D3.3 Final Field Tested Integrated Energy System

Workpackage 3

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Executive Summary

This report summarizes

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1 Introduction

1.1 Aim and Scope

Work Package 3 (WP3) focuses on the design and development of ICT facilitation for social participation in the energy network to manage communities and support energy services. Deliverable 3.3 (D3.3) is described in the CIVIS project proposal as follows:

> D3.3) Final field tested Integrated Energy System: Output of T3.1-5; Based on information provided by the deployment of deliverable 3.2 the software is further refined to provide energy services and community management (open source).

The 3rd year's project activities continued the design and development of the software platform *YouPower*[1], expanding upon the 2nd year's result reported in D3.2 (Huang et al., 2015). As stated in D3.2, the CIVIS platform is composed of two parts (see Figure 1): the services provided by the CIVIS back-end, and the CIVIS front-end application which users directly interact with. To this end, WP4 focuses on the system level ICT services that deal with the energy data and its collection through the smart meters and sensors installed at the Swedish and Italian test sites (see D4.3 for more details). WP3 focuses on the front-end application and the social level ICT services that are related to users/prosumers, households, communities, energy consumptions, etc.

In this report, we discuss the design and development of the WP3 part of the CIVIS platform known as YouPower[2]. The final results are summarized as a whole for readability and usefulness. The refinement and improvement made in the third year are highlighted where necessary when possible. The functionalities of the platform reported are deployed at Stockholm (Sweden) and Trento (Italy) test sites respectively according to the local context. The YouPower software is open source under the Apache v.2 License[3]. It has an online repository at GitHub[4]. The backend API documentation is aslo available online[5].

1.2 Design and Development: the Continuation

Environmental problems have their origins in human behavoir; as a result, any solution to enviromental issues will require changes in behavoir (Schultz, 2014). A novelty of the CIVIS project is that our research attention is geared towards the potentials and challenges of user's collective actions, pro-social values and sense of community. Collective human behavior is deemed critical because it is both a source and a solution to the problem of climate change

[1] `http://civis.tbm.tudelft.nl/` or `https://app.civisproject.eu/`
[2] The CIVIS front-end application used to be called EnergyUP. The old name may be found in some old documents and/or mock-ups.
[3] `https://github.com/CIVIS-project/YouPower/blob/master/LICENSE`
[4] `https://github.com/CIVIS-project/YouPower/`
[5] `http://civis.tbm.tudelft.nl/apidoc/`

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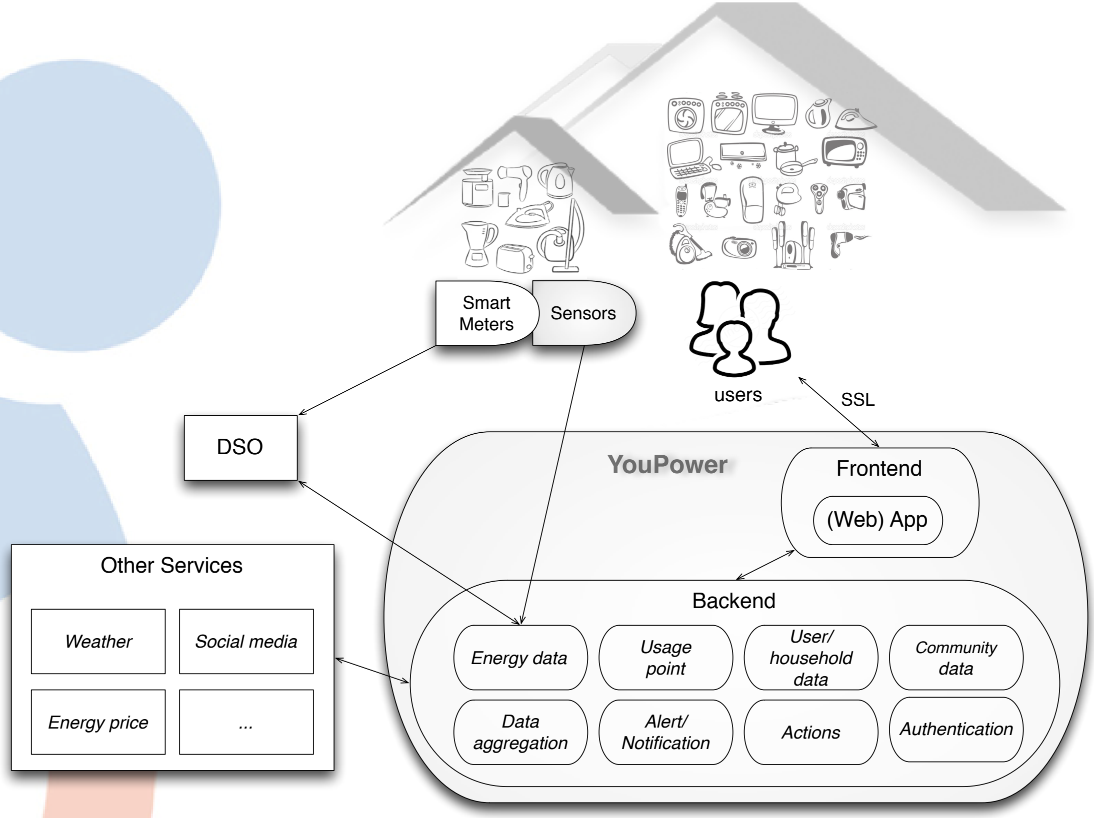

DSO (Distribution System Operators), SSL (Secure Sockets Layer)

Figure 1: CIVIS platform overview

(Masson and Fritsche, 2014). In this context, the design of YouPower aims to support social participation, awareness and engagement by means of ICT in the smart grids to achieve sustainable energy goals such as consumption reduction and load shifting. We as researchers can also use this platform as a communication channel to promote sustainable energy goals, and as a research instrument to observe users' responses and possible outcomes.

The design and development of YouPower is theory-driven, user-centered and iterative (Leffingwell and Widrig, 2000; Leffingwell, 2011). We extensively researched literature on intervention strategies and social smart grid applications directed at promoting pro environmental consumer behavior change. This provided an initial set of design ideas that are iteratively refined and improved through the design process. Applying a user-centered design process can lead to more acceptable, satisfying and effective designs (Brynjarsdottir et al., 2012). This increases the potential of the intervention (Dick et al., 2012a) and may help increase user engagement with respect to the sense of relatedness to the application (Pierce

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et al., 2003; ?; ?).

In the 2nd year of CIVIS, we started with brainstorming sessions and a design workshop. A set of features was prototyped in simple handcrafted mock-ups used as a basis for discussion, and then underwent iterative rapid prototyping which produced wireframes as visual guides that can be more effectively communicated to general users. These prototypes were evaluated by user tests with groups of students and colleagues. Using the wireframe prototypes and later the software prototypes, we conducted focus group studies with consumers in Trento, test studies and focus groups with consumers and housing cooperative members in Stockholm, as well as a user study with pro-environmental participants in Helsinki.

In the 3rd year of CIVIS, the iterative design and development process continued. We paid particular attention to quick responses to changes, user feedback and adaptive development. We also furthered literature research in environmental psychology and intervention design, and expanded the design guidelines based on literature, our design practices and experiences. These guidelines can be useful for a wider group of designers interested in pro-environmental information-based intervention. YouPower has been refined and improved gradually in the 3rd year resulting the current version of the application. The first deployment at the Stockholm test site was in Nov 2015 and Trento test site in Mar 2016 correspondingly. The production server (i.e. CIVIS YouPower server hosted by TU Delft) since then has been updated once there were new parts ready for deployment. The rest of this report presents and discusses the latest version of YouPower.

2 CIVIS Platform Design

2.1 Motivation: Bridging the Attitude-Behavior Gap

Environmentally significant behaviours should be understood as relatively inconspicuous actions performed in the context of everyday life (Burgess and Nye, 2008). People consume energy through many daily practices and routines in households (Burgess and Nye, 2008; Hargreaves et al., 2010; Fehrenbacher, 2011; Burchell et al., 2014). How and to what extent these daily actions affect domestic energy use and in turn the environment are not always readily apparent to average consumers (Burgess and Nye, 2008; Delmas et al., 2013). This knowledge deficit poses significant constraints for consumers to perform and engage in energy conservation (and energy efficiency) behaviors (Schultz, 2002; Burchell et al., 2014). Acquiring such information is often costly (Delmas et al., 2013).

A rich body of empirical research suggests that relevant information tends to result in higher knowledge levels but not necessarily in behavior changes or energy savings (Abrahamse et al., 2005; Delmas et al., 2013; Burchell et al., 2014; Asensio and Delmas, 2015). Despite growing environmental awareness and articulated preference for “green” lifestyles, people’s pro-environmental values and attitudes often fail to materialize in actual actions and behavior changes, from energy conservation, to recycling, to the purchase of green prod-

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ucts (Schultz, 2002; Abrahamse et al., 2005; Claudy et al., 2013). This imparity is commonly referred to as the attitude-behavior gap or the value-action gap (Blake, 1999; Kollmuss and Agyeman, 2002; Claudy et al., 2013).

Although there is no single framework or theory that provides definitive explanations for the attitude-behavior gap (Kollmuss and Agyeman, 2002; Schultz, 2014), literature provides suggestions that shed some light on this issue. People perform (or do not perform) certain pro-environmental actions for many reasons (Schultz, 2002). The reasons for acting are often referred to as motives or motivation (Parfit and Broome, 1997; Moisander, 2007). A distinction can be made between *primary motives* and *selective motives* (Kollmuss and Agyeman, 2002; Moisander, 2007). Primary motives influence decisions to engage (or not to engage) in a whole class of actions or behaviors. For example, *Do I want to bike to work (in general)?* They can be understood as general attitudes towards certain actions. Selective motives influence decisions on specific actions. For example, *(It is cold and raining.) Do I want to bike to work (now)?* They have direct positive or negative impact on the actions. In this sense, primary motives, such as altruistic and social values which build up attitudes, have no direct influence on specific actions. They are often covered up by more immediate selective motives, which evolve around personal and everyday needs and context such as comfort, practicality and complexities in everyday life (Kollmuss and Agyeman, 2002; Berthoû, 2013; Selvefors et al., 2015).

The countervailing influences of context-specific reasons for or against specific actions (that is, the selective motives aforementioned) are strong antecedents of one's decisions on the actions (Claudy et al., 2013). In particular, a decision is often more strongly influenced by reasons against the action (Claudy et al., 2013; Berthoû, 2013). This means, one can decide not to or fail to perform pro-environmental actions (because of context-specific reasons against the actions) even if one holds pro-environmental values and attitudes. For example, load-shifting of electricity use by doing laundry at night is not an option for shared laundry facilities that are only open during daytime (Entwistle et al., 2015); a tenant may depend on the landlord for certain energy reduction actions (that involve investments) to be taken (Dillahunt et al., 2010). In general, one's abilities and willingness to take energy conservation actions are constrained by the context-specific reasons in everyday life. In many cases, people act habitually or routinely rather than making reasoned choices (Steg and Vlek, 2009; Berthoû, 2013). Habits are learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states (Verplanken and Aarts, 1999). Those who have tried to change a habit, even in a minor way, would discover how difficult it is even if the new behavior has distinct advantages over the old one (Kollmuss and Agyeman, 2002). When an individual wants to establish a new behavior, the person has to practice it (Kollmuss and Agyeman, 2002). One might be perfectly willing to change certain behavior but still not do so because the person does not persist enough in practicing the new behavior until it has become a habit (Kollmuss and Agyeman, 2002). A sustained behavior change requires learning a new habit (Dillahunt et al., 2009).

To bridge the attitude-behavior gap, household energy conservation (and load-shifting)

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behavior interventions can be geared towards the facilitation of the behavior change process in everyday life. The goal of this process is to motivate consumers to learn and practice new energy consumption behaviors until those behaviors become new habits that are embedded in the specific context of their everyday life. In particular, this means that (1) consumers need to be provided with accurate information about actionable suggestions on how to achieve potential energy conservation (and load-shifting) , and (2) the intervention design shall also have means to motivate consumers to voluntarily practice and repeat the energy conservation (and load-shifting) actions in the specific context of their everyday life.

2.2 Design Guidelines

This subsection outlines and discusses 10 design guidelines derived from literature and our design experience. The first five guidelines (1 – 5) concern providing accurate and accessible information about actionable suggestions in the behavior change process. Guidelines 6 – 9 address the design part about fostering motivations (and engagement) in the behavior change process. Guideline 10 is more a methodological guideline than a specific design guideline. It is not beyond state of the art, but nonetheless a very relevant and important one that deserves attention. Schultz (2002) distinguishes three types of knowledge in pro-environmental actions. Procedural knowledge is about the where, when, and how of some task. Impact knowledge is an individual's beliefs about the consequence of some task. Normative knowledge is beliefs about behaviors of others. An information-based intervention design can provide information that aim to increase all the three types of knowledge. Guidelines 1 – 4, 4 – 5, and 7 address the three types of knowledge respectively.

1. Develop and enhance consumers' energy conservation know-how through action suggestions that are implementable in everyday life.

Action suggestions are recommendations and tips for energy conservation actions. Besides the literature support stated in Subsection 2.1, the results of user studies at the Italian and Swedish test sites of the CIVIS project also suggest that receiving implementable suggestions from a reliable source would be useful for the households. Hence, we recommend to provide action suggestions that can be easily incorporated into everyday practices. In particular, this means that (1) if possible, make action suggestions inexpensive micro-actions or divide a complex action into smaller steps; (2) the suggestions shall be tailored to the local everyday context, and (3) the suggestions shall be provided (to consumers) in an easily accessible manner.

2. Explicitly express action suggestions with concrete and reliable content.

The complexity of the information presented, the framing of the message, and the credibility of the source are among the key issues in delivering effective information (Schultz, 2002). (Abrahamse et al., 2005) propose to explicitly mention the intervention strategy and specify its exact content and which behaviors are targeted; the benefit is twofold: the specifications (1) can provide clear information and suggestions to consumers, and (2) can be

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used by researchers as a decisive factor in evaluating an intervention's (in)effectiveness. The Italian participants in the user group studies raised the concern that they often found themselves plunged in a series of conflicting advice from various sources. Therefore it is important for them to have a reliable source of information and suggestions on energy conservation strategies or actions. Similarly, some energy managers in the Hammarby Sjöstad housing cooperatives had bad experiences of interactions with energy providers offering energy efficiency services and companies selling energy efficient technologies, and they perceived these companies to have vested interests. The perceived reliable sources are e.g. national and international energy authorities, consumer and environmental organisations, electricity suppliers (CEER, 2015) as well as neighbours and friends, in contrast to salespeople (Selvefors et al., 2015).

3. Provide suggestions range from one-time actions to routine actions.

One-time actions (or one-shot behaviors) refer to efficiency (increasing) behaviors, many of which entail the purchase of energy-efficient equipments (Abrahamse et al., 2005; Gardner and Stern, 2008) e.g. using a fridge with A+++ energy label, and installation of attic insulation. Routine actions refer to curtailment behaviors that involve repetitive efforts to use equipments less frequently or intensively (Abrahamse et al., 2005; Gardner and Stern, 2008), e.g. thawing food in the refrigerator, and air-drying clothes. On the one hand, one-time actions often require purchasing, which offsets their advantage of simplicity, whereas most routine actions have no financial cost (Abrahamse et al., 2005; Gardner and Stern, 2008). On the other hand, one-time actions are often more beneficial and cost-effective in the long-term (Froehlich, 2009), and their energy-saving potential is generally considered to be greater than that of routine actions (Abrahamse et al., 2005; Gardner and Stern, 2008). While many interventions targeted at households aim to change routine practices (Froehlich, 2009), we recommend to provide suggestions that range from one-time actions to routine actions. There are actions that are in-between one-time and routine, such as occasionally vacuuming behind the fridge and regularly defrosting the freezer.

4. Support demand side management through simple time-of-use (ToU) signals.

The overall efficacy of time-of-use tariffs for demand side management is still debated. However, dynamic signals in energy systems with high presence of renewable energy sources (RES), which are characterized by high unpredictability (e.g. wind, solar, hydro with no basins) (Perez-Arriaga and Batlle, 2012), seem yet worth considering (Torriti, 2012; Palensky and Dietrich, 2011).

To a great extent, supporting changes in energy demand – from reduction to shifts – implies supporting people in changing their daily routines, it does not only involve the 'simple' alternative use of an appliance. Energy is 'used for something' and this 'something' is always deeply rooted in people's habits and contexts (Shove and Walker, 2014). Recent literature claimed that interventions aimed at supporting demand side management by focusing

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on the *appliance* level[6] of intervention, have very limited and only short-term implications. More effective approaches work at the level of *practice*: supporting people in doing things differently (Grünewald, 2016). Simplicity and clarity of means to support demand side management at the practice level are key factors to help people adapting and adpoting alternative routines. In the particular case of ToU based approaches, Grünewald et al. (2015) argued for a design of ToU signals that are the easiest to grasp by people.

5. Indicate the effort entailed by a suggested action and its potential impact in an understandable way.

The potential benefits (or outcomes) of an action, and the practicality and convenience (or inconvenience) of performing the action are important for people's decisions on adopting and sustaining the action (Schultz, 2002; Claudy et al., 2013). As discussed earlier, we recommend to provide actions suggestions that are practical and inexpensive so that they can be implemented in busy everyday life, and to include actions that range from one-time to routine actions, as the former has long-term benefits and the latter can be performed straightaway for energy conservation without purchasing. Such information (i.e., both the procedural information and impact information) should be presented to consumers in an easily understandable way.

General consumers often have difficulties understanding energy presented in kilowatt hours or water in cubic centimetres (Froehlich, 2009). These technical units of measurement can be used when needed, while people often prefer to have explanatory information e.g. showing energy use as number of laptops and CO_2 exhaust as number of trees (Petkov et al., 2011). Many studies report that energy conservation outcomes expressed in terms of monetary savings result in underestimation of the impact of the efforts to reduce consumption (Froehlich, 2009; Pierce et al., 2010; Abrahamse and Steg, 2013). We recommend to express the effort and impact of each action in an easy and understandable way, for example, in a scale of one to five. This also makes the suggested actions easily comparable. Impact of actions that have already been taken can also be shown by comparing energy use before and after the action was taken.

6. Enhance and maintain intrinsic motivation; promote more active and volitional forms of extrinsic motivation.

Intrinsic motivation is defined as the doing of an activity for its inherent satisfactions (rather than for its presumed instrumental value); contrarily, extrinsic motivation is the doing of an activity to attain some separable outcome or consequence (Ryan and Deci, 2000). In the context of energy conservation, intrinsic motivators of actions are e.g. pro-environmental values, and common well-being; extrinsic motivators of actions are e.g. monetary incentives, tangible rewards, competitions, and social pressure.

A large body of research favors intrinsic motivation over extrinsic motivation for the following two main reasons. First, intrinsic motivation is more likely to result in long-term

[6]This refers to automated appliances or semi-automated/remotely controlled appliances.

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behaviour change compared to extrinsic motivation (He et al., 2010). That is, extrinsic motivators can motivate energy conservation, particularly for one-time behaviors; however, behaviors that must be repeated (i.e. routine behavior) will likely stop once the external motivator is removed; extrinsic motivators may even inadvertently increase self-centered behaviors over pro-environmental behaviors (Swim et al., 2014). Second, intrinsic motivation will lead to positive spillover of pro-environmental behaviors while extrinsic motivation will lead to negative spillover; positive or negative spillover refers to the effect that one pro-environmental behavior increases or decreases the likelihood of additional pro-environmental behaviors (Thøgersen and Crompton, 2009; Truelove et al., 2014; Knowles et al., 2014).

In situations where intrinsic motivations are low or absent, Ryan and Deci (2000) propose to promote more active and volitional (versus passive and controlling) forms of extrinsic motivation (Ryan and Deci, 2000). (Ryan and Deci, 2000) suggest that extrinsic motivation can vary greatly in the degree to which it is autonomous, i.e., one can perform extrinsically motivated actions with resentment, resistance and disinterest or, alternatively, with an attitude of willingness that reflects an inner acceptance of the value or utility of a task.

For a high level of intrinsic motivation to be maintained or enhanced, or for extrinsic motivation to be more active and volitional, people must experience satisfaction of both the needs for (1) feelings of competence, and (2) senses of autonomy; this means that people must not only experience perceived competence (or self-efficacy), they must also experience their behavior to be self-determined (i.e. free choice rather than being controlled) (Ryan and Deci, 2000). In such cases, an individual has a strong internal locus of control. Feelings of competence can be enhanced e.g. through positive performance feedback and encouragement of small steps or micro-actions, whereas senses of autonomy can be enhanced e.g. through allowing and facilitating people's own choices of taking up actions. In addition, (Ryan and Deci, 2000) suggest that the satisfaction of the needs for (3) senses of relatedness facilitates active and volitional extrinsic motivation (i.e. belongingness and connectedness to the person, group or culture disseminating a goal); intrinsic motivation possesses this condition by definition. Supports for relatedness and competence foster internalization, and supports for autonomy additionally foster integration of values and behavioral regulations (Ryan and Deci, 2000). We recommend to incorporate the facilitation of these three elements into the intervention design.

7. Use social norms and public commitment to address low motivation.

Normative knowledge (i.e. perceived social norms) is an understanding of the behavior of others (Schultz, 2002). Descriptive social norms are beliefs about what other people are doing, often referred to as *norms of is*, whereas injunctive social norms are beliefs about what other people think they should be doing, often referred to as *norms of ought* (Schultz, 2002). Research indicates that normative beliefs can predict a variety of behaviors, and normative interventions are effective in promoting pro-environmental behavior change by giving cues as to what is appropriate and desirable (Allcott, 2011; Schultz, 2002; Petkov et al., 2011; Del-

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mas et al., 2013). They are useful to address low motivation (Schultz, 2015).

Nonetheless, there are quite a few instances where normative beliefs would not be predictive, e.g. when one perceives that a behavior is desired but does not perceive that others are doing it and/or thinks the impact or benefits of one's own actions is very low (i.e. a strong external locus of control), or when one's behavior is not directly observable by other community members (Schultz, 2002; Ockwell et al., 2009). Many of these situations can be characterized as commons dilemmas (a.k.a. the tragedy of the commons (Hardin, 1968)), that is, whether to reduce one's individual rates of consumption, sacrificing their own desires, freedom to consume, and perhaps personal well-being for the future of the group, or to continue using the resources at the same rate for their own gain and with no regard for others, risking the common pool of resources (Edney and Harper, 1978; Edney, 1980). Free riders are concrete examples of the commons problem. In energy consumption, free riders often appear when the energy cost is included in the rent (or utility package) (Munley et al., 1990) or when a residence has shared metering (Dewees and Tombe, 2011).

Besides using private ownership and policy interventions to regulate this problem, communication can lead individuals to act in the interest of the group — individuals are considerably more likely to reduce their use of the common when they believe that others who share access to the common will also limit their use (Edney and Harper, 1978; Schultz, 2002). Public commitment (and disseminating this information) (McKenzie-Mohr, 2000; Abrahamse et al., 2005) is a promise or agreement made publicly by a person (or an organization, etc.) to perform a certain action or behavior. When one?s own behavior and that of others are publicly observable, the behavior is more likely to be affected by changes in normative beliefs, which in turn may contribute to tackling the commons problem (Yim, 2011; Schultz, 2002). Peer-pressure can induce cooperation among self-interested individuals such as free riders (Mani et al., 2013). The user study in Helsinki suggests that people are willing to share publicly (or with a selected group of people) their energy conservation actions, and do not consider this a privacy issue. They are also interested in the conservation actions of others such as household members, neighbors, friends and similar consumers (and households). Similarly, the housing cooperatives in the Hammarby Sjöstad pilot site thought it would be valuable to see building level energy reduction actions taken by other cooperatives and, since it is cooperative level information, they were also willing to share energy data for comparison purposes.

8. Facilitate consumers to reflect on (pro-environmental) lifestyle choices in the process of behavior change.

Brynjarsdottir et al. (2012) critically reviewed ICT technologies designed for environmental behavior interventions (and persuasions). The authors point out that existing design, having a narrowed vision of sustainability, overly focuses on modernistic system change and individual consumption and entrusts designers with the responsibility to decide what is or is not appropriate behavior. They suggest to lessen the prescription of pro-environmental or sustainable actions chosen by designers, who may not connect with users' actual every-

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day life experiences, and instead to make design that help elicit issues of sustainability and encourage users for open-ended reflection on what it actually means to be sustainable in a way and with lifestyle choices that make sense in the context of their everyday life. With this goal, our design (1) lets users to choose and schedule the actions according to their needs and interests, and (2) facilitates commenting and discussions among users.

9. Engage all household members.

It is important to engage all household members in energy conservation in everyday life. The artifacts, technologies and resource systems to date are typically designed for "household resource managers", often men, although they are far from the only energy users in households (Strengers, 2014). Women dominate the everyday practices of the household (particularly cleaning activities), and are often more sensitive to understandings of presentability, body odour, hygiene and cosiness (Strengers, 2014). Women usually show more concern about environmental destruction, and are more emotionally engaged and willing to change (Kollmuss and Agyeman, 2002). Families with children generally consume more energy than those without and this consumption tends to increase as children grow older (Fell and Chiu, 2014). Children and teenagers are commonly recognized as lacking interest in energy bills, and they participate in or are the cause of many energy consuming practices (Berthoû, 2013; Strengers, 2014). Studies show that children enjoy the involvement and responsibility in helping save energy, and parents? commitment also increases when they think about energy conservation in the context of their children's education (Burchell et al., 2014; Fell and Chiu, 2014). Discussing and establishing common family responsibilities around energy consumption is reported to be effective (Huizenga et al., 2015).

10. Define energy interventions through co-design approaches.

As widely reported in literature[7], changes of energy attitudes and behaviours are deeply rooted into the broader social environment in which they shall take place. For instance, failures to properly understand the social constraints that are situated in the local contexts, greatly undermine the possibility for any policy, technology or form of intervention to be effective in the energy domain (Devine-Wright and Devine-Wright, 2005). Pre-existing social norms, concrete and tangible local energy needs (which may well vary at municipality, regional or national levels) as well as perceived energy or environmental challenges, they all impact households and people engagement in improving (sustainably) energy behaviours.

For an energy intervention to have chances of becoming locally relevant and sustainable in a given place, it is crucial to engage with all the related stakeholders (*e.g.* Public Administrations, DSOs, retailers, households, associations) and to involve them in the definition and appopriation of energy interventions – with regards to their objectives and, moreover, to the tools and technologies that support them. Codesign approaches are becoming more and more used to uncover the complexities of energy systems in their local contexts (*e.g.* infras-

[7]For an extensive overview (yet not exhaustive) of how societal aspects intersect behavioural and attitudes change in energy, see (Owens and Driffill, 2008).

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tructures, technologies, target user groups, energy needs) and to design energy interventions that try to align, as much as possible, diverse sets of interests and expectations (Dick et al., 2012b; Tang et al., 2008). Energy interventions can become widespread and public matters of concerns (DiSalvo et al., 2014) with increased sense of belonging and active participation (Throndsen and Ryghaug, 2015; Marres, 2012), if they are designed and deployed through the involvement of relevant stakeholders.

Therefore, processes for stakeholders engagement, practical means and channels for the elicitation and integration of their inputs shall be put in place for the various phases of energy interventions: preliminary studies and design, development and testing, deployment and maintenance.

2.3 CIVIS Platform Design

2.3.1 Action Suggestions

This part of the application is designed and developed not only with the goal to provide users with actionable suggestions for household energy conservation in an easily accessible way, but also to facilitate the process of voluntary behavior change such that this process can be adapted and followed up (e.g. with one-minute use) by users in the busyness and competing priorities of their everyday life.

A list of about fifty actions[8] is composed to provide accurate information about actionable suggestions in the behavoir change process towards energy conservation. It is a pool of concrete household energy conservation actions based on information from credible sources such as reputable national and international energy agencies and associations. Many suggestions selected are micro-actions that are practical and inexpensive to implement in everyday life, including one-time actions such as *Use energy efficient cooktops*, routine actions such as *Line dry, air dry clothes whenever you can*, as well as in-between actions (reminders) such as *defrost your fridge regularly (in x days)*. Each suggestion has a short description, accompanied by a simple explanatory note, and the corresponding effort entailed and the estimated impact (on a five-point scale). Figure 2-(1) shows an example. The action suggestions are tailored to the local (i.e. Trento and Stockholm test sites) context when needed by local project partners, reviewed by user groups, and translated into the local languages.

By way of caveat, some suggestions enlisted may seem obvious and trivial, but this does not mean that users are indeed doing them in practice. The goal of the design is to facilitate the behavior change process to bridge the attitude-behavior gap, making energy conservation actions new habits integrated in everyday household practices.

The action suggestions composed are not meant as prescriptions for what users should do for energy conservation, but to present users different ideas of what they can do and how to do it in common household practices. The users are offered with a pool of actionable options which they can freely choose from according to their own context. This line of thought

[8] https://goo.gl/R11QdZ

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in design is reflected in the way the information is framed and conveyed to the users.

- With the YouPower application, a user can follow a few energy conservation actions at a time. Each user has an overview (the *Your Actions* tab) of his/her own current, pending, and recently completed actions. Figure 2-(2) shows an example.

- A new/next action suggestion is presented to the user when an old/previous action is completed, or when the user wishes to add an action (by clicking an *Add Action* button).

- When prompted with a suggestion, the user can decide whether to take the action, or indicate that he/she is alreading doing it or the suggestion is not applicable to his/her situation. Figure 2-(1) shows an example. (The four options are: I already do this consistently; I want to do this; I don't want to do this; this doesn't not apply to me.)

- After a suggested action is accepted, the user may postpone (i.e. reschedule), abandon or indicate that the action is completed. Figure 2-(3) shows an example. (The three options are: I have done this consistently; I want to postpone this action; I don't want to do this anymore).

- When an action is pending (i.e. scheduled), e.g. *defrost your fridge in x days* (x is set by a user), it will be triggered by time so that the application reminds the user of the pending action.

- In application settings, the user can choose whether to repeat a completed action, reconsider a declined action, or reassess if an action is applicable to the user.

The YouPower application also uses a number of other design elements to promote users' motivation and engagement in the behavior change process. In principle, the focus is placed on providing supports for relatedness, competence and autonomy, promoting pro-environmental and altruistic values, and making one's energy conservation actions and commitments more publicly observable.

- Each action has points (displayed as *Green Leaves*) associated to the effort and impact score of that action. If a user completes an action, the user is awarded with leaves.

- A user can like (with a *Like* button) and comment on the actions (which are visible to all users). After a user completes or abandons an action, the user is asked to provide feedback (to the YouPower team). Figure 3 shows examples. The user is awarded with leaves if he/she gives comments and feedback (1 leaf each).

- The application encourages users to take small steps and gives them positive performance feedback. For example, when a user is taking up many actions, the application can prompt that *You already have x actions in progress. You can add more actions after some of those are completed. Keep on! You are doing great.*

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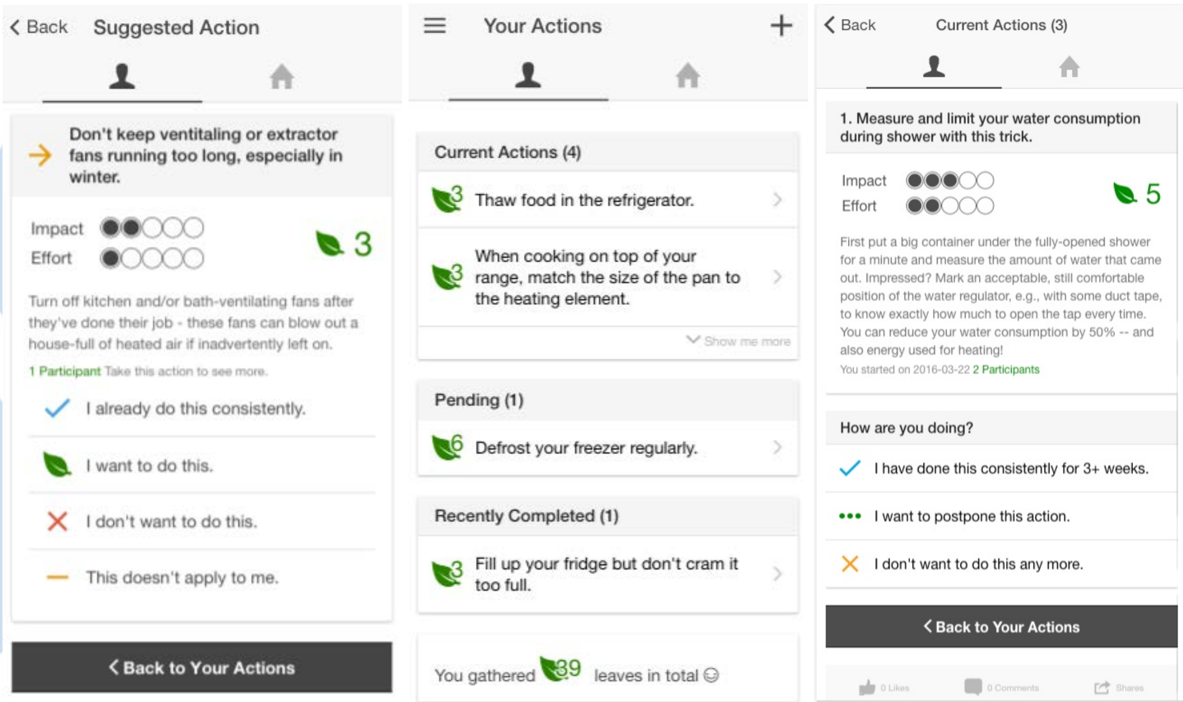

Figure 2: (1) An action suggestion; (2) User actions tab; (3) An action in progress

- A user can signup and login YouPower with a Facebook account. If so, the user can "share" an action on Facebook. Figure 4 shows an example.
- The users are presented with the information about how many users have been taking an action (including Facebook friends when logged in through Facebook).
- A user can configure a personal profile and household profile.
- A user can add members to his/her household; Figure 5-(1). If so, the user can see the actions of household members; Figure 5-(2), and add the actions to his/her own action list.
- A user can send friends Email invitations to join YouPower (Figure 6).

The intention of the design (besides those already mentioned) can be highlighted as follows. For the options of choosing actions, see e.g. Figure 2-(1) and Figure 2-(3), first person narrative (e.g. *I don't want to do this*) is used to create a personal micro-environment for the user (Crumlish and Malone, 2009) to have a moment of self-reflection on his/her own energy conservation actions, e.g. *Does this action make sense to me (or my household)? Am I indeed doing this? Do I want to do this?* By doing so, the user can identify whether an action is feasible in her/his own context, and whether there is an attitude-behavior gap present with

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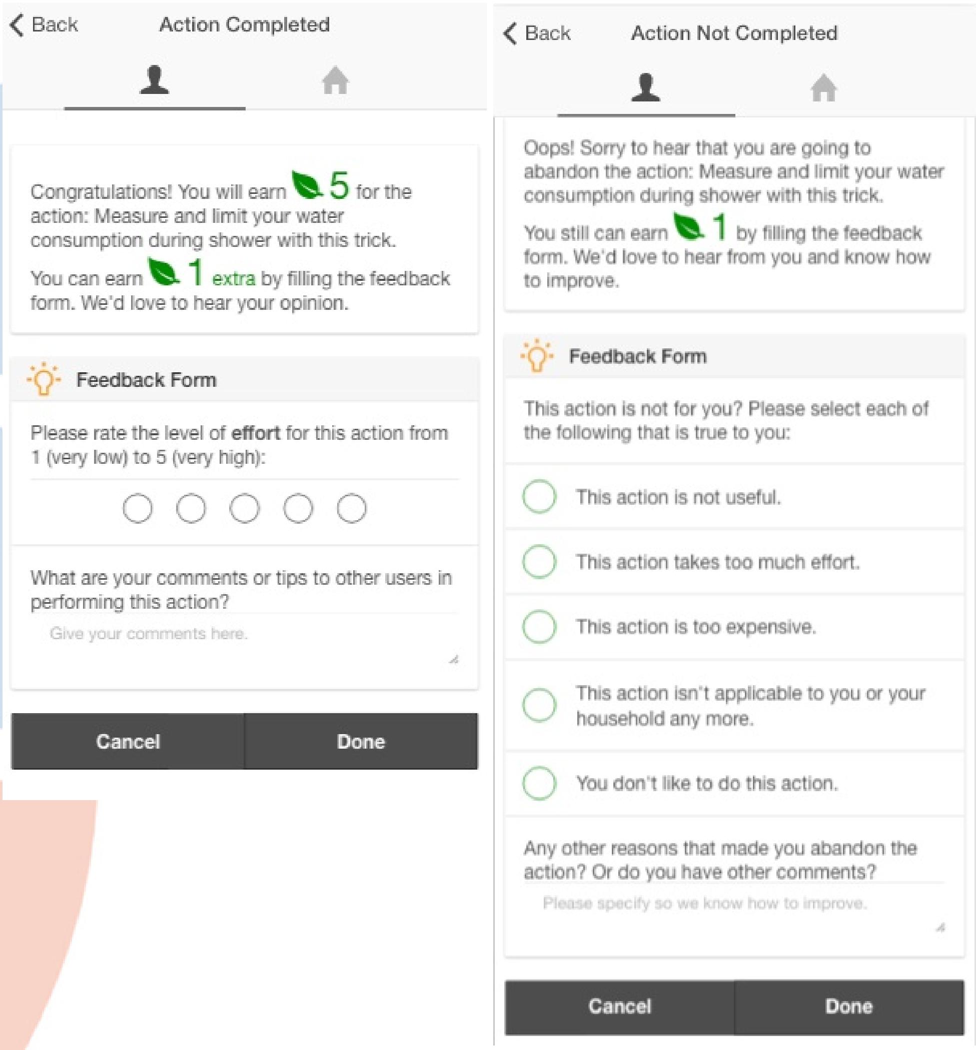

Figure 3: Feedback form when a user (1) completes, or (2) abandons an action

regard to that particular action, and if so should he/she (and would he/she like to) change it; see e.g. Figure 2-(1) and Figure 2-(3).

For the framing of the actions, feedback forms, and other parts of the YouPower interface such as prompt messages, *we* is used referring to the YouPower team, and *you* to address the user (see e.g. Figure 3). This "talk like a person" technique (communicating with the participants in a human voice) is often used in designing social interfaces to adopt a conversational tone which provides an opportunity for users to enter into a dialog with YouPower, creating a non-solipsistic and receptive state of mind (Crumlish and Malone, 2009). "Self-deprecating message" are used e.g. when a user abandons an action ("Oops! Sorry to hear that you are going to abandon the action"), and when there is no results for a search ("We can not find

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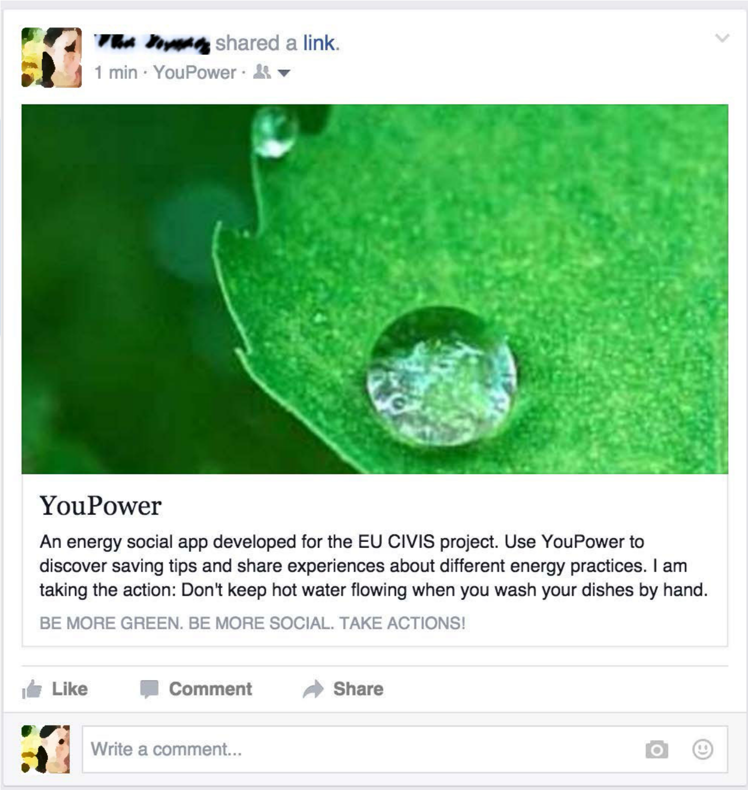

Figure 4: Facebook share of a YouPower action

'foo bar' among YouPower Users"). Error messages and alike should always put the blame squarely on the shoulders of the product's owners and not on those of the users (Crumlish and Malone, 2009).

Users can freely choose whether (and when) to take an action and possibly reschedule and repeat the action according to their own needs and interests. After all, users are experts of their own reality. This makes individual actions and the series of actions suitable in the context of the user's everyday household practices so that he/she can adapt and follow the process of action-taking at a pace that suits his/her situations. Users have free choices of actions as revocable self-commitments, as well as whether to give feedback and invite household members or new users, etc. This facilitates the sense of autonomy which enhances and maintains motivation. Users' choices, e.g. the commitment to an action, the completion or cancellation of an action, together with the other user inputs such as comments and feedback, etc., make a good data source for further research and personalization of the content.

With an in-context email form (see e.g. Figure 6), a user can send an invitation to a friend asking to join YouPower. The benefits of joining and participating in YouPower are clearly articulated to the recipient in the email with a "call to action" button (Crumlish and Malone, 2009). A user can also send household member invitations and act upon them after re-

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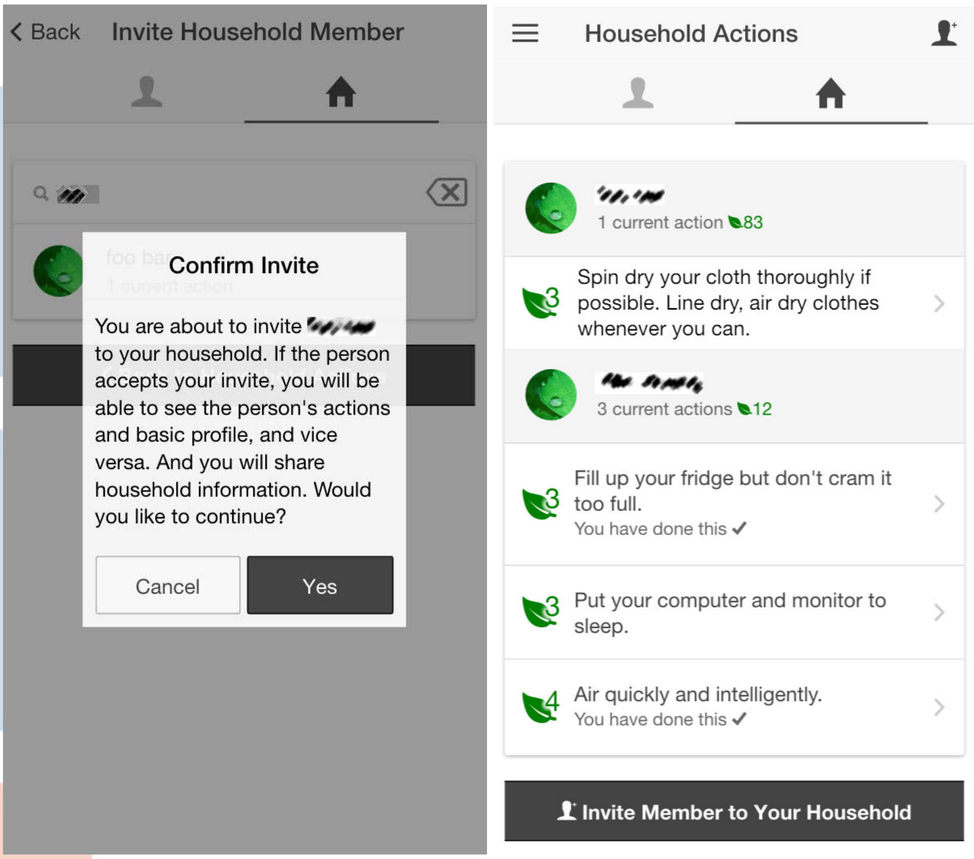

Figure 5: (1) Invite household member; (2) Household member actions

ceipt. By creating households and adding household members, users can have an overview of the household actions. Household energy conservation needs joint efforts, and household members can share the responsibility. The social features such as *Like, Comment, Share, Invite* add social dynamics among users who can share and discuss their experiences and reflections with others.

2.3.2 Housing Cooperatives

2.3.2.1 Aim and target group

The housing cooperative part of the application is used by housing cooperatives in *Hammarby Sjöstad*, Stockholm Test Site. This part provides features for building level energy information and actions.

All apartment owners in Sweden have to be members of a housing cooperative that owns the building. A board is elected among the members and the board is in charge of the cooperative's finances and maintenance of the building. This work may include deciding on

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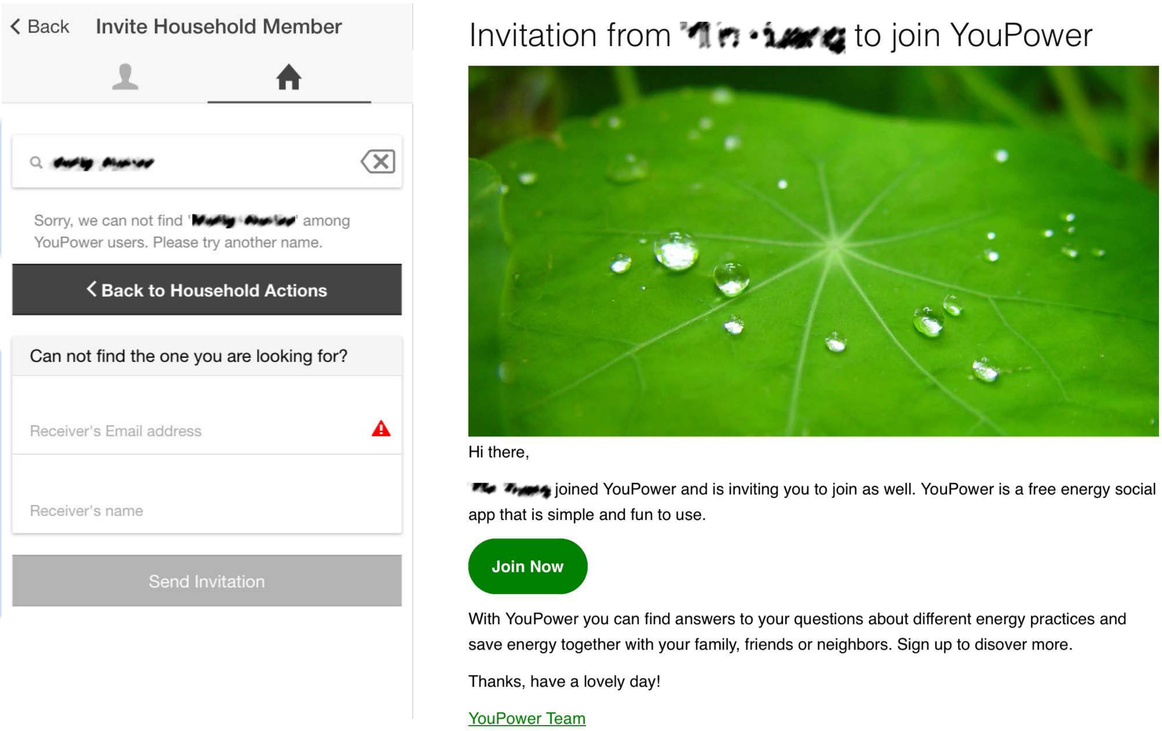

Figure 6: Send Email invitation to join YouPower

energy contracts, making sure energy systems are maintained and proposing investments in more energy efficient technologies. People in the board are volunteers who may have no previous knowledge of energy or building management. Hence, the housing cooperative part of the app aims to support board members in energy management work and, more specifically, in taking energy reduction actions.

In Hammarby Sjöstad, some of the housing cooperatives have an appointed energy manager in the board who is responsible for the energy work. This role, no matter if it is explicitly named energy manager or if it is an implicitly shared responsibility among several board members, is the primary target for the housing cooperative part of the app. The app can also be used by other housing cooperative members who are interested in following the energy work of the cooperative. A third type of user is energy or building management companies working with housing cooperatives. All information in the app is visible for all these user groups and shared between housing cooperatives. This openness of energy data is key to facilitating the users in sharing experiences relevant for taking energy reduction actions.

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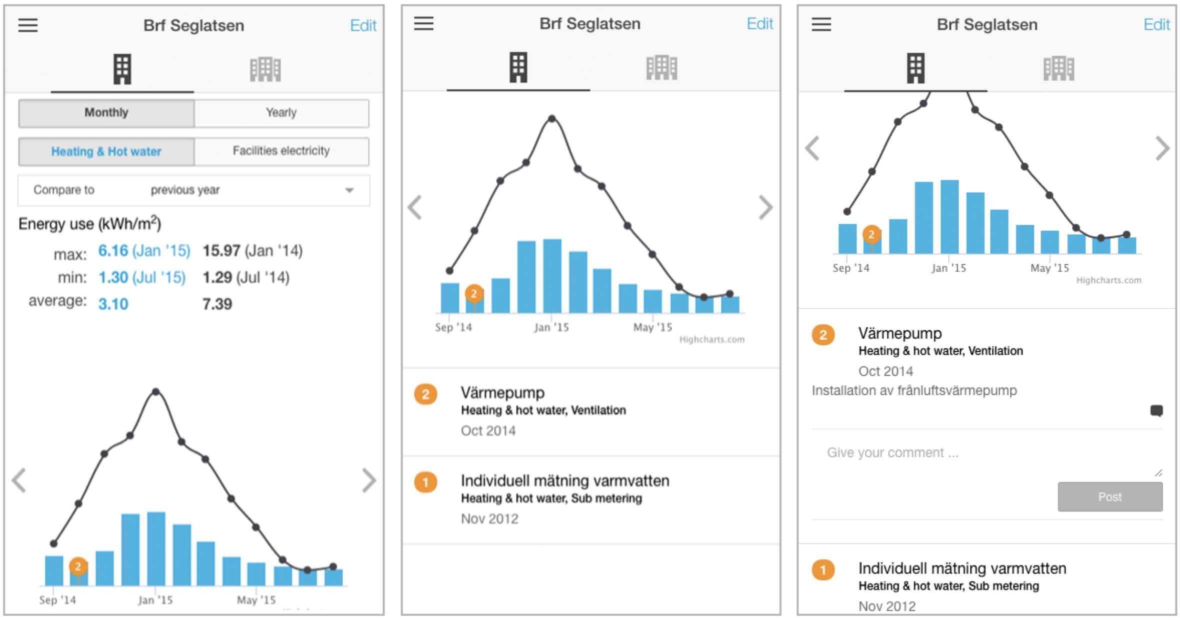

Figure 7: Energy use graph where the blue bars show the current year's energy use and the black line shows the previous year's energy use. Energy reduction actions taken are mapped to the graph and listed below.

2.3.2.2 Linking energy data to energy reduction actions

One of the main housing cooperative features of the app is that it allows for linking energy data with energy reduction actions taken, which makes it possible to follow up on the impact of energy actions (see Figure 7). The energy use is divided into heating and hot water (from district heating) and facilities electricity and the user can switch between these views in the energy use graph (see Figure 7, left). The user can also choose between viewing energy use per month or per year. This provides enough level of detail to show overall changes in energy use. Since the energy data is shared between cooperatives there may also be privacy concerns related to opening up data of higher granularity to people outside of the own cooperative.

Users with editing rights, typically energy managers or other boards members, can in the app add energy reduction actions that the cooperative has taken, including information about:

- Title of the action.
- Type of energy action (e.g. heating optimisation, action affecting the ventilation or action to make lighting more efficient). The action types are in the form of tags (more than one can be added to each action), which makes it possible to add functionality for filtering or searching for specific actions.

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- Month and year the action was taken or completed.
- Cost for taking the action.
- Additional details about the action.

Energy or building management companies that work with a cooperative can also get editing rights and add energy reduction actions they take on behalf of the cooperative. Added actions appear in the energy use graph at the month when each action was taken and all actions are listed below the graph. When clicking on an action in the list, the action is expanded and the details of the action are shown.

To make the impact of energy reduction actions visible, the user can choose to compare the energy use of the viewed months to the energy use of the same months the previous year. This can be used for example when a housing cooperative wants to explore what energy reduction actions to take in the future by looking at the actions taken by other cooperatives and what the effects were in relation to costs.

2.3.2.3 Comparing housing cooperatives

A user can see all cooperatives who are using the app in a map view or list view (see Figure 8). To facilitate comparison between cooperatives the icons in the map and list are colour coded based on each cooperative's energy performance, i.e. the energy use per square meter heated area (kWh/m^2). It uses a scale from red to green, where a red colour indicates a poor energy performance (i.e. high energy use) and a green colour indicates good energy performance (i.e. low energy use). The energy performance scale is calculated in a similar way as for the Swedish energy declaration for buildings[9] but it is calibrated to only include measured energy use for heating and hot water, which is the greatest part of the energy use. In the Swedish energy declarations, facilities electricity is also added but that often requires estimations of different factors to make the number comparable.

For each cooperative in the list or on the map, the user can also see the energy performance as a number (kWh/m^2) and the number of energy reduction actions taken. The number of actions is important to display to make energy reduction efforts of housing cooperatives with a high energy performance (e.g. due to poor construction of the building) visible.

The energy managers in the project stressed that it is important to know what type of housing cooperative you are comparing your own to, in order to understand what any differences in energy performance may depend on and which of their experiences could be relevant for the own cooperative. Therefore, the app provides the following information about each cooperative (see Figure 9):

[9] http://www.boverket.se/sv/byggande/energideklaration/energideklarationens-innehall-och-sammanfattning/sammanfattningen-med-energiklasser/energiklasser-fran-ag/

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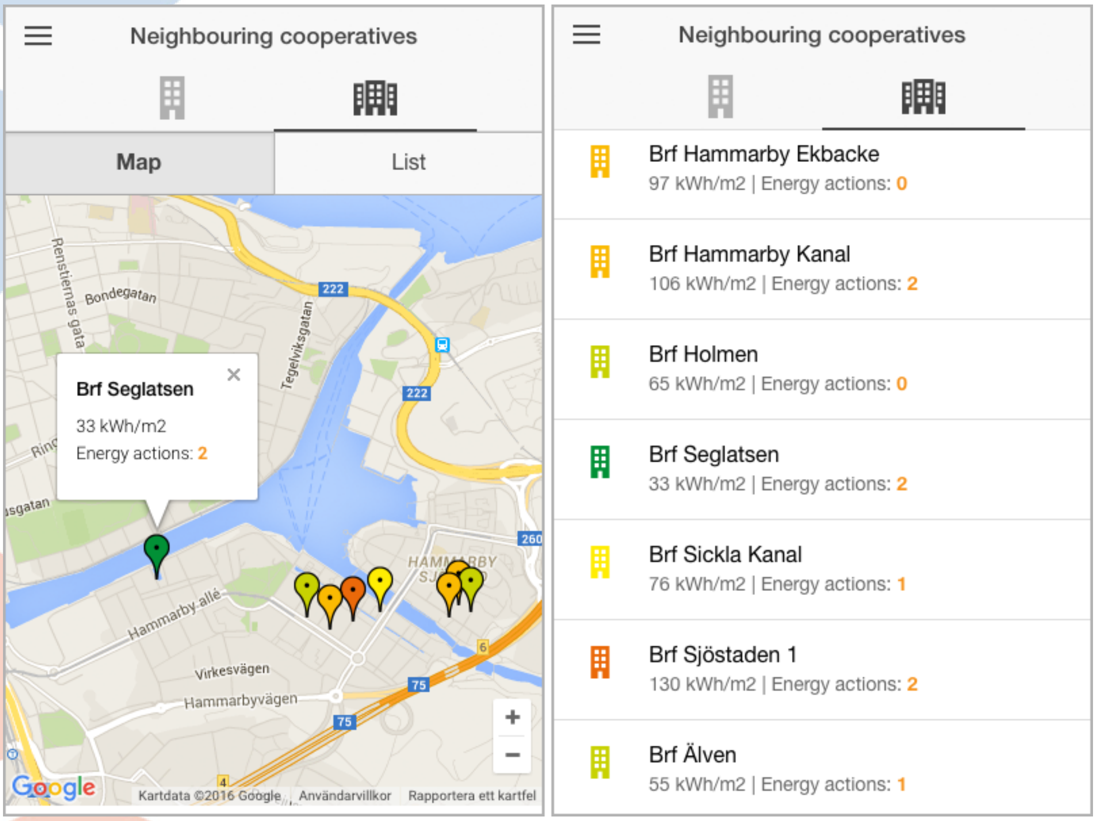

Figure 8: Map and list view of participating housing cooperatives. The energy performance of the cooperatives is indicated by colour and in numbers.

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Figure 9: Information about the housing cooperative that is important for understanding the energy performance and actions taken is displayed in the top of the page.

- Number of apartments in the cooperative.
- The cooperative's heated area (m^2).
- The building's construction year.
- Type of ventilation (e.g. with or without heat recovery).

While the energy performance provides a comparison of the current situation, there is also a feature for comparing a cooperative's energy use over time to the neighbourhood average (see Figure 10). In the energy use graph for each cooperative, divided into heating and hot water and facilities electricity, the user can display the average energy use of the other cooperatives using the app. In that way, the user can get an idea of how a cooperative's energy use has changed over time in relation to other cooperatives. To make the energy use comparable between cooperatives, the energy in the graphs is (in the same ways as the energy performance) displayed as energy use divided by heated area (kWh/m^2).

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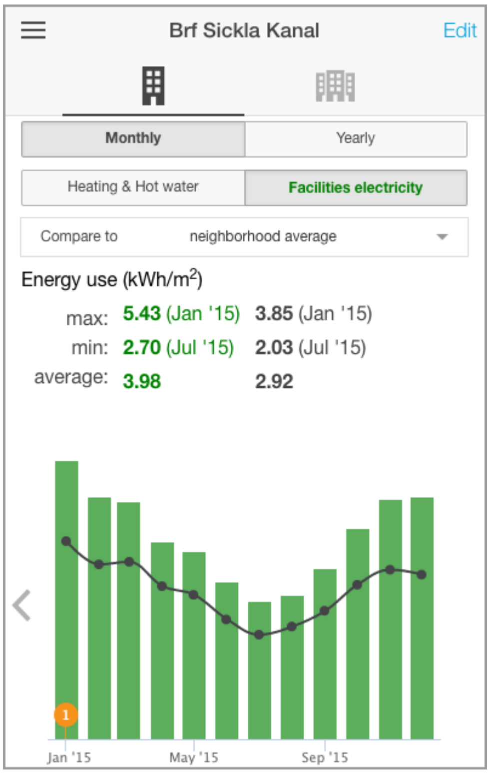

Figure 10: The green bars show the monthly facilities electricity use of the housing cooperative and the black line shows the average facilities electricity use for all housing cooperatives using the app.

2.3.2.4 Sharing experiences

The details about each energy action taken by a cooperative, together with the effects on the energy use, provides information that could support other cooperatives in learning more about which energy reduction actions are effective. However, a cooperative that is interested in taking an action may want more information than what is provided by the person adding the action, e.g. regarding how to take an action, which contractor was used for an investment or how to get buy-in from the cooperative members. The app supports this through a commenting function for each action added, where users can post questions related to the action. The cooperatives can also choose to add an email address to their energy contact person, which is visible on the cooperatives app page, to allow for direct contact.

Sharing of experiences of course also happens outside of the digital world, e.g. during housing cooperative board meetings or meetings with the local energy network in Hammarby Sjöstad. The app is aiming to support discussions and knowledge exchange also in such situations, and it should be easy for someone who wants to demonstrate the impact of an energy investment to just take out the smart phone and show the visualization. Conse-

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quently, the mobile screen format is an important part of the design.

2.3.3 Energy Awareness at Individual and Collective Levels

This part of the application is designed and developed to enable an informed approach to "fair energy use" by making people aware of their energy behaviors in individual and collective terms. Indeed, it includes means for users to visualize in an easily understandable and actionable way a specific set of energy measurements, simple analytics and a time-of-use (ToU) signal.

The access point for this part of the app is the "Energy Data" navigation tab (Figure 11). This tab gives access to an overview of the various functionalities and visualizations of specific information: "Energy Meteo", Visualization of consumption and production data (real time and historical), "Comparisons" data.

There are three main categories of information provided through this part of the app:

- Time of use signal
- Visualization of real time and historical data (individual level)
- Comparative visualizations (collective level)

Although the direct impact of these kind of information can be debated – reported reductions ranging from 2% to 20+% (EEA, 2013) and the fact the their medium and long-term implications received some criticisms (with particular regards to normative "eco-feedback" (Strengers, 2012; Cakici et al., 2014)), this part of the app is in-line with the needs emerged from the pilot sites and the project activities[10]. It also addresses the fact that improvements of dwellers' energy awareness remain a necessary condition towards the long-term adoption of more sustainable behaviors, although not sufficient alone. Indeed, this part of the app has been designed with broader processes of social change in mind[11]. Therefore, "energy awareness" should be considered as instrumental to well defined individual and collective efforts.

2.3.3.1 "Energy Meteo": the Time-of-Use (ToU) signal

It is designed to leverage load elasticity for maximizing self-consumption, with the twofold effect of optimizing usage of locally-installed RESs and minimizing dependency from energy markets. This means that electric loads shall be shifted to periods of time characterized by high local production from renewable energy sources. It provides users with a clear indication of the actual status of the local grid: *green smilies* signal slots when local production exceeds demand; *red smilies* highlight slots when demand exceeds local production[12].

[10] Requirements analyzed as reported in Deliverable 3.1. Design concept validated as reported in Deliverable 3.2.

[11] For further details, see the User Story "Energy Garden" included in Deliverable 1.3.

[12] See Deliverable 4.2 [**NB: VERIFY!!**], for more details on the technical design and implementation of the predictive model of the ToU signal.

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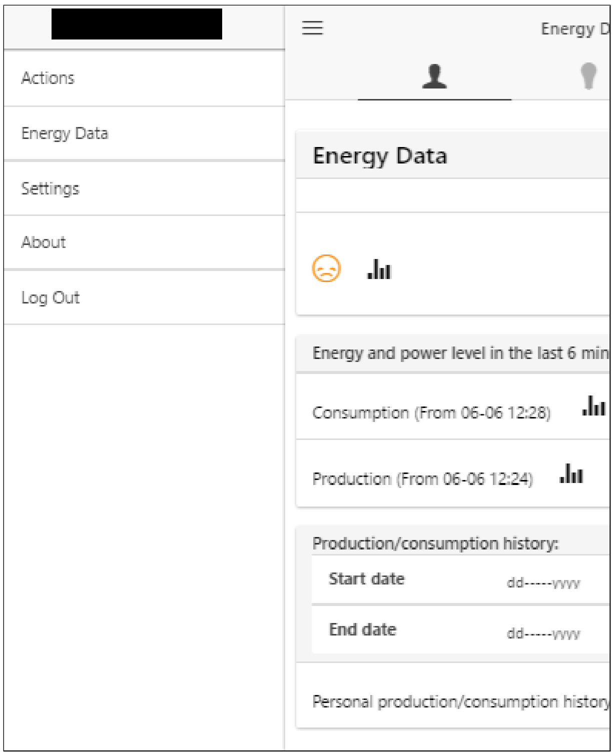

Figure 11: Navigation tab with access to the feature for energy awareness: “Energy Data”

The ToU signal is provided in two distinct ways:

Current. It is available on the main screen (Figure 12-1) and it indicates whether *present* moment is a good (‘green smiley’) or bad moment (‘red smiley’) to consume locally produced electricity.

Forecast. It is available by clicking on “Energy Meteo” field and it provides a detailed overview of the local grid conditions, forecasted in 3-hours time-slots, for the forthcoming 30 hours (Figure 12-2). A new forecast is generated every 24 hours.

2.3.3.2 Visualization of consumption and production (real time)

It is designed to inform users about their (near to) real time electric consumption and (where available) production data.

Users can access these information from the “Energy Data” main screen and either visualize the household’s electric consumption (Figure 13-1) or household’s electric production (Figure 13-2). These visualizations provide meters for:

Energy. It is accounted for the most recent 6-10 minutes monitored.

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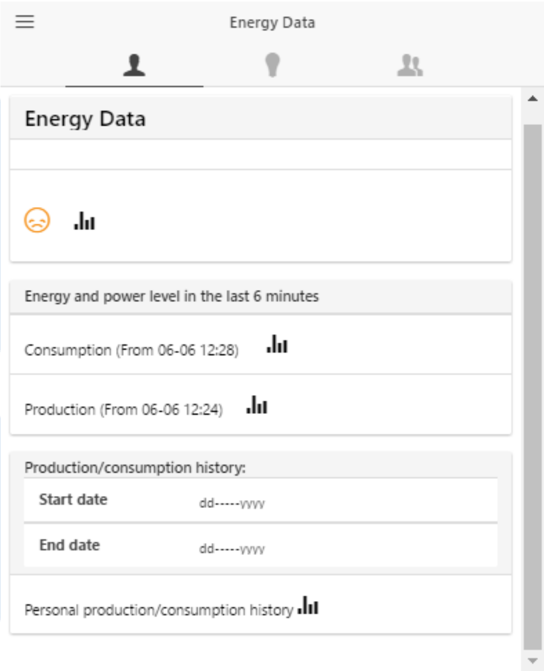

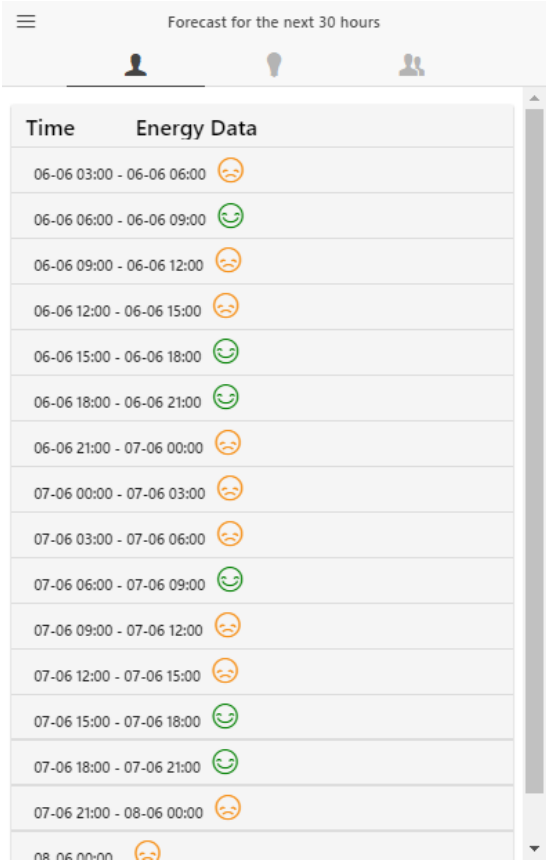

Figure 12: (1) “Energy Data” main screen: overview of the various functionalities and easy access to visualization of specific information; (2) ToU signals with a 30-hours forecast, divided by 3-hours slots.

Power. It provides instant measurement[13].

2.3.3.3 Visualization of historical data

This feature is designed to provide users with a broader temporal overview on their energy habits. Information about historical data are available both for household and appliance levels:

Household. It provides a daily overview of the overall electric energy consumption and production for the chosen data range. This shall give a basis for dwellers to understand and improve their self-consumption.

[13] For technical reasons and depending on several environmental factors (*e.g.* households connectivity for transfer of monitored data) there may be up to approximately 2 minutes delay between the actual power measured and the data displayed through You Power.

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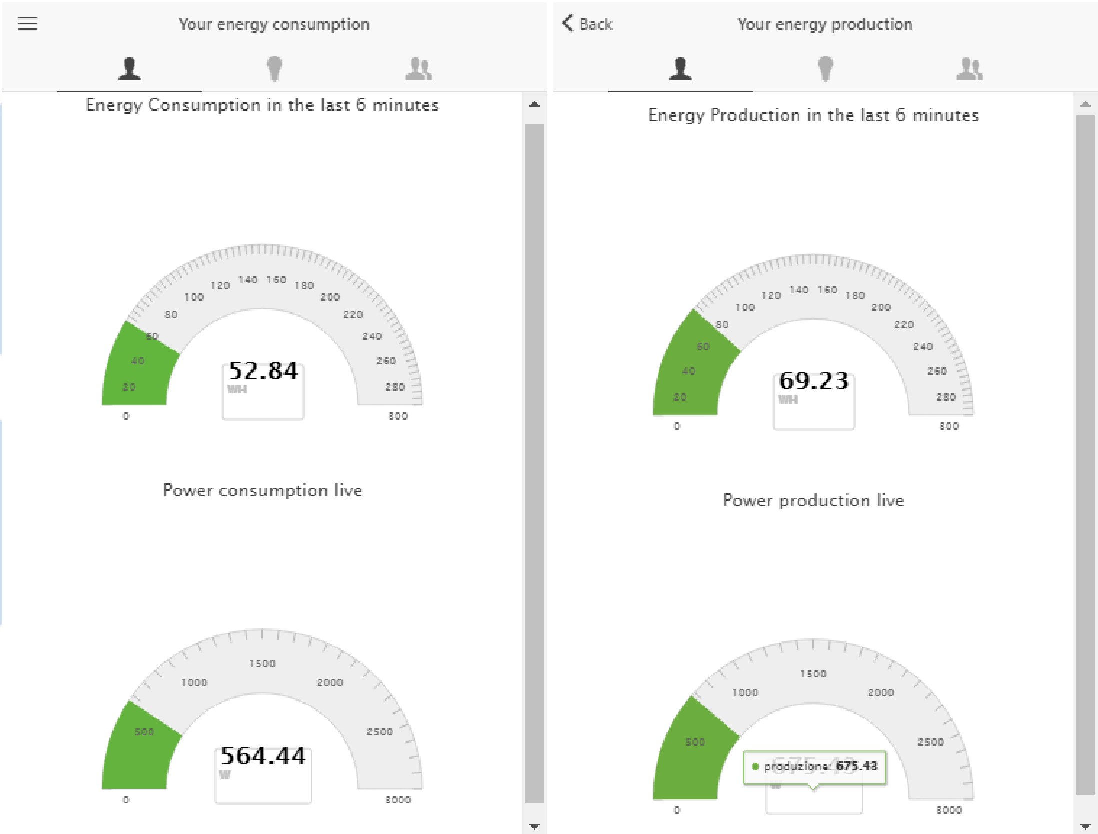

Figure 13: (1) Energy and Power meters for household's electric consumption measurements; (2) Energy and Power meters for household's electric production measurements.

Appliance. It provides a detailed view of the consumption patterns for the selected appliance. Visualized appliances are the ones equipped with smart plugs.

Selection of data ranges are mandatory for these visualizations. They must be set by users at two different places: in the "Energy Data" main screen for the *Household* category; in the 'light-bulb' sub-view for the *Appliance* one, which is accessible from the top level bar.

2.3.3.4 Visualization of comparisons

Comparisons are designed to provide users with reference information about energy performances or behaviors in relation to the neighborhoods. There are two type of comparisons that can be visualized through YouPower:

Consumption distribution on ToU signals It shows a cumulative and progressive distribution of consumption between the green and red ToU signals. On the top part it shows

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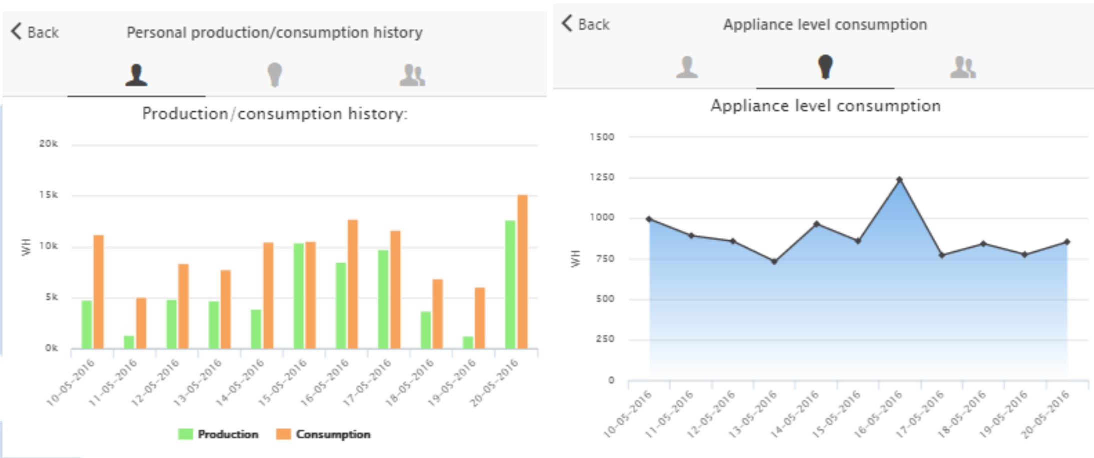

Figure 14: (1) Household overview of electric energy consumption and production, for the chosen data range; (2) Consumption patterns for the chosen data range at appliance level.

the individual household chart, while on the bottom, the community[14] total distribution. This view is a static one and is progressively updated on a weekly basis. The descriptive label for the chart clearly highlights the reference period considered.

Consumption profile benchmark It provides users with a benchmark[15] of consumption profile – *load curve*. It provides two graphs. At the top part of the screen the load curves are shown as average of households enrolled by the two Consortia. At the bottom part, household's load curve is compared with the average and the total of the related Consortium. These information are available only at a daily level. Therefore, users have to select the day (available starting from the previous day and backwards) for which they want to visualize such benchmarks

These features can be accessed by clicking on the "community" icon, which is symbolized by the two people on the top level bar.

[14] In this case community refers to the registered users who are served by the same Energy cooperative through the same local distribution network.

[15] While in principle homogeneous groups of users could be identified to make the comparison more sound, this requires data (household composition, size of dwelling, type and number of appliances preset, thermal isolation ...) which are not currently available for the vast majority of the users engaged in the pilot. Furthermore, the heterogeneity and limited number of users involved would not allow to form meaningful groups for creating sound averages and benchmarking. For this reason the simple community average is used as a benchmark.

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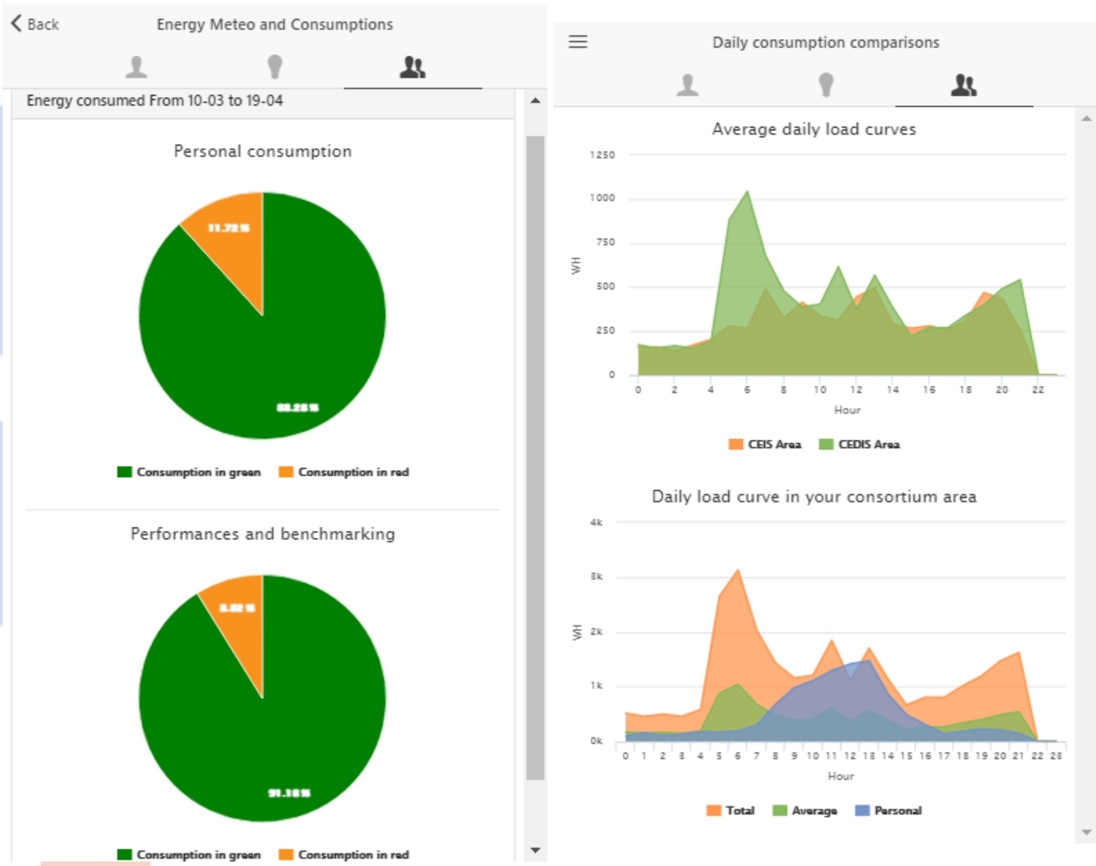

Figure 15: (1) Compares individual consumption with community one with regards to the distribution between the delivered ToU signals; (2) Shows the average consumption load curves at the level of the two Consortia and compares the individual curve with the average and the total of the related Consortium area.

2.3.3.5 Participatory Budgeting external service

This external service[16] and process is designed to accompany users along their efforts of changing their energy behaviors. In particular, it supports the objective to maximize the use of locally produced electricity[17], by means of a collective deliberation process for the allocation of an 'energy bonus', which is collected through the consumptions made under the green ToU signal.

A website has been implemented to:

[16] This service was initially expected to be integrated in YouPower. However, due to the delays for the app deployment it was not possible to fully develop and integrate it in YouPower. Therefore, similar functionalities have been provided through this external service.

[17] The full narrative behind this type of energy intervention is described in CIVIS Deliverable 1.3

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- detail the conditions and regulations for the participatory budgeting process;
- submit idea proposals for the awarding of the “energy bonus”;
- update involved users about the proposals received;
- inform users about the various steps along the evaluation and selection procedures for the awarded proposals.

The website can be reached at https://progettocivis.wordpress.com/.

2.3.4 YouPower App Navigation Structure

The side navigation (nav) of the YouPower front-end application is composed of six items, among which the “Energy Data” or “Housing Cooperatives” is activated respectively after a user authenticated his/her household’s account for energy data (production is only for the Italian case) or after a user is a member of a housing cooperative (the Swedish case); see for example Figure 11, which depicts an Italian case with an open side navigation drawer. Except for the “Log Out” item, each nav item is associated with at least one tab item, which in term has different views. Table 2 presents the navigation structure of the YouPower application.

Table 2: YouPower app navigation structure

Side Nav Items	**Tab Items**	**Views**
Actions	Your Actions	Current Actions (and view/add Comments, Like, Share), Completed Actions (and view/add Comments, Like, Share), Suggested Action, Postpone Action, Action Completed (Form), Action Completed (Form).
	Household Actions	Invited to Your Household, Pending Invites, Members, Actions (of household members), Invite Household Member (search and invite), Send an Invitation by Email
Energy Data	Household Level	Current Tarif (Trentino only), Current Consumption, Current Production, Historical Production/Consumption Patterns, Forecasted Tarifs (Trentino only), consumption comparison in High and low energy tariff, Consumption comparison with total and average consumption of a test site (Trentino only)

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	Appliance Level	Consumption Patterns (for each monitored appliance, status updates (last time consumption data is sent to Reply) for all monitored appliances
	Community Level	Total Community Consumption (last month), Total Community Production (last month), Community Energy Balance, Comparison with Benchmark, Total Community consumption in high and low energy Tariff (Trentino only), Daily consumption comparision between Municipalities (Trentino test sites)
Housing Cooperatives	*Name* (of ones own cooperative)	Cooperative Actions, Consumption (Monthly / Yearly, Heating & Hotwater / Facilities electricity, Compare to neighborhood average / previous year), View/add discussion
	Neighboring Cooperatives	Map/List (of cooperatives and actions)
Settings	Settings	Configurations of actions, Link to Facebook
	Personal Profile	Email, Name, Testbed location, Preferred Language, etc.
	Household Profile	Cooperative (if applicable), size, Household Composition, etc.
About	About	Q&A List, Contact
Log Out		

3 CIVIS Platform Development

The development of the CIVIS platform started in May 2015 (Huang et al., 2015) and continued in the third year's WP3 activities. At the time of writing this deliverable (May/Jun 2016), the development is completed with minor updates took place in the past month. The JavaScript (JS) programming language[18] is used for development at both front- and back-ends. Figure 16 provides an overview of the major technologies used at the front-end and back-end. They are discussed in this section. The platforms and technologies mentioned are all free and open source.

[18] http://www.crockford.com/javascript/javascript.html

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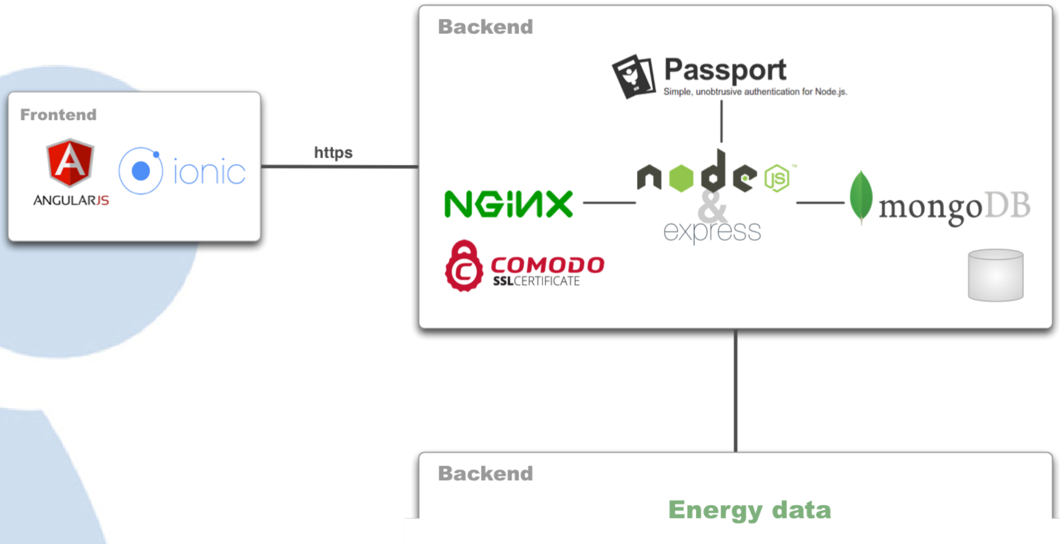

Figure 16: WP3 front-end and back-end overview ("Energy data" is covered by WP4)

3.1 CIVIS Front-end as a Hybrid Application

The CIVIS front-end (YouPower) is developed as a hybrid (cross-platform) mobile application using *Ionic*[19], an HTML5 front-end development framework built with SASS[20] and optimized for AngularJS[21] (a.k.a Angular). The Ionic framework comes with native-styled mobile UI elements and layouts, and handles the look and feel and the UI interactions the app needs in order to be compelling[22].

Angular as a JS framework provides directives (extensions of HTML attributes) and two-way data binding (binds input or output data of the view to a model) that simplify the app development with Model-View-Controller (MVC) architecture. In two-way data binding, the value of a data model is passed on from the view (or loaded from the back-end) to the controller at run-time, and the function in the controller returns the result (of the value manipulation) to the view. Other noteworthy JS and Angular libraries (i.e. besides Ionic) we use for the front-end development are as follows:

- Highcharts[23], a charting library in JS. It provides an easy way to add interactive charts to the application.
- Highcharts-ng[24], a simple Angular directive for Highcharts.

[19] http://ionicframework.com/
[20] http://sass-lang.com/
[21] https://angularjs.org/
[22] http://ionicframework.com/docs/guide/
[23] http://www.highcharts.com/
[24] https://github.com/pablojim/highcharts-ng

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- Angular-translate[25], an Angular module for internationalization and localization of the application. (YouPower is currently available in English, Swedish and Italian.)
- Angular-resource[26], an Angular module for interacting with RESTful server-side data sources.
- Underscore.js[27], a JS library that provides over 100 utility functions.
- Bootstrap-sass[28], a Sass-powered version of Bootstrap 3.
- Moment.js[29], a JS library to parse, validate, manipulate and display dates.
- Ion-datetime-picker[30], a date and time picker for the ionic framework.

3.2 CIVIS Back-end as a JS Runtime Environment

The YouPower back-end is developed using the *Node.js*[31] platform, a well-known JS based open source runtime environment for server-side applications. The platform is easily extensible and has a repository of libraries that support fast web development. TU Delft prepared a virtual machine for CIVIS to host the WP3 back-end[32] using *Nginx*[33], an http and reservse proxy server. A *Comodo*[34] SSL certificate is installed on the server to provide secure communication (i.e. https).

The WP3 back-end interacts with the WP4 back-end, from which the former fetches relevant energy data that is particularly relevant for visualization of energy consumption/production and energy consumption signal. The availability of such data through the WP4 platform represents therefore a pre-condition for the ability of the app to correctly visualize such information.

MongoDB[35] is used as the back-end database. It is document-oriented, and has flexible data schema and expressive query language. A list of the data models at the back-end can be found at `https://github.com/CIVIS-project/YouPower/tree/master/backend/models`. Figure 17 shows the data model schema.

The noteworthy Node.js libraries used for the WP3 back-end development are as follows:

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[25] https://angular-translate.github.io/
[26] https://docs.angularjs.org/api/ngResource
[27] http://underscorejs.org/
[28] https://github.com/twbs/bootstrap-sass
[29] http://momentjs.com/
[30] https://www.npmjs.com/package/ionic-datetime-picker
[31] https://nodejs.org/
[32] http://civis.tbm.tudelft.nl
[33] https://nginx.org/en/
[34] https://ssl.comodo.com/
[35] https://mongodb.org/

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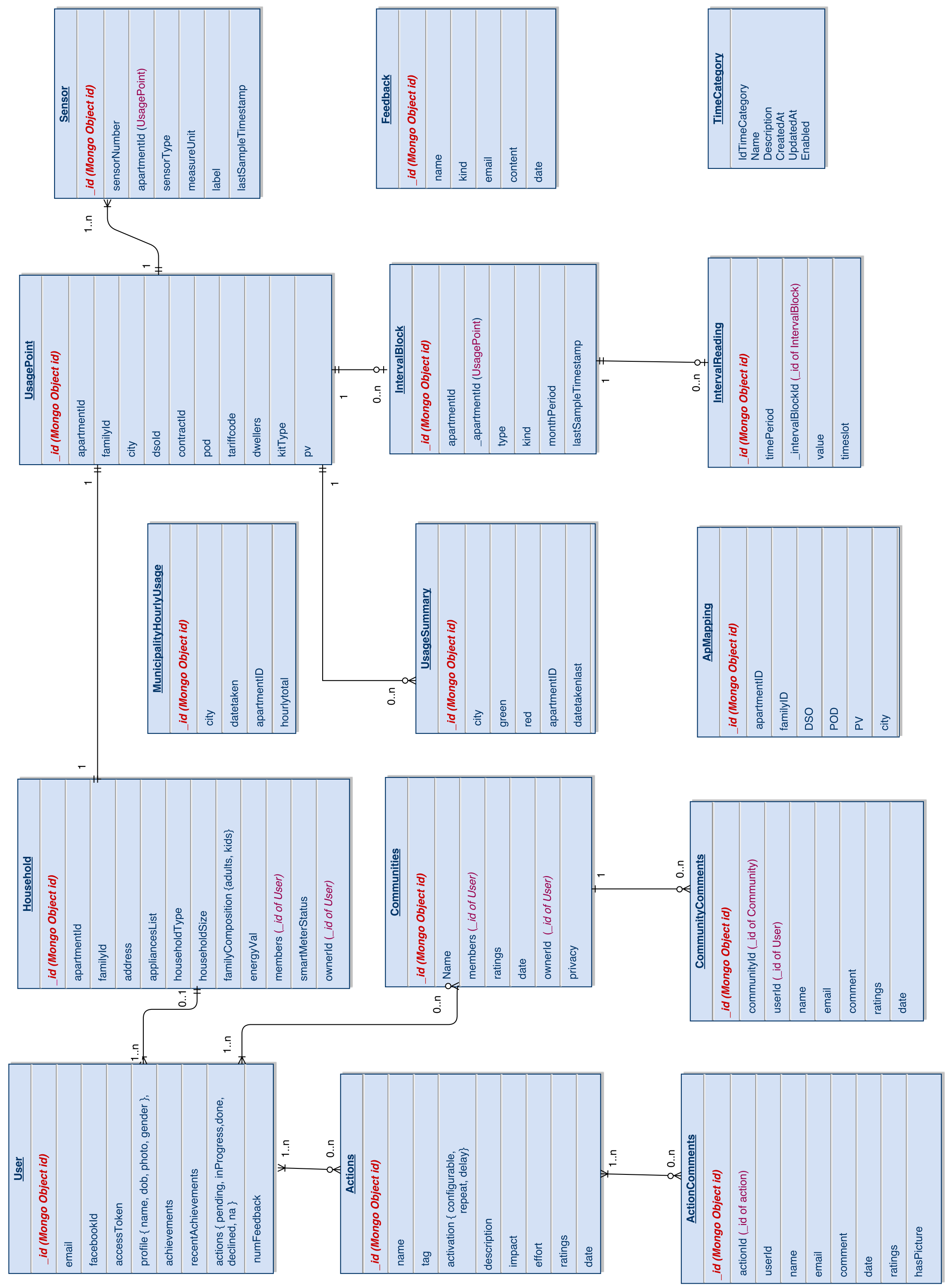

Figure 17: YouPower back-end data model schema

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- Async.js[36], which makes managing and combining asynchronous tasks easier.
- Express.js[37], a Node.js application server framework we use as a basis for the REST API.
- Mocha[38], a JavaScript unit test framework.
- Mongoose[39], a MongoDB driver for Node.js. It provides a schema-based solution to model data.
- Passport.js[40], for handling authentication of REST API requests for Node.js, both local (username password) and Facebook.
- Underscore.js[41], a JS library that provides over 100 utility functions.
- Nodemailer[42], sending emails with Node.js.
- Email-templates[43], a Node.js module for rendering beautiful emails.
- Fb[44], a Node.js library for Facebook.
- Moment.js[45], a JS library to parse, validate, manipulate and display dates.
- APIDOC script[46], for inline documentation for the REST API.
- node-xml2js[47], Simple XML to JavaScript object converter.
- dateformat[48], for formatting dates to custom formats.
- HTTPS[49], A nodeJs module used to make service calls over TLS/SSL.
- querystring[50], for deserializing querystring to an object.

[36] https://github.com/caolan/async
[37] http://expressjs.com/
[38] https://mochajs.org/
[39] http://mongoosejs.com/
[40] http://passportjs.org/
[41] http://underscorejs.org/
[42] https://nodemailer.com/
[43] https://www.npmjs.com/package/email-templates
[44] https://www.npmjs.com/package/fb
[45] http://momentjs.com/
[46] http://apidocjs.com/
[47] https://github.com/Leonidas-from-XIV/node-xml2js
[48] https://www.npmjs.com/package/dateformat
[49] https://nodejs.org/api/https.html
[50] https://www.npmjs.com/package/querystring

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- fs[51], for manipulating file in NodeJS.

The YouPower back-end REST API documentation can be found at http://civis.tbm.tudelft.nl/apidoc/.

3.3 Resources

3.4 Package Management

- Bower[52], a package manager for the front-end development to keep track of and update the packages.
- Gulp[53], a toolkit that helps to automate tasks in the development work-flow.
-

4 Summary of WP3 Tasks Contribution

4.1 T3.1 Community Management

Task 3.1 works in close cooperation with WP5 to explore community management. This is reflected in the diverse CIVIS platform functionalities in supporting housing cooperative activities in the Swedish test site (see Sec. 2.3.2) and the two local Consortia in the Italian test site respectively (see Sec. 2.3.3). Those functionalities are designed and tailored to the local context as follows:

-

4.2 T3.2 Energy Consumer Profiling

This task was carried out between the last quarter of 2014 and the first quarter of 2015. The goal was to provide a method to process individual electricity consumption data in order to define a set of features that can characterize the behavioral patterns of each consumer, and a way to group similar consumers together. The process devised can be summarized as follows:

1. Energy data is provided in XML format in the green button standard.
2. Energy data is stored into a MongoDB database.

[51] https://www.npmjs.com/package/querystring
[52] http://bower.io/
[53] http://gulpjs.com/

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3. The data is cleaned. In particular, missing data are detected and, where possible, interpolated. Outliers are detected and substituted with interpolated data. A report with all the modifications performed on data is produced.

4. Features are extracted from each individual energy consumption dataset. Examples of such features are: average daily consumption, average hourly consumption, peak consumption, peak hour consumption, total daily consumption. Each electric energy consumption time series is mapped to a tuple of such features and stored in a MongoDB database.

5. Features tuples are clustered into similar groups. A range of algorithms are provided. These algorithms are available in the scientific computing package *scikit-learn*[54]. Examples of those algorithms are K-means, hierarchical clustering, affinity propagation, spectral clustering, sb scan.

6. A set of metrics to evaluate the goodness of the achieved clustering is provided. These metrics are implemented in the scientific computing package scikit-learn. Examples of those are CDI, MDI, MSE, DBI.

The software is written in Python and it is available at the GitHub repository[55].

Note: after discussing with the CIVIS partners, we agreed that given the test site context of CIVIS, the consumption profiling part was not a most promising path towards load-shifting. Hence, although significant work has been done in this direction, we did not integrate this contribution to the YouPower application. (Nonetheless this contribution can still be useful for others.) Instead, we devoted extra time and effort for the design and development of an energy production forecasting system, discussed in Sec. 4.2, which can have a strong impact to help users achieve the load-shifting goals.

4.3 T3.3 Interface with System Level

The task 3.3 of CIVIS WP3 took care of exploring the different models for interconnecting the system level developed in WP4, the Energy ICT Platform, with the user level subsystem developed in WP3.

This work, performed between T02 and T08 of CIVIS project, was strictly in connection with the one performed in D4.3, where the interconnection of the two subsystems has been implemented and has been documented in D4.1, where the different models of interconnection have been described.

Sec. 8.3 of CIVIS D4.1 contains the descriptions of three different models that could be used in order to implement the connection between User Level and System Level:

[54] http://scikit-learn.org
[55] https://github.com/massaroantonio/civis

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- Solution 1: single connection and native HiReply MS SQL DB (Sec. 8.3.1 of D4.1);
- Solution 2: single connection and use of a remote DB (Sec. 8.3.2 of D4.1);
- Solution 3: double connection and use of a remote DB (Sec. 8.3.3 of D4.1).

Sec. 8.3 of D4.1 also describes the different features, in terms of scalability, that the three solutions can provide. For the deployment of CIVIS ICT Platform we adopted Solution 1, because it was suitable for achieving all the fixed goals in the provided project time frame and that is represented in Figure 1.

4.4 T3.4 Energy Service Context

This section highlights the lessons learned of business models for emerging social energy initiatives. In its final deliverable (D6.3) work package 6 concludes with four main types of business models that can be applied to the CIVIS maturity scheme (depicting the development from emerging and promising to established energy initiative).

- Efficiency Effects: becoming better at what you're doing - activities that enhance brand awareness and increase customer engagement.
- Diversification: introducing products and services that are different that the initial domain of the organisation – for (indirect) social as well as (longer term) financial benefits.
- Service Provisioning: facilitating others with available expertise – providing available services at marginal costs to others.
- Incubation: enabling innovation outside the organisation – high(er) risk investment in the hope to achieve a financial or technical return on investment.

Regardless of the specific maturity stage an organisation stage has achieved, of these four business model types, trying to achieve efficiency effects is one that is most applicable to any maturity stage.

To that effect, the mobile energy app and the community platform that have been developed as part of this work package can be placed in this category. Both of these tools are prime examples of activities that enhance brand awareness and increase customer engagement in order to either make the members of the cooperatives more energy aware (and efficient) or that it convinces more inhabitants to join the cooperative.

As such these developments are (when introduced in the right way) powerful tools that can strengthen a chosen business model enormously. In work package 6 much attention has given to a step-by-step approach for (emerging) energy initiatives and particularly the use of tooling such as the business model canvas (bmc). The developed tools in work package three

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provides a solution for cooperatives to properly address their (mobile and online) members – in other words, describing the "channel" element of the bmc.

Examples of this have become apparent in surveys with the board members of the test-sites in Sweden and Italy. What CIVIS learned is that there is a distinct advantage in having a (ICT) collaboration or (ICT) information solution available to the cooperative members. While it does not come as a surprise that providing members with information on energy generation, consumption and saving does increases awareness – it is the extent of the impact on awareness that interests us.

While initial uptake of the CIVIS apps has been slow, once people started to use it the awareness of what is happening within the cooperative as a whole is certainly increasing. Though not statistical relevant, several board members have remarked increased feedback from members since making the mobile apps available. For leadership, this kind of feedback and interaction is particularly helpful terms of gauging if certain initiatives have a positive effect within the cooperation. In a sense this contributes more to their understanding than just looking at the amount of website "hits" that are available through the IT responsible department or person. It is a combination of context and hard numbers that makes the learning process possible in the first place.

5 Conclusions and Future Work

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