D3.3 Final Field Tested Integrated Energy System

Workpackage 3

CIVIS

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Executive Summary

This report summarizes

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1 Introduction

1.1 Overview

> D3.2) 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).

In the third year of Work Package 3 (WP3), we continued the design and development of the software platform YouPower[1] based on the results reported in D3.2. In this report, 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 and/or Trento test sites respectively according to the local context. The YouPower software is open source under the Apache v.2 License[2]. It has an online repository at GitHub[3]. The backend API documentation is aslo available online[4].

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1.2 Aims and Scope

As stated in D3.2 (Huang et al., 2015), the CIVIS platform is composed of two parts: the CIVIS back-end services, and the CIVIS front-end application with which users directly interact (Figure 1). WP4 focuses on the system level ICT services that deal with energy data collected by smart meters and sensors 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 deal with data related to user, household, community, action suggestions, etc. Unless otherwise specified, this report discusses the design and development of the WP3 part of the CIVIS platform which is called YouPower. (The CIVIS front-end application used to be called EnergyUP. The old name may be found in some old documents and/or mock-ups.)

...

Environmental problems have their origins in human behavoir, and as a result, any solution to enviromental issues will require changes in behavoir (Schultz, 2014).

1.3 Design and Development: the Continuation

The design and development of YouPower is theory-driven, user-centered and iterative. We researched literature on intervention strategies and social smart grid applications directed

[1] http://civis.tbm.tudelft.nl/
[2] https://github.com/CIVIS-project/YouPower/blob/master/LICENSE
[3] https://github.com/CIVIS-project/YouPower/
[4] http://civis.tbm.tudelft.nl/apidoc/

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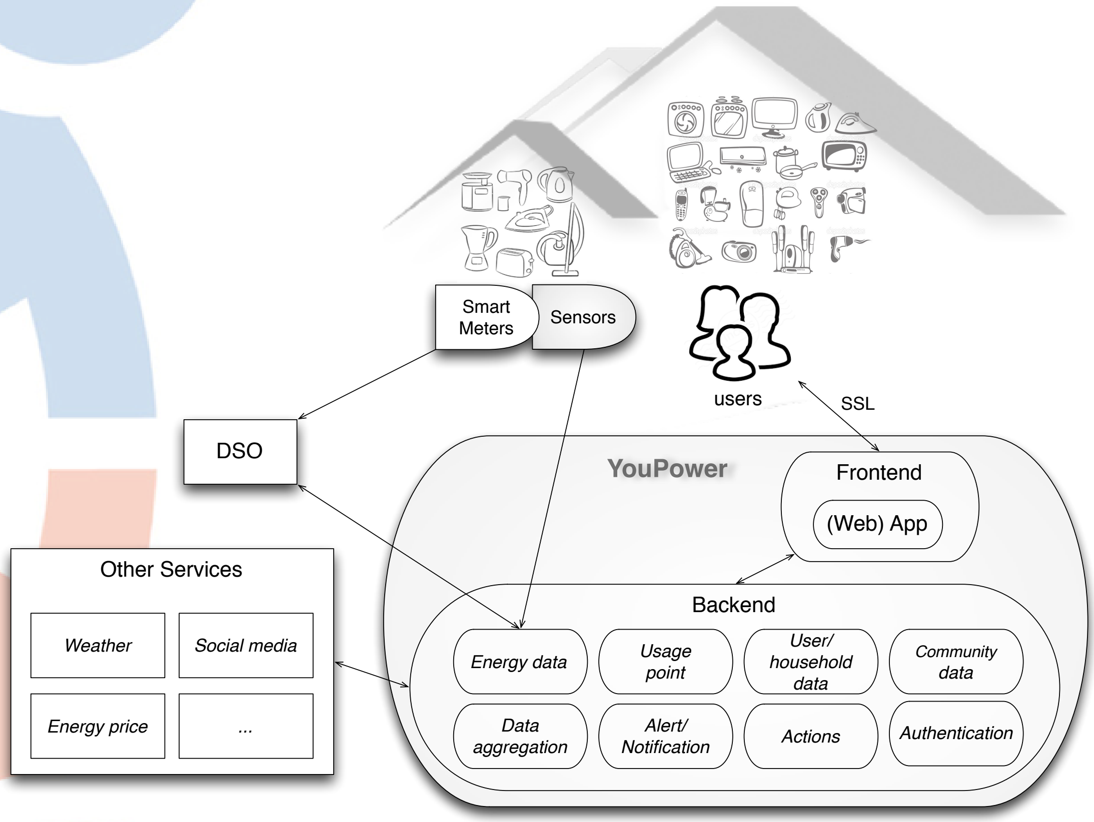

DSO (Distribution System Operators), SSL (Secure Sockets Layer)

Figure 1: CIVIS platform overview

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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., 2012) and may help increase user engagement with respect to the sense of relatedness to the application (Pierce et al., 2003; **?**; **?**).

In the second 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 third year of CIVIS, the design and development continued. We have paid particular attention to quick responses to changes, and adaptive development. We also furthered literature research in environmental psychology and intervention design, and expanded the design guidelines based on our design practices and experiences. These guidelines can be useful for a wider group of designers interested in pro-environmental intervention. .... »>Any events in the third year?«< ... YouPower had been refined and improved gradually in the third year resulting in the current version of the application, which is deployed at Stockholm and Trento test sites. 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 (Abra-

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hamse 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 products (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 cer-

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tain 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) 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

» TODO » Please add a few more guidelines for the part of the app you write !!! « «

TODO: This subsection outlines and discusses XX design guidelines. The first four guidelines concern providing accurate and accessible information about actionable suggestions in the behavior change process. Guidelines 5 to 8 address the design part about fostering motivations (and engagement) in the behavior change process. 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 1-3, 4, and 6 address the three types of knowledge correspondingly.

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.

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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 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. 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 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. 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) shall be presented to consumers in an easily understandable way.

General consumers often have difficulties understanding energy presented in kilowatt

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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.

5. 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 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

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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.

6. 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; Delmas 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 (which is not a focus of this paper), 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

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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).

7. 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 everyday 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.

8. 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).

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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[5] 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 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

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

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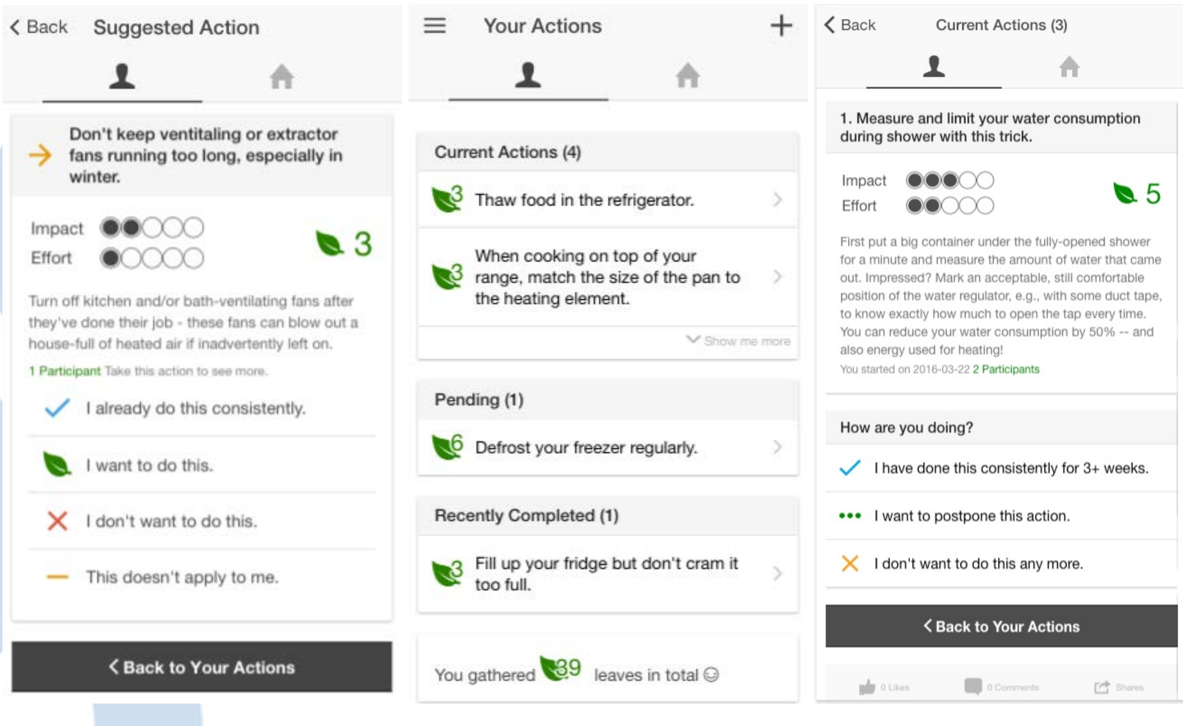

Figure 2: (1) An action suggestion; (2) User actions tab; (3) An action in progress

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.

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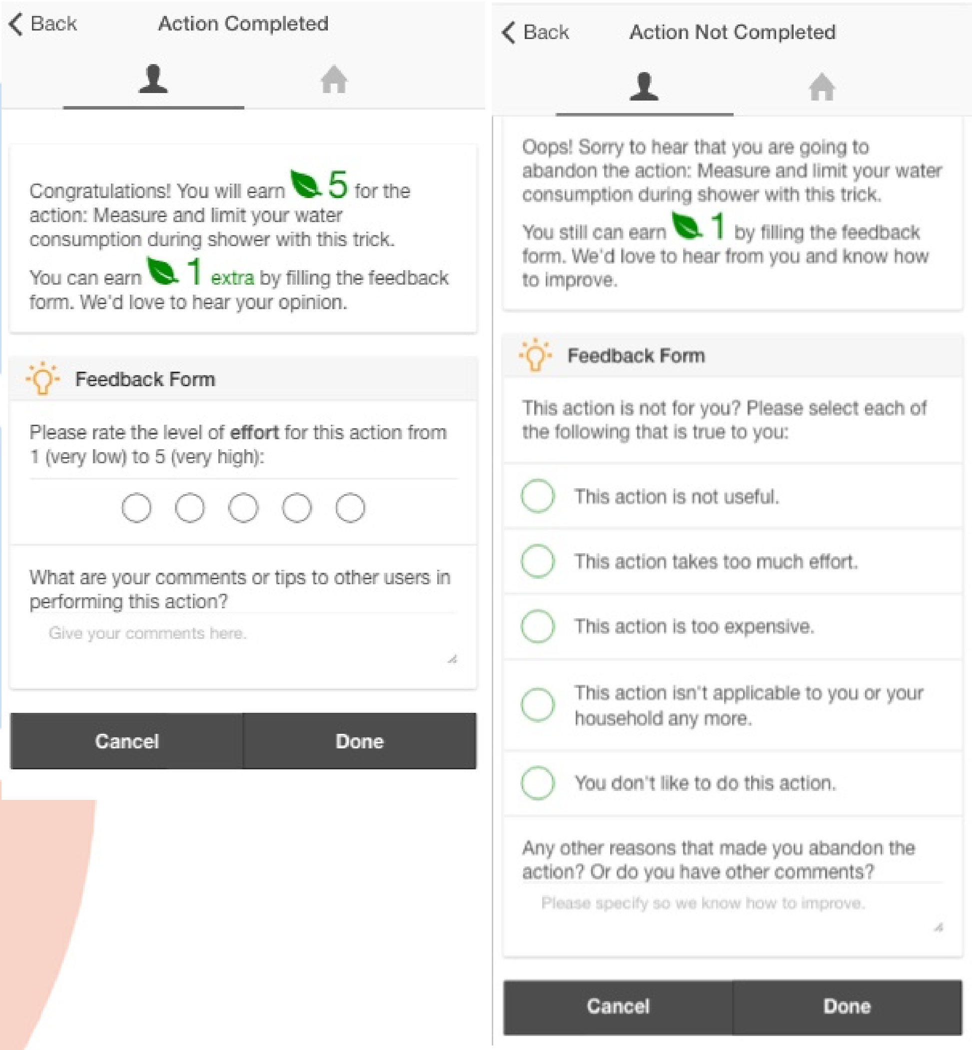

Figure 3: Feedback form when a user (1) completes, or (2) abandons an action

- 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*

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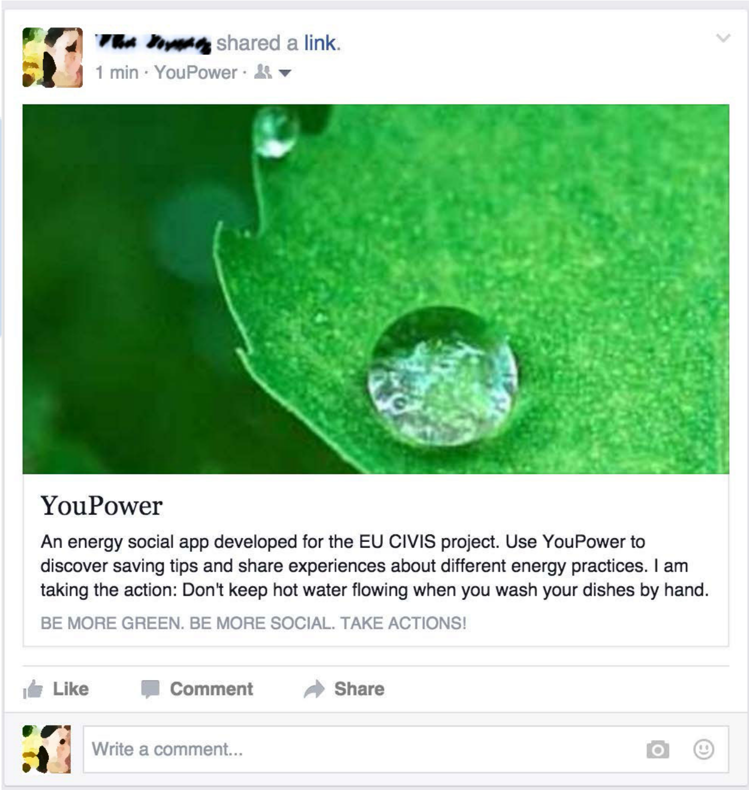

Figure 4: Facebook share of a YouPower action

some of those are completed. Keep on! You are doing great.

- 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

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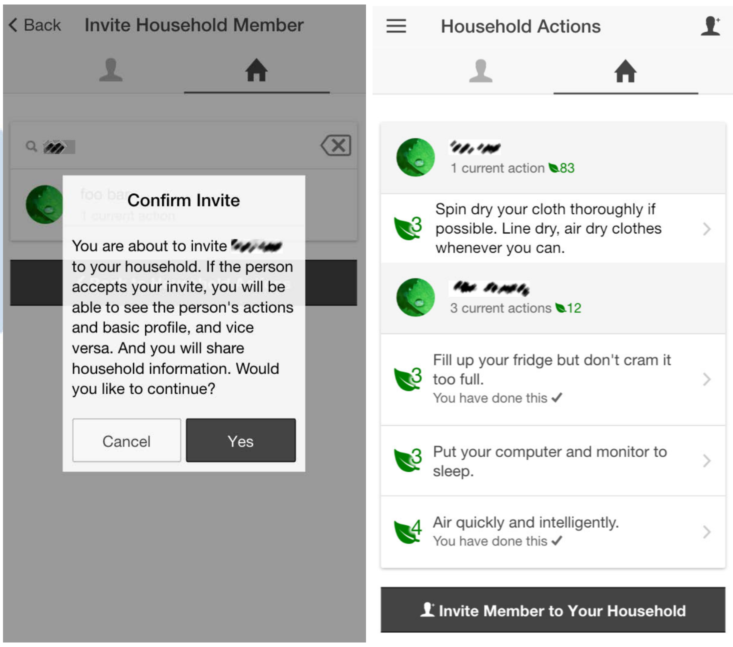

Figure 5: (1) Invite household member; (2) Household member actions

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 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 '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

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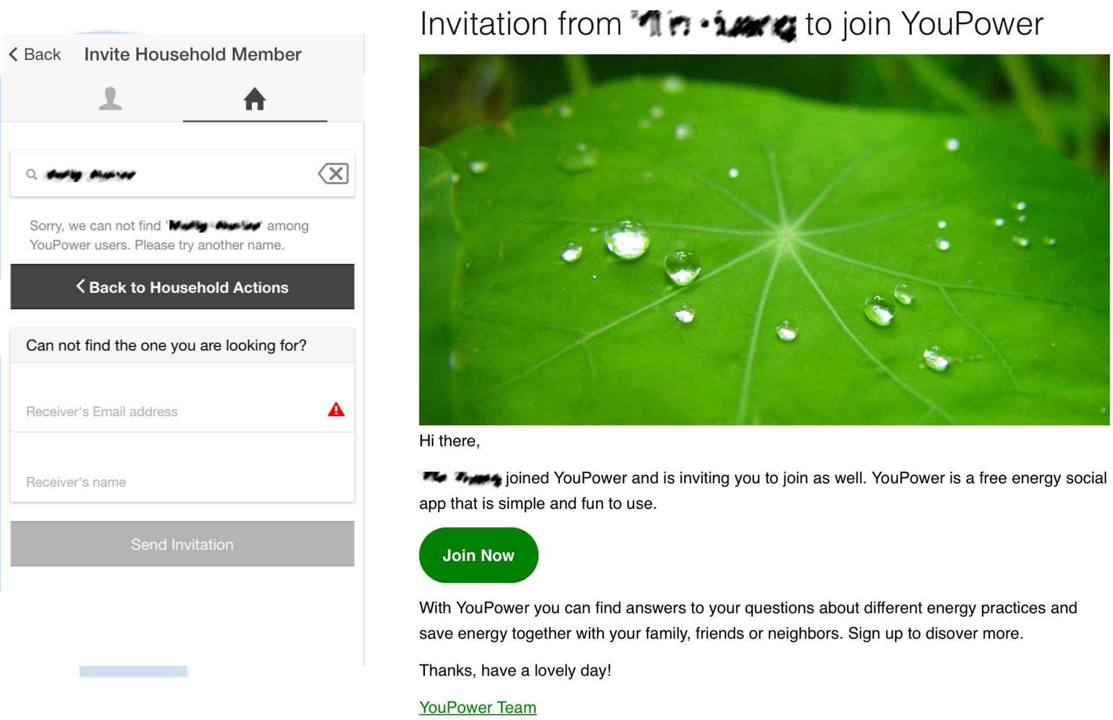

Figure 6: Send Email invitation to join YouPower

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 receipt. 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.

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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 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.

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

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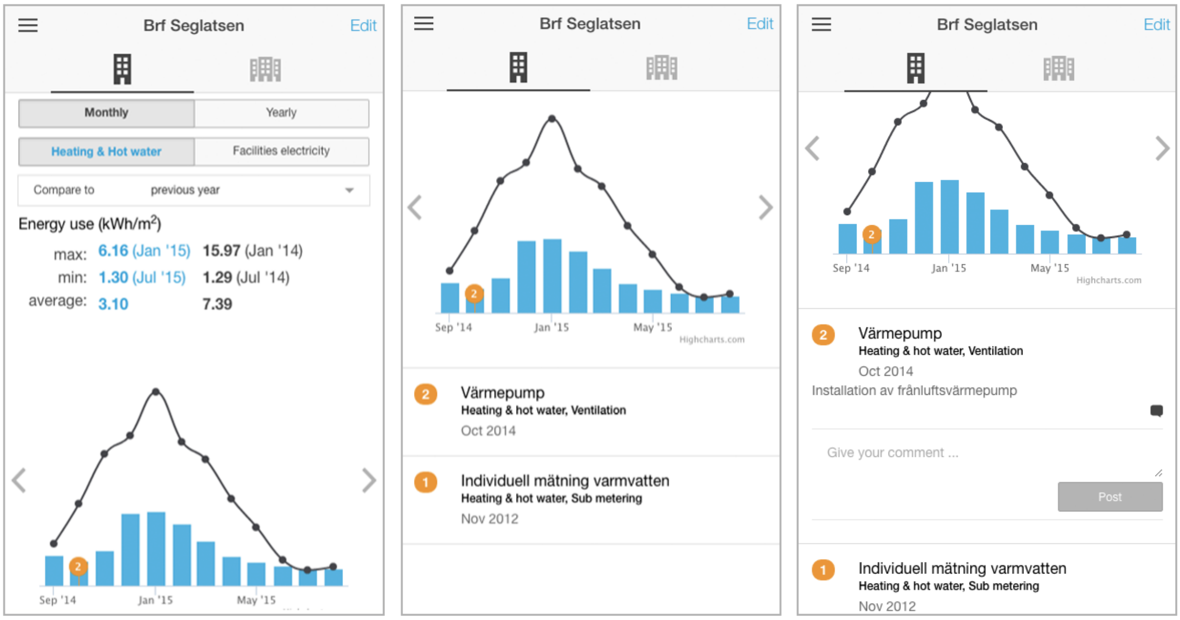

Figure 7: Energy use graph where the blue bars show the current year's energy use and the black line shows the previous year's energy use. Energy reduction actions taken are mapped to the graph and listed below.

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.

- 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.

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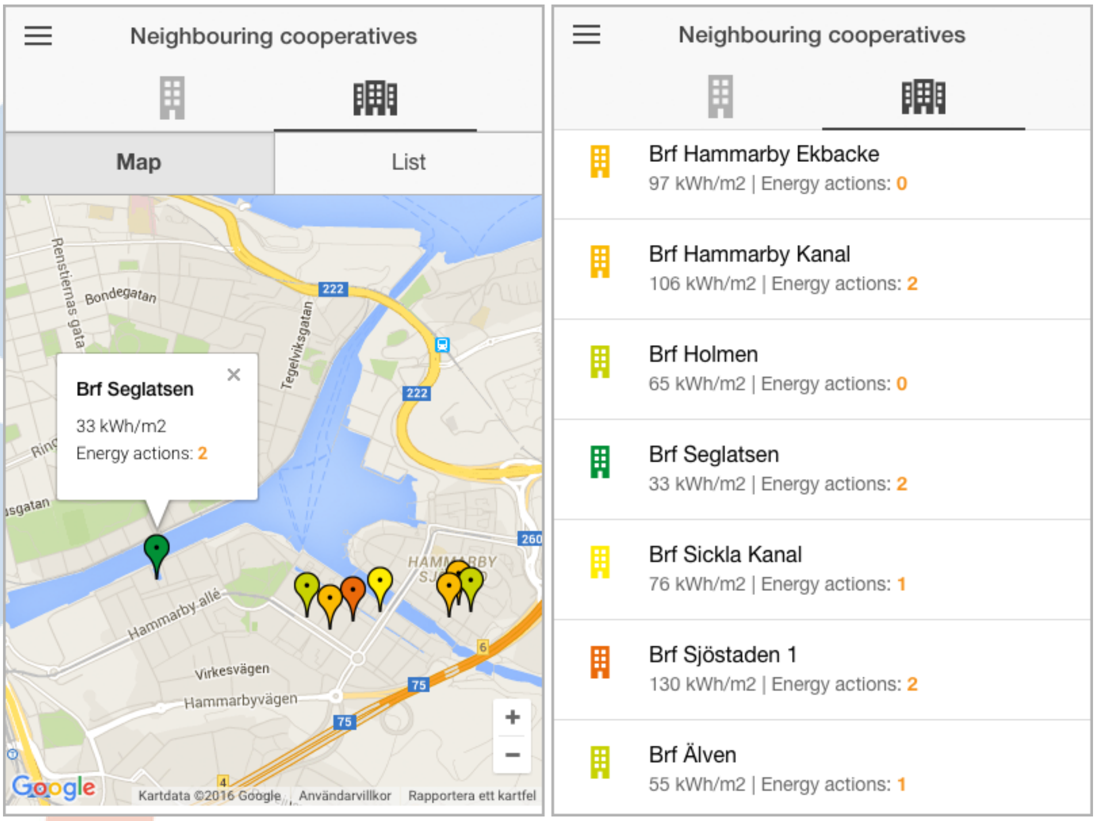

Figure 8: Map and list view of participating housing cooperatives. The energy performance of the cooperatives is indicated by colour and in numbers.

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[6] 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 per-

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

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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.

formance 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):

- 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).

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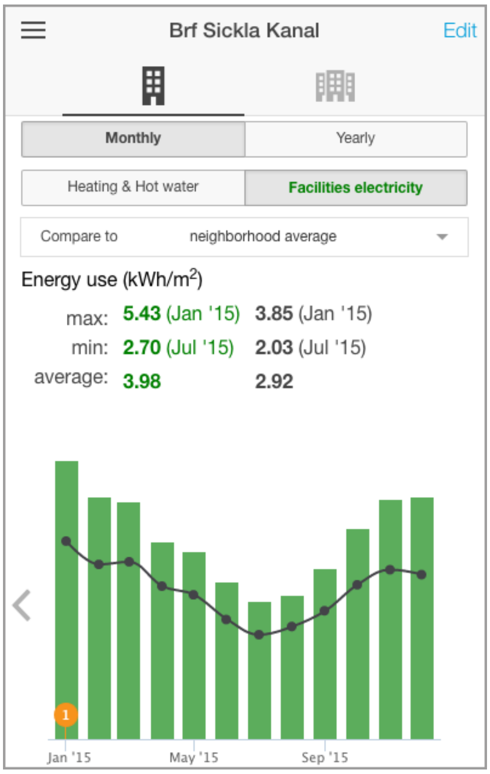

Figure 10: The green bars show the monthly facilities electricity use of the housing cooperative and the black line shows the average facilities electricity use for all housing cooperatives using the app.

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).

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 invest-

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

2.3.3 Energy Data Visualization and Comparison (need another title probably)

Trento test site

The side navigation (nav) is composed of six items, among which the "Energy Data" and "Housing Cooperatives" are activated respectively when a user authenticated his/her household's account for energy data (production is only for the Italian case) or when a user is a member of a housing cooperative (the Swedish case). Each tab item is associated with at least one view. Figure 11 shows an example: the "Action List" view of "Your Actions" tab with a closed (left) and an open (right) side navigation drawer.

The "Action List" is the index view of "Your Actions" tab. It is also the default view after user login. In this case, when the user presses on one of the "Current Actions", the app navigates to the "Action Details" view. Figure **??** gives an example.

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[7] is used for development at both front- and back-ends. The platforms and technologies mentioned in this section are all free and open source.

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[8], an HTML5 front-end development framework built with SASS[9] and optimized for AngularJS[10] (a.k.a Angular). The Ionic framework comes with native-styled mobile

[7] http://www.crockford.com/javascript/javascript.html
[8] http://ionicframework.com/
[9] http://sass-lang.com/
[10] https://angularjs.org/

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Table 2: YouPower app navigation structure

Side Nav Items	**Tab Items**	**Views**
Actions	Your Actions	Action List, Action Suggestion, Action Details, Action Completed Form, Action Abandoned Form, etc.
	Household Actions	Member List, Action List, etc.
	Community Actions	Community List, Top Action List, Discussions, etc.
	Achievements	Achievement List (unlocked/locked), etc.
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)
	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	Your Cooperative	Action List, Consumption per Category, Discussions, etc.
	Cooperatives in Neighborhood	Action Map, Action List, Discussions, etc.
Donation (Trentino only)	n/a	Campaign Information, Campaign Status
Settings	Preferences	Form
	Personal Profile	Form
	Household Profile	Form, Eenergy Data Account
About	Q&A	Q&A List
	Help & Feedback	Contact, Form
	Version Update	Version Info

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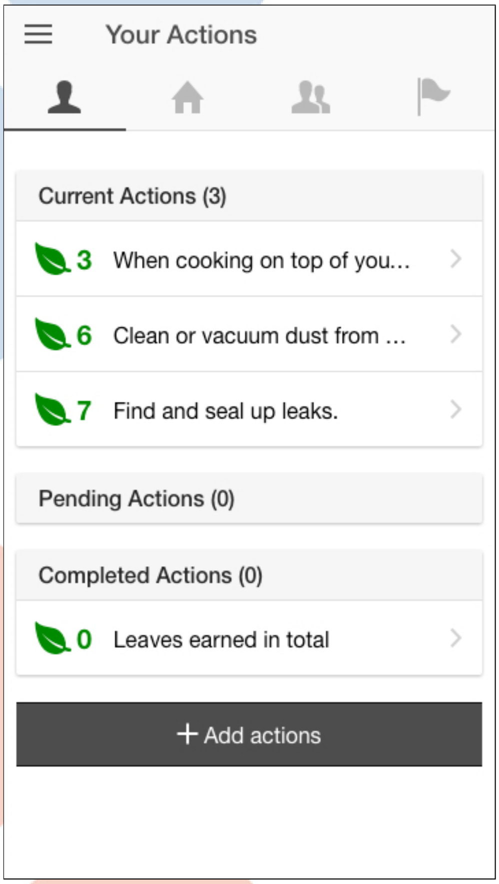

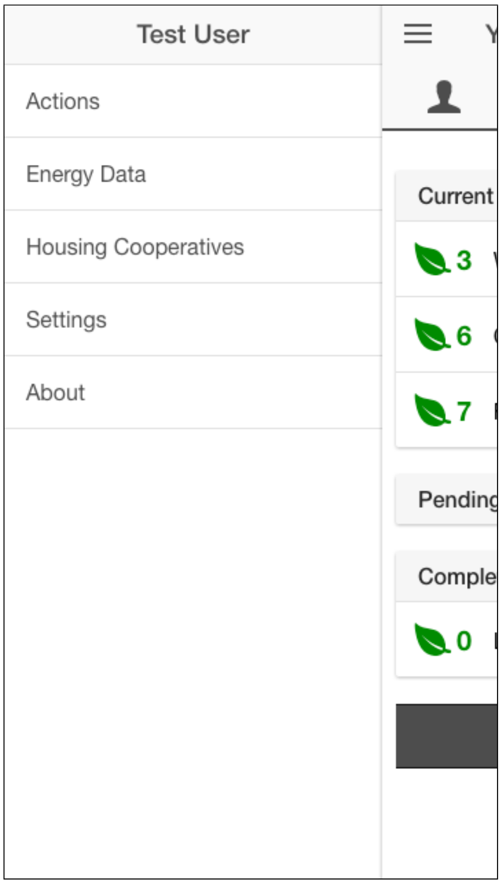

Figure 11: "Your Actions" tab – "Action List" view (left); with an open side nav drawer (right)

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UI elements and layouts, and handles the look and feel and the UI interactions the app needs in order to be compelling[11].

Angular as a JavaScript 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. The noteworthy JS and Angular libraries we use for the front-end development are as follows:

- Highcharts[12], a charting library in JS. It provides an easy way to add interactive charts to the application.
- Highcharts-ng[13], a simple Angular directive for Highcharts.
- Angular-translate[14], an Angular module for internationalization and localization of the application. (YouPower is currently available in English, Swedish and Italian.)

3.2 CIVIS Back-End

An early version of YouPower[15] has its back-end on Firebase[16] to have a quick set-up. For the same reason, the YouPower back-end development is first deployed on Heroku[17]. In July 2015, TU Delft finished preparing a virtual machine for CIVIS, so the WP3 back-end is currently hosted by a TU Delft server at `http://civis.tbm.tudelft.nl`. The CIVIS app back-end interacts with the IT platform developed in WP4, from which it fetches relevant data to be used in the front-end. This is particularly relevant for visualization of energy consumption/production data, energy price data and donation programme data. 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.

The YouPower back-end is developed using the Node.js[18] 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. MongoDB[19] is used as the back-end database. It is document-oriented, and has flexible data schema and

[11] `http://ionicframework.com/docs/guide/`
[12] `http://www.highcharts.com/`
[13] `https://github.com/pablojim/highcharts-ng`
[14] `https://angular-translate.github.io/`
[15] Branch study-protoype `https://github.com/CIVIS-project/YouPower/tree/study-prototype`, `https://app.civisproject.eu/frontend.html`
[16] `https://youpower.firebaseio.com/`
[17] `https://www.heroku.com/`
[18] `https://nodejs.org/`
[19] `https://mongodb.org/`

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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 12 shows the data model schema. The noteworthy Node.js libraries we use for the back-end development are as follows:

- Async.js[20], which makes managing and combining asynchronous tasks easier.
- Express.js[21], a Node.js application server framework we use as a basis for the REST API.
- Mocha[22], a JavaScript unit test framework.
- Mongoose[23], a MongoDB driver for Node.js. It provides a schema-based solution to model data.
- Passport.js[24], for handling authentication of REST API requests for Node.js, both local (username password) and Facebook.
- Ionic Push[25], for sending dynamic push notifications.
- APIDOC script[26], for inline documentation for the REST API.

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

3.3 Feature enhancements (Frontend and Backend)

We added substantial feature for visualizing the energy consumption and production of households in Trentino test sites, CEIS and CEDIS. We have developed a number of end-points that interacts with Reply and TOU signals from CreatNet. In the following sub sections, we described the endpoints we have developed and API path while details on the new endpoints description and parameter list could be found in the API documentation of YouPower.

3.3.1 Accessibility

The energy tab is only visible for users from trentino test site. Users should select their corresponding municipality area (i.e. CEIS or CEDIS) and provide a contract Id in the settings

[20] https://github.com/caolan/async
[21] http://expressjs.com/
[22] https://mochajs.org/
[23] http://mongoosejs.com/
[24] http://passportjs.org/
[25] https://apps.ionic.io/landing/push
[26] http://apidocjs.com/

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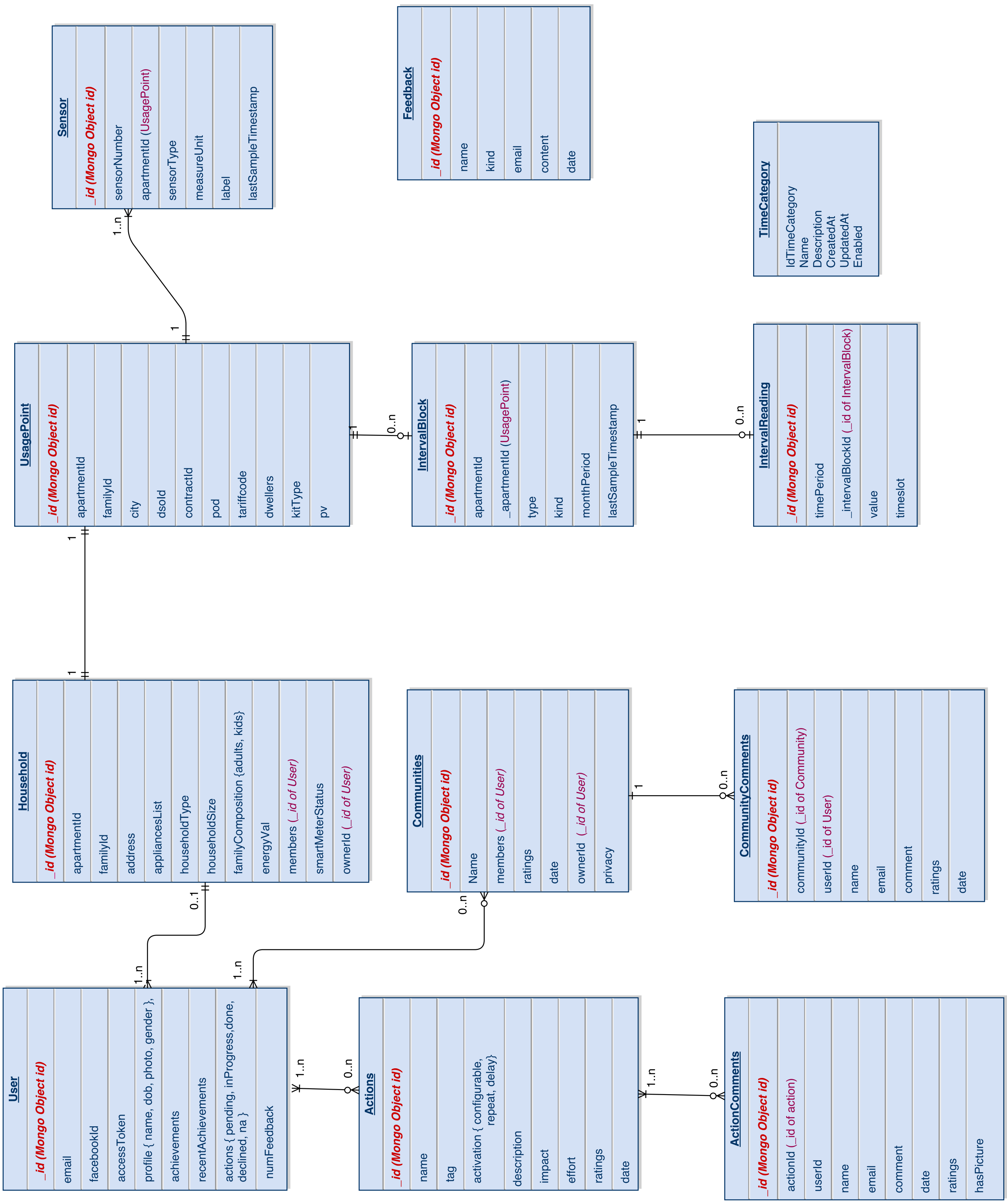

Figure 12: YouPower back-end data model schema

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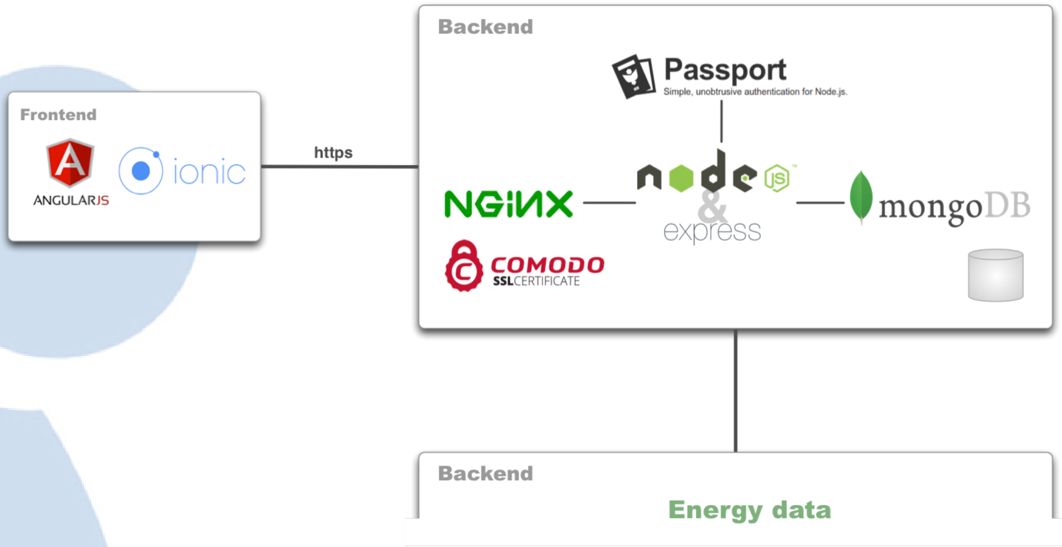

Figure 13: WP3

page. This contract Id will then be mapped to Apartment ID (also called UsagePoint). Apartment Id is unique for each household and data associated with consumption and production recorded from the sensor are referenced through this Ids.

3.3.2 TOU (Time of Use) signals

YouPower provides the current energy level(red smileys representing low energy tariffs and green smiley for high energy tariff levels) and a prediction of energy tariff levels for the following 30 hours. TOU signals are provided with a non-secured protocol(http) which raises mixed content issue since YouPower requires a secure connection. For this, we have developed two backend APIs.

Table 3: TOU endpoints

Endpoint	**Description**
/api/energymeteo/tou	Provides energy level tariffs for previous 30 hours
/api/energymeteo/tou/current	Provides the current energy tariff

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3.3.3 Electric consumption and production updates

The app update users by showing the amount of consumption and production in a given time(energy) and power levels of the last six to eight minutes recorded in either today or the last time a sensor provides this informations. Sometimes, when there is a sudden changes in power, raspberry may need to restart or lack of connectivity to internet may happen. In this cases, sensors may stop sending signals to the Reply server. The app shows the most recent updates that shows the last time an electric consumption and production recorded from sensors.

3.3.4 Appliances consumption updates

The app includes information on consumption per each appliance. List of all available appliances for a household like "Lavatrice" and "Freezer" are listed in the appliances tab of the app, with corresponding timing where last consumption is recorded.

Table 4: Endpoints for getting last consumption records

Endpoint	**Description**
/api/consumption/last	Provides energy level tariffs for previous 30 hours
/api/production/last	Provides the last production amount recorded for a household with a PV
/api/consumption/appliance	Gives list of all available appliances for a household and the last time stamp a consumption data is recorded

3.3.5 Energy data(Consumption and production)

Daily consumption provided by an appliance is accessible from YouPower by setting a range of dates (users can avoid sending unnecessary request of a consumption which may not be available by checking the recent updates) a user is interested at. A series of consumption history for all the appliances of a household can also be obtained by requesting the endpoint with a contract Id.

3.3.6 Consumption comparison in energy tariff levels

This part of the app shows comparison containing consumption record of a household based on red and green levels. The red levels shows the amount of consumption a household used when the energy level is low, and the green for high energy levels.

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Table 5: Endpoints for getting energy consumption

Endpoint	Description
/api/consumption/appliance/:applID	Provides the consumption history of an appliance taking household Id, startdate and enddate as parameters
/api/consumption	Provides a series of consumption history for all appliances of a household in F1, F2 and F3 levels

3.3.7 Community consumption comparison

This section contains two main comparison graphs. The first contains consumption comparison of the two municipalities, CEIS and CEDIS, for the 24 hours period of the required date in intervals of 1 hour. The second part of the graph shows comparison of a household consumption with the total consumption of a municipality and the average consumption of the households in the same municipality. We implemented an endpoint for accessing the daily consumption of all households from reply server and it will be dumped to Delft server for accessing requested resource fast.

3.3.8 Technical issues

We have used the same set of technologies stated in the Backend section of this document. We have listed the issues we have faced during feature improvement.

Table 6: Technical issues

Issue	Status
DatePicker incompatibility with firefox	Not fixed – planned for next update
CORS issue when accessing CN endpoints	Fixed: CN server allow civisproject domain

3.4 Resources

4 WP3 Tasks: Summary of Contributions

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4.1 T3.1 Community Management

4.2 T3.2 Energy Consumer Profiling

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:

- 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

5 Conclusions and Future Work

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