement via l'application mobile. Les enseignements tirés de ces activités seront résumés dans des recommandations et des lignes directrices visant à soutenir le développement du Community Energy Challenge et de sa boîte à outils, pour un impact plus large.

Summary

Individual and collective action is an important driver of energy consumption in households. In Social Power Plus we engage teams of households to raise their awareness and promote active energy sufficiency, efficiency and flexibility measures (electricity and heating). To support this process, we launched living lab activities aimed at co-designing a Community Energy Challenge, supported by a mobile app and on-purpose developed non-intrusive load monitoring algorithms, exploiting digital energy feedback (heating and non-heating energy consumption at the hourly, daily, and weekly level), gamification (goal setting and customized challenges for change, regional energy competition), and social norms (comparison with similar households, sharing of experiences about energy consumption practices through online forums). The field test of the developed elements will be performed in 2022 in three Swiss regions in a quasi-experimental setting with a control group without the app. Overall, around 300 households (100 per region) will be involved for the three-month long Social Power Plus Community Energy Challenge, which will be followed by a nine-month long period of individual energy consumption feedback and notifications over time. Outcomes of the intervention will be assessed by considering: i) the changes in energy consumption (for both heating and non-heating purposes) compared to the baseline historical consumptions in 2021, ii) the changes in reported behaviour, attitudes, personal and social norms, and self-efficacy, measured through three longitudinal surveys (before and after the intervention, and one year later), and iii) the level of in-app interaction measured directly via the mobile app. Learnings from these activities will be summarized in recommendations and guidelines supporting the scaling-up of the Community Energy Challenge and its toolbox, for a broader impact.

Contents

Abbreviations

SPP	Social Power Plus
EKS	Elektrizitätswerk des Kantons Schaffhausen
SWW	Stadtwerk Winterthur
TBW	Technische Betriebe Wil

1 Introduction

1.1 Background information and current situation

Households are responsible for 31.4% of total energy consumption (Bundesamt für Energie, 2017) and are therefore an important intervention point for the Swiss energy transition. Yet, in the context of a strongly centralised energy supply system, until recently households have been considered passive market actors and marginal recipients of technology. Achieving the goals of the Energy Strategy 2050, however, also calls upon households to adjust daily energy usage habits towards sufficiency and to decisions to invest in energy-efficient household equipment. Undoubtedly, this profound paradigm shift – calling for increasingly decentralised energy generation, yielded by active energy citizens ("energy citizenship", Devine-Wright, 2012) – involves raising more awareness, that in turn can bring about a change in social attitude towards environmental challenges, and allow citizens to benefit from the energy transition. In such a context, addressing the human factors underlying energy-relevant decisions and behaviour and the socio-cultural aspects that favour active energy citizenship, becomes essential.

Research is increasingly focusing on better understanding the underlying mechanisms (so-called drivers) that influence human behaviour change and energy savings, and their different effects (Delmas et al., 2013; Sovacool, 2014) and intervention approaches (Frederiks, Stenner, & Hobman, 2015; Karlin, Zinger, & Ford, 2015). Thanks to recent progress in ICTs, with smart metering roll-outs by utility companies, ease of installation of sensors, and the wide availability and diffusion of smartphones by the consumers, energy-saving interventions are increasingly performed by means of applications (apps) for mobile technologies. This uniquely allows for customized, (nearly) real-time energy feedback and possibilities of interaction with and between the users.

Additionally, a significant reduction in energy consumption has been observed in socially embedded interventions (Breukers & Mourik, 2013). In particular, also from the behaviour change perspective, there is a growing tendency to approach consumers no longer as individual agents for change, but rather as socially situated individuals that are part of a wider community (Mengolini et al. 2016). Here, social norms, collective actions and community welfare become important drivers: informative contents typically involve social comparison as an engagement trigger, i.e. they report a household's energy use compared to that of similar neighbours, as well as playful challenges, competitions, collaborations (e.g. self-consumption communities), community rewards and events. In order to avoid boomerang effects, social comparison and descriptive social norms can be accompanied by the activation of injunctive messages coupled with energy-saving tips (Cialdini et al. 1990; Schultz et al., 2007; Allcott, 2011).

1.2 Purpose of the project

All the above elements suggest exploring effectiveness of community-oriented strategies, which adopt a participatory approach to the question of energy-related behaviours with the aim of building a sense of community, shared goals and values. Smart tools exploiting the ongoing large-scale smart meter roll-out, that are aimed at favouring awareness on individual and community-level energy demand, as well as at stimulating an overall demand reduction and optimisation of production and consumption patterns, could support cohesion and enhance feelings of membership to a community. Next to triggering more effectively energy sufficiency behaviour within the residential building sector, they may contribute to the empowerment of energy citizens in general, thus laying some possible groundwork also with respect to the future configuration of the electricity grid into a system of self-consumption communities.

Against this backdrop, the Social Power Plus (SPP) project aims at developing and testing a behaviour change app persuading a reduction in household energy consumptions, by directly engaging its target users in a living lab framework. For this purpose, SPP activates a co-design, participatory process to identify the features of the persuasive app and of a related "Community Energy Challenge" aimed at supporting app use over a three-month period. Once such features have been designed, SPP develops the related software tools, and then tests them in a quasi-experimental setting in real life. Analyses on the outcome of the Community Energy Challenge in three real-life cases provide insights on its overall energy saving effectiveness and the lessons learnt from the whole process allow to develop guidelines and recommendations to favour further diffusion of the SPP Community Energy Challenge and up-scale its impact.

1.3 Objectives

In previous research, our team developed an app-based energy savings challenge, called Social Power (Wemyss et al., 2018), that allowed households to monitor their electricity consumption in real time through a gamified, lay-person visualisation, which connected actions to energy use, without the need for a more complex understanding of the energy system (Hermann et al., 2018; Marek et al., 2020). Households were placed in teams, within which they were invited to collaborate to collectively save a given amount of energy or to save more energy than a rival team (compared to their historical average consumption). While the real-world test of the app-based energy savings challenge successfully resulted in approx. 8% electricity savings in two Swiss cities, the savings were not maintained one year after the intervention ended – at least, in terms of statistical significance. Furthermore, high drop-out rates were observed during the intervention (Wemyss et al., 2019).

We hypothesize that such drop-out and relapse to previous behaviour are due to a lack of explicit incorporation of user knowledge, practices, and preferences, into the design of the Social Power challenge. SPP therefore specifically aims at exploring such hypothesis, by overcoming the expert-based approach and actively engaging potential target users in the design of the behaviour change intervention itself (the community energy challenge), in a "living lab" approach. "Living labs" are processes aimed at co-creating and validating innovation within collaborative, real-world environments (Pallot et al., 2010; Bergvall-Kåreborn et al., 2010; Dell'Era and Landoni, 2014). They open up to "participatory mindsets", where users become active partners of the value creation process (Schuler and Namioka, 1993; Sanders, 2003): beyond "designing for the users", living labs support "designing with the users". The approach involves users during the design process (e.g. through interviews, survey, focus groups, or pilot testing). In this way, the product is designed for its intended use and is argued to be ultimately more effective and efficient (Abras et al., 2004).

Designing with the users has been previously explored in energy transition research, frequently in combination with smart meter-based data collection procedures, in order to improve the effectiveness of energy saving interventions. For example, consumption data has been used as feedback to provide support for energy efficient purchase decisions based on household appliance use (Dalén, A., & Krämer), improve energy efficient appliance use behaviour (Wever et al., 2008; Mourik and Breukers, 2015), or capture multi-faceted benefits including increasing comfort, energy savings, transparency and overall consumer awareness (Böhm, S., & Szwec, 2013). Recently, an SFOE-funded research project in Canton Vaud investigated how to engage local stakeholders in order to identify effective ways to reduce the "energy performance gap" between the energy consumptions of highly energy-efficient buildings according to the project design, and their energy consumption in real life (Mastelic et al., 2018). Differently than all such cases, that always relied on use of technical devices supporting the reduction of energy consumptions (for instance, use of smart shower metering systems, purchase of new electric appliances, use of devices automatically removing any stand-by consumption), in SPP we focus on behavior change measures only, delivered via the Social Power Plus app's persuasive features and the related Community Energy Challenge. Distinctively, we see the behavioural component of the energy transition as additional and complementary to the accompanying technical and regulatory changes planned in the Energy Strategy 2050.

Furthermore, SPP also aims at improving the scope and quality of the feedback offered to households in terms of their energy consumption, by including energy consumption for heating purposes, which represent the largest share of household energy consumption. This supports developing the added-value from the current smart meter roll-out for the demand side. For this purpose, SPP provides households with feedback on their own disaggregated energy consumption data, regarding both heating and non-heating purposes. The analyses on the impact by SPP therefore also explore the capability of the SPP Community Energy Challenge to provide a tangible energy saving impact also on energy consumption for heating purposes.

Overall, the Social Power Plus project complements the recent SFOE project "Living the 2000 Watt Society: Reduction of Energy Consumption through Behaviour Change", (Sandmeier et al. 2020) that designed and tested behaviour change interventions in the field of mobility, warm water, space heating and electricity consumption in the Hüttengraben area in Küsnacht, with the aim of achieving a 2000 Watt society within their building projects. Social Power Plus complements this project by introducing an app-based intervention, specific behavioural suggestions through the Community Energy Challenge, and change in energy consumption habits from persuasive features.

Analyses of impact are performed in three different regions in the German-speaking part of Switzerland, dealing with three different energy providers and the related technology infrastructure. This allows to also assess the effectiveness and real-life feasibility of the SPP Community Energy Challenge under different socio-technical contexts, thus providing additional insight also on the possibilities for exploitation at a larger scale. Particularly, analyses of outcome consider both energy saving as well as energy awareness, engagement over time, and any possible impacts on wellbeing stemming from the new behaviour. Finally, analyses on the outcome of SPP are performed for both the short and the long-term, namely immediately at the end of the Community Energy Challenge and nine months after its end. This allows to test whether any possible impacts observed soon after the SPP Community Energy Challenge are actually maintained over time, or rather there is a relapse to previous consumption levels.

The research questions leading SPP can thus be summarized as follows:

- Can the inclusion of the potential target users in the design of an app-based behaviour change intervention (living lab approach) increase its overall effectiveness, both in the short and in the long-term?
- Can an app-based behaviour change intervention manage to reduce energy consumption for heating purposes in households?

2 Procedures and methodology

Project activities are organised around six work packages (WPs), that are schematically represented in Figure 1. All field activities are run in the German-speaking part of Switzerland, in the regions of the utilities joining Social Power Plus as implementation partners and project co-funders: Wil (Canton St. Gallen), Winterthur (Canton Zurich), and Schaffhausen (Canton Schaffhausen) regions, respectively with Technische Betriebe Wil (TBW), Stadtwerk Winterthur (SWW), and EKS AG.

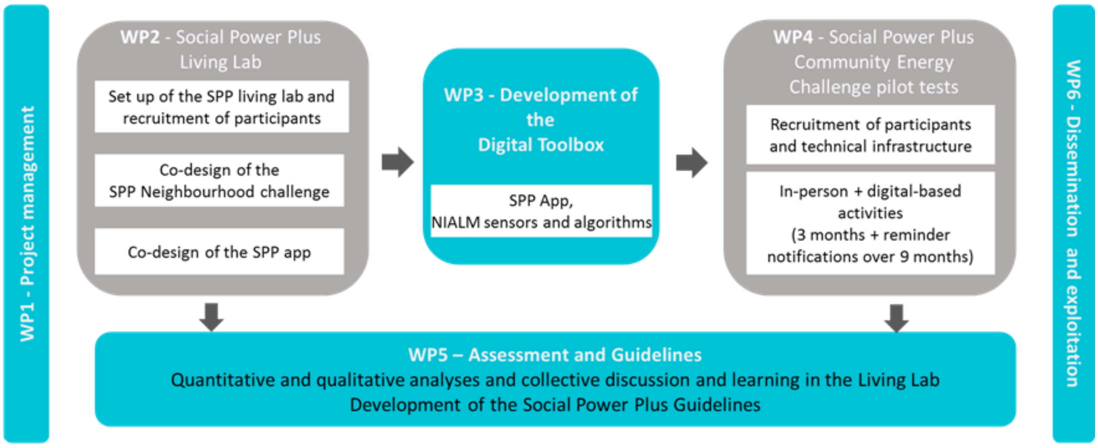

Figure 1: The organisation of project activities in Work Packages (WPs).

First activities are run in WP2 and aim at developing a Living Lab to co-create a SPP Community Energy Challenge that relies on app-based activities to increase awareness of energy consumption and collectively learn how to positively improve energy use at home and within the community (considering energy demands for heating and appliances purposes). The Living Lab involves a small number of households (ten to fifteen per region) and is organised in three meetings, over a period of six months. The utilities support and strictly follow all Living Lab activities.

The app-based SPP Community Energy Challenge resulting from co-design activities app is fed by data from gateways able to collect energy consumption data from gas and/or electricity smart meters or sensors on purpose developed in WP3, and adopt nonintrusive load monitoring tools and algorithms, again developed on purpose in WP3, to disaggregate heating consumption from overall consumption data. All the technological elements needed to support the Community Energy Challenge are developed in WP3 and grouped in the SPP Digital Toolbox, which encompasses the SPP smartphone app, fed by electricity/gas smart meter and/or on-purpose developed sensor data, the sensors themselves, and the related nonintrusive appliance load monitoring algorithms. The resulting SPP Digital Toolbox is sufficiently flexible as to manage data produced in different technological settings, which are in particular different with respect to the characteristics of the installed metering infrastructure.

Once the Community Energy Challenge and the related Digital Toolbox have been developed, their effectiveness is tested in three quasi-experimental real-life pilots in the three regions (WP4) and their impact is assessed in terms of engagement over time, improved awareness and tangible energy savings (WP5). Since the available smart metering infrastructure is different in each region by the three partner utilities, slightly different versions of the SPP toolbox are tested in the SPP Community Energy Challenge launched in each regions. Overall, at least 300 households (100 per region) are involved. Such pilot tests are designed as quasi-experimental interventions, with a self-selected treatment group identified through targeted communication and recruitment activities, and a matched control group randomly identified in each region. The SPP Community Energy Challenge runs for three months with nine additional months for follow-up, during which reminders and energy-relevant information are provided to the participants within and outside the app. These features are aimed at supporting the maintenance of the behaviour (Fischer, 2008) and at reduce the relapse to previous behaviour (Ohnmacht, Schaffner, Weibel, & Schad, 2017). Overall, therefore, the SPP Community Energy Challenge runs for one full year.

In WP5, household members' behaviour is closely tracked with a baseline survey and two post-intervention surveys (directly after the three months and one year after the start of the Community Energy Challenge), to assess environmental awareness, the perception of the social norms developed during the challenge, and reported behaviour, to be compared against baseline values, sociodemographics features, technical affinity, and motivations for participation. The savings impact is instead measured by the mentioned meters and sensors.

Based on insights from such an evaluation, SPP releases a final set of guidelines aimed at providing recommendations to favour the diffusion of the Community Energy Challenge - not only within the same utility companies but also to more contexts across Switzerland and abroad. Also, the Social Power Plus Toolbox is released in a whitelabel version, available for customisation by any future interested energy utilities, thus favouring their exploitation at the national and international level (WP6) and upscaling of the impacts.

3 Activities and results

Project activities are developed according to the Gantt chart reported in Figure 2. In this Section we provide an overview of the activities performed in each WP and deal with milestone achievement.

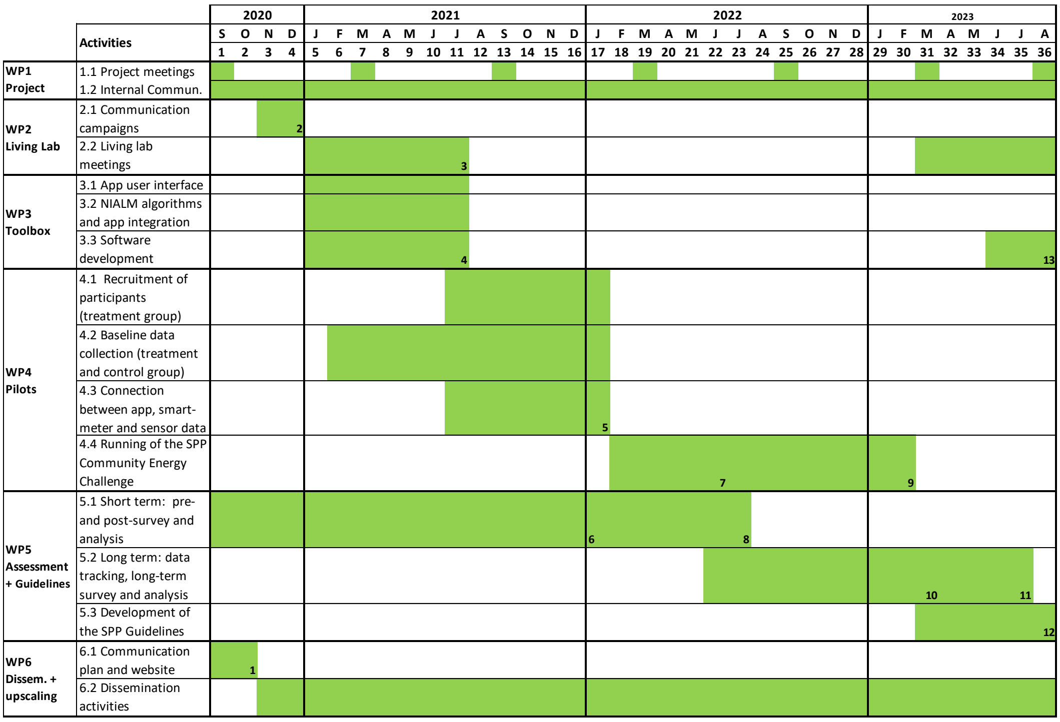

Figure 2: The time schedule of project activities (Gantt chart).

Numbers indicated in the Gantt chart are project milestones. Those related to the current reporting period are:

2. Living lab participants are recruited.
3. Co-design of the SPP challenge and toolbox has been completed.
4. The SPP toolbox is ready to be used in the SPP Community Energy Challenge.

WP1 – Project management

Interaction between project partners has been guaranteed through monthly project meetings of the whole project consortium, involving representatives of each project partner and cooperation partners as well. Additional bilateral meetings between two or more partners have then been performed whenever needed. Project materials are stored in a Switchdrive folder and always accessible to all partners.

WP2 – SPP Living lab

Activities aimed at setting up the campaign for recruiting of participants to living lab activities started in 2020, through the development of flyers, which were then distributed by the three utilities together with energy consumption invoices or separate individual letters, as well as materials for online communications. Potential participants were selected based on whether they had the technical setup of the target group of the app (see below in WP3's description, e.g. single family house and heat pump or single family household and gas heating) and welcoming letters were sent by email or mail. In the region of TBW, potential participants were invited who had already been involved in an innovative heating renovation programme. Overall, approximately 1200 people were contacted. The utilities also offered a small incentive for participation, e.g. a voucher for local businesses.

The recruitment campaign concluded in early January 2021, with the recruitment of 54 household members willing to participate in the co-creation process, of which 45 (83%) participated in at least two workshops. Their socio-economic characteristics are outlined in Table 1.

Table 1: Descriptive information of co-creation participants (N=54)

	%	Number
Average age (in years)	---	53
Women (vs. men)	20%	11
Family households (vs. single-person/adult household)	33%	18
Homeowner (vs. renter)	87%	47
House (vs. apartment)	83%	45

The co-creation process with the participating household members began with an onboarding online survey, followed by three online workshops led by the research team: i) Discover, ii) Design and iii) Evaluate, and ended with a post-process online survey (as shown in Figure 2). These steps follow the context mapping approach of Visser et al. (2005), wherein sensitization to the topic is followed by generating own ideas and then analysis.

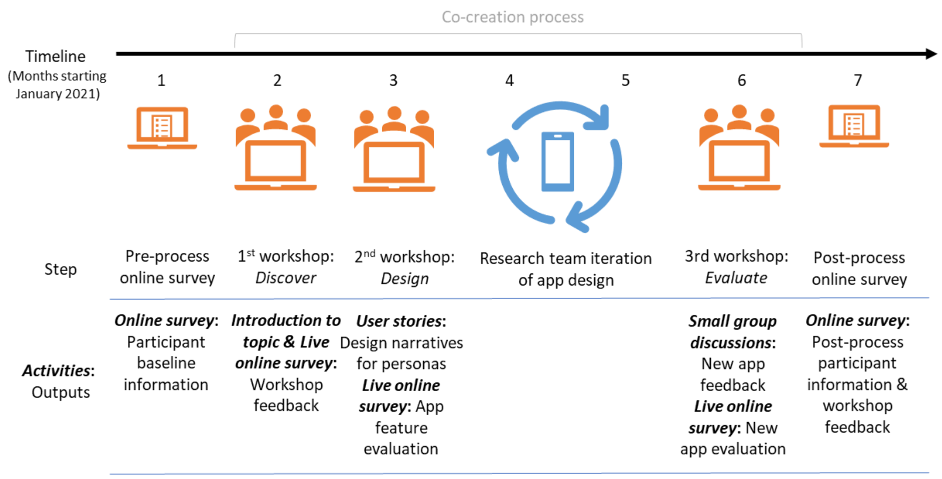

Figure 2: Co-creation process: orange icons represent activities for participants, blue icon involves only researchers.

The workshops were held in parallel in each of the three regions, thus nine workshops were run in total, in order to focus on the local context as the technical setup differed slightly between regions and to give the participants a sense of relation to each other. Due to the COVID-19 restrictions on gathering in groups, all the workshops were held online using the Zoom video conferencing platform.

Details on the organization of the co-design process in the living lab, as well as on its specific outcome and on the analysis of the two surveys, are provided in a manuscript presented at the International Sustainability Transition (IST) 2021 in October 2021: Wemyss, D., Lobsiger- Kägi, E., Jud, S., Cellina, F. “My energy transition at home: Results of co-creating an energy savings app with household members and researchers”. The manuscript, fully reported as Appendix 1, is currently in the process of elaboration for submission to a scientific journal, such as for instance Energy Research and Social Sciences.

Insight from living lab activities lead to design the SPP Community Energy Challenge around the key elements summarized in Table 2: with the overall aim of fostering both energy efficiency, sufficiency and flexibility in consumption, the challenge has to offer both individual and collective level activities and features, all provided via the SPP app. The individual-level features, which need to be as customized as possible, refer to goal setting and individual challenges, besides the provision of detailed feedback on energy consumption (disaggregated at least between consumption for heating and for non-heating purposes) for the individual’s home. Also, comparison with the consumption of similar households is identified among the relevant features to be offered at the individual level. The collective-level features, instead, refer to the possibility to share experiences, including successes and failures when dealing with the individual challenges, with the other participating households. For this purpose, an internal forum or “pinboard” for posting messages is envisioned, that reinforces the feeling of being part of a community of people, all engaged towards the same common goal of saving energy. Furthermore, to boost engagement and build on the feeling of belonging to one’s community, “booster” collective activities are offered from time to time, in the shape of a regional competition that automatically teams up all the households of the same region (EKS, TBW, SWW) and invites them to save more energy than the rival teams of the other regions.

Table 2: Summary of the features of the SPP Community Energy Challenge and related app, as they emerged from co-design activities.

Overall aim of the Social Power Plus Energy Challenge		• Sufficiency and efficiency: save energy (heating and electricity purposes); • Increase flexibility of energy use to help integrate renewables.
Individual features	“My home”	• Provide opportunities to set customized energy saving goals (energy saving percentage against a baseline consumption); • Provide opportunities for engagement in individual energy saving and flexibility challenges (with customized commitments); • Provide feedback on disaggregated energy consumption; • Provide comparison with similar households.
Collective features	“Pinboard”	• Allow possibilities to share experiences with the other households, via a simple online forum/chat.
	“Regional energy saving competitions”	• Exploit both collaborative (within the regions EKS, TBW, SWW) and competitive (between the regions) motivational factors; • Provide a “booster feature”, that is not always active, but is activated on the last week of every month of the SPP Community Energy Challenge; • Engage all the households in one region to collaborate in order to save more energy than the households in the other regions.

More in details, the whole SPP Community Energy Challenge is designed to last 12 weeks, from February, 1 2022 to April, 30 2022. It is then supported by nine additional months for follow-up, during which reminders and energy-relevant information are provided to the participants to avoid relapse to previous energy consumption behaviour. The month of January 2022, regarded as comparable to the following three months in terms of overall heating and non-heating energy requirements, is used to collect the baseline weekly energy consumption, namely the weekly energy consumption that is shown via the app to each household as a reference. All features of the SPP app are in fact aimed at reducing the weekly consumption compared to the weekly baseline value. Such a baseline value, obtained as the weekly average energy consumption value registered in January 2022, is automatically collected for each household by the SPP system, without users having to download the app. They are in fact identified before the end of 2021 through recruitment activities in WP4. For each household, at registration during recruitment activities, the information on the type of household is collected, (families with kids younger than 18 years old, multiple adults, single adults, 65+), to be then used by the app for feedback provision (comparison with similar households).

Goal setting, which is allowed separately for heating and non-heating related energy consumption, is performed by the user at registration. Therefore, all users are given from the very beginning a customized goal for change, that is the first driver for change. Every week then the result towards their goals is computed, and users are given the opportunity to modify their goal, in case it is too simple or too challenging. To help goal-setting, the app provides the households with a slider ranging from 0 to 30% savings and shows the baseline energy consumption of each household and the achievable energy savings stemming from different behaviour/practices regarding household energy consumption depending on where the user sets the slider.

The challenges are tools to provide hands-on suggestions on how to achieve the goal. Challenges are released in sets, focusing on a specific topic/practice, according to the plan represented in Figure 3: heating and showering challenges are released in week 2; cooking and dish-washing challenges are released in week 5; washing challenges are released in week 7; cleaning challenges are released in week 9; studying, working and recreation challenges are released in week 10.

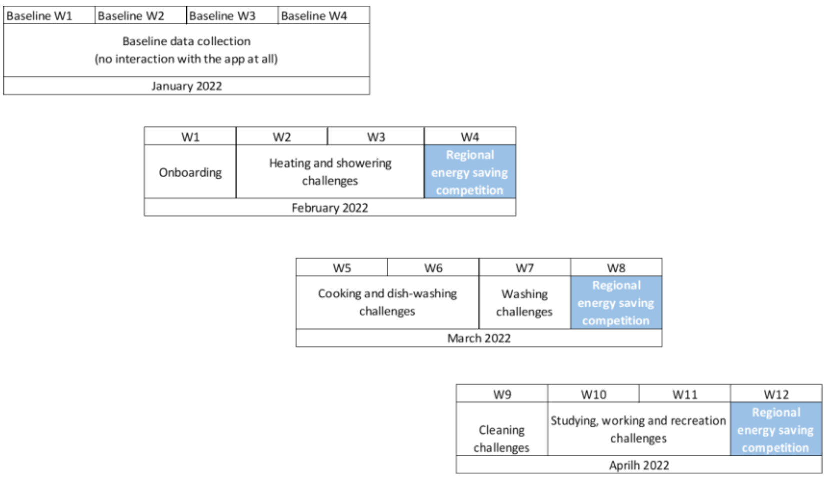

Figure 3: The timeline of release of the challenge and the Regional energy saving competitions, within the SPP Community Energy Challenge (W = week).

Each challenge lasts for two weeks and invites the household, who are free to ignore it or to join it, to make a specific commitment and set her own level of difficulty. Users are free to join one or more challenge at a time, and challenges can be repeated over time, to support habit creation. Importantly, discussion in the living lab lead revealed that challenge achievements do not need to be quantitatively assessed and verified by the energy savings shown in the app. Not only such an assessment would in fact prove to be difficult to perform, given the current low accuracy in disaggregation of energy consumptions between different appliances; but also, it would be far from the reason why the challenges were introduced. In fact, challenges are regarded as a way to stimulate individual critical reflection on current practices, and to favour sharing of experiences on how to effectively activate transformative action. The important thing is therefore to get the commitment by households, and not to measure their quantitative results, as we expect the energy saving to happen synergistically through all the different mechanisms in the app. Challenge achievement is therefore simply performed by asking the users to share a picture, short text, or tip, summarizing the households' experience when engaged towards the challenge. To this purpose, the app includes a «pinboard» section, namely a forum with liking possibilities for its users, that makes the challenge achievement a social experience and strengthens ties between participants.

The regional energy competition is activated in the last week of every month, thus three times during the SPP Community Energy Challenge. All the households are automatically included in the competition, namely they do not need to enroll, and all the households are put in the team of their region, no matter what their characteristics are. They are given the goal to save as much as energy as they can, compared to the other two regions, and results of the winning region are revealed at the end of the week. Also in this case, communication and sharing of experiences between participants is encouraged, via the Pinboard section. To remind households of the upcoming competition, dedicated notifications are sent before, during and at the end of the competition.

WP3 – Development of the digital toolbox

Co-design of the SPP challenge and the related app concluded in the month of June, with the third living lab workshop. Development of the toolbox (the app, the sensors, and the algorithms) were performed in parallel to the development of co-design activities. Based on the latter, the app's user interface has been defined. The document showing the graphical guidelines for each feature and app component is entirely reported as Appendix 2, while a selection of important screenshots is reported in Figure 4. From the user experience point of view, the most relevant aspects of the user interface are the following:

- the "My Home" screen uses a very simple layout and background color code to allow user to immediately understand the current status of their consumption (increase or decrease compared to their own baseline energy consumption collected in January 2022, respectively represented by red or green background);
- the "My Consumption" screen provide users with more information about the house consumption, via bar charts. It also allows user to easily keep track of the energy consumption activities they performed and of the challenges undertaken during the selected timespan;
- the "Challenge" screen uses a layout that allows users to easily access all the information related to the challenge (and customise their own commitment), as well as the information provided by other users in the Pinboard section.

The choice to use the background color in the main screen ("My home") in order to provide the users with an immediate feedback on their energy consumption is consistent with the outcomes of the recent SFOE-funded "EVISU" research project. EVISU specifically aimed at identifying appealing, simple and intuitive visualizations of energy consumption data, based on the interaction with both experts and lay people. Also in their case, the background color of the smartphone emerged as the most effective way to convey immediate and intuitive information about the amount of energy consumption (Marek et al., 2020). More detailed representations, based on bar charts, emerged instead as the most effective way to provide more detailed and disaggregated energy consumption data, such as the ones provided in "My Consumption" in the Social Power Plus app. The element of social comparison with similar households concerning energy consumption and achieved savings proved to be effective in the warm water intervention made in the Hüttengraben area (Sandmeier et al., 2020), consequently we introduced this element in the SPP app as well. As the visualization of their own historical energy consumption was very much appreciated also by the inhabitants in the Hüttengraben area, we decided to keep this information as one of the key elements regarding energy consumption feedback in the SPP app.

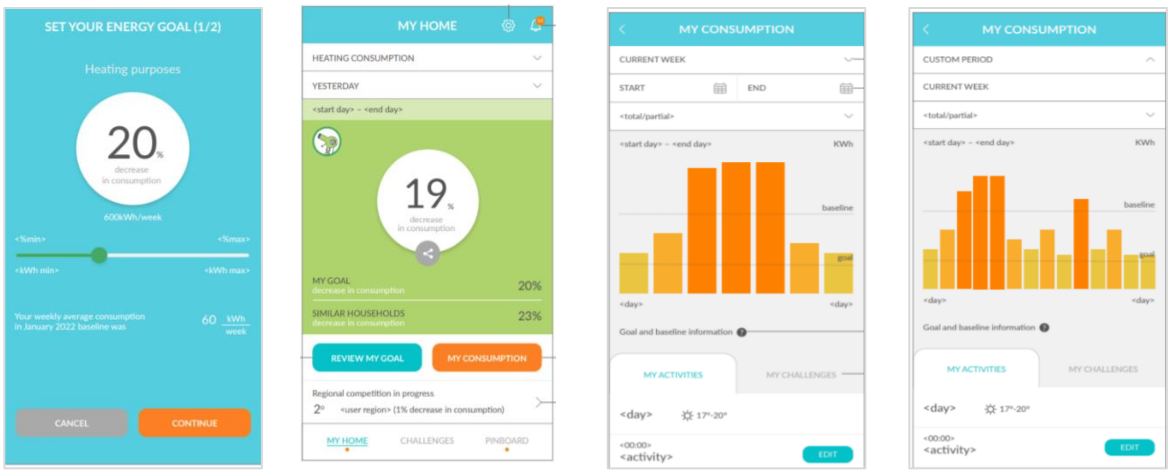

Figure 4a: Excerpts from the SPP app: selection of screenshots representing the most important features: goal setting at registration, home page, feedback on energy consumption.

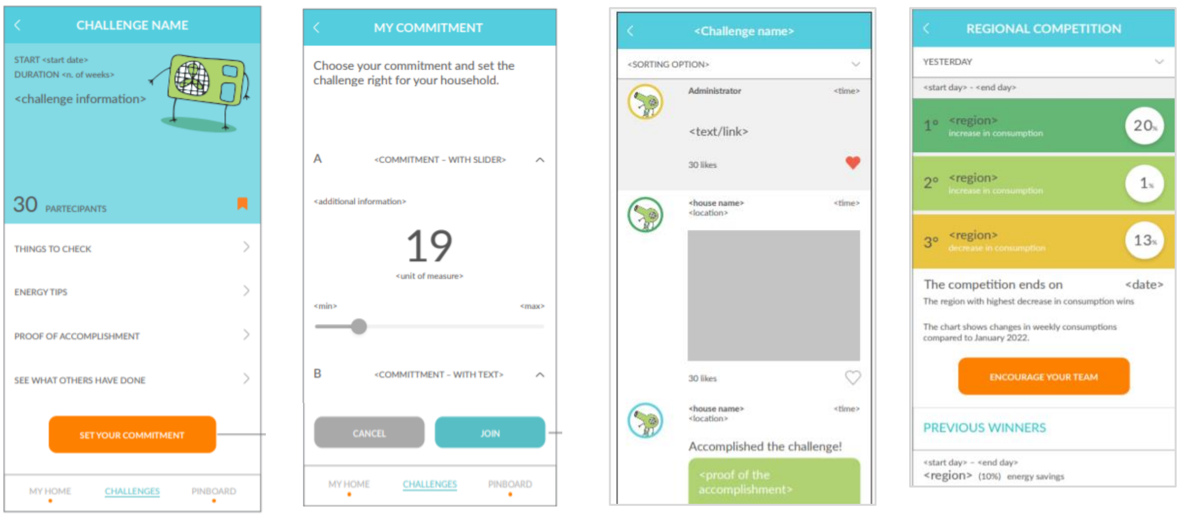

Figure 4b: Excerpts from the SPP app: selection of screenshots representing the most important features: challenge description and commitment, pinboard, and regional energy competition.

Differently than initially planned in the Gantt chart, however, software development of the SPP app was delayed, in order to be able to rely on a stable and shared design of the app's key features. Software development activities were thus mostly performed during Summer and Autumn months. We are currently in the testing and debugging phase of the SPP app, which will be ready for use by the end of the year. Achievement of milestone 4 ("The SPP toolbox is ready to be used in the SPP Community Energy Challenge"), originally planned for July 2021, was thus delayed of about five months. This however is not critical, since the SPP Community Energy Challenge will only start in February 2022.

Besides the SPP app, the other two components of the SPP toolbox are the sensors and the disaggregation algorithms aimed at providing energy consumption feedback. Considering the project budget allows to only develop 100 sensors, a plan on how to allocate them across the regions of the three utilities was at first developed, by considering availability and characteristics of their metering networks. Sensors were all attributed to participants to the SPP Community Energy Challenge living in the EKS region, were currently no smart meters are available, neither for heating nor for electricity consumption. Since such sensors are fed by electricity consumption data, a requirement follows, that households participating to SPP have an electricity heating system. For the region of SWW, instead, smart meters for electricity are currently being deployed by the utility. In this case, we thus opted for using them for data collection (the utility will install and activate them with high priority to the participating households, in order to guarantee they are available for the start of the SPP Community Energy Challenge). Also in this case, therefore, the requirement follows, that households participating to SPP have an electricity heating system. For the case of TBW, instead, smart meters for gas and electricity are available, and they will be exploited during the SPP Community Energy Challenge. Finally, we included another requirement for applicants of the TWB and SWW regions: the absence of a Photovoltaic (PV) installation directly related to the household's energy consumption. Bidirectional smart meters in fact only track the exchange of electricity with the grid, therefore in case of self-consumption of electricity produced by household-related PV plants, lower consumption values than the actual ones would be registered, making the provision of feedback unrealistic. For the region of EKS, instead, the presence of PV plants is not critical, since the sensors measure the whole amount of electricity consumption associated to the households, independently of its source (the grid or a possible PV plant). The installation scheme of the sensors used in EKS is represented in Figure 5.

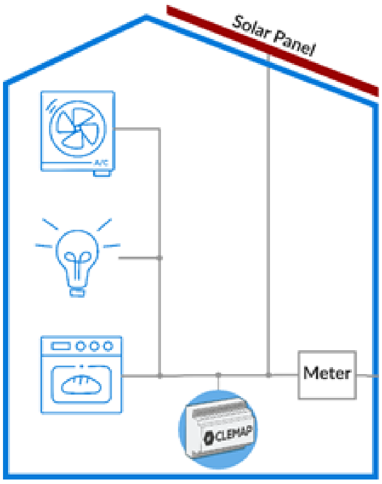

Figure 5: Typical installation of a sensor device with a EKS household with PV-installation.

Regarding the energy consumption disaggregation algorithms, we opted for avoiding disaggregation between different apartments connected to the same heating plant. An additional requirement was therefore set for all participating households, namely the need for independent heating system. Such a requirement basically implies in SPP we target households living in single family houses or households with a dedicated heating system.

Furthermore, again based on the characteristics of the metering network and the type and characteristics of available energy data, we identified the objectives of energy disaggregation algorithms in each region. Disaggregation goals are more ambitious for the case of EKS, since the SPP sensors will have much higher frequency than the smart meters (twelve data points per second compared to one data point per fifteen minutes). In this case, in fact, besides the disaggregation between heating and non-heating purposes, disaggregation of electricity consumption between major large appliances (fridge, oven and stove) and standby consumption (the consumption related to any electrical devices which is always on, apart for fridges, heat pumps, and boilers), will be possible. Within SWW, thanks to the availability of active and reactive power consumption data every 15 minutes, the heating power of heat pumps can be disaggregated from the non-heating part. In addition, availability of active and reactive power consumption data also allows to separately detect standby consumption data. Table 3 summarizes the requirements for households to be involved in the SPP Community Energy Challenge, the data collection sources, and the goals of energy disaggregation algorithms.

Table 3: Requirements for SPP participants, data collection sources, and feedback provided by SPP, for each region.

	Requirements for SPP participating households			SPP collects energy consumption data via…		SPP provides feedback on energy consumption for…
	Type of heating system	Energy source for heating	Presence of PV plant	Heating purposes	Non-heating purposes	
TBW	Individual (single family house)	Gas	Only accepted if energy production is entirely fed into the grid, without self-consumption	Gas smart meters	Electricity smart meters	• Heating (Heat Pump) • Electricity consumption
SWW	Individual (single family house)	Electricity (heat pump)		Electricity smart meters		• Heating (Heat Pump) • Electricity consumption • Standby
EKS	Individual (single family house)	Electricity (heat pump/ direct electric)	If available, it does not affect consumption data collected by the sensors	SPP dedicated electricity meters		• Heating (Heat Pump, Electric Boiler) • Refrigeration • Oven and cooking • Standby • Anything else (electricity)

The disaggregation accuracy of the on-purpose developed algorithm summarised in Table 3 was estimated by CLEMAP to be equal to 80-85% for the case of EKS and equal to 85-97% for the case of SWW. For the case of TBW, disaggregation between heating and non-heating consumption has a 100% accuracy, since the related data comes from two different metering sources.

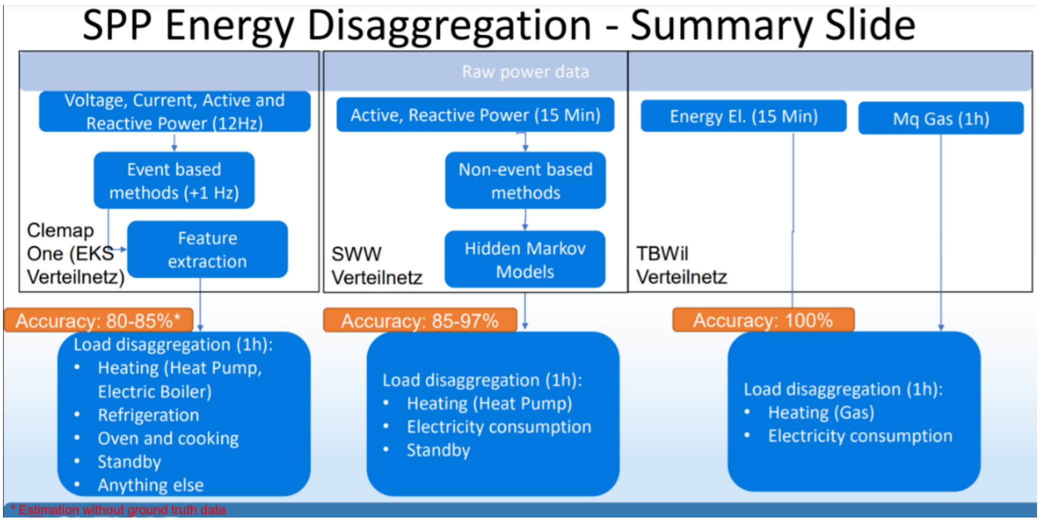

Figure 6: Characteristics of the energy disaggregation algorithms and related accuracy, as estimated by CLEMAP.

Elements of Table 3 show that slightly different app versions will be tested in the three regions: the type of energy consumption feedback provided in the region of EKS will be richer than the other two regions. This could offer the opportunity to assess whether such a richer feedback – all other factors being equal – could lead to higher energy savings in the SPP Community Energy Challenge for EKS participants compared to those in SWW and TBW. Anyway, the design of the SPP quasi-experimental setting (see WP5) will not be strictly aimed at identifying causal relationships between the type of feedback and the consequent amount of energy saving. A strict experimental design would in fact offer the same types of feedback to subsamples of households in each region, in order to rule out any possible effect of unobserved variables that affect energy saving differently, on varying the regions.

Whereas in the case of EKS the whole synchronisation with the server is already available and ready to be used in the project, synchronisation services for TBW and SWW needed to be put in place. In SWW the synchronisation via XML data synchronisation is operative since September 2021, well ahead official start, the synchronisation with TBW server infrastructure (managed by ESOLVA) has been tested via a dedicated FTP server, but is not yet fully operational with pilot customers. The data elaboration happens on CLEMAP Servers and synchronisation towards SUPSI servers (for visualisation on IOS and Android App) is ensured by APIs.

The development of the SPP app was performed following the design requirements presented in Appendix 2. The app is currently available for testing purposes for both iOS and Android operating systems. For Android, the test version is available on the Play store for internal testers, while for iOS it is currently being tested via the Testflight app. The request to publication on Apple's app store for iOS will be performed by the first two weeks of December, to guarantee the app will be available since January 2022. Bug detecting and fixing is currently been performed with the support of the Backlog system, which allows effective tracking and prioritization of debugging activities. The app is accompanied by a backend system, which allow the managers of the SPP Community Energy Challenge to independently modify the content of challenges, tips, and notification messages (both automatic and manual ones) targeting the participants. Also, the app automatically manages bi-lingual translations (it is fully developed in English and then translated in German, apart for a small number of tips, that have been directly developed in German). Such a flexibility has been introduced on-purpose, in order to facilitate the later diffusion of the SPP Community Energy Challenge, in terms of both future editions in the same regions or replication in other regions. Further details on the SPP app, as well as the credentials to test it via Tesflight, are available upon request.

WP4 – SPP Community Energy Challenge pilot tests

The SPP Community Energy Challenge will be tested in three real-life pilots in the regions of EKS, SWW and TBW, with n = 100 participating households each. Recruitment of the participants has been performed from later Summer 2021, with the active involvement of the utilities. A customized post letter has in fact been sent by each utility to a large number of customer households meeting the requirements presented in Table 3 above (3200 personal letters for EKS, 1100 letters for SWW, and 1500 letters for TBW), accompanied by communication activities on their newsletters and social networks. TBW also offered a 50 CHF voucher for their online shop to the first 50 applicants. Participants applied online via the Social Power Plus website using an online registration form (http://www.socialpower.ch/index.php/anmeldung/). The website was also updated with the useful information about the field test, including how sensitive individual data will be managed, stored, and published. At the time of writing (mid November, 2021), the state of applications is summarized in Table 4. Please, note that eligibility criteria were clearly stated on the application page; however, each application has been formally checked by both the SPP team and the representatives of the utility companies. Eligibility checks only referred to the respect of the requirements to enter the SPP Community Energy Challenge listed in Table 3, and no selection among the applicants was performed with respect to socio-demographic criteria of representativeness of the general population. While this would have been largely desirable in terms of increased external validity of the outcomes of the SPP quasi experiment, it would have been detrimental regarding the achievement of the target number of 100 households per region. Therefore, the sample of households participating in the SPP Community Energy Challenge has to be regarded as a self-selected sample.

Also, for TBW and SWW a larger number of applications can be accepted than the target number of 100 households. This is also beneficial, since it allows to manage possible drop-outs during the period of the SPP Community Energy Challenge. In EKS, instead, accepting more households than the target number is not possible, since only 100 sensors are available, given the current budget constraints.

As Table 4 shows, recruitment is completed in the regions of EKS and SWW, with a waiting list of interested participants in EKS, where participation is limited by the number of CLEMAP sensors available. In the region of TBW, instead, a slower application rate was registered than in EKS and SWW, and additional recruitment and communication activities were implemented in October 2021 to reach the target number of 100 households. So far, figures regarding the number of applications received for TBW are not satisfactory yet, and far from the target. Additional recruitment activities have therefore been planned also for the months of December 2021 and (if necessary) January 2022.

Table 4: Number of applications received for the SPP Community Energy Challenge, for each region ("Treatment groups"). State: November 23, 2021.

	Number of received applications	Number of accepted applications	Comments
TBW	49	23	Houses with PV panels or shared heating system were not accepted
SWW	117	111	Houses with PV panels or shared heating system were not accepted
EKS	153	102	30 households are on a waitlist in case there are additional sensors available, or any drop-out happen during installation phase

Once households have been recruited, activities need to be performed in order to guarantee that their energy consumption data will be available to the SPP app from January 2022 onwards. In the case of EKS, this requires that the SPP sensors are installed in each participating household and are properly connected to the automatic data collection system developed for SPP in WP3. This is performed directly by the SPP team, with a support of an electrician, who is paid by dedicated project funds. In the case of SWW, this requires that the households are equipped with the electricity smart meters and that the latter are properly activated, for data connection and sharing with the SPP system. This is done by SWW, and verified by the SPP team. Finally, for TBW smart meters for gas and electricity are already available and connected; however, they currently provide data with a daily frequency, while in the SPP Community Energy Challenge hourly data will be needed. TBW will therefore manually update the data collection frequency for the participant households and the SPP team is responsible for setting up the data connection and sharing system with the SPP app and for verifying that it works correctly. In all cases, by the end of December 2021 all the connection and sharing procedures between the SPP app, the sensors and the smart meters will have been put into place, so that automatic data collection can start from January 2022 for all the participating households in the three regions. This will allow SPP to collect the above-mentioned baseline energy consumption data (weekly average energy consumption of January 2022), to be shown to the users at goal setting and to be used to computed the weekly energy savings (decreases or increases in consumption) shown by the app.

WP5 – Assessment and guidelines

All the above activities and considerations refer to the participants to the SPP Community Energy Challenge. Within the framework of the quasi-experiment we will use to assess the SPP's effectiveness, they correspond to the "treatment groups", namely the self-selected households who will be treated with the SPP Community Energy Challenge and the related toolbox in each region.

Any changes we will observe in their energy consumption patterns will be compared against the changes observed in "control groups" of comparable households in each region, who instead will not be treated with the SPP Community Energy Challenge and toolbox.

The control groups will be selected among the customers of each utility, by randomly picking households that match key characteristic of the households of the treatment groups. In this case, since unfortunately no socio-economic characteristics or information about the number of household members are available to utilities about their customers, the only variable we can use to perform the matches is the energy consumption of the household itself, collected over year 2021. Therefore, as soon as the SPP treatment groups are selected, the range of their annual energy consumption is identified, and comparable members of the control groups are selected as well by the utilities, via random sampling over the sample of customers with the same range of annual energy consumption. This activity is expected to happen between the end of 2021 and the start of 2022; a later identification of the members of the control groups would in any case be still acceptable and non-critical, since no interaction will be performed with the members of the control groups and their energy consumption data is in any case collected by the utilities.

The overall quasi-experimental design we will use to assess the effectiveness of the SPP Community Energy Challenge is visually summarized in Figure 6. We will adopt a longitudinal scheme, comparing the differences between the situation before and the situation during the SPP Community Energy Challenge. This will allow us to properly account for initial different conditions of the involved households. Such a research design requires to collect energy consumption data *before* and *during* the SPP Community Energy Challenge ("baseline consumption data"), to compute their average differences for both the treatment and the control groups, and to verify how such average differences differ between the treatment and the control groups ("difference-in-differences" approach). Energy consumption data will be either automatically collected through sensors and/or smart meters or manually collected through annual meter readings by the utilities (see Table 5).

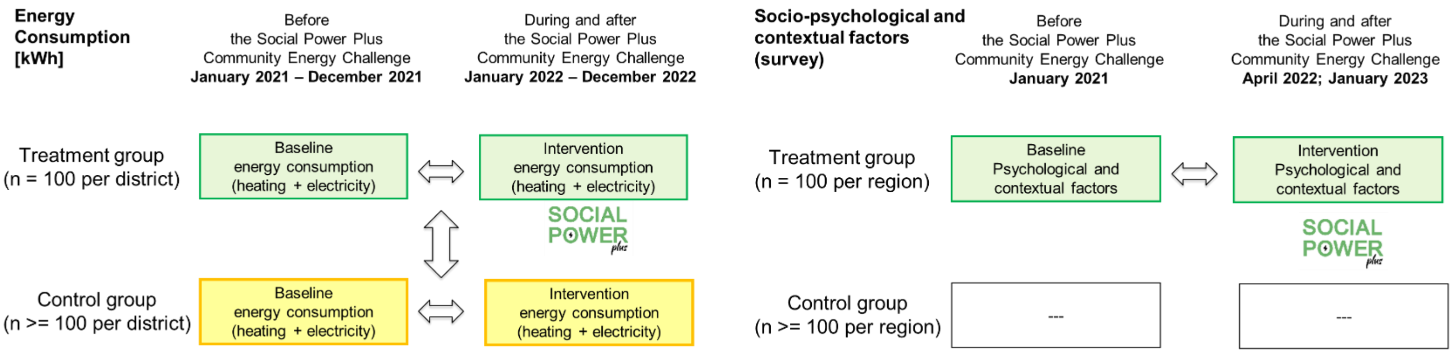

Figure 7: Summary of the quasi-experimental design to assess the effectiveness of the SPP Community Energy Challenge.

Table 5: Available energy consumption data, on varying the utilities, the group (treatment and control), and the period (baseline and SPP Community Energy Challenge).

		Energy consumption data [kWh]	
		Before SPP (baseline[1]) January 2021 – December 2021	**During and after SPP January 2022 – December 2022**
EKS Household customers with electric heating	Treatment group	Manual reading, yearly electricity consumption	Automatic reading (SPP sensors), hourly consumption
	Control group	Manual reading, yearly electricity consumption	Manual reading of yearly electricity consumption data
SWW Household customers with electricity smart meter and electric heating	Treatment group	Manual reading, yearly electricity consumption	Automatic reading (smart meters), hourly consumption
	Control group	Manual reading, yearly electricity consumption	Manual reading, yearly electricity consumption

[1] Please, note the baseline period we refer to for the assessment of effectiveness is different than the baseline we consider in the SPP app (and also show to the user) in order to compute the evolution of energy savings over time.

TBW Customers with gas and electricity smart meter	Treatment group	Automatic reading (smart meters), hourly consumption	Automatic reading (smart meters), hourly consumption
	Control group	Automatic reading (smart meters), hourly consumption	Automatic reading (smart meters), hourly consumption

We will also collect information on socio-psychological and contextual factors (e.g. environmental attitudes, self-efficacy and perception of well-being, etc.), through a before-after longitudinal survey. The survey, however, will only be delivered to members of the treatment groups, to avoid creating any possible biases in energy consumption practices of the control groups, due to a possible Hawthorne effect (changing one's behavior due to the awareness of being monitored).

Ongoing activities, which will be completed by the start of the SPP Community Energy Challenge at the beginning of February 2022, consist in the identification of the control groups, in the collection of the baseline data for both treatment and control groups, and in the design of the survey for the treatment groups, which will be delivered to treatment group members just before the start of the SPP Community Energy Challenge.

Adoption of the before/after scheme requires to collect "baseline" energy consumption data representing the situation before the SPP Community Energy Challenge for the treatment groups, as well as to collect energy consumption data for the baseline and SPP challenge period for the control groups. Such a need largely affects the timeline of the whole SPP quasi-experiment, which has to be set-up in order to guarantee availability of the needed data. In fact, automatic metering infrastructure is already available for a large number of households only in the case of TBW. For EKS and SWW, instead, manual collection of energy consumption data is the only viable option for the control groups and for baseline data collection of the treatment groups. Since such a manual collection is only made once a year for both utilities, providing data for a calendar year, from January to December, the assessment of effectiveness of the SPP Community Energy Challenge can only be performed by comparing yearly energy consumption data for the period January – December 2021 (baseline period) and for the period January – December 2022 (SPP challenge period). For the case of TBW, choice of such periods is completely feasible, since automatic smart meter energy consumption data will always be available

Finally, considering the available energy consumption data, only for the case of TBW both a short-term (after the three core months of the SPP Community Energy Challenge) and long-term analysis (nine months after the end of the SPP Community Energy Challenge) will be possible. The survey aimed at investigating socio-psychological and contextual factors will instead be performed both in the short and in the long term, for all members of the treatment groups in each region (EKS, SWW, and TBW).

WP6 – Dissemination and exploitation

Dissemination of project activities was performed at two levels:

- within the regions of the three utilities, mostly with the aim of recruiting participants to living lab activities and to the SPP Community Energy Challenge;
- and within the scientific community, in order to present the goals and approach of the SPP project, present intermediate results obtained, and collect suggestions for future activities.

As already mentioned, the utilities made available their communication tools and online social networks to present the project. In particular, Appendix 4 reports the short article introducing SPP on the EKS magazine "E on!", with an interview to Evelyn Lobsiger-Kägi of the ZHAW team.

For dissemination within the scientific community, SPP-related activities were instead presented at two conferences by team members: Francesca Cellina of the SUPSI team offered an oral presentation at the 6th European Conference on Behaviour Change for Energy Efficiency (Behave 2021) organized by the Copenhagen Centre on Energy Efficiency; Devon Wemyss offered an oral presentation at the International Sustainability Transition (IST) 2021 conference, hosted by the Fraunhofer Institute for

Systems and Innovation Research of Karlsruhe). Both contributions are included among the conference proceedings, which are currently under development. Appendixes 5 and 1 respectively show the conference submission materials. As already mentioned in the description of activities performed in WP2, the manuscript submitted at the IST conference, already developed as a full paper, will be further elaborated with the aim of submission to a scientific journal.

The project website, available at http://www.socialpower.ch, has been constantly updated in both German and English, with the aim of allowing any interested individuals, either already participating in project activities (living lab, Community Energy Challenge), or simply interested in its goals and content, to find the relevant information.

4 Evaluation of results to date

In the present report we provided a summary of the activities we have performed in each WP and of the related outcomes. As briefly commented in a few sections throughout the document, activities are currently on track and critical milestones for progress of project activities have been achieved.

In fact, despite the COVID-19 measures, we were able to successfully pivot the Living Lab activities to be fully online and the project deadlines have all been kept: activities in Living Labs have been developed and evaluated, the SPP Community and Energy Challenge have been designed and the related toolbox developed, and recruitment of participants to the SPP Community Energy Challenge has been performed. The design of the quasi-experiment aimed at assessing the effectiveness of the challenge has been performed. Looking forward to the SPP Community Energy Challenge, we also do not anticipate a negative impact from the COVID-19 situation, apart from the fact that in-person events are still difficult to plan or not at all feasible, which would have been one of the possibilities to support the sense of community within a region. A delay has been shown for milestone 4 (“The SPP toolbox is ready to be used in the SPP Community Energy Challenge”, originally planned for July 2021). However, we have already remarked that such a delay is not critical, since it will not prevent start of SPP Community Energy Challenge at the beginning of February 2022, coherently with the planning on the Gantt chart.

The only critical situation, that we have timely identified and we are currently addressing, refers to the low recruitment rate of participants in the region of TBW. For this purpose, besides the personal, printed letter sent to all home owners living in the TBW district, additional recruitment activities have been organized and will be implemented in the very next days, before the Christmas holidays. In particular, communication of project activities will be performed by TBW via their own employees to find participants in their community and an additional round of personal printed letters will be sent out by TBW to eligible households. The progress on recruitment of participants to the SPP Community Energy Challenge in the region of TBW will be closely monitored and, in case it remains low, additional communication measures will be activated on early January (press releases, social network campaigns, personal phone calls), with the aim of further increasing the number of participants. Anyway, the case of TBW differs slightly from the other regions, in that we may be witnessing a sense of “participant fatigue” as there have been two similar energy savings campaigns that have been run in the past several years in the region, which, according to evaluations by TBW unfortunately did not run well and left some negative impressions on the customers. We cannot know this for certain, but the lack of response from the TBW customers, following the same successful approaches for SWW and EKS, is curious and therefore may be context dependent.

The SPP Community Energy Challenge will in any case be run in the TBW district, together with all the related analyses, even if the number of participants will not reach the target value of 100 households.

Finally, from the project management perspective, we are satisfied with progress of project activities and have no critical elements to notify. From the perspective of contents, a preliminary evaluation of the effectiveness of the SPP Community Energy Challenge will be possible only with the 2022 Interim report, when at least part of the longitudinal data-sets will have been collected.

5 Next steps

Apart for the above-mentioned additional effort aimed at engaging a sufficient number of households in the region of TBW, which will occur in the very next weeks until the end of January 2022, activities for 2022 will be developed according to the project schedule, with no relevant modifications to notify:

- Electricity meters are installed in EKS households, and synchronization activities will be finalized for TBW participants;
- baseline energy consumption data will be collected for both the treatment and the control groups;
- the SPP Community Energy Challenge will be run from February to April 2022, and it will be followed by notifications and reminders until the end of the year;
- a longitudinal survey aimed at exploring socio-psychological and contextual factors will be run before the start of the SPP Community Energy Challenge in January 2022, then repeated in April 2022 (short-term outcome) and finally again in January 2023 (long-term outcome).

Once all the data will be available, quantitative analyses of the effectiveness of the SPP Community Energy Challenge will be performed, from late 2022 onwards. Results of such analyses will be the basis for the development of recommendations and guidelines for upscaling of the project outcomes and the large-scale exploitation of the SPP Community Energy Challenge and toolbox.

6 National and international cooperation

The whole project is based on a trans-disciplinary research project based on collaboration between partners from SUPSI, ZHAW, and CLEMAP, and cooperation partners from the three utilities EKS, SWW, and TBW. Apart for the above-mentioned presentations to conferences, no additional international collaborations have been activated so far.

7 Publications

- Conference paper: Cellina, F., Carabias-Hütter, V., Castri, R., De Luca, V., Granato, P., Kienast, P., Lobsiger-Kägi, E., Wemyss, D. , Social Power Plus: Empowering Households to Energy Sufficiency through Co-designed App-based Community Energy Challenges. In: Zhu, X. , Prata Dias, G. (Eds.), Conference proceedings BEHAVE 2020-2021 - The 6th European Conference on Behaviour Change for Energy Efficiency, April, 21-23 2021, Online (hosted by Copenhagen Centre on Energy Efficiency). ISBN: 978-87-94094-01-6. https://c2e2.unepdtu.org/wp-content/uploads/sites/3/2021/04/behave-2020-2021-conference-proceedings.pdf
- Conference paper: Wemyss, D., Lobsiger- Kägi, E., Jud, S., Cellina, F. “My energy transition at home: Results of co-creating an energy savings app with household members and researchers”. International Sustainability Transition (IST) 2021, October 2021 (proceedings under development).

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9 Appendix

Appendix 1

Manuscript presented at the International Sustainability Transition (IST) 2021 in October 2021: Wemyss, D., Lobsiger- Kägi, E., Jud, S., Cellina, F. “My energy transition at home: Results of co-creating an energy savings app with household members and researchers”.

Appendix 2

Graphical guidelines for the Social Power Plus app.

Appendix 3

Article introducing SPP on the EKS magazine “EKS on!”.

Appendix 4

Manuscript presented at the Behave 2021 Conference and included in Conference proceedings (pages 93-97): Cellina, F., Carabias-Hütter, V., Castri, R., De Luca, V., Granato, P., Kienast, P., Lobsiger-Kägi, E., Wemyss, D. , Social Power Plus: Empowering Households to Energy Sufficiency through Co-designed App-based Community Energy Challenges. In: Zhu, X. , Prata Dias, G. (Eds.), Conference proceedings BEHAVE 2020-2021 - The 6th European Conference on Behaviour Change for Energy Efficiency, April, 21-23 2021, Online (hosted by Copenhagen Centre on Energy Efficiency). ISBN: 978-87-94094-01-6.