

D3.3 Final Field Tested Integrated Energy System Workpackage 3



Responsible Unit: TU Delft
Authors:



Document technical details

Document Number	D3.3
Document Title	Integrated Energy System
Version	1.3
Status	Final
Work Package	3
Deliverable Type	R/T
Contractual Date of delivery	01/10/2015
Actual Date of Delivery	07/10/2015
Responsible Unit	TU Delft
Contributors	CN, KTH, AALTO, KIT
Keywords List	social smart grid platform, design, mock-up, prototype
Dissemination Level	PU



Document changelog

Version	Date	Status	Author (Unit)	Description
0.1	May 12, 2016	Outline	Y. Huang (TU Delft)	The first outline
0.2	May 13	Draft	Y. Huang (TU Delft)	2.1; 2.2; 2.3.1
0.x	May 13, 2016	Outline	Y. Huang (TU Delft)	



CIVIS Consortium

CIVIS (Grant Agreement contract No. 608774) is a Collaborative Project within the 7th Framework Programme, theme FP7-SMARTCITIES-2013, ICT-2013.6.4. As defined in the Consortium Agreement [2], members of the Consortium are:

No.	Beneficiaries
1	UNIVERSITA DEGLI STUDI DI TRENTO, established in VIA CALEPINA 14, 38122 TRENTO - ITALY, represented by Mr Paolo COLLINI, Rector, or his authorised representative, the beneficiary acting as coordinator of the consortium (the "coordinator").
2	AALTO-KORKEAKOULUSAATIO established in OTAKAARI 1, 00076 AALTO - FINLAND, represented by Mr Ilkka NIEMELÄ, Deputy President and/or Mr Tuija PULKKINEN, Vice President, or their authorised representative.
3	FONDAZIONE CENTRO STUDI ENEL established in VIALE REGINA MARGHERITA 137, 00198 ROMA - ITALY, represented by Mr Francesco STARACE, President, or his authorised representative.
4	IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE established in Exhibition Road, South Kensington Campus, SW7 2AZ LONDON - UNITED KINGDOM, represented by Ms Carole MEADS, Senior Negotiator, European Policy and/or Mr James LLOYD, Contracts Administrator (Europe), or their authorised representative.
5	INSTITUTO SUPERIOR TECNICO established in Avenida Rovisco Pais 1, 1049-001 LISBOA - PORTUGAL, represented by Mr Arlindo OLIVEIRA, President, or his authorised representative.
6	Karlsruher Institut fuer Technologie established in Kaiserstrasse 12, 76131 Karlsruhe - GERMANY, represented by Mr Bernhard DASSELAAR, Head of Cost and Fund Management and/or Mr Wolf FICHTNER, Head of IIP, or their authorised representative.
7	KUNGLIGA TEKNISKA HOEGSKOLAN established in BRINELLVAGEN 8, 100 44 STOCKHOLM - SWEDEN, represented by Mr Peter GUDMUNDSON, President and/or Mr Kenneth BILLQVIST, Head of Research Office, or their authorised representative.
8	SANTER REPLY SPA established in VIA ROBERT KOCH 1/4, 20152 MILANO - ITALY, represented by Mr Luigi CICCHESE, Partner, or his authorised representative.



9	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK - TNO established in Schoemakerstraat 97, 2600 JA DELFT - THE NETHERLANDS, represented by Drs. René HOOIVELD, Director of Sustainable Energy, or his authorised representative.
10	TECHNISCHE UNIVERSITEIT DELFT established in Stevinweg 1, 2628 CN DELFT - THE NETHERLANDS, represented by Mr Jeroen VAN DEN HOVEN, Dean and/or Mr Hans DE BRUIJN, Vice-Dean, or their authorised representative.
11	CREATE-NET (CENTER FOR RESEARCH AND TELECOMMUNICATION EXPERIMENTATION FOR NETWORKED COMMUNITIES) established in VIA ALLA CAS-CATA 56/D, 38123 TRENTO - ITALY, represented by Mr Imrich CHLAMTAC, President, or his authorised representative.
12	FONDAZIONE BRUNO KESSLER established in VIA SANTA CROCE 77, 38122 TRENTO - ITALY, represented by Mr Andrea SIMONI, General Secretary and/or his authorised representative.



Table of Contents

Executive Summary	6
1 Introduction	7
1.1 Overview	7
1.2 Aims and Scope	7
1.3 Design and Development Process: the Continuation	7
2 CIVIS Platform Design	9
2.1 Motivation: Bridging the Attitude-Behavior Gap	9
2.2 Design Guidelines	11
2.3 CIVIS Platform Design	15
2.3.1 Action Suggestions	16
2.3.2 Housing Cooperatives	21
2.3.3 Energy Data Visualization and Comparison (need another title probably)	23
3 CIVIS Platform Development	25
3.1 CIVIS Front-End as a Hybrid Application	25
3.2 CIVIS Back-End	26
3.3 Resources	28
4 WP3 Tasks: Summary of Contributions	28
4.1 T3.1 Community Management	28
4.2 T3.2 Energy Consumer Profiling	28
4.3 T3.3 Interface with System Level	28
4.4 T3.4 Energy Service Context	28
5 Conclusions and Future Work	28
References	29



Executive Summary

This report summarizes



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 YouPower¹ 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 License². It has an online repository at GitHub³. The backend API documentation is also available online⁴.

...

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 behaviour, and as a result, any solution to environmental issues will require changes in behaviour (Schultz, 2014).

1.3 Design and Development Process: the Continuation

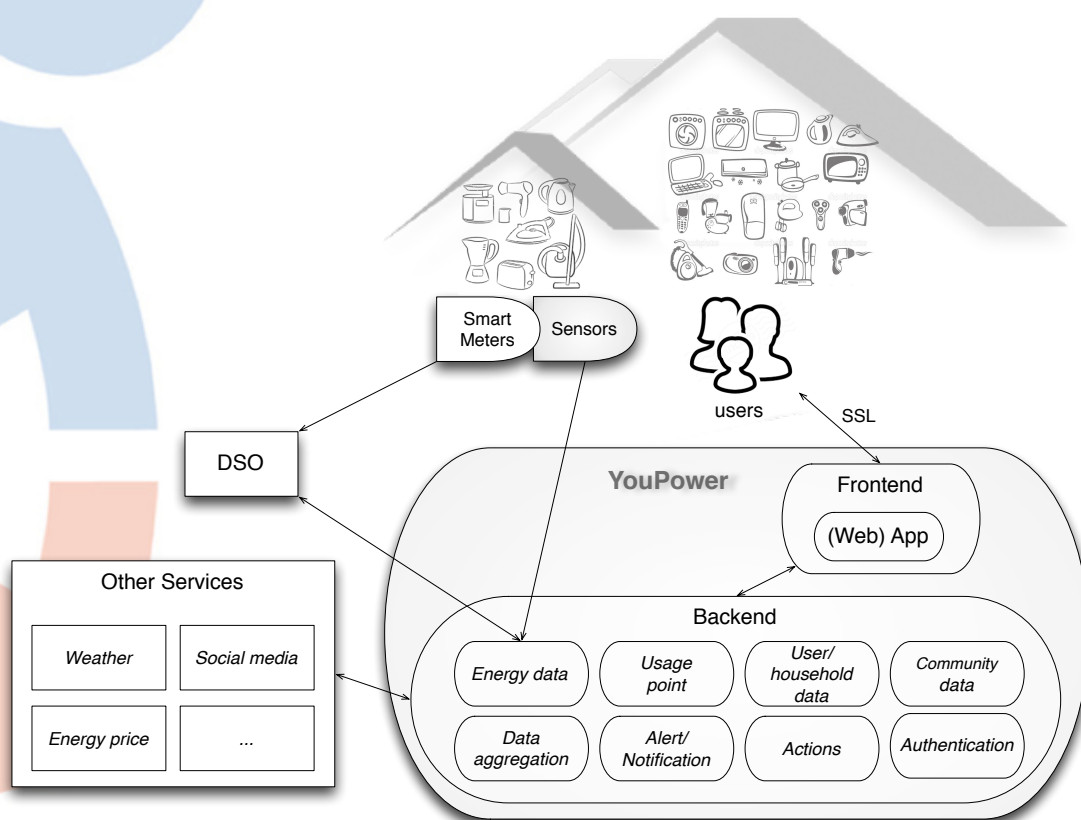
The design process of YouPower is theory-driven, user-centered and iterative. We researched literature on intervention strategies and social smart grid applications directed at promoting pro-environmental consumer behavior change. This provided an initial set of design

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/>



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

Figure 1: CIVIS platform overview



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 (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 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 (Dillahunty 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 (Dillahunty et al., 2009).

To bridge the attitude-behavior gap, household energy conservation 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 conservation 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 (2) the intervention design shall also have means to motivate consumers to voluntarily practice and repeat the energy conservation actions in the specific context of their everyday life.

2.2 Design Guidelines

This subsection outlines and discusses XX design guidelines.

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

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.

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 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 CO₂ 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 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 (Deweese 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 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 ([Berthou, 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](#)).

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 actions⁵ is composed to provide accurate information about actionable suggestions in the behavior 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 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 already 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.)

⁵<https://goo.gl/R11QdZ>

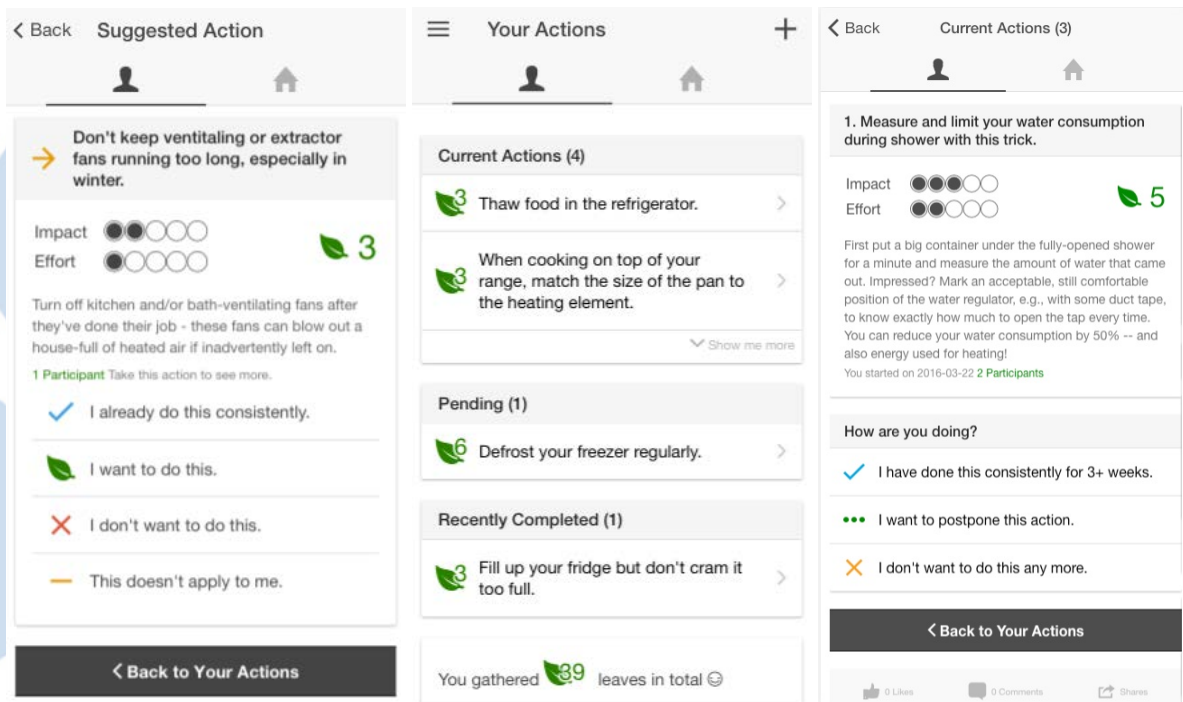
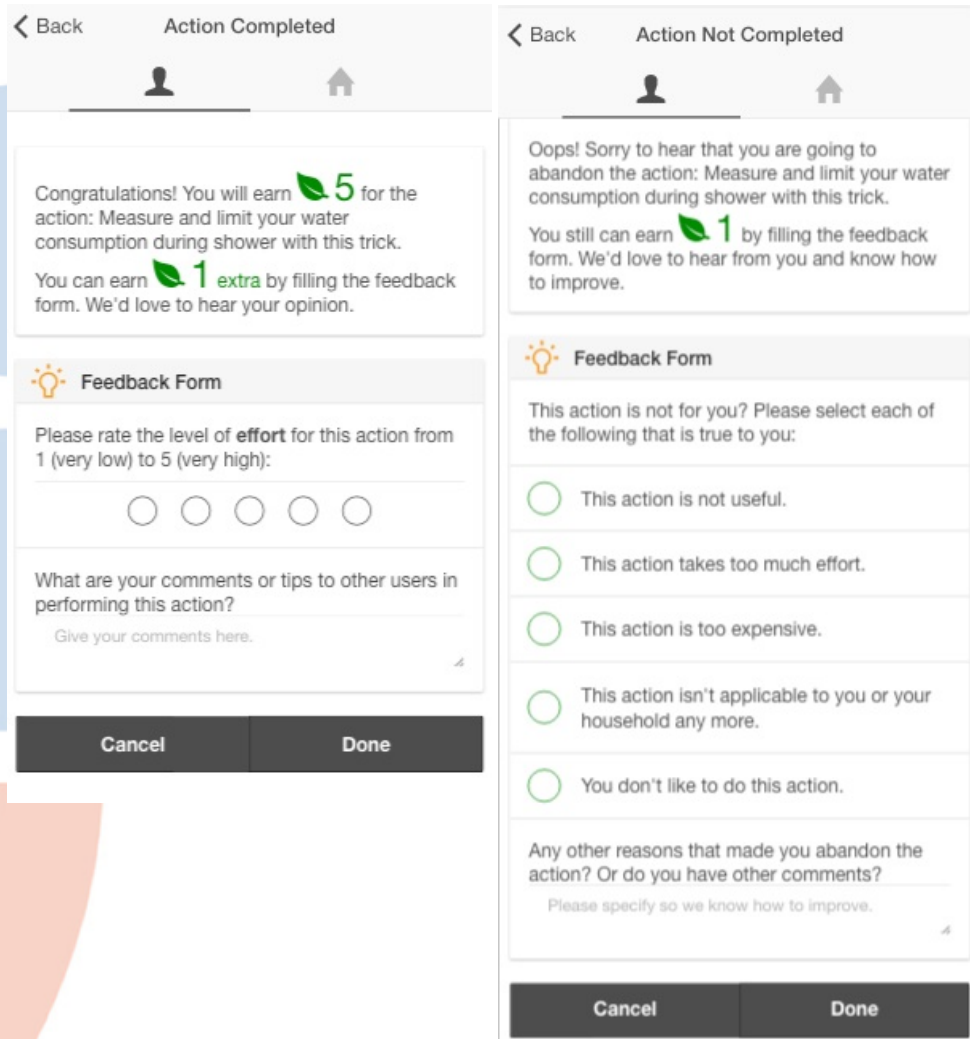


Figure 2: (1) An action suggestion; (2) User actions tab; (3) An action in progress

- 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.



Action Completed

Back

Congratulations! You will earn **5** for the action: Measure and limit your water consumption during shower with this trick.

You can earn **1** extra by filling the feedback form. We'd love to hear your opinion.

Feedback Form

Please rate the level of **effort** for this action from 1 (very low) to 5 (very high):

○ ○ ○ ○ ○

What are your comments or tips to other users in performing this action?

Give your comments here.

Cancel Done

Action Not Completed

Back

Oops! Sorry to hear that you are going to abandon the action: Measure and limit your water consumption during shower with this trick.

You still can earn **1** by filling the feedback form. We'd love to hear from you and know how to improve.

Feedback Form

This action is not for you? Please select each of the following that is true to you:

☐ This action is not useful.

☐ This action takes too much effort.

☐ This action is too expensive.

☐ This action isn't applicable to you or your household any more.

☐ You don't like to do this action.

Any other reasons that made you abandon the action? Or do you have other comments?

Please specify so we know how to improve.

Cancel Done

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

- 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.*
- A user can signup and login YouPower with a Facebook account. If so, the user can



Figure 4: Facebook share of a YouPower action

“share” an action on Facebook. Figure 7 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

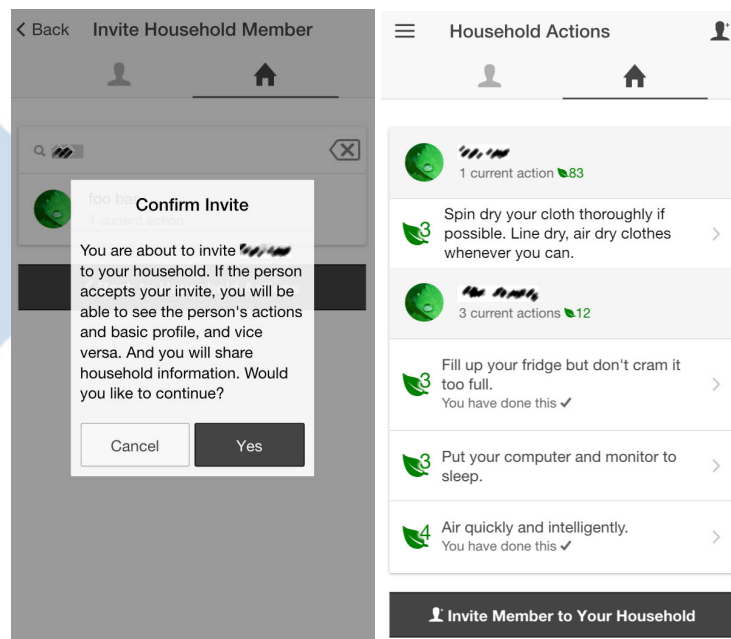
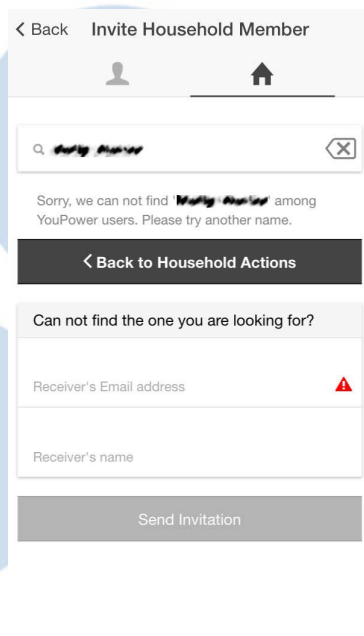


Figure 5: (1) Invite household member; (2) Household member actions

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 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



Invitation from **Wally House** to join YouPower



Hi there,

Wally House joined YouPower and is inviting you to join as well. YouPower is a free energy social app that is simple and fun to use.

[Join Now](#)

With YouPower you can find answers to your questions about different energy practices and save energy together with your family, friends or neighbors. Sign up to discover more.

Thanks, have a lovely day!

[YouPower Team](#)

Figure 6: Send Email invitation to join YouPower

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.

2.3.2 Housing Cooperatives

Hammarby Sjöstad, Stockholm Test Site

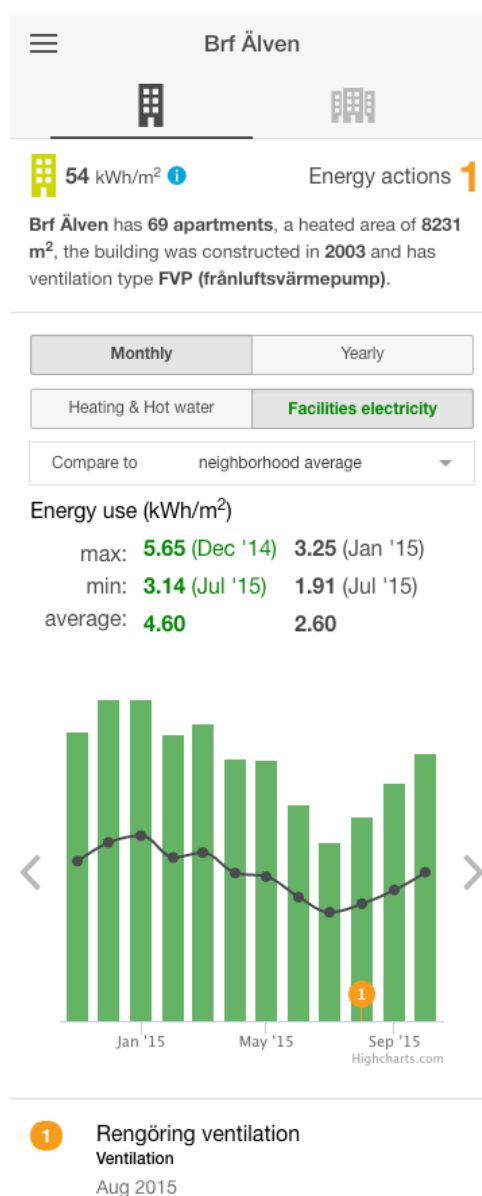


Figure 7: BRF

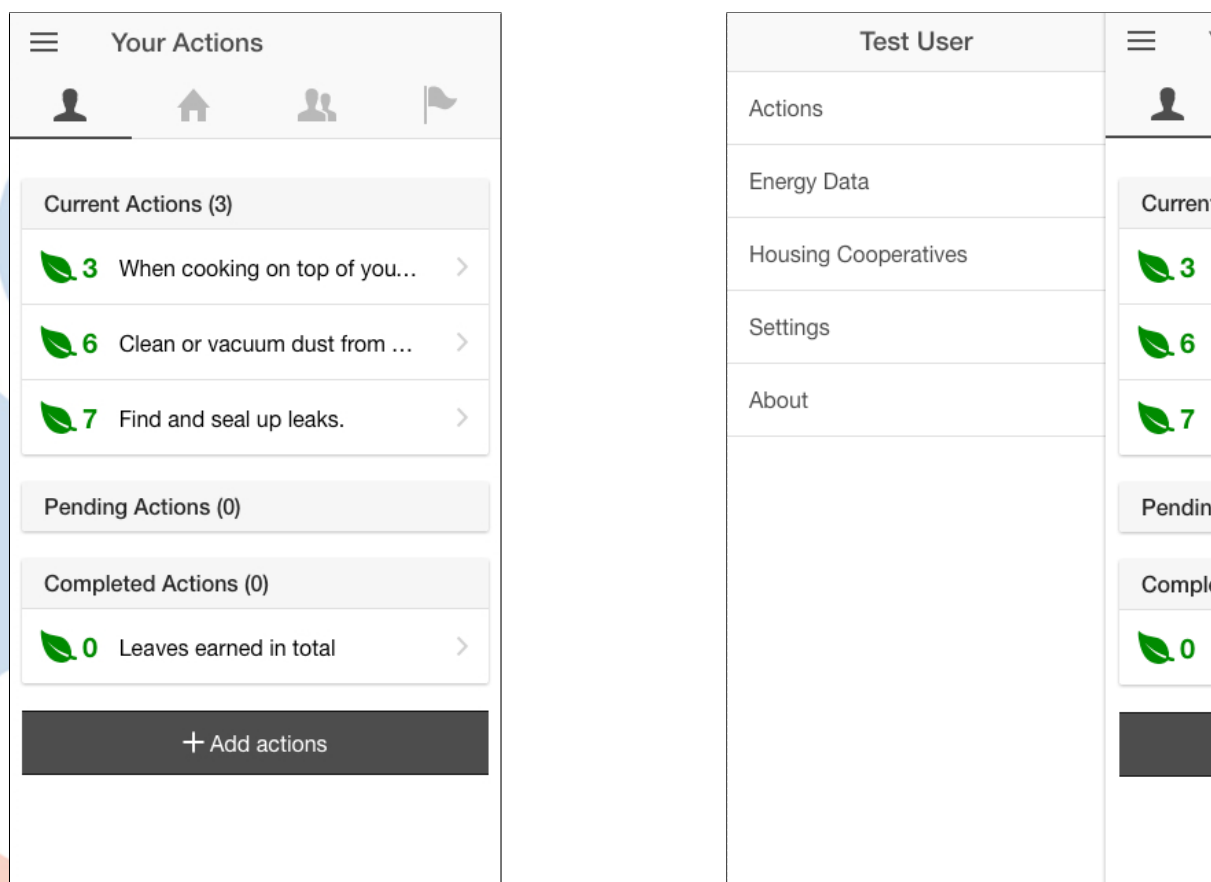


Figure 8: “Your Actions” tab – “Action List” view (left); with an open side nav drawer (right)

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 8 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.

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)
	Appliance Level	Consumption Patterns (for each monitored appliance)
	Community Level	Total Community Consumption (last month), Total Community Production (last month), Community Energy Balance, Comparison with Benchmark
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



3 CIVIS Platform Development

The development (implementation) of the CIVIS platform was started in May 2015 (Huang et al., 2015) and continued in the third year's WP3 activities. At the time of writing this deliverable (Jun 2016), the development is completed with some minor updates took place in the past month. The JavaScript (JS) programming language⁶ 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 Ionic⁷, an HTML5 front-end development framework built with SASS⁸ and optimized for AngularJS⁹ (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 compelling¹⁰.

The energy data visualizations are built using the HighCharts library¹¹, wrapped using the `highchart-ng` directives for Ionic¹².

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 MVC architecture. The "Current Actions" in the "Action List", for example, are rendered with the following HTML code:

```
<div class="...">Current Actions ({{_.size(currentUser.actions.inProgress)}})</div>
<a class="..." ng-repeat="action in currentUser.actions.inProgress" ng-href="#/app/actions/active/{{$index}}">
  {{getActionPoints(action)}} {{action.name}}
</a>
```

where `currentUser.actions.inProgress` is a model of a list (array) of the user's actions (the data) that are dynamically loaded into the corresponding controller from the CIVIS back-end at runtime. The Angular directive `ng-repeat` then iterates through the list, takes each element as an action, and displays the data in the view. The function `getActionPoints(action)` is defined in the controller. It is a good example of two-way data binding where the value of action (the model) is passed on from the view to the controller, and the function returns the result form the controller to the view.

⁶<http://www.crockford.com/javascript/javascript.html>

⁷<http://ionicframework.com/>

⁸<http://sass-lang.com/>

⁹<https://angularjs.org/>

¹⁰<http://ionicframework.com/docs/guide/>

¹¹<http://www.highcharts.com/>

¹²<https://github.com/pablojim/highcharts-ng>



3.2 CIVIS Back-End

An early version of YouPower¹³ has its back-end on Firebase¹⁴ to have a quick set-up. For the same reason, the YouPower back-end development is first deployed on Heroku¹⁵. 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.js¹⁶ 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. MongoDB¹⁷ 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 9 shows the data model schema. The noteworthy Node.js libraries we use for the back-end development are as follows:

- Async.js¹⁸, which makes managing and combining asynchronous tasks easier.
- Express.js¹⁹, a Node.js application server framework we use as a basis for the REST API.
- Mocha²⁰, a JavaScript unit test framework.
- Mongoose²¹, a MongoDB driver for Node.js. It provides a schema-based solution to model data.
- Passport.js²², for handling authentication of REST API requests for Node.js, both local (username password) and Facebook.
- Ionic Push²³, for sending dynamic push notifications.

¹³Branch study-prototype <https://github.com/CIVIS-project/YouPower/tree/study-prototype>, <https://app.civisproject.eu/frontend.html>

¹⁴<https://youpower.firebaseio.com/>

¹⁵<https://www.heroku.com/>

¹⁶<https://nodejs.org/>

¹⁷<https://mongodb.org/>

¹⁸<https://github.com/caolan/async>

¹⁹<http://expressjs.com/>

²⁰<https://mochajs.org/>

²¹<http://mongoosejs.com/>

²²<http://passportjs.org/>

²³<https://apps.ionic.io/landing/push>

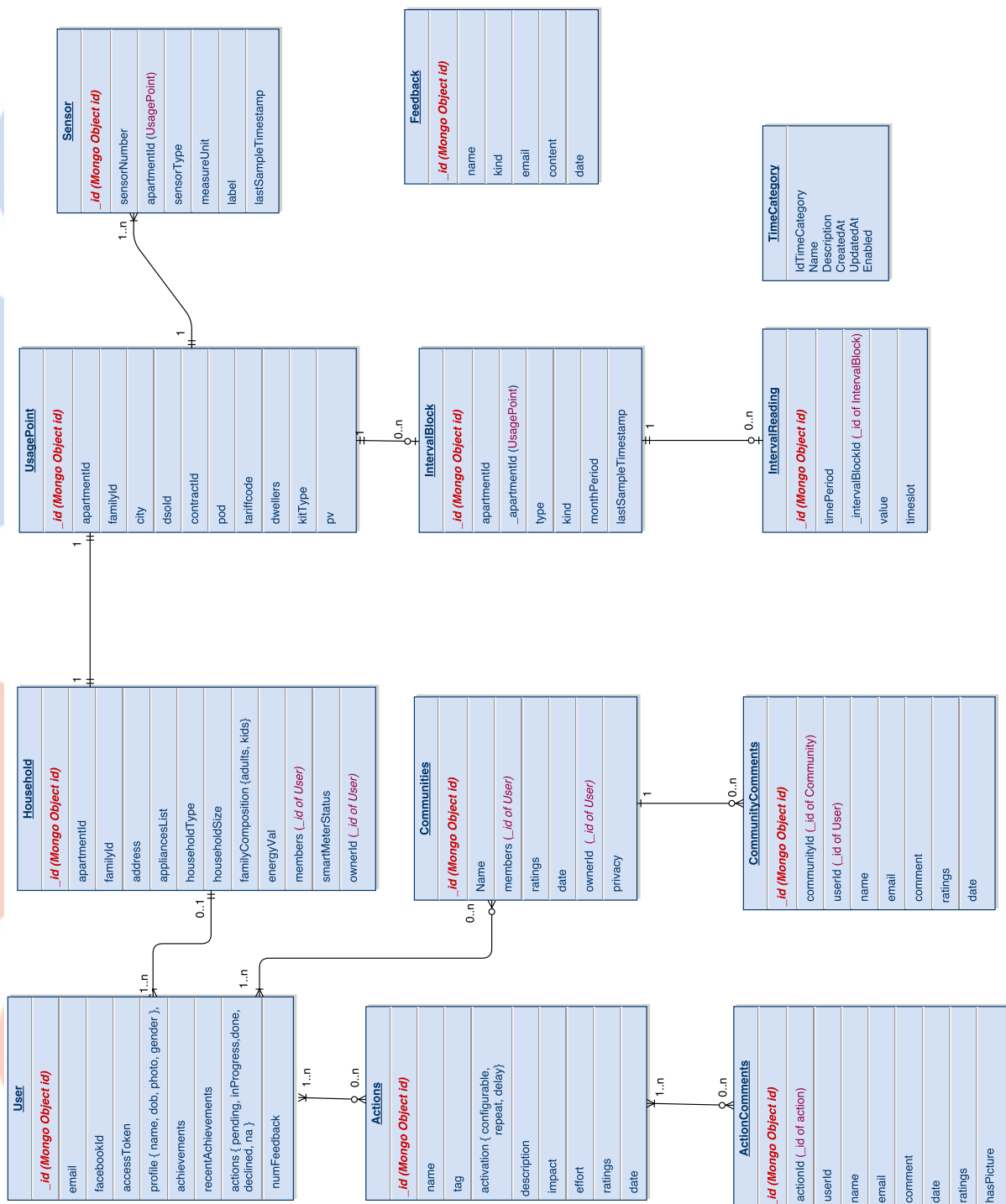


Figure 9: YouPower back-end data model schema

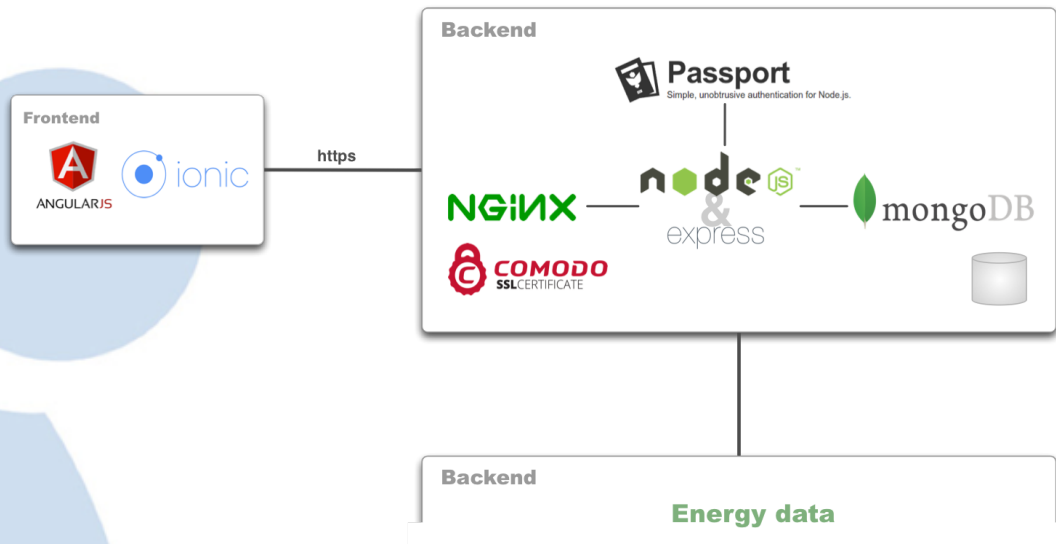


Figure 10: WP3

- APIDOC script²⁴, 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 Resources

4 WP3 Tasks: Summary of Contributions

4.1 T3.1 Community Management

4.2 T3.2 Energy Consumer Profiling

4.3 T3.3 Interface with System Level

4.4 T3.4 Energy Service Context

5 Conclusions and Future Work

²⁴<http://apidocjs.com/>



References

- Abrahamse, W. and L. Steg (2013). Social influence approaches to encourage resource conservation: A meta-analysis. Global Environmental Change 23(6), 1773–1785.
- Abrahamse, W., L. Steg, C. Vlek, and T. Rothengatter (2005). A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology 25(3), 273 – 291.
- Allcott, H. (2011). Social norms and energy conservation. Journal of Public Economics 95(9-10), 1082–1095.
- Asensio, O. I. and M. A. Delmas (2015). Nonprice incentives and energy conservation. Proceedings of the National Academy of Sciences 112(6), E510–E515.
- Berthou, S. K. G. (2013). The everyday challenges of pro-environmental practices. The Journal of Transdisciplinary Environmental Studies 12(1).
- Blake, J. (1999). Overcoming the 'value-action gap' in environmental policy: Tensions between national policy and local experience. Local Environment 4(3), 257–278.
- Brynjarsdottir, H., M. Håkansson, J. Pierce, E. Baumer, C. DiSalvo, and P. Sengers (2012). Sustainably unpersuaded: How persuasion narrows our vision of sustainability. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '12, New York, NY, USA, pp. 947–956. ACM.
- Burchell, K., R. Rettie, and T. Roberts (2014). Working together to save energy? report of the smart communities project. Technical report, Behaviour and Practice Research Group, Kingston University.
- Burgess, J. and M. Nye (2008). Re-materialising energy use through transparent monitoring systems. Energy Policy 36(12), 4454 – 4459. Foresight Sustainable Energy Management and the Built Environment Project.
- CEER (2015). Advice on customer information on sources of electricity. Technical Report Ref: C14-CEM-70-08, Council of European Energy Regulators.
- Claudy, M. C., M. Peterson, and A. O'Ádriscoll (2013). Understanding the attitude-behavior gap for renewable energy systems using behavioral reasoning theory. Journal of Macromarketing 33(4), 273–287.
- Crumlish, C. and E. Malone (2009). Designing Social Interfaces: Principles, Patterns, and Practices for Improving the User Experience. O'Reilly Media.
- Delmas, M. A., M. Fischlein, and O. I. Asensio (2013). Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. Energy Policy 61, 729 – 739.
- Deweese, D. and T. Tombe (2011). The impact of sub-metering on condominium electricity demand. Canadian Public Policy 37(4), 435–457.
- Dick, H., H. Eden, G. Fischer, and J. Zietz (2012). Empowering users to become designers: using meta-design environments to enable and motivate sustainable energy decisions. In Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases-Volume 2, pp. 49–52. ACM.



- Dillahun, T., J. Mankoff, and E. Paulos (2010). Understanding conflict between landlords and tenants: implications for energy sensing and feedback. In UbiComp 2010, pp. 149–158.
- Dillahun, T., J. Mankoff, E. Paulos, and S. Fussell (2009). It's not all about "green": Energy use in low-income communities. In Proceedings of the 11th International Conference on Ubiquitous Computing, UbiComp '09, New York, NY, USA, pp. 255–264. ACM.
- Edney, J. J. (1980). The commons problem: Alternative perspectives. American Psychologist 35(2), 131–150.
- Edney, J. J. and C. S. Harper (1978). Environmental management. Environmental Management 2(6), 491–507.
- Entwistle, J. M., M. K. Rasmussen, N. Verdezoto, R. S. Brewer, and M. S. Andersen (2015). Beyond the individual: The contextual wheel of practice as a research framework for sustainable hci. In CHI.
- Fehrenbacher, K. (2011, Jun). 5 reasons Google PowerMeter didn't take off.
- Fell, M. J. and L. F. Chiu (2014). Children, parents and home energy use: Exploring motivations and limits to energy demand reduction. Energy Policy 65, 351–358.
- Froehlich, J. (2009). Promoting energy efficient behaviors in the home through feedback: The role of human-computer interaction. In HCIC 2009 Winter Workshop.
- Gardner, G. T. and P. C. Stern (2008). The short list: The most effective actions u.s. households can take to curb climate change. Environment: Science and Policy for Sustainable Development 50(5), 12–25.
- Hardin, G. (1968). The tragedy of the commons. science. 166, 1103–1107.
- Hargreaves, T., M. Nye, and J. Burgess (2010). Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. Energy Policy 38(10), 6111 – 6119. The socio-economic transition towards a hydrogen economy - findings from European research, with regular papers.
- He, H. A., S. Greenberg, and E. M. Huang (2010). One size does not fit all: Applying the trans-theoretical model to energy feedback technology design. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '10, New York, NY, USA, pp. 927–936. ACM.
- Huang, Y., D. Miorandi, H. Hasselqvist, M. Warnier, S. Scepanoic, and R. Eskola (2015). D3.2 intergrated energy system. Technical report, CIVIS Project.
- Huizenga, J., L. Piccolo, M. Wippoo, C. Meili, and A. Bullen (2015). Shedding lights on human values: an approach to engage families with energy conservation. In 15th IFIP TC.13 International Conference on Human-Computer Interaction - INTERACT. Springer.
- Knowles, B., L. Blair, S. Walker, P. Coulton, L. Thomas, and L. Mullagh (2014). Patterns of persuasion for sustainability. In Proceedings of the 2014 Conference on Designing Interactive Systems, DIS '14, New York, NY, USA, pp. 1035–1044. ACM.
- Kollmuss, A. and J. Agyeman (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environmental Education Research 8(3), 239–260.



- Mani, A., I. Rahwan, and A. Pentland (2013). Inducing peer pressure to promote cooperation. Scientific reports 3.
- McKenzie-Mohr, D. (2000). Fostering sustainable behavior through community-based social marketing. American psychologist 55(5), 531.
- Moisander, J. (2007). Motivational complexity of green consumerism. International Journal of Consumer Studies 31(4), 404–409.
- Munley, V. G., L. W. Taylor, and J. P. Formby (1990). Electricity demand in multi-family, renter-occupied residences. Southern Economic Journal, 178–194.
- Ockwell, D., L. Whitmarsh, and S. O'Neill (2009). Reorienting climate change communication for effective mitigation: forcing people to be green or fostering grass-roots engagement? Science Communication.
- Parfit, D. and J. Broome (1997). Reasons and motivation. Proceedings of the Aristotelian Society, Supplementary Volumes 71, 99–146.
- Petkov, P., F. Köbler, M. Foth, and H. Krcmar (2011). Motivating domestic energy conservation through comparative, community-based feedback in mobile and social media. In Proceedings of the 5th International Conference on Communities and Technologies, C&T '11, New York, NY, USA, pp. 21–30. ACM.
- Pierce, J., D. J. Schiano, and E. Paulos (2010). Home, habits, and energy: Examining domestic interactions and energy consumption. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '10, New York, NY, USA, pp. 1985–1994. ACM.
- Pierce, J. L., T. Kostova, and K. T. Dirks (2003). The state of psychological ownership: Integrating and extending a century of research. Review of general psychology 7(1), 84.
- Ryan, R. M. and E. L. Deci (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary Educational Psychology 25(1), 54–67.
- Schultz, P. (2002). New Tools for Environmental Protection: Education, Information, and Voluntary Measures, Chapter Knowledge, information, and household recycling: examining the knowledge-deficit model of behavior change, pp. 67–82. Washington DC: National Academy Press.
- Schultz, P. W. (2014). Strategies for promoting proenvironmental behavior - lots of tools but few instructions. European Psychologist 19(2), 107–117.
- Schultz, P. W. (2015). Strategies for promoting proenvironmental behavior. European Psychologist.
- Selvefors, A., I. Karlsson, and U. Rahe (2015). Conflicts in everyday life: The influence of competing goals on domestic energy conservation. Sustainability 7(5), 5963–5980.
- Steg, L. and C. Vlek (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. Journal of Environmental Psychology 29, 309–317.
- Strengers, Y. (2014, July). Smart energy in everyday life: Are you designing for resource man? interactions 21(4), 24–31.
- Swim, J. K., N. Geiger, and S. J. Zawadzki (2014). Psychology and energy-use reduction policies. Policy Insights from the Behavioral and Brain Sciences 1(1), 180–188.
- Thøgersen, J. and T. Crompton (2009). Simple and painless? the limitations of spillover in



- environmental campaigning. Journal of Consumer Policy 32(2), 141–163.
- Truelove, H. B., A. R. Carrico, E. U. Weber, K. T. Raimi, and M. P. Vandenbergh (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. Global Environmental Change 29, 127 – 138.
- Verplanken, B. and H. Aarts (1999). Habit, attitude, and planned behaviour: Is habit an empty construct or an interesting case of goal-directed automaticity? European Review of Social Psychology 10(1), 101–134.
- Yim, D. (2011). Tale of two green communities: Energy informatics and social competition on energy conservation behavior. In AMCIS.