Demonstration of **Inte**lligent grid technologies for renewables **Inte**gration and **Inte**ractive consumer participation enabling **Inte**roperable market solutions and **Inte**rconnected stakeholders

Task 1.4 – Design of Consumer's Engagement Strategies

Consumer's Engagement Strategies

D1.4

European Commission | Horizon 2020 European Union funding for Research & Innovation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731218

Topic	Demonstration of smart grid, storage and system integration technologies with increasing share of renewables: distribution system
Call	LCE 02 - 2016 - SGS
Grant Agreement Number	731218
Project Acronym	InteGrid
Document	D1.4 Consumer's Engagement Strategies
Type (Distribution Level)	☒ Public ☐ Confidential
Due Delivery Date	30.06.2018
Date of Delivery	30.06.2018
Status and Version	1
Number of Pages	94
WP Responsible	CNET
Deliverable Responsible	KTH
Author(s)	Carmen Escudero Guirado | Comillas Victoria Labajo | Comillas Carmen Valor | Comillas Paula Bögel | KTH Annika Giersiepen | KTH Carolina Koronen | KTH Aram Mäkivierikko | KTH Anders Nilsson | KTH Hossein Shahrokni | KTH
Reviewer 1	Pedro Coimbra Costa | EDP Comercial
Reviewer 2	Rafael Cossent Arín| Universidad Pontificia Comillas
File Name	InteGrid_D1.4_ Design_of_Consumer's_Engagement_Strategies

Acknowledgements

The following people are hereby duly acknowledged for their considerable contributions, which have served as a basis for this deliverable:

Name	Partner
Manuel Pio Silva	CNET
Carmen Escudero Guirado	Comillas
Victoria Labajo	Comillas
Carmen Valor	Comillas
Rafael Cossent Arín	Comillas
Alexandra Lemos	EDP Distribuição
Diogo Lopes	EDP Distribuição
Nuno Ferreira	EDP Distribuição
Pedro Coimbra Costa	EDP Comercial
Uršula Krisper	Elektro Ljubljana
Olle Hansson	Ellevio
Ricardo Bessa	INESC TEC
Luisa Gonçalves	INESC TEC
Cláudia Rocha de Abreu	INESC TEC
David Rua	INESC TEC
Paula Bögel	KTH
Susanna Elfors	KTH
Annika Giersiepen	KTH
Olga Kordas	KTH
Carolina Koronen	KTH
Simona Laza	KTH
Aram Mäkivierikko	KTH
Anders Nilsson	KTH
Hossein Shahrokni	KTH
Alena Soo	SIM
Matheus Boschetti	SIM
Patrik Nyström	SIM

Executive Summary

This deliverable is the outcome of task 1.4 in the InteGrid project; it revolves around an inherently transdisciplinary challenge: long-term engagement of consumers in the smart electricity grid. The contributions of this report stand on three legs that provide the InteGrid with insights, and practical guidelines on how to better engage the end users in the smart grid, across the demo sites in Sweden, Portugal and Slovenia. The results are however also relevant to the wider smart grid community.

The first leg of this report is a literature review on eco-feedback covering feedback-based interventions for increasing energy savings. The review was oriented to identify key design features of devices and/or features related to the implementation of the devices (e.g. device placement). This review resulted in a number of practical recommendations to the project that are particularly important to HLUC 9 and HLUC 11. The recommendations included feedback timing, duration of feedback, mediums used, content of feedback, granularity of feedback, units, tailored feedback with concrete recommended actions, working with penalties and rewards, design strategies, and specifically, designing devices for families and homes. To enable more tailored feedback, algorithms with household-specific baselines were proposed to customise the feedback to the actual household and to increase consumer trust in the feedback.

The second leg of the report is related to the local stakeholder consultation workshops with end users of smart grid solutions. This report provides guidelines for how to conduct stakeholder consultation workshops towards these aims. A literature review was also conducted that highlighted how stakeholder consultation workshops have been used in the energy field in the past, and what stakeholders were included. This spanned questions that have been discussed with residential users, such as their reactions and beliefs to dynamic pricing, self-consumption, and smart meters.

Subsequently, residential stakeholder consultation workshops were conducted in Stockholm and Lisbon where the main topics were community storage and feedback. In addition, two office employee stakeholder consultation workshops were conducted by Elektro Ljubljana with their office employees in Domzale and Ljubljana, aimed at identifying a CSR program where office employees could support flexibility increasing actions and their role in the building's peak load reduction. The workshop objectives were therefore: to raise awareness on building energy performance among employees; to find out about current habits and attitudes related to energy; to identify action points in an upcoming behavioral change program aimed at conserving and shifting energy; and to build approval of the program among employees. The workshop resulted in the decision to focus on two measures in the behavioral change program: management of the air conditioning; and close attention to switching off computers and their equipment when not in use.

To better understand how consumers interpret and react to energy feedback given in the context of a social network application, two stakeholder consultation workshops were held – one in Stockholm and one in Lisbon – where a visual prototype of the energy feedback functionality was presented and discussed in focus groups. The participants generally found that presenting the feedback as percentages made it difficult to grasp and they would prefer colors and bars. They appreciated the concrete tips provided on what practical actions to take in order to reach the energy goals. In the Portuguese workshop, they also wanted data on how much money they were saving by reaching their energy goals. The attitudes towards comparing energy conservation and load shifting achievements with other households or neighborhoods were different among the participants; the competitive element appealed to some but not to others. The

Stockholm workshop also assessed the significance of feedback aggregation levels; apartment, building or neighborhood. The results suggested that apartment level may be the most relevant in encouraging people to take action and it also makes their contribution directly visible in the feedback. Building or neighborhood level however may add more to the social sustainability by uniting people towards a common goal.

The workshop on energy storage in Stockholm revealed a desire for independence and a need for a "comfortable" solution that completely takes care of customers' needs, as two contrasting motives underlying residents' decision on energy storage facilities in their apartments. Several participants also associated the new, shared energy system with an improved sense of community, addressing a need for increased social belonging in a currently rather isolated society. In Portugal the majority of participants favored having an own battery in their apartments while in Sweden nearly all participants favored a common battery. This relates to findings on preference for shared versus individual solutions in the two countries: While Swedish participants favored a shared option, Portuguese partners perceived this rather as a risk. The named risks, e.g. running out of energy due to high demand of neighbours, was also mentioned by some Swedish participants but played an overall smaller role in the decision process. A reason for this might be that sharing concepts in housing, e.g. shared laundry rooms are more common in Sweden and people got used to this solution. A compromise of this conflict that was named in both workshops is a "limited sharing", e.g. with the possibility to reserve a certain amount of energy for each resident.

In Ljubljana and Domzale the office employees indicated an interest and willingness to participate in the projects peak reduction program by reducing plug loads during the mid-day peak hours, particularly during their lunch hour.

The third leg of this report – evaluation – while outside the scope of this task, was considered important to be developed in T1.4 for further implementation in the demonstration work packages. A survey was designed that covers energy attitudes, behaviours, and intentions, as well as social identity and cohesion in their neighbourhoods and buildings. The baseline surveys were conducted and summarized in Lisbon and Stockholm, where there are residential consumers in the demonstrators.

The Stockholm survey shows that participants energy saving behavior is mainly influenced by their attitudes and the perceived control they have over energy saving activities. Neighbours opinions did not have an influence, possibly because participants did not identify strongly with them. Measurements of social cohesion reveal room for improvement regarding neighborhood social bonds and again indicate a need for increased social belonging.

The Lisbon survey did not find an influence of attitudes and perceived control on energy saving behavior, which might be partly due to the fact that a shorter version of the questionnaire, designed to increase usability, was tested here. However, as in the Swedish sample, we found a comparatively low identification with the neighborhood and need for improvement in social bonds.

Differences between the samples regarding both energy behavior and the evaluation of social interactions highlight the importance of tailored approaches to engage consumers in different communities with different needs.

Table of Contents

List of Figures

List of Tables

List of Equations

Abbreviations and Acronyms

AH	Active House
AMI	Advanced Metering Infrastructure
CSR	Corporate Social Responsibility
DSO	Distribution System Operator
EV	Electric Vehicle
FG	Focus Group
FMT	Feedback Management Technology
GA	Grant Agreement
HEMS	Home Energy Management System
HLUC	High-Level Use Case
IAP2	International Association for Public Participation
IHD	In-Home Display
MV	Medium Voltage
NGO	Non-Governmental Organisation
PUC	Primary Use Case
PV	Photovoltaics
SCW	Stakeholder Consultation Workshop
SME	Small and Medium-sized Enterprises
SRS	Stockholm Royal Seaport
TSO	Transmission System Operator
VPP	Virtual Power Plant

1. Aims and Objectives of the Report

This report outlines how the consumer-facing smart grid technologies should be adapted to capture the requirements of users and support them to enroll in flexibility products. It particularly provides recommendation on how interfaces and feedback mechanisms should be adapted and designed. As such, this work supports the vision for the InteGrid project which is precisely to bridge the gap between citizens, technology and the other players of the energy system.

The report is structured around insights from three research methods employed. These were literature review studies, stakeholder consultation workshops, and surveys for evaluation. The literature reviews formed the basis for providing design recommendation on feedback mechanisms. The stakeholder consultation workshops provided additional insights on how proposed solutions are understood and received by their intended users. Finally, the surveys were designed and developed for the demonstration work packages to evaluate how their user-facing technologies are influencing user engagement over time. The stakeholder consultation workshops also explored the barriers and opportunities on community storage solutions.

1.1. Objectives

The objectives of D1.4 and their clarifications are found in Table 1.

Table 1. Listing and clarification of the objectives of D1.4.

Objective	Definition
Objective 1: To capture consumer's requirements to enroll in flexibility products and grid support actions [REF GA]	**Requirements** = Here refers to residents' needs and preferences to enroll and act, and how to best meet those needs **Flexibility products** = Different residential demand side management programs **Grid support actions** = Engaging with residential demand side management programs to provide flexibility from households
Objective 2: To design innovative engagement strategies with a mix of several welfare criteria and targeting communities [REF GA]	**Design** = Written design recommendations for engagement strategies **Welfare criteria** = Also including feedback on e.g. economic, environmental, and social aspects in engagement strategy **Community** = As opposed to individual consumers. Could be a building, a number of buildings, or a neighbourhood

1.2. The Challenge of Long-Term Residential Engagement in the Smart Grid

A smart grid needs engaged residents to reach its full potential (Honebein, Cammarano and Boice, 2011). Households, which are associated with 20% of the European CO_2 emissions (Eurostat, 2016), could contribute to the mitigation by reducing their overall consumption and by also participating in demand-side management programs, acting as controllable energy consumers. However, achieving long-term household engagement for these kinds of measures has proven to be hard for various reasons. The monetary savings are often too low compared to the lost comfort (Hargreaves, Nye and Burgess, 2013); appealing to environmental concern is believed to be important but shows little effect in reality (Cialdini and Schultz, 2004); and initial interest in pure environmental feedback (i.e. from in-home energy monitors) diminishes over time (Hargreaves, Nye and Burgess, 2013). On the other hand, social "pressure" together with a sense of community responsibility has shown some promise. Whether by increasing comfort, appealing to environmental concerns, reducing household costs, or utilizing collective goals while strengthening local group identity - identifying effective long-term residential engagement mechanisms is vital to the future smart grid. This report aims to further that pursuit for the design and evaluation of engagement mechanisms in the InteGrid project and those of the other European smart grid projects.

2. InteGrid's Consumer-Facing Technologies and Flexibility Goals

This section provides a description of consumer-facing use cases in the InteGrid project. The consortium partners have each indicated their ambitions with the respective technology implementations in their local demonstrators as summarized in Table 2.

Table 2. InteGrid Energy and Flexibility Goals Across Residential Pilots

	Lisbon	Stockholm Royal Seaport	Bagarmossen	Ljubljana and Domzale	Average Reference in Literature
Technology	Home energy management system (HEMS)	Active House (AH)	LocalLife	CSR	
Energy Reduction Goal	3 %	-	8 %	4 %	7 %
Flexibility Goal	1.5 %	5 %	2.5 %	2 %	1.5%

2.1. HLUC 9 – Home Energy Management System

The High-Level Use Case 09 (HLUC 09) purpose is to support energy management of residential consumers to maximise self-consumption and self-sufficiency through the use of a Home Energy Management System (HEMS). This will be accomplished through monitoring, controlling and assessing the amount of energy that each individual consumer can generate, the load-shift pattern and the storage capacity in each time period. This allows consumers to explore the potential of self-consumption and electricity cost minimisation.

The HEMS makes use of existing energy use flexibility to produce the optimal schedule for the following day according to an optimisation goal (e.g. cost reduction, self-consumption PV maximisation, etc.) and to the preferences and configurations set by the user for the associated appliances and systems.

The optimisation scheme is driven either by prices (or other economic incentives), set locally by the user or remotely by a service provider (market participation), or by self-consumption/local CO_2 reduction goals. In the case of market participation, HEMS provides a flexibility index upon which service providers can leverage the negotiation, typically aggregated, and consequently define the expected participation. This flexibility will be modelled into a virtual battery system that can be differentiated into clusters depending on the upwards or downwards power change capability. This solution will be implemented in Stockholm and Lisbon.

2.2. PUC 01-11 – Active House

The Active House (AH) is a residential demand response intervention program taking place in a city district under current development in Stockholm; the Stockholm Royal Seaport. The AH program aims to stimulate energy conservation and increase demand flexibility – with a set target of 5-15% peak load reduction – among 154 newly built apartments equipped with HEMS's. All households were recruited through a broader agreement with the housing and property companies (body corporates) collaborating with the AH program; tenants signed participation agreements during the acquisition of the apartments. In general, the consumer engagement strategy of the AH program builds on the assumption that HEMS allows for increased monitoring and control of household energy consumption. Hence, it is hypothesised that households will engage with HEMS for reduced energy costs, reduced climate impact, and increased home comfort.

A new HEMS innovation, *Tingco Home*, was developed for the AH program by the local power utility company, involving several types of monitoring options and features provided to the householders through in-home displays. The in-home display (see Figure 1) includes the following main functionalities:

- Energy feedback: Feedback on current consumption of electricity, hot tap water, and heating, accompanied by historical comparisons (hourly/daily/weekly/monthly) and comparisons to other participating households of similar size.
- Smart lightning: For control of lightning (switching on/off/dimming lamps) of different rooms.
- Smart plugs: Each household has two smart plugs to attach to optional appliances, to monitor and control (switch on/off) appliance-specific consumption.
- Smart washing machine/dryer: Allowing for time scheduling of washer/dryer sessions.
- Home/Away switch: To switch on/off all lightning and smart plugs simultaneously.

Figure 1. The start-page dashboard of the Tingco Home display.

The display is laid out as follows: Feedback on electricity (top left); hot tap water (top middle); and heating (top right) consumption, respectively, accompanied by historical comparisons (green dots, and hourly/daily/weekly/monthly consumption by clicking on the energy meters) and comparisons with other households (yellow dots). Feedback on monthly distribution of electricity, hot tap water, and heating consumption, respectively, is provided at the bottom left, and day-by-day historical comparisons at the bottom right. Additionally, menus for accessing smart home features are located in the bottom middle.

2.3. PUC 02-11 – LocalLife

2.3.1. Background

The potential for environmental feedback to be noticed and acted upon increases if it is displayed in an everyday, frequently used context. Generally, when a product or service becomes frequently used, this indicates an underlying *user need*. As the aim is to target households, our design approach rests on identifying *household needs* (market-pull) relevant to the engagement problem of energy utilities (technology-push) (Goncalves Da Silva et al., 2012). A number of household needs were explored, in focus group discussions with residents, as possible intervention strategies for integrating household energy feedback including the need to be able to stay updated with real-time information about the surrounding area (traffic, public transport, crime, and relevant news) (Ectors, 2014); a joint family calendar for planning household-related tasks; and a household health and stress monitoring application to monitor household well-being.

The need that was most compatible with the intended aim was identified by a strong trend best articulated by Hayes (2007): "globally connected yet locally isolated". People have rapidly become globally connected, with numerous social networks providing real-time interactivity with friends and family around the globe, public figures and organisations, and colleagues across continents. At the same time, there has been a trend for increasing "local isolation", exemplified by the fact that more than half of Americans (Smith, 2010) and over 70% of all Swedes living in an apartment (Svenska Postkodlotteriet, 2016) only know a few, if any, of their neighbours well. This local isolation erodes the local social capital (Putnam, 1995) – the very fabric that holds societies together. One way of increasing local social capital is by fostering relationships among neighbours. They often have locally relevant information that is not readily available online and has the potential to be helpful in numerous ways. The chosen context should therefore provide a way that helps neighbours connect, in order to reverse this trend of local isolation.

Having recognised the potential for a digital, neighbour-connecting communication platform containing a social aspect, we decided to explore the idea of using a *social network specifically targeted at neighbourhoods* as a context. To discover neighbourhood needs that would be facilitated by such a social network and to design features that catered for those needs, five neighbourhood-based focus groups were consulted. They are presented in Table 3.

The main needs identified by the focus groups were related to a better way of local communication about various issues of importance and different types of local events. These communication needs were reflected in the design of the proposed social network.

Table 3. Focus groups used to refine neighbourhood needs in Hammarby Sjöstad, Stockholm, during fall of 2015

Focus group	Description	Lead
FG1: Residents	Five residents from the area	Researcher from KTH
FG2: Housing cooperatives	Four board members from local housing cooperatives	Researcher from KTH
FG3: Environment	Five board members (no overlap with FG2) from local housing cooperatives, having an interest in energy and the environment.	Energy manager in one of the housing cooperatives
FG4: Culture & Local Associations	Seven representatives from cultural associations in the area	Manager of the local cultural association
FG5: School	A School IT coordinator and a number of parents.	School IT coordinator

Table 4. Benefits of a communication platform on different urban scales according to identified needs

Urban scale	Benefits	Fulfilled needs identified by the focus groups (from Table 3)
Building/housing cooperative	- Allows for private communication within the cooperative for discussing sensitive matters - Gives the board an easy way to communicate with its members and supplies recent contact details for each member	- FG2: An internal discussion forum for the housing cooperative - FG2: Need for an updated list of members
Neighbourhood/surrounding neighbourhoods	- A channel for communication and for spreading information about local news and events. - A way of citizen empowerment by facilitating discussions about important community matters.	- FG1: Better information about current local events - FG1: Better coverage of local news - FG1: Better and more frequent information from the municipal authority and city hall - FG4: Need for an events calendar - FG5: Need for channel for school pupils to create local content
Interest groups	- Creates bonds between neighbours - Allows local organisations to spread information to the neighbourhood.	- FG4: Channel for local groups/organisations to inform others in the area about events etc.

Based on the outputs from the focus groups and the literature review, we developed the concept of a sustainability-oriented local social network called LocalLife. It is designed to blend the digital neighbourhood with the physical neighbourhood and functions on three urban scales: the building/housing cooperative, the neighbourhood and surrounding neighbourhoods. It caters to everyday needs in a neighbourhood by strengthening neighbour-to-neighbour interactions, in which building- or neighbourhood-level local interest groups can be created, either ad hoc by neighbours or by existing organisations.

The different urban scales and interest groups allow for separate communications; private internal discussions can be held within housing cooperatives and interest groups, while sending a message to the neighbourhood or surrounding neighbourhoods quickly spreads information to a large area. This design has the potential to meet most of the local information- and communication-based needs identified by the focus groups as shown in Table 4. Peer moderation is used as a way to minimise inappropriate content.

2.3.2. LocalLife as a Context for Energy Feedback

Being a social network, LocalLife is by its nature a social context, and it is expected to be frequently used since it caters for neighbourhood needs identified by the authors and in focus group consultations. This means LocalLife should be suitable for energy feedback, according to the literature. By showing feedback as part of this frequently used context, it should have greater chances of being noticed by the residents compared with conventional feedback contexts such as web pages provided by energy utilities, energy apps or in-home energy displays.

Household energy consumption can be compared with that of similar households (descriptive social norm), while also enabling collective comparison and feedback on the housing cooperation and neighbourhood level. This collective feedback is expected to decrease the boomerang effect of already energy-efficient households by making them part of a collective reduction effort. The dynamics of the neighbourhood – with new neighbours joining, others moving away, and some hopefully changing their behaviour – by itself adds a changing element to the feedback. Gamification elements could make it even more appealing, especially to younger residents. The feedback, including any energy-saving tips, can be individually tailored, possibly based on different types of *personas.* According to the literature, feedback based on these design principles has the potential to be effective.

One advantage of having full control over LocalLife is that the feedback design, its placement and its intertwining with other features of the social network can be fully controlled and customised. This would not be possible had the feedback been included as part of an existing social network such as Facebook. For example, this makes it possible to show an energy feature in a space that would commonly be occupied by advertisements. It also enables deeper links to the content of the social network, such as showing encouraging and/or spurring posts about the household's or the neighbours' energy performance in relation to individually set goals; creating periodic energy reports; having energy savings competitions; and including gamification that could give rewards. Such rewards could be badges or some form of virtual currency usable for other future services within the network. A first version of the visual appearance of the energy feedback within LocalLife is described in detail in section 3.2.1.1.

The electricity consumption data for the energy feedback, provided in hourly or monthly resolution, is collected from the local Swedish distribution system operators (DSO's). In order for LocalLife to gain access to household consumption data, each household must give its consent. This process normally requires the user to find their meter ID, sign a printed contract and send it to the DSO – a task that probably only the most environmentally interested users would complete. To increase the chances of getting a larger user base for energy feedback, we have been cooperating with one of the largest DSO's in Sweden, resulting in an easier and fully digital consent process that can be initiated from within LocalLife.

2.3.3. LocalLife as an Enabler of Social Sustainability

LocalLife is designed not only to provide a context for energy feedback and thus increase environmental sustainability, but also to help increase social sustainability when introduced in an area. Local needs are met through offering possibilities for communication and self-organisation of neighbours, thus facilitating everyday tasks such as getting a recommendation on a local dentist, notifying neighbours about a lost wallet, borrowing a tool, initiating a local project and quickly alerting neighbours about local incidents. The increased frequency of communication and physical meetings between neighbours is expected, in turn, to increase aspects of social capital such as the feeling of place identity, social cohesion, safety and trust. The latter is also an important enabler for the sharing economy; as local social capital and a sense of trust increases, eventually neighbours may feel more comfortable participating in sharing economy activities that require a higher degree of trust such as car-sharing or babysitting. As sharing economy activities are usually less resource-intensive than conventional options, in both an economic and environmental sense, it can be concluded that an increase in local social capital also has the potential to increase both environmental and economic sustainability in a neighbourhood.

2.4. HLUC 12 – Virtual Power Plant

Another use case that will benefit from these findings is one directly connected to demand response schemes. A virtual power plant (VPP) offers bids in flexibility markets by aggregating the flexibility from eligible consumers and distributed energy resources and exploit management functions to support their participation in energy and ancillary services (i.e., frequency services for TSO and non-frequency services for DSO). The VPP, comprising distributed generation and loads, will be integrated with AMI, EV charging system, commercial buildings and existing, small scale grid batteries management systems and combined with MV optimization, estimation and forecasting algorithms [REFD4.1]. This solution will be implemented in Ljubljana and Lisbon. The results from this report can support the demand side management programs in these roll-outs.

3. Methodology

3.1. Literature Review

To assess the most promising engagement strategies with residential consumers for energy savings, a literature review was conducted. The review has identified the core parameters or success factors pinpointed by previous studies. For each of these parameters, a summary is offered of previous results to guide decision makers. When possible, the review differentiates between design of feedback and design of device. However, there is a dearth of studies examining the influence of design-related features on energy savings (e.g. whether use of coloured bars vs. black-and-white bars when providing the information influence energy consumption) (Vine et al., 2013). Future studies should thus examine whether design features influence household energy conservation behaviour.

There have been other papers trying to offer a guideline for designers. For instance, Bartram (2015, p. 2) proposed such model so to "develop a framework for this still ill-defined design space, underpinned by three interlinked types of factors: knowledge (cognitive), motivation, and effort (technological overhead)". The design framework proposed organises dimensions into five categories: Data, psychological factors, effort and interaction, context, and communicative scope. These are described as follows:

- *Data dimensions* describe the mental model, physical and social scope of information, and level of detail.
- *Psychological dimensions* describe the communicative intent of the feedback, which cognitive models and motivational strategies it addresses, and the kind of knowledge the feedback supports (analytic, awareness, or operational).
- *Effort* is determined by the attentional requirements, cognitive interpretation, and interactivity expected of the user. For example, does the visualization require active attention and interaction, or does it support at-a-glance, passive awareness?
- *Contextual dimensions* consider how the visualization is situated: where and when the resource is consumed in relation to where the feedback is provided and how tightly bound the data representation is to the delivery context.
- The dimensions of *communicative scope* include aesthetics, appeal and affect, and ecological fit.

Although this paper may be useful to identify the key parameters upon which the designer has to make decisions, the suggestions are not grounded on solid evidence. This is a shortcoming that the present document tries to address.

Papers were selected using Google Scholar and Web of Science (WOS) with the keywords: "eco feedback" OR "feedback AND energy" OR "feedback AND shift load" OR "smart meter" AND "feedback". Only papers published in the year 2000 and onwards were included in the review. Meta-analysis and review papers were privileged in the selection filters. After screening out papers with little bearing on the subject, 35 journal papers and 10 conference papers were selected and analysed. In addition, papers on customer engagement from the marketing discipline (10 papers) and past papers reporting results of similar European-funded projects were also added and included (20 case studies).

Also, to guide the stakeholder consultation guidelines, a toolkit was developed to assist the partners in the process. The purpose of the stakeholder consultation varies depending on at what point in the process it is being carried out. Before implementing the solutions, the stakeholder consultation aims to explore the users' views of the planned intervention, in order to identify potential shortfalls and barriers that may jeopardise the success of the intervention. It also aims at identifying what support different stakeholders must provide to ensure the success of the intervention, as well as informing strategies to align different stakeholders with the desired goals (European Union, 2014). Users are not aware of how energy systems work; providing such information in advance may contribute to device solutions for potential problems (Natural Resources, 2014).

After implementation, the stakeholder consultation aims at evaluating the interventions to ensure replicability. This evaluation focuses on identifying the drivers and barriers for users' engagement and on proposing new avenues of work that can improve consumer engagement, community participation and involvement of stakeholders in the European energy policy targets.

More generally, stakeholder consultation facilitates decision making processes, as those with a stake in the project have a say at the initial stages. This helps identifying potential problems that could jeopardize the feasibility of the project and fosters innovation by obtaining the views of different parties involved. It also facilitates reaching agreements among stakeholders with different goals and preferences. As it creates a sense of ownership, it contributes to enhanced involvement with the interventions. Stakeholder consultations should be understood as a continuous learning process that allow for better design and delivery of sustainable solutions, especially in those interventions or policies that demand active participation and acceptance of citizens.

Bear in mind that the relationship with stakeholders may go from informing stakeholders to co-creation and co-implementation of solutions. Asking the views of stakeholders, commenting on decisions and collaboratively working on solutions lies between consultation and involvement of stakeholders (Community Places, 2014; Natural Resources, 2014).

As aforementioned, a toolkit was created to facilitate the design and implementation of stakeholder consultation in InteGrid project. The design of the consultation involves deciding who should be consulted; about what they should be consulted; how they should be involved; timing and budget consideration. To facilitate these decisions, this report will provide four tools, each covered in the respective section: (1) a stakeholders mapping and identification tool; (2) a suggestion of items for the consultation; (3) a proposal of methods for stakeholders' involvement and (4) information about the budget and time involved. Templates have been created to assist partners to design and implement the consultation processes locally (following Natural Resources 2014).

To prepare this toolkit different sources have been used. First, other guidelines for stakeholder consultation compiled by the European Union, the World Bank or regional authorities such as the Scottish government have been used for inspiration and advice; the websites of the International Association for Public Participation (IAP2) and VOICE have been invaluable. Second, past research reporting stakeholder consultations in energy projects (usually with consumers, DSO's and retailers) (Boork et al., 2014; Gangale et al., 2013; Geelen et al., 2013; Krishnamurti et al., 2012; Paetz et al., 2012; Park et al., 2014). Third, examples of stakeholder consultation of energy companies have been revised.

The proposed design for stakeholder consultation is inspired and intends to honour the pillars for participation outlined by the IAP2. These are:

Public participation…

- is based on the belief that those who are affected by a decision have a right to be involved in the decision-making process.
- includes the promise that the public's contribution will influence the decision.
- promotes sustainable decisions by recognizing and communicating the needs and interests of all participants, including decision makers.
- seeks out and facilitates the involvement of those potentially affected by or interested in a decision.
- seeks input from participants in designing how they participate.
- provides participants with the information they need to participate in a meaningful way.
- communicates to participants how their input affected the decision.

The toolkit identifies three key decisions: stakeholder mapping, content of consultation, and consultation methods. Templates have been created to facilitate information collection and dissemination among partners and to facilitate consultation planning (see Annex 1). Each of the key decisions are explained below.

Decision 1: Stakeholder mapping

The first decision in the process of design and implementation of stakeholder consultation is to determine who should be consulted. Given the heterogeneity of stakeholders, this identification must be accompanied by an assessment of the importance that each of them represents to the project, so that priorities can be set. Representing this identification and assessment in tools, such as figures or maps, facilitates decision making.

These steps correspond to the first three phases of the methodology of Stakeholder Circle®, that has been designed to put stakeholders on the "project management radar", as this method helps to:

- Identify the project's stakeholders and understand their needs
- Prioritize the stakeholders
- Visualize the key stakeholders using the Stakeholder Circle®
- Engage with the stakeholders, by building and implementing an effective communication plan based on the stakeholders' supportiveness and receptiveness
- Monitor changes over time to analyse the effectiveness of the communication plan

The first three phases of this decision, that are appropriate to conduct in the stakeholder identification are explained in the following sections.

Step 1: Identify your project's stakeholders and understand their needs

Before determining appropriate engagement methods and developing communication messages, it is important to first identify key stakeholders. A stakeholder is any individual, group or organisation affected by, or able to affect, a proposed project and its implementation. Those individuals or groups depend on a potential action to fulfil their own goals and on whom, in turn, it depends. Stakeholders can be divided into internal stakeholders (e.g. managers and staff) and external stakeholders. External stakeholders are of four types:

- Economic (e.g. operators, suppliers)
- Social/political (e.g. government agencies, academia)
- Technological (e.g. standards agencies)
- Community (e.g. local residents, non-profit and community-based organisations)

In order to determine stakeholders, a number of tools may be utilized, including brainstorming, mind mapping, generic stakeholder lists, and reviewing previous similar projects with stakeholder identification and consultation.

Siano (2014) proposes a conceptual model for the smart grid that can be useful to understand all the agents implicated in the electric power system. See Figure 2.

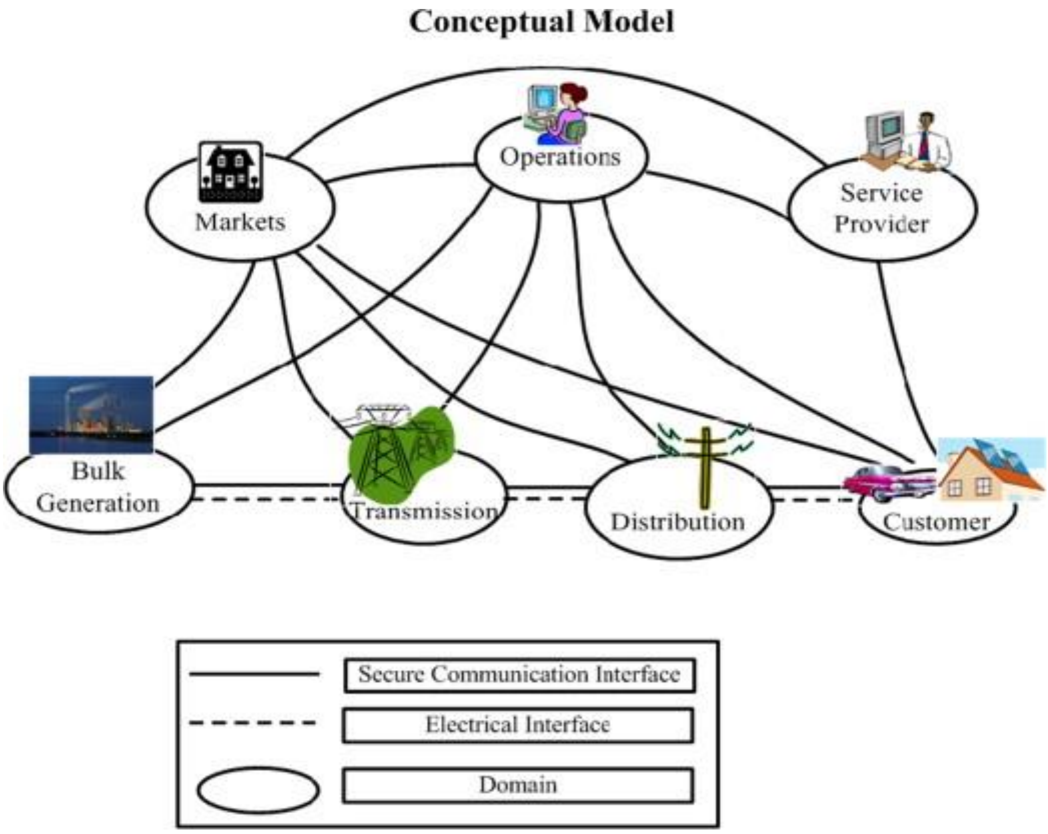


Figure 2. Conceptual Model for Smart Grids. Source: Siano (2014, 464)

Inspired by CIVITAS Initiative (2011), a comprehensive list of potential stakeholders of energy consultation can be found in Table 5.

Table 5. Potential Stakeholders for Energy Consultarion. Source: CIVITAS Initiative (2011).

Government/Authorities	Businesses/Operators	Communities/ Local/Neighborhoods	Others
European Union	Utility companies	Environmental NGOs	Research institutions
Ministry of Energy/Energy Agency	Network operators	Media	Academia, universities
Regional and local government	Storage developers	Authority forums	Experts
Politicians	Developers	Community organisations	Foundations
Regulators	Engineers/contractors	Citizens	
Other decision makers	Retailers	Local interest groups	
Professional staff	Commercial users		

Following Natural Resources (2014) and Grünewald et al. (2012), in the context of energy, the following main external stakeholders could be identified:

1. Developers: This category encompasses all professionals involved in designing and constructing new buildings (real estate developers, commercial developers, home builders, and architects/engineers).
2. Residential users: For detached housing, the individual homeowner will be both the decision maker and end user of energy. In the case of multi-unit dwellings, the original developer or strata council will likely make the final decision on the energy system. However, occupants of each unit may influence the decision maker. For new real estate projects, developers are the segment to engage with.
3. Commercial users: Similar to the preceding market, commercial developers usually decide whether to accept an energy system but tenants within the office buildings or retail spaces may persuade them to adopt a certain course of action. Industrial parks and stand-alone corporate buildings have strong influence in the uptake of energy in certain areas and could be approached to be anchor players in energy engagement projects.
4. Institutional/Government: This dimension incorporates municipal, provincial and federal facilities.
5. Utility companies, network operators and storage developers.
6. Engineering and environmental consulting firms.
7. Equipment manufacturers.
8. Academia.
9. Non-profit and community-based organizations: NGO's that are interested in sustainability, clean energy and environmental health typically have a stake in energy projects.

Step 2: Prioritise the stakeholders

Stakeholder mapping identifies stakeholder power and attention in order to understand political priorities. In a scenario of scarce resources for attention, communication and negotiation with all groups affected by a potential action, this prioritization is essential for the allocation of time and efforts between groups. The degree of mobilization of each stakeholder, as well as their ability to influence, are not independent from the set of actions or issues to be discussed that are being considered in each situation, so each course of action or consultation point will require different maps.

There are different models and frameworks that may help to categorise stakeholders. Despite the differences between them, they also have some common characteristics. They all try to guide the reflection based on the interest of each group in the action that is being evaluated and its ability to influence, both in the definition of the action and in its implementation. These models also allow us to build an influence-interest matrix that categorises stakeholders according to their stake in the consultation point, as well as their influence. The most important thing is to involve as many stakeholders as possible who can be considered key players (with high degree of influence and a high stake), while stakeholders with a low level of influence and a low stake requires minimal effort.

In this toolkit, the methodology of Newcombe (2003) for the design of the power/attention matrix is adopted. The matrix classifies stakeholders in relation to the power they hold and the extent to which they are likely to attend actively to a particular issue.

For this purpose, power is the ability of individuals or groups to persuade, induce or force others into following certain courses of action. Different sources of power must be considered:

- Hierarchy (formal power), e.g. autocratic decision-making, regulation
- Influence (informal power), e.g. charisma, leadership
- Control of strategic resources, e.g. materials, money
- Possession of knowledge or skills, e.g. partners, specialists
- Involvement in action implementation

Stakeholders also vary in the attention they pay to a particular issue. Even powerful stakeholders may not attend closely to everything. Three factors are particularly important:

- Criticality – how much does it matter to the stakeholder? The extent to which the particular expectations of a stakeholder may be affected (positively or negatively) by a particular action, determines its level of interest. Stakeholders can express their interest in a topic through different mechanisms. An explicit communication indicating its agreement or disagreement with certain actions, a call to mobilise for or against a plan, or a clear acknowledgment of personal priorities and the importance of these (whatever the chosen action), enable testing the degree of interest of a stakeholder.

- Channels – are the communication channels good? If the appropriate communication channels are not established, the apparent lack of mobilisation of a stakeholder, in the face of a potential action, may respond more to their lack of knowledge about it than to their indifference. This leads to a risk of conflict at a later point in the process, when certain proposals that could have avoided it are no longer feasible.

- Cognitive capacity – there may be too much information to process effectively.

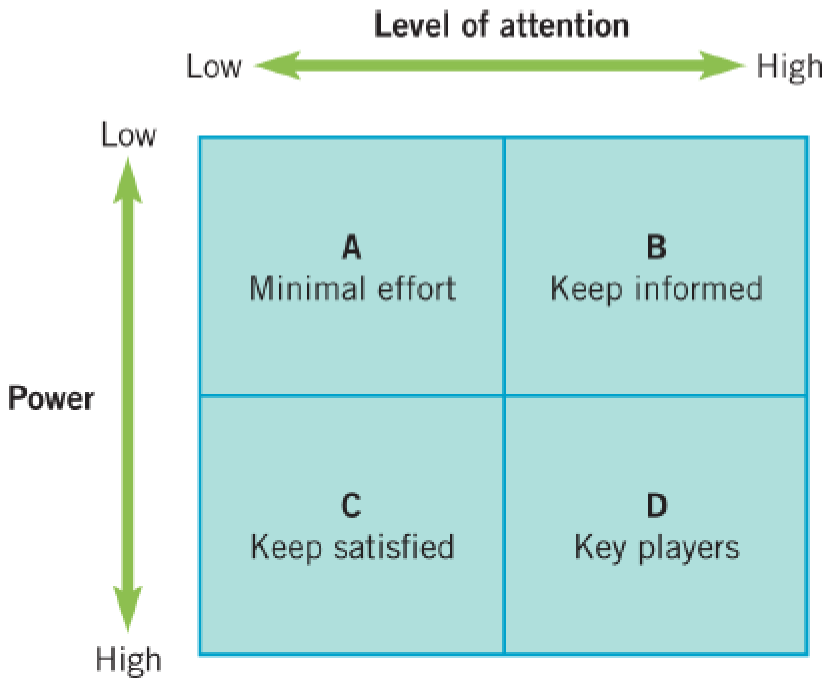


Figure 3. Stakeholder mapping: the power/attention matrix. Adapted from Newcombe (2003).

Figure 3 depicts the power-attention matrix, which visualises a categorisation of stakeholders according to their respective power and level of attention. Depending on the category, this model proposes different avenues to deal with these stakeholders. Stakeholders with little interest in energy activities and little power to influence in strategies, policy or business models (Zone A) will require minimal effort on the consultation process. Those stakeholders in Zone B with a high level of interest in the energy activities but little power to influence them will need to be kept fully informed of the potential actions, so good communication with this type of stakeholder is essential. Stakeholders in the remaining two zones C and D represent different but equally important problems. Clearly the acceptability of decisions to the key players in Zone D is a major consideration when formulating a strategy, a policy or an action, but often it is the stakeholders in Zone C that are the most difficult to manage. Their level of interest in the actions will remain low as long as they feel satisfied with the policies adopted. However, if they become dissatisfied, they can easily increase their interest and, because of their powerful position, move to Zone D, thus becoming key players.

The role of stakeholders in Zones A and B needs monitoring and controlling because, although lacking power (at least formally), they may have disproportionate influence on the more powerful stakeholders. Stakeholders as media, users through social networks or representatives of the community can perform this kind of indirect influence.

Step 3: Visualize the key stakeholders using the Stakeholder Circle®

A ranked list of all the stakeholders would provide a starting point for developing a communication plan. The Stakeholder Circle® allows to map the top 15 stakeholders into a symbolic circular stakeholder community, using colour codes, size and placement in the diagram to depict their relative importance. It shows the relative influence of each stakeholder and offers a visual tool to facilitate decisions about the amount of effort the project team will allocate when managing the relationship with any given stakeholder. An example of a stakeholder circle is found in Figure 4.

The overall size (or area) of a stakeholder's segment gives an indication of the overall influence of that stakeholder on the project. The power of a stakeholder is represented by the radial depth of the segment. The importance and degree of influence of the stakeholder is represented by the relative size of the segment measured on the outer circumference. Power and proximity values interact on the same dimension.

Colour coding is essential to interpreting the nature and structure of the stakeholder community: senior managers (upwards) are coded orange; external stakeholders (outwards), blue; the project team (downwards), green; the project manager's peers, purple. The relationships are summarised by showing each stakeholder's priority number, direction of influence and the nature of their relationship with the project (Bourne, 2006).

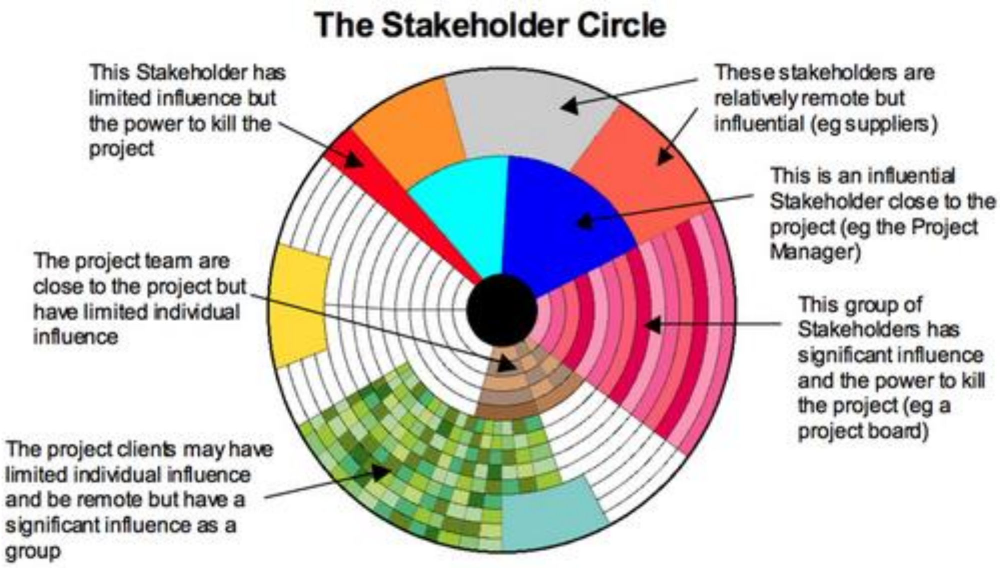


Figure 4. The Stakeholder Circle for stakeholder visualization. Source: https://stakeholder-management.com/.

Categorisation and charting of key stakeholders holds the key to targeting the right stakeholders at the right time in the life of the project and providing them with the right level of engagement, information and communication.

Decision 2: Consultation content

The second decision of the design involves defining the items stakeholders will be consulted about. To design this stage, reflection about the role of each stakeholder in the process of adoption and implementation of the desired change is the first task. On the basis of this reflection, items to consult about can be proposed for each stakeholder.

A review of the literature on stakeholder consultation in previous energy projects suggests the items listed in Table 6 as potential elements to be included in the consultation. No paper has been found that reports consultation of DSO's, energy firms, or governmental and non-governmental organisations.

Table 6. Synthesis of the literature review on stakeholder consultation in energy projects.

Stakeholder	Items	Literature
Residential users	• consumer reactions to smart grids: reactions to dynamic pricing and incentives and to real time information about energy prices or energy sources, changes in energy management (automation), mobility. • disposition to co-provision (producing own energy and trading surplus with neighbour households) • foreseen benefits of smart grids, smart meters and IHD • trust in the system and the players • understand the drivers and barriers for consumers' engagement in the four aspects of co-provision • characterise consumers with positive, negative and ambivalent dispositions towards smart grids to ultimately facilitate segmentation and customization • beliefs about smart meters, IHD and their functions • beliefs about the potential negative impacts of smart meters and device ("big brother" effects, concerns about privacy, health effects, etc.) • beliefs and experiences about what approaches contribute to develop smart energy communities • are consumers supported in their smart energy management by the involvement of other stakeholders? if so, who?	Boork et al. (2014) Gangale et al (2013) Geelen et al (2013) Krishnamurti et al. (2013) Park et al. (2014) Paetz et al. (2012)
SME's	• reactions to smart grids: reactions to dynamic pricing and incentives and to real time information about energy prices or energy sources, changes in energy management (automation), mobility. • disposition to co-provision • foreseen benefits of smart grids, smart meters and IHD • trust in the system and the players • understand the drivers and barriers for engagement in the four aspects of co-provision • what type of products could help SMEs in saving or co-producing energy • what pricing schemes are preferred by SMEs • what drivers and barriers SMEs face • how they implement changes ad intra • SMEs are supported in their smart energy management by the involvement of other stakeholders? who?	Boork et al. (2014) Gangale et al (2013) Park et al. (2014)
Operators	• Advantages and disadvantages in terms of operation, value provided, costs, and profits. • Environmental and social externalities	Grünewald et al. (2012)

Decision 3: Consultation Methods

There are different methods that can be used to involve stakeholders in the planning or evaluation process (Community Places 2014; Natural Resources 2014). Here four of these methods are described:

- Surveys
- In-depth interviews
- Workshops
- Web-based engagement

Surveys are widely used in stakeholder consultations as they allow collecting homogeneous data from large samples in short time. In particular *online surveys* are easy to distribute and very affordable, although they usually attain low responses rates and are inadequate to reach the digital illiterate. Bear in mind that if you need a sample of 200 you will have to contact a population of 2000 to obtain the sample, as responses rates are as low as 10%. Online surveys can be supplemented with pen-and-pencil questionnaires to reach other segments of population.

In-depth interviews are adequate for establishing a real dialogue with stakeholders, eliciting their opinions about the intervention. Also, they may avoid the problem of the desirability bias that may arise in workshops: as informants feel more anonymity and privacy they speak more freely about certain matters than in focus groups. *Focus groups* are similar but a group of 8-10 people is invited to discuss together an issue.

Workshops are usually carried out in groups of 6-10 people. Workshops can be done for each type of stakeholder or alternatively, a single workshop with representatives of different stakeholders can be held.

In *web based engagement* participants are prompted with questions, vignettes or photos to initiate a discussion using dedicated blogs, forums, websites, or social media pages. This technique is especially suitable for consultation of geographically scattered stakeholders that cannot be gathered in focus groups or workshops.

Other techniques that can be used to energise and stimulate discussion and innovation in the context of workshops are listed here (Community Places 2014):

- Photography: Disposable cameras can be given to selected stakeholders so that they may capture their likes and dislikes in an area. The results can be exhibited to generate further discussion or to promote additional events.

- Image elicitation: Participants are asked to choose images that reflect the main drivers and barriers with the project or that capture their overall evaluation. Images are then posted in a college to stimulate collective discussion.

- Vox Pox: Short, interviews with representatives of stakeholders at different times. Like photographs the results can be shown to other participants and used to prompt discussion.

- Maps and photographs of neighbourhood or houses: Can be used to illustrate how people can manage energy in their area; what they like or dislike, or improvements they would like to see in order to save more energy. Ideas are generated in small group discussions and recorded on post-it notes or pre-prepared cards. Collage building with these post-its helps explore key issues, build consensus and identify potential solutions and problems.

3.2. Stakeholder Consultation Design

To integrate stakeholder consultation within InteGrid two different consultation methods were used: (1) stakeholder consultation workshops and (2) a survey.

The aims of the stakeholder consultation workshops were two-folded, addressing different stakeholder groups. Workshops in Sweden and Portugal aimed at co-creating design with users. These workshops covered two different topics: (I) development of energy feedback and (II) stakeholders’ preferences for energy storage business models. While these workshops addressed residential users, the workshop in Slovenia focused on employees’ energy behaviour and the identification of action points through occupant participation. More detailed information on workshop objectives and methods used to obtain the objectives are presented in the following section of this report.

The survey was part of LocalLife and aimed at (a) understanding the status quo of residents’ energy behaviour; (b) the status quo of social sustainability in the neighbourhood and (c) the influencing factors for energy behaviour and behaviour change, with specific regard to the influence of social factors to examine the connection between ecological and social sustainability. Findings from the results will be used for improving the design of LocalLife, e.g. to analyse if individual versus group level feedback can be assumed to achieve better results. A telephone survey was used for this. Telephone surveys combine some of the advantages of the above mentioned online surveys and interviews: with standardised questions and conducted via telephone they are more economic than in-depth personal interviews and can therefore create bigger sample sizes. At the same time, the more personal approach increases the response rates compared to online surveys. The methodology of the survey is described in detail in 3.2.2.

3.2.1. Stakeholder Consultation Workshops (SCW)

3.2.1.1. SCW on Energy Feedback

In this consultation workshop, a visual prototype of an energy feedback functionality as part of the social network application LocalLife was tested in focus groups, with people who are representative of the target users. The workshop was designed to examine participants’ understanding of feedback about their household energy use and how this feedback can motivate them to change their behaviour, towards achieving energy conservation and load-shifting.

Objectives

The general objective of the workshop was

- To assess how residents understand, relate to and are motivated by feedback on household energy use and local community social sustainability, when it is given to them as part of a social network with different aggregation levels.

The theoretical assumption behind this is that feedback on household electricity consumption provided in a frequently used context and containing social elements is more effective than the energy feedback provided by energy companies in a traditional way.

More specifically, the workshop aimed to answer the following questions:

- How should the feedback of household electricity use in the social network application be designed in a way that makes it comprehensible, motivating and engaging?
- What social aggregation level is most relevant and/or motivating?

The considered aggregation levels are apartment level, housing cooperation or building level, and neighbourhood level.

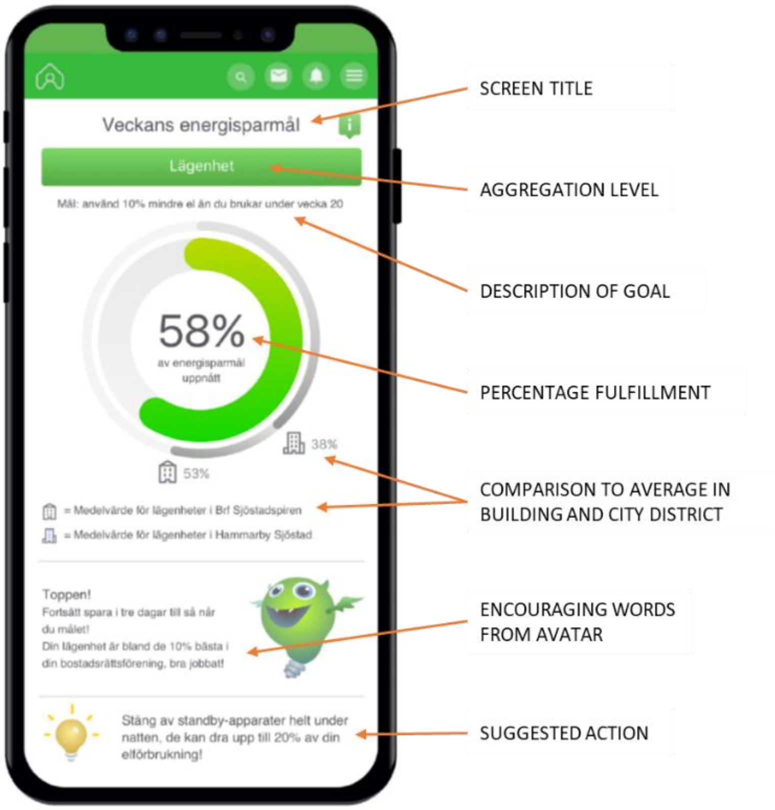


Figure 5. Example of feedback screen used in the energy feedback consultation workshop.

Design

The workshop was set up as a stepwise information process with moderated group discussions centered around different aspects of the energy feedback. An example of one of the prototype screens used in the workshop is found in Figure 5Figure 5. Example of feedback screen used in the energy feedback consultation workshop.. The first step revealed the participants’ immediate reactions and spontaneous understanding of the information on the feedback screen, as they are asked to interpret it without any prior explanation. Then followed an explanation of the various features on the screen and the discussion about the design continued. The participants were asked to share their impressions and thoughts on the following aspects of the energy feedback screens:

- Spontaneous interpretation and understanding

- Influence of explanation on understanding
- Relevance of the information in helping to achieve goals
- Relevance of motivational features in helping to achieve goals
- Clarifications and other suggested changes

There were four focus groups of which half discussed a prototype with feedback given on an apartment level, i.e. *individual* household feedback, while the other two discussed feedback given on a building and neighbourhood level, i.e. *collective* feedback. By comparing the outcome of the different group discussions, the workshop also provided insights on:

- Significance of aggregation level

Participants of the workshop were divided into groups of 4-6 people and the discussions were moderated by a member of the KTH team. The group discussions were recorded by voice recorder for later analysis.

3.2.1.2. SCW on Energy Storage

Objectives

The aim of this workshop was to engage consumers at an early stage of the development of energy storage projects in order to understand their preferences on different business models (Burlinson & Giulietti 2017). Consumers' perceptions and related actions will be crucial for the question which business models for energy storage will prevail in the long run; as Burlinson & Giulietti (2017) in their presentation on business models conclude: "it is essential to identify the target customers in energy storage business models (e.g generators, network operators, households etc.) and evaluate whether the business model can deliver something that is valued by such customers (e.g. flexibility, aggregation, affordability).

The workshop focused on household consumers and their role with respect to innovative concepts of energy storage in apartment buildings. A key issue in this regard is the different roles assigned to consumers in the business models – ranging from the (currently) mostly passive user of energy to an active prosumer role, engaging in energy production, consumption and distribution. Previous studies indicate that consumers' attitudes towards energy storage models seem to be overall positive (Romanach at al. 2013), and recent findings from research projects on energy storage in the UK indicate overall acceptance of the new technologies. The willingness to share energy storage facilities might be related to an overall willingness to share. Findings on the motivations behind the attitudes suggest that these might differ between countries, e.g. based on different attitudes towards sharing concepts in more general terms, which in turn are supposedly related to different level of individualism versus collectivism (Hofstede 2001). To examine cross-country differences the workshop was conducted both in Sweden and Portugal, with Sweden representing rather high levels of individualism compared to Portugal (Index Sweden: 71; Index Portugal: 27).

A key challenge on early consumer engagement is that consumers show low levels of awareness of the new technologies (Achterberg et al. 2010; Zachariah-Wolff & Hemmes, 2006). This results in difficulties to derive meaningful responses with regard to consumers' perceptions, e.g. the problem of "pseudo opinions" and "non-attitudes" (de Best-Waldhober et al., 2009). As mentioned in the guidelines on consumer engagement from the IAP2 presented earlier in this report, a precondition is therefore that "public participation provides participants with the information they need to participate in a meaningful way". To achieve this goal, we used storytelling for the presentation of the technology. Storytelling was recently discussed as an innovative methodology approach in energy research (Moezzi et al. 2017). Previous approaches focus first on existing stories and narratives as a form of data, and secondly on storytelling as a process to facilitate stakeholder engagement[1]. Our approach instead combines the previously separated two approaches; storytelling as a process to improve participation, but also as a method of simultaneous data collection, to gain a deeper understanding of consumers’ perception of new energy storage technologies. A detailed description of the workshop methodology is given below.

Design

The workshop consisted of “three acts”. The main storyline used was to ask participants to imagine that they had just recently bought a new apartment – still under construction – which uses innovative energy solutions and that their input is needed on their preferences during the construction phase.

In Part 1 of the workshop they were asked to individually specify their preferences for the energy storage in their new apartment buildings. To facilitate this task, a morphological table (Pereverza et al., 2017) was used with five criteria and these criteria were presented one at a time, including two options for each criterion that participants could choose between. The following five criteria were included:

(1) Place of battery: common battery in cellar vs. individual battery in apartment;
(2) Financing of battery: buy vs. rent;
(3) Management of battery: local energy supplier vs. self-management;
(4) Electric vehicles: bi-directional charging vs. no inclusion of EVs in the storage system;
(5) Sharing: sharing energy vs. use of individual production/storage.

A short overview on advantages and disadvantages of the two options were given to provide participants with relevant information while trying to keep the information balanced. The overview is found in Table 7.

Table 7. Advantages and disadvantages of options presented to the participants in the energy storage consultation workshop.

Criteria	Specifications	
(1) Place of battery: common battery in cellar vs. individual battery in apartment	***Common battery*** + financial risks are lower; takes up no place in flat - less control over purchase and installation	***Own battery*** + greater control - takes place in apartment; (low) potential health risk; access to apartment needed for maintenance
(2) Financing of battery: buy vs. rent	***Renting*** + no initial investment - higher costs in the long run	***Buying*** + cheaper in the long-run - major investment at the beginning; pay back isn’t sure

[1] See e.g. https://www.smartgrid-engagement-toolkit.eu/fileadmin/s3ctoolkit/user/guidelines/TOOL_MONITORING_AND_EVALUATION_THROUGH_STORIES_-_MOST_SIGNIFICANT_CHANGE.pdf

(3) Management of battery: local energy supplier vs. self-management	***Local energy company*** + no time investment - no control over use of energy; distribution might not be optimized for your own needs	***Self-management via App*** + save energy based on own needs; earn money when selling energy - need to invest tie; functions could be complex
(4) Electric vehicles: bi-directional charging vs. no inclusion of EV's in the storage system	***Bi-directional charging*** + lower costs; increased capacity - cars might be discharged when needed; transportation system might change and less cars are needed for transport	***No EV's included*** + cars will also be charged - higher costs because more batteries in the house are needed
***(5)* Sharing:**[2] sharing energy vs. use of individual production/storage	***Sharing*** + more flexibility as stored electricity will be available to everyone - first come, first served: energy might be used up	***Individual use*** + fair use - total costs increase because not all energy is used

After all criteria were presented, participants were given another few minutes to reflect on their choices and changes answers now that they knew all options.

Part 2 of the workshop was a focus group discussion regarding criteria choices. To facilitate discussions, participants were first asked to "move into" one of two houses with the two houses representing opposite combinations of the five criteria.

House 1 represented a *Prosumer-Sharing* solution including

(1) a common battery,
(2) renting the battery,
(3) self-management,
(4) EVs not included and
(5) sharing of energy

House 2 represented a *Comfort-Independence* option, including

(1) an own battery in each apartment,
(2) buying the battery,
(3) local energy company managing the system,
(4) EV's as a part of the system and

[2] In Sweden many participants interpreted the sharing also with relation to costs: They assumed that a shared concept would include a flat rate for energy use.

(5) no sharing

Secondly, for each option two groups were formed and participants were asked to discuss their choices on given questions, including an elaboration on which aspects were important for them and for which criteria they would be willing to compromise. Focus group discussions lasted for ten minutes.

Part 3 of the workshop focused on storytelling as a method to gain data. Participants were asked to imagine that one month after moving into their apartment and lifestyle magazine wants to publish an article about their life with the new energy solutions. To facilitate the writing process, participants were asked to interview another participant based on a given list of questions, then fill in a newspaper article with partly prepared text, either as a resident or as an interviewer. This facilitation allowed producing stories in rather short time, with the exercise taking 10-15 minutes.

Place and participants

One workshop was held on the 14th of May 2018 in the city district Hammarby Sjöstad in Stockholm, Sweden. One of the main reasons to hold the workshop in this particular city district was that there are plans to install energy storage systems, including bi-directional charging with electric vehicles, in newly build apartments. 18 (potential) consumers participated in the workshop. Half of them were residents of Hammarby Sjöstad. The other half came from other city districts in Stockholm. 8 of the participants were female and 10 were male. The age of the initially 22 registered participants (of which 18 attended, but age data was only gathered at registration) spanned a broad range, which is depicted below in Figure 6.

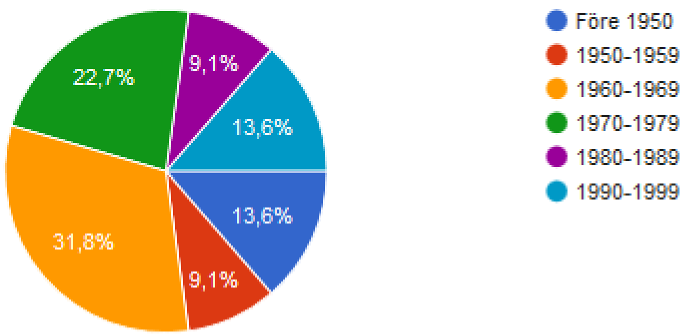


Figure 6. Age distribution of registered participants in the energy storage consultation workshop

A replication of the energy storage workshop also took place in Caldas de Rainha on June 4th 2018 with 46 participants.

3.2.1.3. SCW on Employees' Energy Behaviour

Objectives

The workshop was developed around a number of objectives. The different activities in the workshop were all aimed at contributing to one or more of these.

The workshop objectives were to:

- Inform and educate the occupants on building energy
- Gather information on occupant behaviour and attitudes

- Identify action points through occupant participation
- Build approval and motivation for the program among occupants

The design of the workshop is freely based on user/employee awareness advice found in the publication *Creating an awareness campaign*[3].

Design

Informing and educating the occupants creates a common knowledge and understanding of the building energy situation. This is beneficial for the participative parts of the workshop as it puts all participants on an equal knowledge level, contributing to equal influence in the discussions. The theoretical background of the test case and the occupant behaviour program shows the occupants *why* they are asked to contribute and hence supports acceptance and motivation. To fulfil this objective the workshop began with an introduction of the InteGrid project and the theoretical background of grid flexibility and occupant behaviour demand response. The specific energy profiles of the Elektro Ljublijana office buildings were shared and the influence of the respective plug-loads were explained.

The next objective of the workshop was to gather information about the occupants' working hours, the existing plug-loads in the building and the occupants' interactions with them. This information is important input in the development of the action plan, since it provides a list of appliances, flexibility time frames and the starting point occupant behaviours. Asking questions forces occupants to reflect on their plug-load interactions and creates awareness. In this part of the workshop, participants were asked to list the plug-loads in their office and to report how and when they interact with them. The occupants were also asked to report their typical office hours, including breaks. This was done individually aided by a written survey during the workshop.

The most central purpose of the workshop was to facilitate a participative, bottom-up process for developing the building occupant behaviour program. Involving the occupants in the creation of the program and taking their opinions and concerns into consideration early on is a way of building acceptance and motivation. It also raises the quality of the program and gives it a better chance of succeeding since the suggested actions can be refined to better align with the reality of the occupants. In the workshop, the occupants were divided into smaller groups and tasked with setting up action points for building flexibility and conservation. The suggested actions were then discussed, with all participants, in terms of ease of implementation and how they would affect the occupants' work environment. The occupants were also asked to give their advice on the timing, responsibilities and any practical requirements needed to follow the program.

The objective of building approval of the program permeated each stage of the workshop. The leader of the workshop was advised to listen and take note of all suggestions and concerns that are raised by the occupants. It was also discussed what the occupants might need in terms of motivational reminders and awards that could contribute to a successful implementation of the occupant behaviour program.

[3] The Carbon Trust, *Creating an Awareness Campaign*, [PDF guide], 2013, https://www.carbontrust.com/home/

3.2.2. Survey Design

To measure environmental awareness and selected aspects of social sustainability, questionnaires were used. This questionnaire, carried out at the time of the introduction of our proposed social network LocalLife in a neighbourhood, provides the baseline against which changes can be traced with the aid of follow-up questionnaires.

3.2.2.1. Method Sweden

A Swedish version of the baseline questionnaire (see Annex II) was conducted in Stockholm Royal Seaport (SRS), one of LocalLife’s pilot neighbourhoods, during April and May 2018. The data collection was done using phone interviews by the marketing research company Novus. Novus conducted 300 phone interviews with SRS residents who were randomly chosen from the overall population. 33 participants were existing LocalLife users since around 1-3 months back. However, as LocalLife hasn’t yet gone beyond registration and first information we did not expect to find an influence of LocalLife on the social sustainability parameters but rather consider this as a baseline measurement The energy attitudes are assumed to be unchanged since no energy feedback existed in LocalLife at that point of time. The participants were informed that the survey was conducted by the Royal Institute of Technology (Kungliga Tekniska Högskolan, KTH) to gain understanding of the social context in their neighbourhood, to prepare for energy technology interventions.

The survey contained several sub-groups of questions dedicated to the different constructs measured. To align the structure of this method section with the results section below, the following scales are described in a slightly different order, by construct rather than timeline.

At the beginning of the survey, three questions assessed the participants’ living situation: What kind of household they live in (apartment, row house, separate house, student room or other), the ownership the building they live in (housing cooperation, rented, self-owned, other) and their personal ownership of the apartment/house they live in (own, rent, rent second/third hand, lodger, other). The answers to these questions were used by the interviewer in all following questions to replace generic terms such as “your building”/”your neighborhood” with the actual names of the individual participants building and neighborhood to make the questions more relatable and relevant for the participants.

The constructs measured as influencing factors of energy saving behaviour were based on the Theory of Planned Behaviour (Ajzen, 1991; Fishbein & Ajzen, 2010). The scales to measure the additional constructs relating to social identity theory were based on those used by Fielding and Colleagues (2008), who studied the influence of TPB variables and social identity on sustainable agricultural practices. Items were adapted for the context of energy saving behaviour. This was to extend comparability of our results with previous work on the connection between social identity and sustainable behaviour.

The general attitude towards saving energy in one’s household was therefore measured using six semantic differentials. Participants rated each of the statements “*I feel that saving energy at my household is good (…is wise/beneficial/pleasant/satisfying/favourable)*” on a seven-point scale (e.g. from 1= *extremely bad* to 7 = *extremely good*).

To measure perceived behavioural control, one of the central influencing factors in the Theory of Planned Behaviour, we asked how much control participants have over saving energy at their household (1= *very little* to 7 = *a great deal*), if saving energy is easy for them (1 = *very difficult* / 7 = *very easy*) and to rate their knowledge about possible ways to save energy (1 = *very low* / 7 = *very high*). We only used three of the five items from Fielding et al. (2008) for this construct, to limit the overall length of the survey. For past behaviour, participants indicated how much effort and how much time and labour, respectively, they have been putting into saving energy (both 1 = *none at all* to 7 = *a lot*).

Behaviour at the present time and behavioural intention were each measured with one item each, asking to what extent participants were saving energy at the time of the survey and to what extent they planned to do so in the next six month, both on a scale from 1 = *not at all*, to 7 = *a lot*. To gain a more detailed understanding of the status quo of energy saving behaviour, we also added some further questions to measure specific energy saving behaviours. These were taken from the 2016 version of a yearly citizen survey "Du och din miljö" (*You and your environment*) conducted by Stockholm Municipality (obtained by personal correspondence). Items unrelated to apartments were removed. The original binary scale (*yes/no*) was replaced with a categorical (*often/sometimes/never*) to provide more nuance to the responses. Items inquired about participants' purchase of environmentally certified electricity, actions done in the past to save energy for their household (first spontaneous and then aided) (see the results section for the full list) and actions already mentioned spontaneously were skipped.

The survey also contained a question to assess the willingness of the participants for load shifting. As this concept might not be familiar for all participants, we used a form of vignette: Participants were asked to assume that they own a washing machine and usually wash clothes during the afternoon when the electricity consumption is high in the area they live in. The interviewer then asked if they would instead wash their clothes during the night if they knew that a) it would save money due to cheaper electricity prices and b) it would be good for the environment due to less polluting electricity production. Answers were given on a scale from 1 = *extremely unlikely* to 7 = *extremely likely*.

As one potential influencing factor for energy saving behaviours, we assessed different forms of social influence: both the influence exerted by the broader group of important others and also of relevant reference groups (e.g. Terry & Hogg, 1996; Terry et al., 1999). In the context of this study, the inhabitants of a participants building were seen as a relevant reference pool for energy saving behaviour. We also included the broader group of inhabitants of their neighbourhood, in case a lot of participants lived alone in their building and therefore did not have a reference group on the building level. Hence, social influence was measured for each of this groups separately. For the subjective social norms with regard to important others, participants were asked if people important to them would approve of them saving energy, would think saving energy would be desirable, and would think that they should save energy. To measure the perceived group norms of people living in their building, the interviewer asked how many people in the participants' building would think that saving energy was a good thing, how likely it was that the other people in the building saved energy, and how much agreement there is among the inhabitants of the building that saving energy is a good thing. The items for the perceived group norms of the neighbourhood were identical, with the name of the neighbourhood replacing the name of the building. All answers were given on seven-point Likert scales (e.g. from 1 = *disapprove* to 7 = *approve* or from 1 = *very few* to 7 = *most*). Again, these items were adapted from Fielding et al. (2008) for our context but shortened to three instead of five items per group.

Next, group identification with both the building and the neighbourhood participants lived in were assessed with four items each. This scale was a shortened adaptation of Hogg and Hains' (1996) group relations questionnaire, also used by Fielding et al. (2008). Participants rated how important the people in their building/neighbourhood are to them (from 1 = *not important at all* to 7 = *very important*), how much they identify with them (1 = *not at all* / 7 = *very much*), how strong the ties to them are (1 = *very weak ties* / 7 = *very strong ties*) and to what extent they see themselves as belonging to the people of their building/neighbourhood (1 = *not all at* / 7 = *very much*).

As the concept of the neighbourhood as a social network is central to LocalLife, and in order to assess the status quo of social sustainability, we included several items and scales to measure constructs related to this more in detail. These were adaptations from a survey conducted by Eriksson (2010; based on several other instruments, see e.g. Onyx and Bullen, 2001; Narayan and Cassidy, 2001) on building environment and health. First, we included a scale of six items the perceived trust and safety participants experience in their building and neighbourhood (Eriksson, 2010). The interviewer asked if the participant felt they can trust people in general, in their building and in their neighbourhood, respectively, and if they feel safe in their building and in their neighbourhood (all answers on a scale from 1 = *not all at* to 7 = *yes, completely*). These questions were rephrased to fit the context of our study and the answering format changed to a seven-point scale to make it more consistent with previous scales of our survey and thus easier to understand for the participants.

To measure the social bonds that participants experience in their neighbourhood, they were asked how common it is for neighbours at the place the participant lives to talk to each other when they meet (1 = *not common all at* / 7 = *very common*). Like the items above, this was an adaption from Eriksson (2010) where we changed the answering format to a seven-point scale. We also added two scales and two single item measurements from the same survey to further assess this construct. The first scale contained five statements describing the social bonds in the participants living area, e.g. "*Where I live, you take responsibility for each other's children*", which were rated on a three-point scale (1 = *too much* / 2 = *moderate* / 3 = *too little*). The second scale assessed the social network of the participants by asking if they have a good social relationship with their family, relatives, friends, neighbours and peers, respectively (with a *yes/no/not applicable* scale). Finally, participants were asked how many of their neighbours they thought know where they live (in categories from 1 = *none* to 6 = *more than 15*) and how often they hang out with any of their neighbours (from 1 = *daily/almost daily* to 5 = *never*).

Another construct regarding the social aspects of the participants neighbourhood that we measured was the place attachment participants felt regarding their neighbourhood. Place attachment is defined as "the bond between people and places" by Kudryavtsevet al. (2012, p. 2). We adapted a scale from the same authors which originally measured place attachment to the Bronx, by inserting the name of our participants neighbourhood in the eight items of the scale. Three of these Items were reversed, e.g. "*there are better places to be than my neighbourhood*"; all items were rated on a scale from 1 = *I completely disagree* to 7 = *I completely agree*. As with previous items, we changed the answering options from a five- to a seven-point-scale for consistency reasons.

As a final construct regarding the social sustainability of our participants neighbourhood, we measured to what extent they participated in a sharing economy. To this end, we adapted a scale from the previously mentioned "Du och din miljö" survey from its original "*yes/no*" scale to a version where participants were asked if they had "*borrowed from their neighbours / lent to their neighbours / used a pool to share with* *their neighbours*" a number of different items (clothes, toys, tools, home appliances, computer/tablet/mobiles, tv/video/dvd/stereos, bicycles, cars/other motor vehicles).

At the end of the survey, participants were asked some demographic questions regarding year of birth, age, education and occupation, and country of birth. This section also included some questions about the household the participants lived in, such as the number and age of people living in the same household, the size of their apartment or house and if they felt they could live comfortably on their current household income. These were mainly adapted from Eriksson's (2010) study as well. Finally, participants were given some information about LocalLife and directed to the projects homepage if they expressed interest to learn more about it.

3.2.2.2. Method Portugal

A shortened version of the questionnaire used in Sweden was conducted in Caldas da Rainha from 19th March until 30st March, 2018. The data collection was done via intercept interviews by a team from EDP Distribuição. All in all, 65 interviews were conducted. Each interview took about 15 to 20 minutes.

The questionnaire was a shortened and translated version of the Swedish survey described above. Most of the answering formats were altered to a ten-point scale to attune them to the cultural frame of evaluation widely used in Portugal; some were adapted to better fit the circumstances in Portugal, for example regarding the most common living arrangements. The goal of these changes was to test a more user-friendly version of the questionnaire in terms of length and complexity. Again, the following measurements are described by construct rather than the exact timeline of the interview.

First, participants were asked where they live (house, semi-detached house, apartment) and whether they own or rent that space. The general attitude towards saving energy in one's household was measured with one item, asking "*Do you feel that saving energy at your household is….*" (from 1 = *very bad* to 10 = *very good*). To measure behavioral control, we asked how much control participants felt they have over saving energy at their household (1= *very little* to 10 = *a great deal*).

Current energy saving behavior was measured by two items asking if the participants currently save energy at their household (1 = *very little* to 10 = *too much*) and how much effort they put into doing so (1= *very little* to 10 = *a great deal*). Behavioral intention was measured by asking participants if they plan to save energy in their household in the next 6 months (1 = *I completely agree* to 10 = *I completely disagree*). Load shifting was assessed using the same example and two questions as in the Swedish survey on a scale from 1 = *extremely unlikely* to 10 = *extremely likely*.

To gain a more detailed understanding of the energy saving behavior of the participants, we also asked if the household they live in has an energy certification (*yes/no/I don't know*) and with which frequency they take actions to save energy in their household (*never/occasionally/frequently*). Afterwards, the interviewer read the participants a list of seven energy saving behaviors and asked if the participant had performed this action in the past to save energy (turn off unneeded lights, buy efficient home appliances, turn off TV instead of standby, add insulation, lower indoor temperature, use less hot water, adjust temperature in fridge/freezer).

To measure subjective social norms and group norms, participants were asked if they think people important to them think that they should save energy (1 = *should not* to 10 = *should*). As the participants' neighborhood was identified as the most relevant reference group for energy saving behavior in this sample, we also asked if the participants believe that their neighbours save energy (1 = *extremely unlikely* to 10= *extremely likely*).

Group identification in this sample was assessed with a single-item-measurement asking how the participants describe the relationship to their neighbors (1 = *extremely unlikely* to 10= *extremely likely*). The items measuring trust (both general and in participants neighbors) and perceived safety were the same as described in the Swedish sample, but with a ten-point scale.

The items measuring social bonds were again mostly the same as in the previous survey, with the answering format to the question “*Is it common for people at the place where you live to talk to each other when they meet*” adapted to a ten-point scale (1 = *not common at all* / 10 = *very common)*. In the questions regarding the social relationships with family, friends etc., the category “relatives” was excluded for translation reasons and the additional answering option of “not presently” was added. Place attachment was assessed with a shortened version of the scale described in the Swedish sample, with only the five items and the answering format again adapted to a ten-point scale for consistency (1 = *I completely disagree* to 10 = *I completely agree)*. The scales for sharing economy were again the same as those used in the Swedish survey as were the final demographic questions.

4. Results

4.1. Feedback Design Recommendations

Informational strategies are widely used to support energy conservation policies (Steg, 2008). Information strategies work on the assumption that people do not behave as they should because they are unaware of their own energy consumption. If provided with such information, they would act curbing down their consumption (Jain et al., 2012).

However, evidence has shown that information alone increases knowledge but does not lead to behavioral change (Steg, 2008; Hargreaves et al., 2013). This could be for a number of reasons:

(1) Information strategy is ill-devised.
(2) Individuals do not care, so even if provided with the information they will not change their behavior. Information is only effective if the user already holds a strong goal to act based on that information (McCalley and Midden, 2002).
(3) Contexts make it difficult or impede that individuals change their behavior. Buchanan et al. (2014) emphasise that feedback may be of little use in situations where energy use cannot be reduced.

In support of the first line of work, extensive work has been conducted to unveil the conditions under which information strategies, in particular information based on feedback, may lead to energy conservation (Burguess and Nye, 2008). Yet, Buchanan et al. (2014) criticised the paucity of work on how feedback works, as most papers have focused on whether or not it works. Additionally, there has been limited empirical work on feedback and shift load: the majority of papers have examined the influence of feedback on energy savings. However, according to the meta-review of Ehrhardt-Martinez et al. (2010), programs targeting load shifting are more successful than those targeting energy savings, but energy savings are greater in the latter. Demand response programs (see a review in Shariatzadeh et al., 2015) offer a wide set of possibilities for encouraging load shifting.

The review of literature shows that points 2 and 3 have been limitedly addressed. Moreover, even when the information strategy is well-devised the problems 2 and 3 may still hold: users are not particularly inclined to use the eco-feedback devices (Buchanan et al., 2015). Those already concerned about energy savings are more willing to use it; thus, there is a risk of self-selection that may confound the effect of feedback and lead policymakers to believe that displays may provide the solution to achieve the target of 20% reduction. There is other evidence that suggests that eco-feedback may only work when users are motivated to engage with them. For instance, number of interactions is a good predictor of energy decrease; user logins correlate with savings (Jain et al., 2012). However, it is difficult to maintain motivations; even households interacting with the devices seem to lose interest over time and stop engaging with it – an effect called *fallback effect* (Buchanan et al., 2015). Thus, there is need to develop more innovative feedback mechanisms that are engaging and simultaneously avoid or minimise the potential shortcomings. Feedback mechanisms should be complemented with motivational mechanisms (Ehrhardt-Martinez et al., 2010).

Feedback can be delivered by different means. We focus on interactive feedback, provided by a computer, mobile or device accompanying a smart meter or in-home display (hereafter IHD, eco-devices or devices). Studies on eco-feedback has shown great variability in results, from 5% to 55% energy reduction (Jain et al., 2012). Darby (2006) found that improved feedback may reduce consumption by up to 20%, but the Energy Demand Research Project obtained a reduction of 1% (cited in Buchanan et al., 2015). These differences are attributed to characteristics of the device (Jain et al., 2012), household demographics and weather contexts (Buchanan et al., 2015), as well as type of energy. The Energy Demand Research Project, the largest project to date on feedback and energy reduction, found that electricity was reduced but not gas, failing to provide any theoretical explanation for this finding. If effects of feedback are moderated by sociodemographic information, the conclusion follows that it must be specifically adapted to the households' characteristics (age, housing type and household income) and consumer preferences in order to make it relevant for end users. Additionally, it is important to identify households with larger savings potential during the early stages of these types of studies (Vassileva et al., 2013). The use of energy information feedback devices in groups of households where consumption is already low might, in some cases, cause the opposite effect: when realising that they consume less, occupants give less importance to their behavior impact on electricity consumption. However, to our knowledge, studies have not tested the moderating effect of these contextual features on feedback-based interventions, examining only how different features of feedback may improve energy savings.

This review examines past studies on feedback interventions and design of feedback devices in order to (1) identify the parameters of design that should be taken into account when creating such devices and (2) recommend courses of action for each of them.

Ten parameters were identified in the literature that are further broken down in relevant dimensions. These are summarized in a table at the end of the section together with the main recommendations for design.

1. Frequency and immediacy

The ideal frequency of feedback is unclear, but computerized feedback systems provide a level of flexibility in data presentation and access that was previously unavailable (Froehlich, 2009).

Regarding frequency four possibilities are found:

- Real time feedback. Real time feedback decreases energy use (Delmas et al., 2013; Parker et al., 2008) that some authors estimate that could lie between 5-15% (Faruqui et al., 2010) or 2.7-18% (PowerCost Monitor4). Feedback reviews and users' evaluation suggest that real time feedback is superior to enhanced feedback (Ehrhardt-Martinez et al., 2010; Fitzpatrick and Smith, 2009; Vine et al., 2013)
- Indirect feedback. Indirect feedback is provided via letters, billings and door hangers. It is less effective than real time feedback (Delmas et al., 2013).
- Number of interactions. Frequent feedback is more effective than infrequent. Also, more logins result in greater decreases in energy (Karlin et al, 2013).
- Push vs. pull information (information always available in a visible place vs "on demand" info). Even when "push" mechanisms seem to be effective (Becker and Seligman, 1978; cited by Froehlich, 2009) reported that an average of 15% savings in energy consumption was found in homes that contained the signaling device. It is likely that an effective system would consist of both push and

[4] https://www.bluelineinnovations.com/features

pull approaches.

2. Duration of feedback to change habits

For each additional month of experiment based on feedback, there is a small but significant increase in energy use. This casts doubts on durability of effects (Delmas et al., 2013) after the so-called "honeymoon period" (Hargreaves et al., 2013). Erhardt-Martínez et al. (2010) found that it is more effective in periods less than 6 months than in longer periods. Also, Karlin et al. (2013) found lesser effect in studies with a length of more than a year. Persistent effects would be more likely if feedback is given over a longer time (Fisher, 2008) but long-term effects of feedback are unknown; few long-term studies (> 12 months) show that energy savings cannot be maintained (Vine et al., 2013). Thus, overall studies are pessimistic about the persistence of effects due to feedback; after one year of deployment of the eco-feedback it was not possible to see any significant increase or decrease in the household consumption (Pereira et al., 2013). Results show an increased awareness regarding electricity consumption despite a significant decrease in interactions with the device (Hargreaves et al., 2013).

3. Medium

Two basic media may be used: electronic media and written material (Fisher, 2008).

- Electronic feedback: It is the medium providing flexibility, real time data and customisation. However, it demands more involvement from users. In workplace contexts, emails were considered better communication channels than posters and leaflets (Kamilaris et al, 2015).
- Written feedback: Electricity bill as a carrier of feedback information. As an advantage it is read more carefully and raises more interest than additional material. However, it only provides indirect feedback.

Household characteristics have also been found to play an important role when it comes to choosing a visualisation tool (type of display). Households with high income usually prefer websites or in-home displays (Vassileva et al., 2013). Recent studies show that linking energy consumption and source through localised displays is a promising direction (Froehlich, 2009). McCalley and Midden (2003) gave consumers immediate feedback about washing machine energy usage via an attached control panel and found a 21% reduction in energy use. Ueno et al. (2005) installed sensors for each home appliance and monitored total electric power and gas consumption and found a 12% reduction in energy usage after system installation.

4. Content

Most studies have examined content of feedback; in particular, content has been provided in comparative terms, being the comparison with the user, with peers or with a goal set by user or given by an external party.

Historical comparison compares present consumption with past consumption; 24 hours, weekly or monthly. From this consumption and the recall of past activities, users can infer what causes energy consumption (however, many studies show that users are not that willing to make such inferences or that their inferences are not very accurate and defend the need for disaggregation). Most studies and meta-analysis acknowledge that historical comparison is a basic feature of the device (Faruqui et al., 2010; Jain et al., 2012; Vine et al., 2013). The opposite to historical comparison is to provide users with estimations of how much energy will be used in a 30-day period (Faruqui et al., 2010). However, there have been no studies testing the influence of such feature on energy savings.

Normative comparison uses social influence to impact the energy consumption behaviour of users exposed to normative eco-feedback (state change empirical ratio value of 1.5) (Jain et al., 2013). Yet, in meta-analysis social comparative feedback is the least effective form of comparison. Abrahamse and Steg (2013) in a meta-analysis of social influence approaches found that social comparison in feedback provision is the second least effective of all strategies considered. Worse, Fisher (2008) found a boomerang effect, where best performers found a sort of "moral license" to spend more energy. Comparison is more effective if it is established with people that are similar to us (same building or neighbourhood) (Jain et al., 2012). Regarding content of normative comparison, it seems important to provide injunctive and not only descriptive norms; that is, do not give only the comparison, but offer some form of valuation, for instance in the form of smiley or angry faces (Vine et al., 2013). In Jain et al (2012) users logging into the normative comparison logged twice as much as users without this feature but did not save significantly more energy. It raised curiosity but did not change behaviour. Also, some countries may reject comparative standards (UK) while others seem to prefer them (US and Norway) (Darby, 2006; Vine et al., 2013). For the UK (IEA 2005) and for Sweden (Sernhed et al., 2003) citizens are more interested in comparison with their own previous consumption, and less with other households. On the contrary, Finnish customers (Haakana et al., 1997) and Japanese (Ueno et al., 2005) prefer comparisons with peers (Fisher, 2008).

Goal comparison or goal-based feedback significantly increased energy savings (Vine et al, 2013). Even when users are not given real-time feedback the commitment to a specific goal yielded greater savings in gas consumption (McCalley and Midden, 2002). In contrast, groups with no goals and feedback did not achieve significant savings. Furthermore, in combination with other interventions it yielded better results. It is argued that in the case of goal comparison, energy savings cannot be explained by psychological or sociodemographic characteristics; interventions based on goal setting and feedback do not work only with those environmentally motivated (Abrahamse et al., 2009).

Regarding the goal-setting and the characteristics of the goal, there are a number of things to consider:

- It is key that the person sets goals at the appropriate level in the hierarchy (e.g. focal task goals). Feedback effects on performance are enhanced if feedback is directed to the focal task level (McCalley et al., 2011). For instance, users should be told to reduce energy by 10% when doing the washing up, rather than fighting climate change or being environmentally friendly.
- Feedback + goal and feedback + goal + incentive had higher effect sizes than feedback alone (Karlin et al., 2013). The size of the standard-feedback gap may be significant but it has not been studied.
- It makes no difference whether the goal is set by the person or set by an external party (Abrahamse et al., 2007). It is significant the reduction if the goal is difficult (they set 5%; experimental group did decrease energy consumption by 5%). Vine et al. (2013) report another study where a goal of 2% was set but the experimental group managed to decrease energy by 5.7%. However, the group given a difficult goal of 20% managed to reduce 15.7%.
- Group goal setting and group feedback, although it had been successful at workplace settings, did not lead to energy savings (Abrahamse et al. 2007). The person should be able to choose the goal in different measurement units.

It is key to provide the information together with an evaluation (Buchanan et al., 2015). Consumers have difficulties in deciphering their consumption. Thus, the design of the feedback has to provide clues of the evaluation; whether they are in red or green, whether they are increasing or decreasing compared to yesterday, whether their costs are being down certain threshold etc. Still, evaluation may differ across users, which also depend on their motivation. Also, it may provide wrong incentives, so that consumers feel that their actual levels of consumption are ok if they see them in green, reducing motivation to further decrease consumption.

Regarding the design, usually comparative information is given in the form of bars. Bars are usually coloured (red, yellow, green) to show good or bad performance (Jain et al., 2012). Bars are preferred to curves by users (Vine et al., 2013). Appliance level information is better displayed in pie charts with texts for further clarification (Vine et al., 2013). Other IHD use lines graphs. There are no sound empirical evidences to support a decision about what form of graph yields better results (see some evidence in Wood and Newborough, 2007 but not based on experimental studies).

Yet, bars are not the only choice to instruct users about their consumption. Rodgers and Bartram (2011) propose other forms of visualisation of power consumption based on ambient technologies and tested them for understandability in a small sample of 25 users. Results show that users prefer these forms of feedback to conventional bars and numbers. However, according to users' surveys, users do not wish ambient technologies incorporated into smart meters (Fitzpatrick and Smith, 2009). Thus, whether or not ambient features can improve the effectiveness of devices is a matter for further research.

For goal comparison, some devices have used ticks and cross to show whether or not the user is on target to meet a goal (Hargreaves et al., 2010).

Regarding normative comparison bars are also chosen, where a green bar usually means that a given user was 20% below the average of building, and red 20% above. Also, some IHD allow users to add friends to the friends feed and use this set for further comparisons. Other devices show in the friends feed whether friends have redeemed points or obtained incentives, rather than giving only the normative information. In most of devices normative information is voluntary, i.e. only displayed if the user chooses to.

Design should also manage two psychological problems: Cognitive dissonance and information overload. First, it may create a cognitive dissonance, as meta-analysis show that this is a requirement for a change of habits (make people aware that their own consumption is greater than they thought). However, if the person is systematically a poor performer it may respond by rejecting feedback or distancing from the situation. Also, design should avoid the information overload, displaying the information in a friendly and understandable manner.

As aforementioned the friends feed can be an important feature of the device. Other studies have suggested that social networking has an important role to play in supporting education and personal change of energy consumption and emissions. However, the role of Facebook and other social sharing sites in supporting social issues is a relatively new topic of research (Mankoff et al., 2007). One role that social networking sites may play is in providing accountability and pressure to be energy efficient. Pallack et al. (1980) carried out an experiment involving households. The group that agreed to publish the results of their performance used 15% less natural gas and 20% less electricity. It is likely that users who share their energy usage online will similarly feel pressure to engage in energy efficient behaviour (cited in Froehlich, 2009).

5. Disaggregation

Disaggregation, also called granularity, could be considered a parameter in itself or a part of the feedback content. It regards the level of disaggregation of information to appliance level, so that users know how much energy is used by each appliance (Faruqui et al., 2010). Jain et al. (2012) did not find significant differences, but meta-analysis show that granularity is a key moderator of feedback effect; granularity increases energy savings, especially when accompanied with tips on how to save more energy when using such appliance. Vine et al. (2013) report a study having reached savings of 17.8% with disaggregated information. Providing disaggregated feedback could help users learn what is provoking their energy use and try to minimize it (Buchanan et al., 2015). Appliance-specific feedback can also increase the consciousness of the relevance of one's own behaviour and the sense of control (Fisher, 2008), as well allowing focus on task-related goals. However, as it is very costly, few IHD contain this feature (Darby, 2006).

Furthermore, even if all IHD had it, there is a limit to the energy savings that can be obtained, as use of certain appliances is unavoidable or undesirable as it may compromise comfort or current lifestyles (Hargreaves et al., 2010). Appliances may pose a limit as they cannot be switched off easily or completely (Hargreaves et al., 2010). In a longitudinal qualitative study of households with smart meters in UK, Hargreaves et al (2013) found that users became irritated as the meter did not differentiate between normal usage, baseline that cannot be reduced, and extraordinary usage. Users felt that they have reduced the bad habits and only good ones remain, habits that cannot be changed. This uneasiness has led some users to place the smart meter in a less conspicuous place and stop paying attention to it.

Wood and Newborough (2007) suggest grouping at least appliances into types that are similar in features and user behaviour. Information thus will aid comprehension. Group 1 are appliances with a low level of automation and a large number of settings and so the user is frequently needed to supervise operations (e.g. cooker). Group 2 are appliances with high automation and low number of settings (e.g. TV). Group 3 comprises appliances with a high level of automation and several settings, which once chosen do not require or permit user interaction (e.g. washing machine). Group 4 are highly automated appliances with a low number of settings, the appliance operates continually (e.g. refrigeration) and users can do little to save energy.

6. Measurement

Feedback can be given in different units: money, watts, emissions, or other yet to be proposed. It is noteworthy that the type of presented feedback will influence how the environmental problem is perceived (e.g., as wasting money or as wasting energy), the motives it activates and the reasoning process that individuals engage in (Buchanan et al., 2015). Some devices allow displaying different units; dollars and watts for instance (Faruqui et al., 2010). There are no studies that compare the effectiveness of different forms of measurement, and for each form of measurement that test the effectiveness of different levels of abstraction. To our knowledge, only Karlin et al. (2013) tested such effect. They did not find differences on energy savings on the basis of measurement units. They suggest that when converting kilowatts into money or emissions, the amount decreases and this may lead to perceptions of irrelevance (10 kWh = 1 dollar ≈ 0.007 metric tons of CO_2).

Some of the units in which energy feed-back can be provided are listed and explained below.

- *Pecuniary information*. Feedback in the form of gains and losses of money due to energy use is one of the most researched strategies. Studies have suggested strong effects of price signals on energy consumption (Delmas et al., 2013); however, in their meta-analysis they found significant effect in raising energy use, probably due to licensing effect. Karlin et al. (2013) did not find any significant effect. Stern (2011) suggests framing choices in terms of losses (you are losing 80 dollars) rather than gains (you could save 80 dollars), as people respond to the cognitive bias. However, as Buchanan et al. (2015) suggested gains/losses are often minimal and could discourage action. Also, payment in arrears may prove less effective when combined with feedback (Darby, 2006); keypad meters, progressive block pricing or pay-as-you-go pricing strategies could create synergies with feedback. Pecuniary feedback may not work if the prices of energy are low or flat (Wood and Newborough, 2007).

- *Kilowatts*. This should be understood as the most neutral measurement and may reinforce the abstractness of energy, jeopardising motivation for improvement. It is the least preferred by users (Fitzpatrick and Smith, 2009) as it is difficult to decipher (Wood and Newborough, 2007).
- *Emissions*. Emissions may stimulate environmental concerns. Again, emissions are abstract and may not help focus on task-related goals. Fitzpatrick and Smith (2009) found that although users have expressed a preference for CO_2 emissions, in practice they did not use the feature of the display, partly because they did not understand what the amount of emissions meant and partly because they did not feel the information was useful for them.
- *Health*. Health-based frame induced persistent energy savings behavior of 8-10% over 100 days; whereas a more traditional cost savings frame, drove sharp attenuation of treatment effects after 2 weeks with no significant savings versus control after 7 weeks (Asensio and Delmas, 2016).

7. Problem solving

Some IHD provide recommendations for users to act upon their energy consumption. There are two main problem-solving strategies:

- *Audits or tailored recommendations*. Audits or personalised recommendations (e.g. plug out your kettle and you will save this amount of energy) have yielded significant effects in energy reductions (Abrahamse et al., 2007; Delmas et al., 2013). Also, specific advice about targeted ways to save energy and specific information on the impact on the environment were the most useful for users (Kamilaris et al., 2015)
- *Energy tips*. These are broad, general tips for reducing energy. They have had a non-significant effect in energy conservation (Delmas et al., 2013).

8. Consequences of feedback

As aforementioned, some authors claim that feedback itself may not lead to behavioural change unless is accompanied with penalties or rewards. There has been a paucity of studies addressing the effect of penalties/rewards on energy use.

- *Penalties.* Users who receive penalisations in the first engagements are less likely to use the device again (Jain et al., 2012).
- *Rewards.* Receiving rewards in initial engagement, makes it more likely (2.5 times) to engage again (Jain et al., 2012). Other forms of rewards are incentives or the possibility of obtaining points and redeem it for prizes or discounts (Jain et al., 2012). This may influence positively energy savings. Also, Delmas et al. (2013) found that incentives significantly decreased energy use. However, financial incentives may crowd out prosocial motivations.

9. Other lessons learned from user-centered design of devices

Eco-feedback is one strategy; one step further is scripting (Lilley et al. 2005) where the product is designed in such a way that the design triggers the sustainable use by either creating obstacles for unsustainable use, or by making sustainable behaviour so easy, it is performed almost without thinking about it by the user. A third strategy would be forced-functionality; intelligent products (as defined by Lilley, 2005) that adapt automatically to changing circumstances, or to designing-in strong obstacles to prevent unsustainable behaviour.

10. Design for families and homes

Horn et al. (2011) discussed the role of learning in the design of eco-feedback and management technology (eco-FMT) and establish two conditions:

(1) Design technology to encourage entire families, children as well as adults, to become meaningful and active participants in the management of household resource.

Design interactive systems to engage families in inquiry-based learning around concepts of consumption and sustainability. Rather than creating artifacts to reinforce predetermined behavioural outcomes, we suggest that designers should instead focus on empowering families to define sustainability on their own terms in the context of their own unique situations. For this purpose, supporting inquiry learning is a valuable strategy because it emphasises the idea that learning involves integrating knowledge with authentic practices in meaningful contexts. This is important as the IHD will be used by different members of the household with varying attitudes and values towards savings and environment (Hargreaves et al., 2010) but unless all members commit to using it, energy savings of one member may be offset by the energy spending of another one. Worse, Hargreaves and cols. (2010) document arguments among members due to the device, as it may be interpreted by family members as a form of surveillance on them.

(2) Integrate into decor.

Most IHD are not integrated gracefully into the decor nor do they stimulate an emotional reaction (Rodgers and Bartram, 2011). Design should not forget the aesthetic qualities of devices.

Summary

The ten points described above are summarised in Table 8 below.

Table 8. Feedback for energy conservation. Synthesis of recommendations based on literature review.

Parameters	Dimensions	Recommendations
1. Frequency & immediacy (Feedback timing)	Real time feedback Indirect Feedback Number of interactions Push vs pull information	Device should provide real-time information whilst encouraging frequent consultations. Combination of push and pull approaches. Push mechanisms may compensate for lack of logins
2. Duration of feedback	Short term Medium term (6-12 months) Long term (>12 months)	Long term feedback useful for increase awareness and persistent effects but need to redefine strategy in order to keep engagement.
3. Medium	Electronic or written feedback Speech (spoken or no) Location of device	Electronic feedback should provide specificity and location. Link

	Physical appearance (screen, robot)	consumption and source can boost reduction in energy use. Including "social cues" (speech and/or robot) results in lower energy consumption
4. Content	Comparison (historical, normative, goal) Sign of feedback (positive/negative) Persuasion strategy Cognitive load & Image type	Combination of different forms of content but privilege goal-based feedback; include friends feed if social comparison is socially accepted. Need to take into account individual's goal orientation and emotional traits as well as persuasion profile. Make people aware that their own consumption is greater than they thought, displaying the information in a friendly and understandable manner (graphs, colours, images)
5. Disaggregation (granularity)	Information broken down by appliance or source of energy Broken down by group of appliances Aggregated information	Prior evaluation of energy saving potential according to users´ habits and appliances; Information as disaggregated as possible (at least group of appliances)
6. Measurement unit	Monetary units Kilowatts Emissions Health	No differences on energy savings on the basis of measurement units, energy conservation could be long-lived with health framing. Frame as potential losses rather than potential gains.
7. Problem solving	Audits or tailored recommendation Energy tips	Provide smart meters with tailored recommendations for users to act upon their energy consumption, not general tips. If possible combine other features of the device with audit (e.g. goal setting, granularity)
8. Consequences of feedback	Penalties Rewards	Incorporate rewards to strengthen the commitment to using smart meters
9. Design strategies	Eco-feedback Scripting Forced functionality	Scripting (product is designed in such a way that the triggers the sustainable use). Forced-

		functionality (intelligent product that adapt automatically to changing circumstances or prevent unsustainable behavior).
10. Design for families & homes	Target and interaction	Combine the variety of family unit profiles with an aesthetically attractive design

In addition to this guideline and in order to illustrate each of the parameters, examples were sought among already commercialised apps and home energy management devices. A tutorial for device designers was created. Papers were read and analyzed seeking to respond to the research questions listed in Figure 7 below.

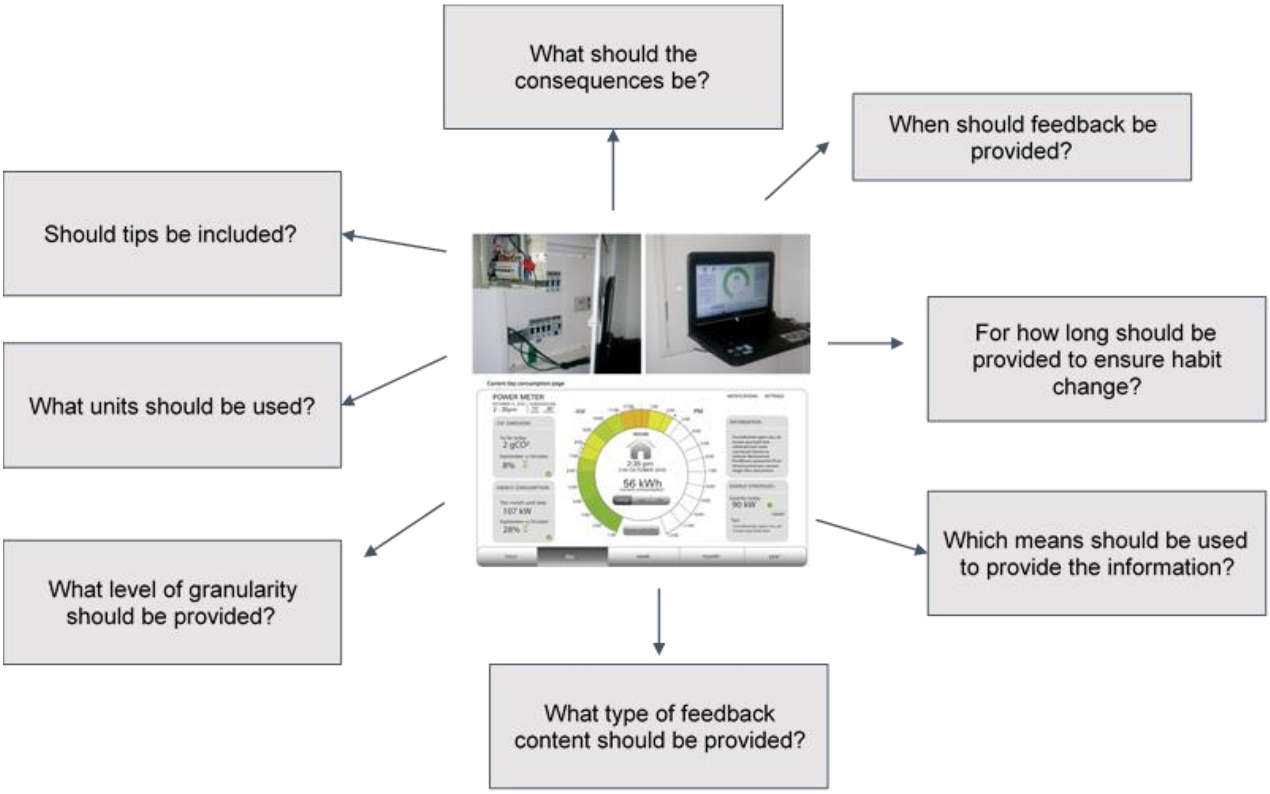


Figure 7. Research questions for literature review on engagement strategies

4.2. Providing Comparative Feedback

The identified recommendations for feedback in the previous section may lead to some new challenges. In particular, recommendation 4 (content: comparisons and persuasion strategy), 5 (disaggregation: prior evaluation of energy saving potential) and 7 (problem solving: prior evaluation of energy saving potential), imply that if normative feedback is to be provided, it has to be done in a fair and concrete way, so as not to lose the trust of the end users when providing energy feedback. The following section provides a methodology for partially overcoming this problem.

4.2.1. Problems with Comparative Feedback

To increase the likelihood of engagement, feedback on household energy performance should be carefully designed using best practices from the field of human-computer interaction and behavioural sciences (Karjalainen, 2011; Pierce et al, 2010). Comparative feedback is suggested to be an effective feedback mechanism as it has led to sustained engagement in some cases (Allcott, 2011). One challenging problem with this type of feedback is that if it only considers the total household electricity consumption – usually the only data point that is available through smart meters – the feedback cannot be normalised in a fair way; a large family that make efforts to reduce their energy use will almost always perform worse than a single-member household in the same community.

One common normalised metric of energy use in buildings is energy consumption per floor area (kWh/m^2), which allows for meaningful comparisons of area-dependent energy use such as heating. For household electricity consumption (kWh_{elec}) however, this metric is not optimal since other factors such as the type of household, the number of residents, or the existence of certain electricity loads such as electric vehicles often affect the consumption more.

In order for a household to better understand its electricity consumption performance, it is common to compare its consumption to its previous consumption or to the consumption of other households. These types of comparisons have limitations that are discussed below.

Comparisons with the household's previous consumption can show a decreasing or increasing trend in the consumption, but not whether the actual consumption is high or low, taking into account the characteristics of the apartment. This makes it harder to set fair energy reduction goals. For example, a reduction goal of, say, 20% is easily achieved by a household with a wasteful energy behaviour, while an already energy-efficient household will find the same 20% reduction challenging. Therefore, knowing a baseline consumption based on the household's characteristics would be useful when setting reduction goals.

Comparisons with other households are often used to give comparative feedback. A direct electricity use comparison using kWh can be done between apartments, but it is only suitable when comparing apartments with similar characteristics; a small one-person apartment will most probably use much less than a large apartment having four residents. To make households comparable, the kWh/m^2 metric is often used, but household area is only one of many determinants of the energy consumption. Figure 8 shows the electricity consumption of 124 Swedish apartments divided into six groups of similarly-sized household. It shows a trend of increasing use per area, but the trend is broken for the largest household sizes. More importantly, the data reveals that the number of residents within each area group and their behaviour have an important effect on the total energy consumption. The importance of the number of residents is further confirmed by simulations (see Figure 9); a large 110 m^2 single-person apartment consumes less than small 30 m^2 one with two residents.

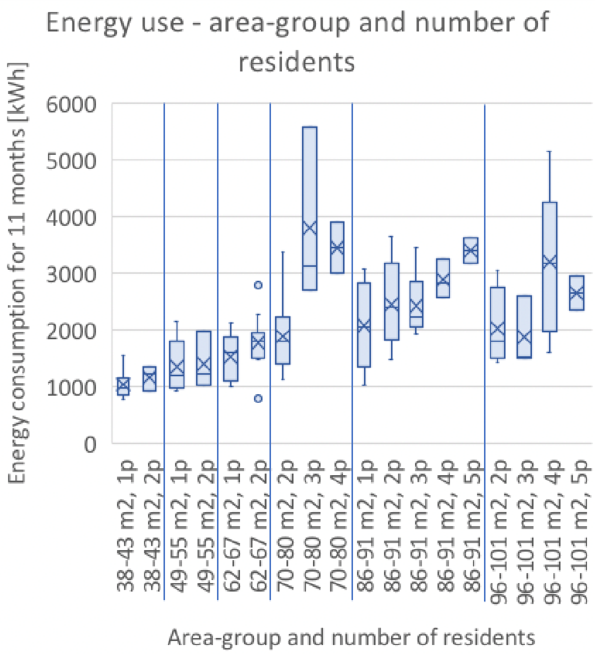


Figure 8. Energy consumption statistics (0-25-50-75-100 percentile) for 11 months in 124 apartments divided into six area groups. The apartments are recently built and participate in a pilot in the InteGrid EU project in Stockholm Royal Seaport.

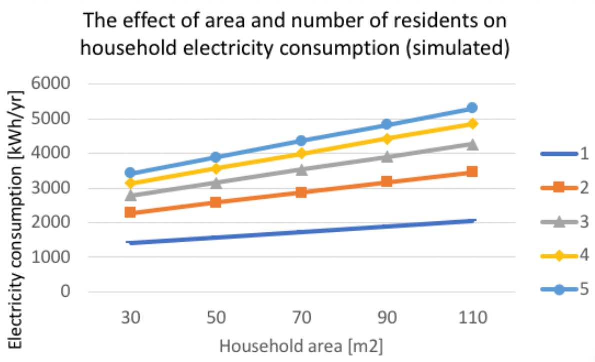


Figure 9. Simulated energy consumption for Swedish apartments for different combinations of area (30-110 m2) and number of residents (1-5). Simulated using Energikalkylen, an online household electricity calculator provided by the Swedish Energy Agency.

Thus, it is unfair to use kWh/m^2 to compare apartments; for example, the energy use of a large two-person apartment with normal consumption could be similar to a smaller, energy-saving four-person apartment, but when divided by the area, the large apartment would seem more energy-efficient. The risk with this is that energy-saving residents feel that their saving or shifting efforts do not matter. This fairness aspect is yet to be addressed in demand side management programs and energy communities. A parallel can be drawn to the comparison of greenhouse gas emissions of cities that is always normalised per capita to avoid this very problem.

4.2.2. Proposed Solution: Household-Specific Baselines

To overcome the limitations of conventional comparative feedback, our proposed solution is a household-specific baseline. The baseline is calculated using selected household characteristics and indicates how much an average household with the same characteristics would consume. Comparing the household's actual consumption with the baseline reveals how energy-efficient the household is compared to the average household. Household-specific baselines would allow for:

1. *Personalized goals*. Figure 10 compares two hypothetical households, A and B. By only looking at the current consumption (grey bars), household B seems to be more efficient than A. However, by introducing the household-specific baseline (black horizontal lines), it can be seen that A is actually more efficient since its consumption is below its baseline. When setting reduction goals, instead of giving both households a 20% goal (red bars) relative to their current consumption, the efficient household A could get a personalized goal of 10% while B gets 30% (green bars).

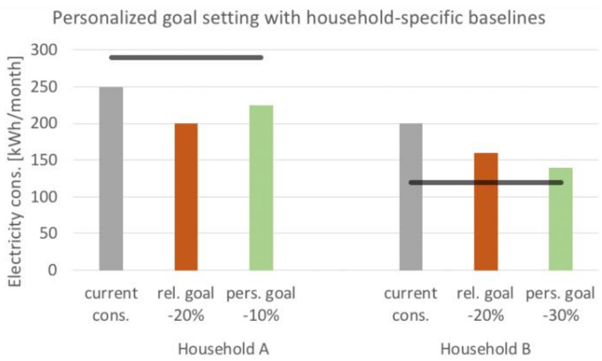


Figure 10. Example of personalized goal setting using household-specific baselines for two hypothetical households.

2. *A fairer comparison of energy efficiency between households*. By using the deviation in percent from the household-specific baseline as a metric, households with differing characteristics can be compared with each other. For example, in Figure 10, household A is about 15% below its baseline while B is 65% above, so A is much more efficient than B. Another example: An apartment with a young couple consuming 300 kWh/month and a similarly sized household of four with both parents working from home consuming 800 kWh/month can be said to be equally energy efficient if they both consume 20% below their household-specific baseline.

Baseline construction: Main determinants of household energy use

In order to calculate a fair baseline, the characteristics that are most relevant to the household energy consumption need to be considered. Common ways to calculate baselines include online energy calculators or energy simulations, but these often require many input parameters that are not readily available unless a detailed survey is given to the household. Our approach is to minimise the number of parameters and make assumptions based on the parameters to get a baseline that is good enough. For typical Swedish apartments, Vassileva (2012) suggests that apart from behaviour and attitudes, the household income, number of residents and floor area affect the consumption. As the household income is likely to be correlated with the other parameters (i.e. larger income affords a household with a larger floor area), and since our main interest is comparisons within neighbourhoods having a relatively similar income level, our hypothesis is that it is possible to create a meaningful baseline calculation using the following two main determinants of household energy use:

- The number of residents
- The floor area

We also suggest using people hours as a main determinant, but this is outside the scope of this paper and is explained in the "future research" section.

Baseline construction: Main household electricity loads

The main household electricity loads and their dependence on the main determinants are presented in Table 9. Out of the loads, only the lights are dependent on the household area, while the rest are mainly dependent on the number of residents and their behaviour. Our hypothesis of mainly person-dependent loads was verified by studying simulation results from Energikalkylen, an online household electricity calculator made by the Swedish Energy Agency. This is obviously a representation of Swedish conditions and would need to be generalized for other types of households.

A model for calculating a household-specific baseline

Based on this understanding on how the main determinants of household energy use affect different household loads, we suggest the following simple model as a starting point for calculating a household-specific baseline:

Inputs:

A: household area [m^2]

r: number of residents

w: has/uses washing machine (1 or 0)

r_{home}: number of residents who usually work from home, can be a decimal value such as 0.5 or 1.5 if the residents work from home part-time.

Output:

$E_{baseline}$: the baseline household electricity consumption [kWh/year], which is a sum of the individual loads, described in Equation 1.

Table 9. Electrical household loads, their typical share of household electricity use (Source: simulations using Energikalkylen), and their assumed dependency on floor area, number of residents and people hours. L = linear dependency (y=k*x+m), S = step function, x = affected by type of people- hour.

Load	Typical household elec. share	Floor area	# residents	People-hours (future research)		
				Amount	Time of day	Awake
Lights	11% E_{lights}	L	L	x	x	x
Washing machine	15% E_{wash}		L			
Clothes dryer			L			
Cooking	24% $E_{kitchen}$		L	x		x
Dishwasher				x		
Fridge/Freezer	12% E_{fridge}		S			
Electric devices	38% $E_{devices}$		L	x		x
Standby			L	x		
Charging			L	x		

Equation 1. Baseline household electricity consumption

$$E_{baseline} = E_{lights} + E_{kitchen} + E_{devices} + w * E_{wash} + E_{fridge}$$

where the first four individual loads are calculated as linear dependencies (y = k*x + m) and the first three are increased if people are working from home:

$$E_{lights} = (k_{lights} * A + m_{lights}) * (1 + f_{home} * r_{homeupTo1})$$

$$E_{kitchen} = (k_{kitchen} * r + m_{kitchen}) + (k_{kitchen} * r_{home} + m_{kitchen}) * f_{home}$$

$$E_{devices} = (k_{devices} * r + m_{devices}) + (k_{devices} * r_{home} + m_{devices}) * f_{home}$$

$$E_{wash} = k_{wash} * r + m_{wash}$$

in which

f_{home} is a factor for increased energy use if working from home

$r_{homeUpTo1}$ decreases the use of lights if a single person is working part-time from home according to:

$$r_{homeUpTo1} = \{r_{home} \text{ if } 0 \leq r_{home} < 1, 1 \text{ if } r_{home} \geq 1\}$$

The last individual load is a step function dependent on the number of residents, assuming that three residents or more need a separate fridge and freezer:

$$E_{fridge} = \{E_{combinedFridgeFreezer} \text{ if } r \leq 2,\ E_{separateFridgeFreezer} \text{ if } r \geq 3\}$$

The k and m linear equation parameters need to be customized for different countries and living conditions. For Swedish apartments, the following values, in Table 10, are suggested, based on the Energikalkylen simulations. The value for the f_{home} parameter is an assumption, and the energy use for the fridge/freezer are from Energikalkylen.

Table 10. Input values for household electricity consumption calculation.

	k	m
lights	4.5	20
kitchen	120	400
devices	120	250
wash	180	0
f_{home}	0.2	
$E_{combined}$	350 kWh/year	
$E_{separate}$	520 kWh/year	

4.3. Residential Consultation Workshops on Feedback and Community Storage

This section presents the results of the workshops on feedback and community storage in Lisbon and Stockholm.

4.3.1. Feedback – Stockholm

There were four focus groups in total of which two discussed a screen design on apartment level feedback and two discussed building- and neighbourhood-level feedback.

The general outcomes of the workshop discussions are summarised below, organised by design aspect. The constructive criticism and suggested changes are listed as bullets under the respective design aspect. If not otherwise specified, the statements are true for both apartment level and building- and neighbourhood level groups.

Spontaneous interpretation and understanding of the feedback screens

In terms of understanding, it was quickly clear to the participants that the information on the screen had something to do with fulfilling an energy-related goal. The colours green and red efficiently signal if you are currently doing "good" or "bad". Though, at a closer look, many participants found the percentages hard to interpret, especially on the load-shifting screen. It was not clear to the participants how the percentages were calculated and hence what they were showing, or what they as residents could do in their home to reach the goal. One participant also found the colours problematic due to colour blindness.

In terms of sentiments, several participants described it as fun and challenging to get this overview of their electricity consumption. The avatar was also a generally appreciated feature that gave the feedback screen a playful and less harsh tone. Many participants however found that the screen contained too much information and with fonts that were too small.

Suggested changes

- Express the goal and the progress in a simpler way, possibly in absolute numbers (kWh) or visually with bars.
- Decrease the amount of information on the main screen. Let users click or swipe to additional screens for more information.

Influence of explanation on understanding

After having received an explanation of the feedback, including how the percentages were calculated, participants generally found it easier to understand. The explanation hence had some positive impact on their understanding. However, the information on load-shifting was still difficult for some of the participants to grasp even after the explanation. The reason for this seemed to be that the very concept of load-shifting was unfamiliar to the participants and not everyone understood why it was even desirable.

Suggested changes

- Provide a better knowledge base on load-shifting. An energy profile in the application might help visualising the concept.
- Consider finding a more relatable, layman-like term for load-shifting. (There were however no suggestions of what it should be called instead.)

Relevance of the information in helping to achieve goals

Although participants found most of the provided information relevant, many of them were asking for additional information and a clearer connection between the energy goals and the residents’ concrete interactions with appliances, as they found the overall energy goal somewhat abstract. Some participants did however turn the feedback information into own ideas of actions. Using timers on dishwashers and washing machines to shift loads away from peak hours, and unplugging stand-by appliances were actions mentioned in several of the groups.

The actions suggested on the feedback screen were considered rational and relevant, but some participants thought they would only follow those that did not interfere with their comfort and everyday life. For example, fixed working hours restrict residents from using certain appliances at optimal times.

Getting feedback on what happened yesterday or last week gave some participants the feeling that it is too late to do anything. The feedback screen also does not tell the user what they did right or wrong, which some participants thought made it difficult to know what behaviour to change.

Several participants found it counterintuitive that the percentage *grew* as a result of *reduced* energy use and felt it would make more sense to design the feedback in a way so that an increased use of energy meant a growing number or graph.

Suggested changes

- Provide a more extensive list of actions that residents can take, and their relative contribution to the goals.
- Provide more instant feedback, or even forecasts, to allow users to see the impact of their actions.
- Make visual representation more intuitive by correlating decreasing energy use with a shrinking graph and vice versa.

Relevance of motivational features in helping to achieve goals

The element of comparing results and possibly competing against other residents at different aggregation levels was appealing to some, but not to all participants.

To create a stronger incentive, participants in all groups wanted to see how much money their energy conservation was worth and how much money they could save (as individuals) by taking actions. In the apartment level groups, some participants felt that they would be more motivated if they could set their own goals and compare their results from different weeks.

Suggested changes

- Provide information on how much money the residents have saved or could save by taking actions.
- Allow users to set their own goals.

Significance of aggregation level

When asked about what motivational features could be added to the application, both apartment and building level groups mentioned, with emphasis, the individual financial gain from reducing energy costs. In other words, even when the feedback is given on an aggregated level, this individual incentive is very relevant.

A list of suggested actions and their relative contribution to energy conservation was requested from groups on both aggregation level. However, the discussion about individual home appliances was more pronounced in the apartment level groups, while building and neighbourhood level groups mentioned things like building ventilation and (although not relevant to electricity use) heating. These slightly different perspectives could be a reflection of the different aggregation levels that the groups were discussing. If so, the apartment level feedback might be more efficient in encouraging people to take individual action.

One of the apartment level groups discussed the importance of feeling like they would have a real and direct influence on the energy use reviewed by the application. One aspect of this would, according to the group, be to have a small enough aggregation level so that their individual contribution could actually make a visible change. This suggests that aggregation level should not be higher than perhaps building level.

In terms of comparing results in a competitive way, some in the apartment level groups who were sceptic towards an individual contest would feel more positive about competing as a community against e.g. other buildings.

One of the building and neighbourhood level groups were explicitly asked about their opinion on having goals on an aggregated as opposed to individual level. The group thought that for joint goals to be relevant, there must be a sense of community among the participating households. On the other hand, provided that such social capital exists, it can be strengthened by joining forces for energy conservation. The suggested awards from achieving the goals in this context were not money, but rather things that could bring the community closer – a social event or shared goods that can be useful to many, such as lawn games or toolboxes.

4.3.2. Feedback – Lisbon

The workshop in Lisbon was held on the 4th of June 2018 in the area Caldas da Rainha. In terms of demography, many of the inhabitants of this area belong to a senior age group, which was also reflected in the composition of workshop participants.

A summary of the results from the energy feedback stakeholder consultation workshop is found below. In the results from the Lisbon workshop, the participants' understanding of the feedback is, unlike the Stockholm results above, not divided into before and after explanation but presented together as the general understanding. The Lisbon participants also got to discuss a feedback screen about social sustainability, containing information about neighbourhood identity, trust and safety.

Understanding of the feedback screens

The participants found it overall difficult to understand the feedback screens and interpretation of them required quite some time. The message conveyed through colours (green = good, red = bad) was clear, but the data was not intuitive. Comparing the different feedback screens, the feedback on energy conservation was found to be easier to understand than the feedback on load shifting. A suggested change was to use bars instead of the current type of graphic.

Elderly people might generally find it harder to understand new apps and digital services, compared to younger generations. This is important to keep in mind when designing the feedback, so that this age group do not get excluded from using it.

Relevance of the information

The advice and suggested measures for reaching the goals were useful, according to the participants of the workshop. They would like to be able to see during what hours people were consuming the most energy, presumably to better know when to load shift themselves.

Relevance of motivational features

The participants in this workshop were questioning the need to compare to other neighbourhoods, which suggests that they did not find it relevant as a motivational feature. Instead they thought it would be useful to see the monetary savings they had achieved and could achieve by taking action.

4.3.3. Energy Storage Stockholm

In the following section, results regarding the five different criteria from Part 1 and Part 2 of the workshop are presented with the order based on interrelations between decisions for the different criteria becoming obvious in the focus group discussions. As results, as anticipated, differ between countries, in the following chapter 4.3.3 results for Sweden are presented. Afterwards, chapter 4.3.4 summarizes findings from the stakeholder consultation workshop in Portugal and compares them to the Swedish findings.

Place of battery: Common battery in cellar vs. individual battery in apartment

Nearly all participants (n = 15) preferred a common battery in the cellar rather than an individual battery in their apartments (n = 3).

Arguments in favor of an own battery were:

- an increased value of the flat due to the purchase
- an increasing independence from the neighbors and the overall energy system

As one of the participants put it:

> *“I am in favour of having your own battery, I rely on being able to use it even during periods of power failure, as a backup. With the shared solution on the other hand, you do not have the same control and there may be problems. I did like the thought of having my own battery, because I would know that I would be in charge of it."*

Related to this was distrust in neighbors to handle the energy wisely:

> *“Yes, if everybody were using it at the same time and no one gave it a second thought. It might not be obvious to everybody that cutting down on consumption during a power failure and with everyone having their own battery would be advisable. I would very much have liked to have my own battery so that I could at least do the most necessary things.”*

The latter quote also illustrates another finding, namely that participants in favor of having an own battery rather than a common battery would also prefer to manage the energy facility themselves in order to gain the greatest level of control.

Likewise, arguments in favor of the common battery show a relation to decisions on sharing and management of the storage system – but in an opposite direction than the control approach outlined above. Some participants preferred a common battery in combination with a sharing approach both based on the assumption that this would be the option with the least level of involvement, remaining in their role of a passive consumer rather than becoming a prosumer.

Other arguments for the common battery were:

- perceived risk that the technology might be too complicated to handle without expert knowledge
- health risk, as the following quote illustrates

> *“I have a tremendous respect for things like that. I don’t even want to charge my phone near my bed. It is still kind of an experiment. We are living like that, we have no idea what it is.”*

Sharing: Sharing energy vs. use of individual production and storage

The majority of participants favored a shared option (n = 11). This result is especially noteworthy given that some of the Swedish participants assumed that sharing energy would assume a sharing of costs, e.g. in form of a “flat rate” for energy as it is currently the case for water consumption in Sweden.

Arguments for sharing relate to social sustainability and solidarity:

"I mean, presume you are having a massive party and lots of guests, or people who are staying over, you will be consuming lots of electricity. Over a longer period, though… I think about solidarity as well…. Looking back on my childhood, having a ridiculous number of siblings, there were eight of us when I grew up and my mum became a single mother. You see, the washing machines are used constantly, and a lot of electricity is being consumed. Now, as an adult with my children moving out and things like that, perhaps I … I mean, what kind of society are we… Do I regard this as being part of a large society or do I regard it as my personal house now?"

However, the pro-arguments for the sharing option do not only relate to social aspects as one might assume based on the business model literature but rather refer to the argument of gaining independence - which for other participants led to choices for individual solutions – was mentioned with regard to the combination of sharing and self-management:

"But the advantages with having this app is that… then we won't have Eon, that you buy electricity from, saying that "during these times you will have this and that and this and that much" but instead you are sharing it between yourselves. I think you have your own facility. I think it would work better."

And

"Yes, and then there is this thing about trust, that you have your mobile app. I used to live in a house and I think that even if I know how to read my electricity gauge, there will be someone who comes over and does it anyhow. I do not trust them completely because it is about making a lot of money too, there is a lot of money in it."

Other participants address once more the need to be independent from other users:

"That is to say, the last question to me was that: here the electricity usage, and the first person to connect draws electricity from the battery, if it is a shared one. Whereas here, I am guaranteed my share, and you can pay a little extra or sell some if there is a surplus. That is why I chose individual supply."

The findings suggest that two different levels of gaining autarky and independence need to be differentiated: (1) individual independence and (2) societal independence from current energy suppliers.

The wish to be independent contrasts with the above-mentioned preference of some participants to stay in a passive role; while participants are motivated by the concept of energy independency, a need for comfort and low responsibility is also mentioned several times, e.g.:

"About shared or individual, I can actually make a compromise there. It would be quite nice if others took care of it."

Management of battery: Local energy supplier vs. self-management

The concept of becoming a prosumer is of interest to the majority of participants (n = 13). A key argument in favor of self-management of the energy facility is the possibility to get feedback on one's energy consumption and this is seen as relevant to reduce consumption and save money. Further economic benefits are seen for this version, namely higher profits are expected without a third-party involvement. Another argument is related to comfort: energy self-management allows optimizing the consumption based on own needs. This can of course be somewhat automated, but the preferences still need to be set by the residents.

While the majority prefers managing the energy facility rather than letting it be controlled by a local energy supplier, findings also show that the concept of being a prosumer rather than a passive consumer is clearly not attractive to everyone. Given the euphoria over the prosumer-model in energy future scenarios, one should also pay attention to the fact that five people decided for leaving the management responsibility with the local energy supplier. Furthermore, it is noteworthy that even the 13 participants that preferred the self-management of the energy facility via an app only want to take over responsibility in a limited way. Namely, the assumed complexity of the system and the time investment discourage participants:

> *"The only thing I hesitated about was this mobile app. I agree with what you are saying, but I think it could … you are an amateur after all… and you are supposed to control it with an app."*

> *"And you have a life, I think. You might not want to spend hours on end every day to, I don't know, there are so many more important things in my life than checking an electricity gauge."*

> *"I was even considering having one of those apps that you control yourself. On the other hand, wouldn't I get bored silly? I probably would, and I would be happy to know there is an electricity supplier that takes care of things like that."*

Financing of battery: Buy vs. rent

The majority of participants (n = 12) prefer to rent rather than buy the battery with the main reason being that they expect a quick development of the technology and a leasing option would allow easier access to the newest option. Another reason that also relates to less financial risks is that a rented battery wouldn't include an initial investment.

The third argument mentioned in favor of renting the battery relates to an aspect that also becomes salient in the above described criteria: Comfort. Participants assume that a rented battery is easier to handle, e.g. serviced by the providing company.

Electric vehicles: Bi-directional charging vs. no inclusion of EVs in the storage system

The majority of participants (n = 12) preferred to include bi-directional charging with electric vehicles in the energy storage system of the house. Main reason for participants to decide against this option was the risk of having an uncharged vehicle in the morning. A compromise mentioned by participants was to include electric vehicles in the system but define a charging minimum dependent on residents' needs.

Insights from stories

First of all, it is noteworthy that it only took participants a moment to get used to this more creative task and then they were very motivated during this exercise and discussed intensively. Findings from a first analysis of the stories reveal additional and sometimes also deeper insights into connections between the new technology and consumers' everyday life than gained during the classical methodology of focus groups. This is not supposed to imply that focus groups are not of value – the findings above clearly show they derive relevant insights into consumers' perceptions of new energy systems – but rather to point out that new methodologies like storytelling could complement this picture, e.g. by addressing emotional aspects rather than rational arguments.

Findings from the stories are in many aspects are in line with the above-mentioned results, e.g. they further emphasize that the ease of use is important for integration of the new technology in consumers’ everyday life:

> *“It is like a self-playing piano in a way, where I do not have to get that involved in the process, which is important for me as I have a great many other things to deal with. 100% renewable energy is also important, because although I am not very active it means I can still contribute.”*

While new high-tech solutions are overall described very positively in all stories it is also highlighted that they shouldn’t interfere with consumers’ life:

> *“It is important that things like air conditioning, being able to open a window or a balcony door feels natural. I want to know that I have access to everything, for instance being able to get in and out of the building despite there being an electrical failure. In other words, too much hi-tech can be daunting.”*

The results point out several benefits for consumers that could be gained from the new energy storage system, including the ones mentioned above, namely (1) comfort (*ease of use bringing me peace of mind)* and (2) economic benefits.

There are, however, also benefits highlighted that have not been mentioned in the focus groups. This also indicates that storytelling as a method for data collection could derive new insights into consumers’ perceptions of new energy technologies. The main new benefit revealed here relates to sustainable development as a driver for adapting new energy systems, including both ecological and social sustainability.

Am I contributing to a better world?

This is the open question at the end of one of the stories created during the workshop.

Particularly the social benefits of the new system are highlighted in several stories, as the following quotes show:

> *“Living in an energy-efficient house creates a great sense of community among residents”*
>
> *“Creating a natural way of interacting with and getting to know your neighbours, leading to an increased sense of security and to be able to make a difference.”*
>
> *“Shared resources, for instance electricity, gives happier neighbours.”*
>
> *“We are in this together.”*

Summary

The workshop shows heterogeneous findings with regard to residents’ perceptions of the prosumer concept presented in several business models on energy storage in particular and the future of energy systems in general; an approach that contrasts with the currently rather passive role of consumers in an often decentralised energy system in many European countries. The focus group discussions reveal relevant insights into underlying motives of consumers’ preferences that we did not assume beforehand, e.g. while House 1 was designed as a – rather active – *prosumer-sharing* option, focus groups show that – quite the contrary – some participants choose this option because they assumed that a shared facility would result in low responsibility from their side. Likewise, the self-management via the app was assumed to provide energy feedback but besides providing a possibility to monitor energy use to function rather automatically, as the following quote shows

> *“I think it is a quite good app that controls everything automatically, so it is good to have an app.”*

Overall, two contrasting motives seem to underlie residents’ decisions on energy storage facilities in their apartments and relating preferences for business models on energy storage: (1) the desire to be independent – being it independent as a community from energy suppliers or individual independence – and (2) a need for a comfortable version that would be completely taken care. With the latter motive clearly limiting the feasibility of the prosumer approach, as the following quote illustrates:

> *“And you have a life, I think. You might not want to spend hours on end every day to, I don’t know, there are so many more important things in my life than checking an electricity gauge.”*

Other relevant arguments mentioned by participants are (3) the reliability of the system and energy (4) energy saving, with the latter mostly being of interest with regard to monetary savings.

The key controversy between independence and comfort encouraged participants to discuss compromises between the two extremes and that they feel would fit best for them, e.g. to share energy but leave certain parts individually; to *reserve* energy as participants formulate it. Another compromise is mentioned with regard to the question of management: Residents are interested in an app to monitor their energy consumption but do not want to be involved beyond this. The latter example illustrates the overall perception of participating residents: There is an interest in becoming a little more active than in the current system, e.g. there were very positive reactions with regard to energy feedback but at the same time to remain key responsibility for energy system with third-parties. Given the distrust towards current big energy suppliers displayed in the focus group discussions, this might be a good opportunity for niche companies to gain momentum in the market.

The storytelling exercise reveals another factor that could drive the change towards shared energy systems: social sustainability and the need for increased social belonging in our currently rather isolated society. Several residential participants associated the new, shared energy system with an improved sense of community.

4.3.4. Energy Storage – Lisbon

In the following, main results from the Portuguese workshop are presented and cross-country comparisons between Sweden and Portugal are discussed.

Place of battery: Common battery in cellar vs. individual battery in apartment

The majority of participants (n = 27, 58.7%) preferred an individual battery in their apartment compared to a common battery in the cellar. This result contrasts with the findings in Sweden where nearly all participants decided for a common battery rather than an individual battery in their apartments.

Sharing: Sharing energy vs. use of individual production and storage

The vast majority, 87% of participants, favored an individual access option over shared access. Again, this contrasts with the Swedish findings. In the Swedish workshop, the majority of participants favored a shared option. This is particularly noteworthy as findings from the focus group discussion in Part 2 of the workshop reveals that this criterion was for many participants the key criterion for their decision between the *Prosumer-Sharing* option (House 1) versus the *Comfort-Independence* setting (House 2). Namely, from the 32 participants that decided for the *Comfort-Independence* option, 22 mentioned that the avoidance of a shared solution was the key argument for them. This had more weight for them then the – perceived disadvantageous – solution of a bought battery rather than a rented battery. Thus, they accepted the perceived higher costs for acquisition and maintenance in order to remain – or gain – independency from their neighbors' behaviour. A strong sense of property and possession accompanied the question of independence from other people's energy behaviour.

Management of battery: Local energy supplier vs. self-management

The majority of participants (n = 32, 73.9%) were interested in proactively managing the battery themselves using an app. This criterion seemed to be of relevance for Portuguese participants. For the participants that decided for the *Prosumer-Sharing* option the community energy control was a key factor for their decision.

Likewise, the majority of participants (n = 13) in Sweden were interested in using the app to control the energy storage system themselves rather than relying on an energy supplier. It should however be kept in mind that findings from the focus groups in Sweden also revealed that the participants expected the app to manage most of the system automatically and that they would only partly be active. Similarly, Portuguese participants also saw advantages of not taking over responsibility but rather leave this with network operators.

Financing of battery: Buy vs. rent

The majority of participants (n = 28, 60.9%) prefer to rent rather than buy the battery. This result is in line with the Swedish findings; in Sweden the majority of participants (n = 12) also prefer to rent rather than buy the battery.

Electric vehicles: Bi-directional charging vs. no inclusion of EVs in the storage system

In contrast to the Swedish findings, the majority of participants (n = 27, 58.7%) preferred to not include electric vehicles as part of their energy storage system. However, the focus groups discussion revealed that this criterion is of less relevance for participants' preference on house configuration presented in Part 2 of the workshop. This might be caused by the slower uptake of electric vehicles in Portugal than in Sweden.

Insights from stories

This part of the workshop differed a little bit between the two countries. Namely, the Swedish workshop asked for participants to imagine their life with the new energy storage solutions while the Portuguese participants were presented a broader scenario of a smart house that would also include energy storage. Participants in Portugal were then asked to list perceived advantages and disadvantages of living in a smart house.

While the instructions differed a little, the findings were still in many ways comparable. Both Swedish and Portuguese partners see ecological and economic benefits of the new technologies, mainly due to increased efficiency and energy savings, as well as an increased level of comfort with positive results on well-being.

An aspect that Swedish partners mentioned but that was not discussed in the Portuguese workshop was improvements with regard to social sustainability, namely the closer connection between neighbours due to shared energy facilities.

Another difference between participants from the two countries lies in the negative aspects mentioned in this part of the workshop. In Portugal participants were more concerned about technological dependence and the related risk of failures. Also security, including data protection, was raised as an issue. In addition, energy justice was brought up in the discussions, relating to the aspect that the new technologies would not be available for everyone. None of these topics were brought up in the Swedish workshop.

4.4. Evaluation Survey – T0 Baseline Sweden

4.4.1. Descriptive Statistics

Sample

Of the 300 participants, 142 (47.3%) were female and 158 (52.7%) male, all aged between 18 and 81 years (M = 49.55, SD = 16.71). The majority of participants were born (91.0%) and/or raised (95.0%) in Sweden and had a university degree (82%), 17.0% had finished secondary school and 1.0% had a primary school education. Most participants were either employees (56.0%), retired (23.7%) or self-employed (9.0%).

On average, our participants shared their household with 1.30 other people (SD = 1.14). The majority of them said the current income of the household was enough to live on comfortably (46.7%) or very comfortably (30.0%), 19.0% were coping on current income and 4% found it difficult or very difficult to live on their income at the time of the survey. Almost all participants (97.3%) lived in an apartment. The buildings these apartments were in belonged mainly to a housing cooperation (58.7%) or to owners who rented individual apartments (39.0%). The average floor size of participant's apartments or houses was 70.75m^2 (SD = 24.97).

Status quo of energy saving behaviours

On average, participants rated the extent to which they currently save energy in their household as 4.80 on a seven-point scale (SD = 1.37). The past effort to save energy was rated at 4.41 (SD = 1.57), the past time and labour invested in this goal at 3.61 (SD = 1.53). 39.90% obtained environmentally certified electricity, 21.00% obtained other forms of energy and 39.70% did not know the kind of energy in their household obtained.

The results for the interview questions regarding specific energy saving behaviours are displayed in Table 11. Most of the participants (83.7%) mentioned at least one action they take to save energy in their household, after listening to the examples of the interviewer this percentage rose to 91.3%. Almost half of the participants (43.0%) mentioned at least one action that was not covered in the prepared list the interviewer used, these included the use of energy saving light bulbs, cycling and composting. The most frequently mentioned energy saving behaviours was turning of unused lights (45.0%), while only 3.3% of the subjects had added isolations to windows or walls. For almost all behaviours (except the insulation of windows and walls and the setting and defrosting of fridges/freezers), the majority of those who displayed the behaviours reported to do so often.

Table 11. Frequency of energy saving behaviours mentioned in the survey (Sweden).

Action	Mentioned		Frequency		
	free recall	prompted	often	occasionally	never
Turned off lights when not needed	45.0%	48.0%	93.2%	6.8%	0.0%
Turned off TV instead of using standby	21.7%	45.7%	77.7%	18.8%	3.5%
Bought energy efficient home appliances	10.7%	36.3%	68.1%	24.1%	7.8%
Set temperature in fridge/freezer, defrost	2.3%	55.7%	49.4%	45.4%	5.2%
Lowered indoor temperature	13.3%	31.0%	59.4%	36.1%	4.5%
Added insulation to windows or walls	3.3%	11.7%	40.0%	51.1%	8.9%
Lowered consumption of hot tap water	22.3%	42.3%	68.0%	28.9%	3.1%
Other 1 Item	43.0%	-	89.1%	9.4%	1.6%
Other 2 Items	14.0%	-	86.4%	13.6%	0.0%
Other 3+ Items	4.0%	-	100.0%	0.0%	0.0%
Used/bought energy saving light bulbs[a]	15%	-	-	-	-
Recycled/sorted waste[a]	6.3%	-	-	-	-
Run washing machines full	5.7%	-	-	-	-
None	16.3%	8.7%	-	-	-

Note: Frequency are percentages only of those who mentioned an item, in free recall or after prompting

Status quo of social sustainability

On the scale for place attachment (Cronbach's α = .881), participants average score was above the scale mean, M = 4.25, SD = 1.29. To the question if people talk to each other when they meet in participants neighbourhood, the average answer was 4.95 (SD = 1.53).

For the measuring of social bonds, as can be seen in Table 12, the majority of our participants were content with the social bonds where they lived as they considered them neither too high nor too low. However, 25% of participants think that there is too little insight into the lives of others in their community and 23.3% of those who said this topic applies to them think that people take too little responsibility for each other's children. This shows that despite the overall positive responses, there are aspects of social bonds where people feel the need for improvement.

The same can be said for participants' description of their social bonds (see Table 13): while they generally reported good social relationships with all of the groups of people covered in our survey, with especially high numbers for friends and family, there certainly is still room for improvement regarding social bonds to neighbours.

Table 12. Measurement of social bonds (Sweden)

Where I live we....	too much	moderate	too little	n/a
...care about each other	4.3%	80.0%	13.3%	2.3%
...are prepared to help each other	6.7%	80.0%	9.3%	4.0%
...have insight into each other's life	5.0%	66.0%	25.0%	4.0%
...take responsibility for each other's children	3,3%	46.0%	15.0%	35.7%
...are expected to be engaged in questions concerning the area	11.3%	72.3%	14.3%	2.0%

Table 13. People in participants social network (Sweden)

Social bonds with	yes	no	n/a
family	96.0%	1.0%	3.0%
relatives	86.0%	12.0%	2.0%
friends	98.3%	1.3%	0.3%
neighbors	56.0%	41.3%	2.7%
work/peers	70.0%	14.3%	15.7%

Additionally, we measured the frequency of our participants’ social meetings with their neighbours and the number of neighbours they personally know (see Table 14). In these results it notable that a third of all people interviewed never meet any neighbours in an social context and almost half of them (44%) only know up to four of their neighbours personally – even though, as reported above, almost all participants live in buildings with several apartments and therefore quite close to at least some neighbours.

Table 14. Additional descriptive statistics social sustainability (Sweden)

Social meeting with neighbors		Neighbors who know where you live	
daily/almost daily	6.7%	0	12,3%
some time/week	15.3%	1-3	31,7%
some time/month	27.3%	4-6	24,7%
some time/year	17.7%	7-10	13,0%
never	33.0%	11-15	8,3%
		16 or more	10,0%

To assess the degree of sharing economy, we added up any instance of sharing, borrowing, or lending/renting a person reported over all the items covered in our scale. The mean value for this scale was 0.87 instances of sharing behaviour per person (SD = 1.40), with 58.3% of participants not participating in any sharing behaviour.

If people participated in sharing, it was mostly by borrowing/renting from someone (M = 0.36, SD = 0.81) or lending/renting to someone (M = 0.73, SD = 0.81) directly. Participation in sharing pools was lower (M =

0.13, SD = 0.38) compared to both borrowing (t(299) = 5.12, p < .001) and lending (t(299) = 4.18, p < .001). The amount of borrowing and lending reported did not differ significantly (t(299) = 0.65, p = .518).

4.4.1. Influencing Factors of Behavioural Intentions

Table 15 shows descriptive statistics and correlations of the scales measuring possible influencing factors of people's behavioural intentions regarding energy saving in accordance with the theory of planned behaviour (Ajzen 1991; Fishbein and Ajzen, 2010) and Fielding et al. (2008). As almost all participants lived in houses with several apartments, we used the building level as the reference point for calculating group norms and group identification.

Two hierarchical regressions were conducted to see which constructs that are significant predictors of energy saving behaviour. The results can be found in Table 16. These analyses were done in accordance with Fielding et al. (2008), with past behavior included in the first step. As the first model shows, attitude and perceived behavioural control are significant predictors of intention to save energy and can explain variance beyond past behaviour. We did not find perceived group norms to be a significant predictor, meaning that the perceived norms of the other inhabitants of the building a person lives in do not have a measurable connection to their intention to save energy.

It is possible that group norms do not have a general influence on behaviour, but only in cases where people identify with a group (compare e.g. Fielding et al., 2008). To test for this possibility, we included an interaction term between group norms and group identification in the second regression model. This interaction did not explain any additional variance (see Table 16), meaning that the above hypothesis is not supported by the data in this sample.

Table 15. Descriptive and correlations of behavioural and social scales (Sweden).

		M	*SD*	1	2	3	4	5	6	7	8
1	reported behaviour	4.80	1.37	/							
2	behavioural intention	5.23	1.78	.604**	/						
3	past behaviour	4.01	1.39	.528**	.431**	.76					
4	attitude	5.46	1.12	.506**	.501**	.528**	.84				
5	subjective norms	5.17	1.32	.406**	.377**	.468**	.535**	.82			
6	behavioural control	5.10	1.16	.635**	.448**	.411**	.469**	.346**	.70		
7	group norm	4.97	1.15	.351**	.309**	.271**	.338**	.504**	.380**	.72	
8	group identification	3.82	1.32	.269**	.148*	.198**	.188**	.249**	.145*	.246**	.85

*Notes: *p < .05, **p < .01. Scale reliabilities in diagonal.*

Table 16. Hierarchical regression analyses predicting intention to save energy (Sweden)

Step	predictor	R	R^2	R^2ch	Δ F	df	β
1	past behaviour	0.43	0.19	0.18	67.94**	1/298	0.16**
2	attitude	0.58	0.34	0.33	13.56**	5/293	0.27**
	subjective norms						0.05
	behavioral control						0.21**
	group norms						0.07
	group identification						0.01
1	past behavior	0.58	0.34	0.33	25.01**	6/293	0.16**
	attitude						0.27**
	subjective norms						0.05
	behavioral control						0.21**
	group norms						0.06
	group identification						0.01
2	group norms x identification	0.58	0.35	0.32	0.184	1/292	-0.02

*Notes: *p < .05, **p < .01. β-coefficients computed with all variables in the model*

One reason for the nonsignificant results regarding the social variables might be the comparatively low identification our participants reported with the relevant reference group – in our case their neighbours. As a reference, Fielding and colleagues (2008) found an interaction between perceived group norms and group identification only in their second study, where the average group identification was 5.41 (*SD* = 1.51) on the same seven-point scale we used in our survey. In their first study, where this interaction did not reach significance, mean group identification was at 4.58 (*SD* = 1.63) which is still higher than our samples mean of 3.82 (*SD* = 1.32).

4.5. Evaluation Survey – T0 Baseline Portugal

4.5.1. Descriptive Statistics

Sample

Of the 65 participants of this survey, 33.8% were female and 66.2% were male, all aged between 21 and 75 years (M = 40.97, SD = 13.77). 95.4% of the participants were born in Portugal and 98.5% grew up there.

The majority (56.9%) had a university degree, 40.0% had secondary education and 1.5% each had finished middle school and primary school.

Most of our participants were employees (80.0%), fewer were retired (7.7%), self-employed (6.2%), unemployed (4.6%) or students (1.5%). Participants shared their household with an average of 3.23 other people (SD = 2.93). The majority said they were coping on their current income (50.8%), 29.2% were living comfortably and 20.0% found it difficult or very difficult to live on their current income. About half of the people in our sample lived in a house (50.8%), the others lived either in an apartment (41.7%) or a semi-detached house (7.7%). 81.3% owned the space they lived in while 16.9% rented. The average floor size of participants' apartments or houses was 182.68 m^2 (SD = 151.10).

Status quo of energy saving behaviour

At the time of the survey, participants rated their energy saving behaviour at 8.09 on a ten-point scale (SD = 1.48). Behavioural intentions were rated at 8.58 (SD = 1.80). 47.7% of the participants lived in a household with an energy certification, 32.3% did not have such a certification and 20.0% did not know if they had one. The majority (66.2%) said they save energy frequently, 32.3% reported to do so occasionally and 1.5% never save energy. The frequency with which participants show the concrete energy saving behaviours covered in the survey can be found in Table 17.

Table 17. Frequency of energy saving behaviour (Portugal)

	yes	no
Turned off lights when not needed	93.8%	6.2%
Turned off the TV instead of using the standby mode	38.5%	61.5%
Bought energy efficient home appliances	66.2%	33.8%
Set correct temperature in fridge/freezer, defrost regularly	27.7%	72.3%
Lowered the indoor temperature	38.5%	61.5%
Added insulation to windows or walls	43.1%	56.9%
Lowered the consumption of hot tap water	61.5%	38.5%

Table 18. Measurement of social bonds (Portugal).

Where I live we....	too much	moderate	too little
...care about each other	30.8%	50.8%	18.5%
...are prepared to help each other	26.2%	63.1%	10.1%
...have insight into each other's life	38.5%	44.6%	16.9%
...take responsibility for each other's children	9.2%	50.8%	40.0%
...are expected to be engaged in questions concerning the area	33.8%	44.6%	21.5%

Status quo of social sustainability

On the shortened scale for place attachment (Cronbach's α = .889), participants average score was above the scale mean, M = 6.59, SD = 1.76 – as in the Swedish sample. To the question if people talk to each other when they meet in participants neighbourhood, the average answer was 7.55 (SD = 2.24).

As can be seen in Table 18, for all items the majority of our participants were content with the social bonds where they lived. Compared to the Swedish sample, there is more variety in the Portuguese answers, indicating more divergence in opinions. It's especially noteworthy that the percentage of people who rate certain aspects of social bonds as "*too much*" is much higher in the Portuguese sample than in the Swedish one. This highlights that different communities have different needs in regard to their social bonds and interactions, which is important to keep in mind when transferring a social network like LocalLife to different communities or countries.

Regarding the social bonds to the different groups of people covered in the questionnaire, the answers between the two samples were more comparable (see Table 19). Just like the Swedish participants the Portuguese participants reported overall good bonds with extremely high values for family and friends and by far the lowest score for their neighbours. This demonstrates that in this sample, too, there is still room for improvement in people's social relationship with their neighbours.

The frequency of our participants social meetings with their neighbours and the number of neighbours they personally know are displayed in Table 20. Overall, the Portuguese participants descriptively reported higher values on both measurements.

Table 19. People in participants social network (Portugal).

Social bonds with	yes	no	not presently	n/a
family	96.9%	0.0%	0.0%	3.1%
friends	96.9%	1.5%	0.0%	1.5%
neighbors	53.8%	33.8%	9.2%	3.1%
work/peers	73.8%	12.3%	12.3%	1.5%

Table 20. Additional descriptive statistics social sustainability (Portugal).

Social meeting with neighbors		Neighbors who know where you live	
daily/almost daily	26.2%	0	0.0%
some time/week	33.8%	1-3	4.6%
some time/month	13.8%	4-6	15.4%
some time/year	12.3%	7-10	18.5%
never	13.8%	11-15	16.9%
		16 or more	44.6%

The scale for sharing economy was computed as described in the Swedish survey. The mean value for this sample was 1.34 instances of sharing behaviour per person (SD = 1.83), with 44.6% of participants having not participated in any sharing behaviour in the past.

In this measurement, we found the same pattern as in the Swedish sample: People were most likely to borrow/rent from someone (M = 0.51, SD = 0.99) or lent/rent things to someone (M = 0.62, SD = 1.23) directly. Participation in sharing pools was lower (M = 0.22, SD = 0.67) compared to both borrowing (t(64) = 2.02, p = .048) and lending (t(64) = 2.34, p = .022), whereas the amount of borrowing and lending did not differ significantly, t(64) = 0.56, p = .578.

4.5.2. Influencing Factors of Behavioural Intentions

To identify possible influencing factors driving the intention to save energy, we conducted the same analyses as reported above in the Swedish sample. The descriptive statistics for the relevant variables can be found in Table 21, the results of both hierarchical regression models in Table 22.

As can be seen in the tables below, we did not find the same results in this sample as in the Swedish sample. Therefore, we did not replicate the results mostly found in the literature on the theory of planned behaviour that attitude towards saving energy and the perceived behavioural control impact behavioural intentions (see Fielding et al., 2008). We also – as in the Swedish sample – found no significant influences of group norms, group identification or the interaction of the two.

This difference in results, from both our first survey and the general findings in the relevant literature suggest that in this context, single-item scales – while increasing usability and potentially response rates – might not measure the relevant constructs as well as longer scales covering several different aspects of the construct. Therefore, further studies on this topic should likely be conducted using a more traditional multi-item-approach.

Table 21. Descriptives and correlations of behavioural & social scales (Portugal).

		M	*SD*	1	2	3	4	5	6
1	behavioural intention	8.58	1.80	/					
2	past behaviour	8.38	1.55	$.568^{**}$	/				
3	attitude	9.25	1.28	$.399^{**}$	$.569^{**}$	/			
4	subjective norms	9.03	1.38	$.370^{**}$	$.579^{**}$	$.688^{**}$	/		
5	perceived behavioural control	7.42	1.85	.170	$.469^{**}$	$.315^{*}$	$.289^{*}$	/	
6	group norms	7.40	1.66	.109	$.274^{*}$	$.493^{**}$	$.302^{*}$	$.344^{**}$	/
7	group identification	7.05	2.39	.073	.012	.227	.118	.165	.157

*Notes: *p < .05, **p < .01.*

Table 22. Hierarchical regression analyses predicting intention to save energy (Portugal).

Step	predictor	R	R^2	R^2ch	Δ F	df	β
1	past behaviour	0.57	0.32	0.31	29.99**	1/63	0.59**
2	attitude	0.60	0.36	0.29	0.64	6/58	0.14
	subjective norms						-0.01
	perceived behavioural control						-0.15
	group norms						-0.08
	group identification						0.07
1	past behaviour	0.57	0.32	0.31	29.99**	1/63	0.56**
2	attitude	0.60	0.36	0.29	0.64	6/58	0.18
	subjective norms						-0.02
	perceived behavioral control						-0.11
	group norms						-0.09
	group identification						0.06
3	norms x identification	0.61	0.37	0.29	0.82	1/57	0.10

*Notes: *p < .05, **p < .01. β-coefficients computed with all variables in the model*

4.6. Office Employee Consultation Workshops – Ljubljana and Domzale

This workshop concept was applied in Slovenia on the 10th of April 2018 in two office buildings belonging to Elektro Ljublijana – one situated in central Ljublijana and one in Domzale – under the leadership of the Elektro Ljublijana employee Uršula Krisper. Uršula reported overall successful workshops with occupants showing positive attitudes and interests in the project.

Current occupant behaviour

These are the summarised results of the survey, enquiring about plug-load interactions and work hours:

- The plug-loads listed by the occupants in the survey were the following: Computers, monitors, system printers, ceiling lights, individual air heaters, thermostats for heating and cooling, radio, phone charger, refrigerator, microwave oven and toaster.
- The occupants believe that they are generally good at turning off appliances (specifically computers and lights) that are not being used. Only a minority of occupants tend to leave computers on.

- The occupants typically arrive to the office at 6.30, take a lunch break around 10.00-11.00 and leave the office at 14.30. By 15.00 cleaners arrive to the building.

Identifying action points

During the group discussions when the workshop participants were asked to suggest action points, many creative and thoughtful suggestions came up. This is positive and shows occupant interest and understanding of the issue.

A considerable share of the energy demand for Elektro Ljublijana comes from the air conditioning. This was therefore central to the discussions about possible action points towards conservation and flexibility. It was well understood and raised by the occupants themselves that this issue matters the most to the overall building energy.

The actions suggested by the occupants, related to the air conditioning were, in summary: Using the blinds to lessen need for air conditioning; turning off the air conditioning at the end of the workday; turning off air conditioning when windows are open; and using the ventilation to take in cold air during the night in summer time.

A concern highlighted by the occupants was that the air conditioning is controlled centrally and not by any of the participants in the workshop. To change the air conditioning use pattern, a new scheme would have to be communicated to the staff managing the central cooling of the building. It was also discussed that the management of air conditioning must be done with care and precision in order not to compromise the thermal comfort in the office.

In terms of other plug-loads in the office, the following actions were suggested: Turning computers off during longer absence; turning the lights off in the bathrooms; charging electric vehicles during the night; running washing machines and dryers during low tariffs and only when they are full; replacing old bulbs with LED lights.

Some occupants expressed a concern that there is not much room for them to further switch off appliances without affecting the working process.

Action points

It was concluded in the dialogue with the workshop participants that the occupant behaviour program should focus on smarter management of the air conditioning and on encouraging occupants to be thorough in switching off computers and monitors that are not in use, especially during the lunch breaks.

Fulfilment of objectives

The fulfilment of the workshop objectives is discussed below.

- *Inform and educate the occupants on building energy*

The background of the project and the concept of grid flexibility was explained to the occupants during the workshop. Although there was no explicit indicator of how well the occupants followed the theoretical introduction to building energy, the thoughtful suggestions and discussions during the later parts of the workshops show that the occupants had a good understanding of the issue at hand.

- *Gather information on occupant behaviour and attitudes*

The reported plug-load interactions and working hours were listed and provided input for the development of the occupant behaviour program. The occupant attitudes were not surveyed, but their active participation in the workshop shows interest and the workshop leader reported that the overall attitudes towards this initiative were positive.

- *Identifying action points through occupant participation*

Management of air conditioning and thorough attention to switching off un-used computers and monitors were identified as focal points in the occupant behaviour program for Elektro Ljubljana. Both action points were found among occupant suggestions and were discussed and deemed acceptable from an occupant perspective.

- *Building approval and motivation for the program among occupants*

The level of achievement of this soft objective is difficult to measure at this point, since the workshop constitutes only an initial phase of a long-term occupant behaviour program. However, the fact that occupants were active during the workshop and positive about the outcome are satisfactory signs with respect to the fulfilment of this objective. Through the dialogue between occupants and the manager of the behavior change program that took place in the workshop, insights were also gained about occupants' (self-reported) drivers and concerns with respect to changing their energy behavior. These factors – such as rewards, frequency of reminders, thermal comfort and effect on productivity and workload – will be considered in the consequent design and implementation of the behavioural change program. Respecting and meeting these occupant needs will count towards a more wide-spread approval of the program and stronger motivation.

5. Summary

This deliverable is the outcome of task 1.4 in the InteGrid project – and it revolves around an inherently transdisciplinary challenge: long-term engagement of consumers in the smart electricity grid. The contributions of this report stand on three legs that provide the InteGrid with insights, and practical guidelines on how to better engage the end users in the smart grid – across the demo sites in Sweden, Portugal, and Slovenia. The results are however also relevant to the wider smart grid community.

The first leg of this report was a literature review on feedback mechanisms, that drew on findings from existing field tests and the subject matter expertise of the authors. This resulted in a number of practical recommendations to the project that are particularly important to HLUC 9 and HLUC 11. Towards this aim, algorithms for household-specific baselines were also important to tailor the feedback to the actual household and to increase consumer trust in the feedback.

The second leg of this report was the local stakeholder consultation workshops where consumers in Portugal and Sweden were invited to discuss community storage and feedback, and office employees in Slovenia were invited to discuss their role in the building's peak load reduction. This report also provides comprehensive guidelines for how to conduct stakeholder consultation workshops for these aims.

To better understand how consumers interpret and react to energy feedback given in the context of a social network application, two stakeholder consultation workshops were held – one in Stockholm and one in Lisbon – where a visual prototype of the energy feedback functionality was presented and discussed in focus groups. The participants generally found that presenting the feedback as percentages made it difficult to grasp and they would prefer colors and bars. They liked the concrete tips provided on what concrete actions to take in order to reach the energy goals. In the Portuguese demo workshop, they also wanted data on how much money they were saving by reaching their energy goals. The attitudes towards comparing energy conservation and load shifting achievements with other households or neighborhoods were different among the participant; the competitive element really appealed to some but not to others.

The Stockholm workshop also assessed the significance of feedback aggregation levels; apartment, building or neighborhood. The results suggested that apartment level may be the most relevant in encouraging people to take action and it also makes their contribution directly visible in the feedback. Building or neighborhood level feedback was encouraged by the participants as it adds more to the social sustainability by uniting people towards a common goal. However based on the baseline survey results, further research is required to determine whether social identity can be used to strengthen engagement.

Regarding consumers' attitudes towards energy storage business models, the workshops showed that while in Portugal the majority of participants favored having an own battery in their apartments, in Sweden nearly all participants favored a common battery. This relates to findings on preference for shared versus individual solutions in the two countries: Swedish participants favored a shared option, Portuguese partners perceived this rather as a risk. The named risks, e.g. running out of energy due to high demand of neighbours, was also mentioned by some Swedish participants but played an overall smaller role in the decision process. A reason for this might be that sharing concepts in housing, e.g. shared laundry rooms are more common in Sweden and people got used to this solution. A compromise of this conflict that was named in both workshops is a "limited sharing", e.g. with the possibility to reserve a certain amount of energy for each user.

In Ljubljana and Domzale the office employees indicated an interest and willingness to participate in the projects peak reducton program by reducing plug loads during the mid-day peak hours, particularly during their lunch hour. The workshops resulted in a one year campaign proposal at Elektro Ljubljana based on a flexibility competition between two offices [REFD4.1].

The third – evaluation – while outside the scope of this task, was considered important to be developed in T1.4 for further implementation in the demonstration work packages. A survey was designed that covers energy attitudes, behaviors, and intentions, as well as social identity and cohesion in their neighborhoods and buildings. The baseline surveys were conducted and summarized in Lisbon and Stockholm, where there are residential consumers in the demonstrators. The Stockholm survey shows that the participants' energy saving behaviours are mainly influenced by their attitudes and the perceived control they have over energy saving activities. At this point in the project, the residents did not identify strongly with their neighbourhood or buildings, which therefore made the role of social identity inconclusive. Measures of social cohesion reveal room for improvement regarding neighbourhood social bonds and again indicate a need for increased social belonging.

The Lisbon survey did not find an influence of attitudes and perceived control on energy saving behaviour, which might be partly due to the fact that a shorter version of the questionnaire, designed to increase usability, was tested here. Differences between the samples regarding both energy behaviour and the evaluation of social interactions highlight the importance of tailored approaches to engage consumers in different communities with different needs.

References

InteGrid Documents

[REF GA] InteGrid's Grant Agreement

[REF D6.1] Concept of the market hub, central platform and services. Deliverable D6.1, June 2017.

External Documents

Abrahamse, W., & Steg, L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings?. *Journal of economic psychology*, *30*(5), 711-720.

Abrahamse, W., & Steg, L. (2013). Social influence approaches to encourage resource conservation: A meta-analysis. *Global environmental change*, *23*(6), 1773-1785.

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2007). The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. *Journal of environmental psychology*, *27*(4), 265-276.

Achterberg, P., Houtman, D., van Bohemen, S., & Manevska, K. (2010). Unknowing but Supportive? Predispositions, Knowledge, and Support for Hydrogen Technology in the Netherlands. *International Journal of Hydrogen Energy,* 35 (12), 6075–83.

Ajzen, I., 1991. The theory of planned behavior. Orgnizational Behav. Hum. Decis. Process. 50, 179–211. doi:10.1016/0749-5978(91)90020-T

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*.

Asensio, O. I., & Delmas, M. A. (2016). The dynamics of behavior change: Evidence from energy conservation. *Journal of Economic Behavior & Organization*, *126*, 196-212.

Bartram, L. (2015). Design challenges and opportunities for eco-feedback in the home. *IEEE Computer Graphics and Applications*, *35*argeant, J., Mcnaughton, E., Mercer, S., Murphy, D., Sullivan, Sargeant, J., Mcnaughton, E., Mercer, S., Murphy, D., Sullivan, P., & Bruce, D. A. (2011). Providing feedback: exploring a model (emotion, content, outcomes) for facilitating multisource feedback. *Medical teacher*, *33*(9), 744-749.

Boork, M., Thomtén, M., Brolin, M., Uyterlinde, M., Straver, K., Kraan, C., ... & Maggiore, S. (2014). Key success factors and barriers to end-user engagement in smart grid projects. In BEHAVE2014-Behaviour and Energy Efficiency Conference.

Bourne, L. (2006). Project relationships and the Stakeholder Circle. Paper presented at PMI® Research Conference: New Directions in Project Management, Montréal, Québec, Canada. Newtown Square, PA: Project Management Institute.

Broms, L., Katzeff, C., Bång, M., Nyblom, Å., Hjelm, S. I., & Ehrnberger, K. (2010, August). Coffee maker patterns and the design of energy feedback artefacts. In *proceedings of the 8th ACM conference on designing interactive systems* (pp. 93-102). ACM.

Buchanan, K., Russo, R., & Anderson, B. (2014). Feeding back about eco-feedback: How do consumers use and respond to energy monitors?. *Energy Policy*, *73*, 138-146.

Buchanan, K., Russo, R., & Anderson, B. (2015). The question of energy reduction: The problem (s) with feedback. *Energy Policy*, *77*, 89-96.

Burgess, J., & Nye, M. (2008). Re-materialising energy use through transparent monitoring systems. *Energy Policy*, *36*(12), 4454-4459.

Community Places (2014) Community Planning Toolkit, https://www.communityplanningtoolkit.org/sites/default/files/Engagement.pdf

Darby, S. (2006). The effectiveness of feedback on energy consumption. *A Review for DEFRA of the Literature on Metering, Billing and direct Displays*, *486*(2006).

Darby, S. (2008). Energy feedback in buildings: improving the infrastructure for demand reduction. *Building Research & Information*, *36*(5), 499-508.

de Best-Waldhober, M., Daamen, D., & Faaij, A. (2009). Informed and uninformed public opinions on CO2 capture and storage technologies in the Netherlands. *International Journal of Greenhouse Gas Control*, *3*(3), 322–332. Retrieved from http://www.sciencedirect.com/science/article/B83WP-4TS5795-1/2/b91075f64df407db46dfc2d69274fad4

Delmas, M. A., Fischlein, M., & Asensio, O. I. (2013). Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. *Energy Policy*, *61*, 729-739.

Ehrhardt-Martinez, K., Donnelly, K. A., & Laitner, S. (2010, June). Advanced metering initiatives and residential feedback programs: a meta-review for household electricity-saving opportunities. Washington, DC: American Council for an Energy-Efficient Economy.

Eriksson, M. (2010). *Social capital, health and community action: implications for health promotion* (Doctoral dissertation, Umeå university).

European Union, Involving Stakeholders: Toolkit on Organising Successful Consultations, the Civitas initiative, http://civitas.eu/sites/default/files/Results%20and%20Publications/Brochure_STAKEHOLDER_CONSULTATION_web.pdf

Faruqui, A., Sergici, S., & Sharif, A. (2010). The impact of informational feedback on energy consumption—A survey of the experimental evidence. *Energy*, *35*(4), 1598-1608.

Fielding, K.S., Terry, D.J., Masser, B.M., Hogg, M.A., 2008. Integrating social identity theory and the theory of planned behaviour to explain decisions to engage in sustainable agricultural practices. Br. J. Soc. Psychol. 47, 23–48. doi:10.1348/014466607X206792

Fischer, C. (2008). Feedback on household electricity consumption: a tool for saving energy?. *Energy efficiency*, *1*(1), 79-104.

Fishbein, M., Ajzen, I., 2010. Predicting and Changing Behavior: The Reasoned Action Approach. Psychology Press, New York.

Fitzpatrick, G., & Smith, G. (2009). Technology-enabled feedback on domestic energy consumption: Articulating a set of design concerns. *IEEE Pervasive Computing*, *8*(1), 1536-1268/09.

Froehlich, J. (2009, February). Promoting energy efficient behaviors in the home through feedback: The role of human-computer interaction. In *Proc. HCIC Workshop* (Vol. 9, pp. 1-11).

Froehlich, J., Findlater, L., & Landay, J. (2010, April). The design of eco-feedback technology. In P*roceedings of the SIGCHI conference on human factors in computing systems* (pp. 1999-2008). ACM.

Froehlich, J., Findlater, L., Ostergren, M., Ramanathan, S., Peterson, J., Wragg, I., ... & Landay, J. A. (2012, May). The design and evaluation of prototype eco-feedback displays for fixture-level water usage data. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 2367-2376). ACM.

Froehlich, J., Larson, E., Gupta, S., Cohn, G., Reynolds, M., & Patel, S. (2011). Disaggregated end-use energy sensing for the smart grid. *IEEE Pervasive Computing*, *10*(1), 28-39.

Gangale, F., Mengolini, A., & Onyeji, I. (2013). Consumer engagement: An insight from smart grid projects in Europe. Energy Policy, 60, 621-628.

Geelen, D., Reinders, A., & Keyson, D. (2013). Empowering the end-user in smart grids: Recommendations for the design of products and services. Energy Policy, 61, 151-161.

Grünewald, P. H., Cockerill, T. T., Contestabile, M., & Pearson, P. J. (2012). The socio-technical transition of distributed electricity storage into future networks—System value and stakeholder views. *Energy Policy*, *50*, 449-457.

Ham, J., & Midden, C. (2010). Ambient persuasive technology needs little cognitive effort: the differential effects of cognitive load on lighting feedback versus factual feedback. *Persuasive Technology*, 132-142.

Hargreaves, T., Nye, M., & Burgess, J. (2010). Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. *Energy policy*, *38*(10), 6111-6119.

Hargreaves, T., Nye, M., & Burgess, J. (2013). Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term. *Energy policy*, *52*, 126-134.

He, H. A., Greenberg, S., & Huang, E. M. (2010, April). One size does not fit all: applying the transtheoretical model to energy feedback technology design. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp.927-936). ACM.

Hofstede, Geert (2001). Culture's Consequences, 2nd edition, Sage Publications, Thousand Oaks, California.

Horn, M. S., Davis, P., Hubbard, A. K., Keifert, D., Leong, Z. A., & Olson, I. C. (2011, June). Learning sustainability: families, learning, and next-generation eco-feedback technology. In *proceedings of the 10th international conference on interaction design and children* (pp. 161-164). ACM.

Jain, R. K., Gulbinas, R., Taylor, J. E., & Culligan, P. J. (2013). Can social influence drive energy savings? Detecting the impact of social influence on the energy consumption behavior of networked users exposed to normative eco-feedback. *Energy and Buildings*, *66*, 119-127.

Jain, R. K., Taylor, J. E., & Peschiera, G. (2012). Assessing eco-feedback interface usage and design to drive energy efficiency in buildings. *Energy and buildings*, *48*, 8-17.

Karjalainen, S. (2011). Consumer preferences for feedback on household electricity consumption. *Energy and Buildings*, 43(2–3), pp.458–467.

Kamilaris, A., Neovino, J., Kondepudi, S., & Kalluri, B. (2015). A case study on the individual energy use of personal computers in an office setting and assessment of various feedback types toward energy savings. *Energy and Buildings*, *104*, 73-86.

Karlin, B., Zinger, J. F., & Ford, R. (2015). The effects of feedback on energy conservation: A meta-analysis.Psychological Bulletin, Vol 141(6), 1205-1227.http://dx.doi.org/10.1037/a0039650

Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental education research*, *18*(2), 229-250.

Krishnamurti, T., Schwartz, D., Davis, A., Fischhoff, B., de Bruin, W. B., Lave, L., & Wang, J. (2012). Preparing for smart grid technologies: A behavioral decision research approach to understanding consumer expectations about smart meters. Energy Policy, 41, 790-797.

McCalley, L. T., & Midden, C.J. (2002). Energy conservation through product-integrated feedback: The roles of goal-setting and social orientation. *Journal of economic psychology*, *23*(5), 589-603.

McCalley, L. T., de Vries, P. W., & Midden, C. J. (2011). Consumer response to product-integrated energy feedback: Behavior, goal level shifts, and energy conservation. *Environment and Behavior*, *43*(4), 525-545.

Moezzi et al. 2017: Using stories, narratives, and storytelling in energy and climate change research, Energy Research and Social Science, 31, 1-10.

Narayan, D., & Cassidy, M. F. (2001). A dimensional approach to measuring social capital: development and validation of a social capital inventory. *Current sociology*, *49*(2), 59-102.

Natural Resources, 2014, Stakeholder Engagement Guide, https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/engagementguide_eng_12.pdf

Neubert, M. J. (1998). The value of feedback and goal setting over goal setting alone and potential moderators of this effect: A meta-analysis. *Human Performance*, *11*(4), 321-335

Newcombe, R. (2003). 'From client to project stakeholders: a stakeholder mapping approach'', *Construction Management and Economics*, 21(8), 841-8.

Onyx, J., & Bullen, P. (2001). The different faces of social capital in NSW Australia. *Social capital and participation in everyday life*, 45-58.

Paetz, A. G., Dütschke, E., & Fichtner, W. (2012). Smart homes as a means to sustainable energy consumption: A study of consumer perceptions. *Journal of consumer policy*, *35*(1), 23-41.

Park, C. K., Kim, H. J., & Kim, Y. S. (2014). A study of factors enhancing smart grid consumer engagement. *Energy Policy*, *72*, 211-218.

Parker, D., Hoak, D., Meier, A., & Brown, R. (2006). How much energy are we using? Potential of residential energy demand feedback devices. *Proceedings of the 2006 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA*.

Pereira, L., Quintal, F., Barreto, M., & Nunes, N. J. (2013). Understanding the limitations of eco-feedback: a one-year long-term study. In *Human-Computer Interaction and Knowledge Discovery in Complex, Unstructured, Big Data* (pp. 237-255). Springer, Berlin, Heidelberg.

Pereverza, K., Pasichnyi, O., Lazarevic, D. & Kordas, O. (2017).: Strategic planning for sustainable heating in cities: A morphological method for scenario development and selection, *Applied Energy*, 186, 115-125.

Pierce, J., Fan, C., Lomas, D., Marcu, G. and Paulos, E. (2010). Some consideration on the (in)effectiveness of residential energy feedback systems. *Proceedings of the 8th ACM Conference on Designing Interactive Systems - DIS ’10*, [online] p.244. Available at: <http://portal.acm.org/citation.cfm?doid=1858171.1858215>.

Rodgers, J., & Bartram, L. (2011). Exploring ambient and artistic visualization for residential energy use feedback. *IEEE transactions on visualization and computer graphics*, *17*(12), 2489-2497

Romanach L, Contreras Z, Ashworth P. *Australian house holders’ interest in active participation in the distributed energy market: Survey results*. Pullenvale: Report No.: EP133598.

Shariatzadeh, F., Mandal, P., & Srivastava, A. K. (2015). Demand response for sustainable energy systems: A review, application and implementation strategy. *Renewable and Sustainable Energy Reviews*, *45*, 343-350.

Siano, P. (2014). Demand response and smart grids—A survey. *Renewable and sustainable energy reviews*, *30*, 461-478.

Steg, L. (2008). Promoting household energy conservation. *Energy policy*, *36*(12), 4449-4453.

Stern, P. C. (2011). Contributions of psychology to limiting climate change. *American Psychologist*, *66*(4), 303.

Terry, D.J., Hogg, M.A., 1996. Group norms and the attitude-behavior relationship: A role for group identification. Personal. Soc. Psychol. Bull. 22, 776–793.

Terry, D.J., Hogg, M.A., White, K.M., 1999. The theory of planned behaviour: self-identity, social identity and group norms. Br. J. Soc. Psychol. 38 (Pt 3), 225–244. doi:10.1348/014466699164149

Vassileva, I. (2012). Characterization of household energy consumption in Sweden: energy savings potential and feedback approaches (dissertation). *Mälardalen University Press Dissertations*, Sweden

Vassileva, I., Dahlquist, E., Wallin, F., & Campillo, J. (2013). Energy consumption feedback devices’ impact evaluation on domestic energy use. *Applied energy*, *106*, 314-320.

Vine, D., Buys, L., & Morris, P. (2013). The effectiveness of energy feedback for conservation and peak demand: a literature review. *Open Journal of Energy Efficiency*, *2*(1), 7-15.

Wever, R., Van Kuijk, J., & Boks, C. (2008). User-centred design for sustainable behaviour. *International journal of sustainable engineering*, *1*(1), 9-20.

Wood, G., & Newborough, M. (2007). Energy-use information transfer for intelligent homes: Enabling energy conservation with central and local displays. *Energy and buildings*, *39*(4), 495-503.

World Bank, Five steps for iterative consultation, https://www.ifc.org/wps/wcm/connect/5a4e740048855591b724f76a6515bb18/PartOne_Stakeholder Consultation.pdf?MOD=AJPERES

Yang, R., Newman, M. W., & Forlizzi, J. (2014, April). Making sustainability sustainable: challenges in the design of eco-interaction technologies. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 823-832). ACM.

Zachariah-Wolff, J. L. , & Hemmes, K. (2006). Public Acceptance of Hydrogen in the Netherlands: TwoSurveys That Demystify Public Views on a Hydrogen Economy. *Bulletin of Science, Technology & Society,* 26(4, 339–45.

Annex I – Templates to facilitate consultation

consultation plan

Stakeholders: **Identification** Select the stakeholders that have some kind of stake in the pilot from the list below

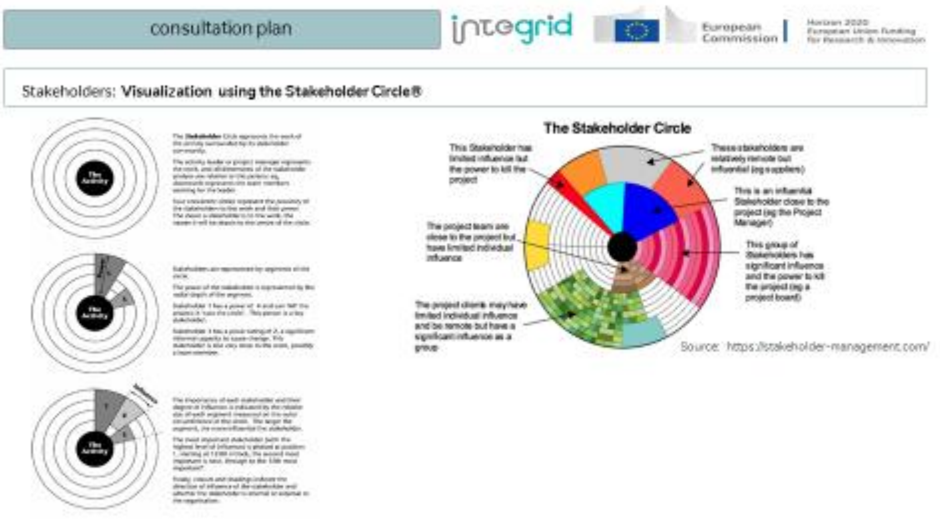
Government/ Authorities	YES /NO	ACCESS FACILITATOR	Businesses/ Operators	YES /NO	ACCESS FACILITATOR	Communities/ Local/Neighborhoods	YES /NO	ACCESS FACILITATOR	Others	YES /NO	ACCESS FACILITATOR
European Union			Utility companies			Environmental NGOs			Research institutions		
Ministry of Energy/Energy Agency			Network operators			Media			Academia, universities		
Regional and local government			Storage developers			Authority forums			Experts		
Politicians			Developers			Community organisations			Foundations		
Regulators			Engineers/contractors			Citizens					
Other decision makers			Retailers			Local interest groups					
Professional staff			Commercial users								

consultation plan

Stakeholders: **Prioritization**

Stakeholders	Power		Attention	
	High	Low	High	Low

[Insert stakeholders in the matrix above according to the criteria]


consultation plan
integrid
European Commission
Stakeholders: Visualization using the Stakeholder Circle®
The Stakeholder Circle
This Stakeholder has limited influence but the power to kill the project
These stakeholders are relatively remote but influential (eg suppliers)
This is an influential Stakeholder close to the project (eg the Project Manager)
The project team are close to the project but have limited individual influence
This group of Stakeholders has significant influence and the power to kill the project (eg a project board)
The project clients may have limited individual influence and be remote but have a significant influence as a group
Source: https://stakeholder-management.com/

consultation plan

consultation objectives	planned consultation points

consultation point XXX

prior knowledge:

objectives	stakeholder response rate target	method

consultation design	timeframe	who by	resource requirements	notes
participation period				
response analysis				
evaluation				

report back

we asked	you said	we did
[insert summary]	[insert summary]	[insert summary]

What happens next?

[insert summary]

Wants to find more? [insert contact details]

Annex II – Questionnaire on environmental awareness and aspects of social sustainability

A Swedish version of the following questionnaire was conducted in Stockhom Royal Seaport, Stockholm, Sweden. A shorter version without repeating questions for most of the scales was conducted in Caldas da Rainha, Portugal.

Instructions to interviewer:

1. Read the introduction.
2. Ask the questions about the variables.
3. Ask the questions in the numbered sections.

a. Do not read the subheadings to the interviewees.
b. In the subsections 2.1 and 3.1, there are many subjects, for example “Group identification (building)” that are measured by three or four similarly-worded questions. The order of these questions should be randomized so that questions measuring the same subject do not follow each other where possible. However, the order of the subsections should be kept so that i.e. each question in 2.1 is asked before starting with the questions in 2.2.
c. The order of the questions in section 2.4 should be randomized.

Variables:

The following variables will be used in the questions.

<your/the building>: see the “Questions to determine the variables” section
<your neighborhood>: name of the neighborhood, for example “Norra Djurgårdsstaden”

Introduction:

This is a survey prepared by Kungliga Tekniska Högskolan (KTH) and will help getting an understanding of the social context to prepare for energy technology interventions in your area.

1. Questions to determine the variables

a. In what type of household do you live? (apartment, row house/chain house, separate house, student room, other: freetext)
b. What type of ownership does your <household type from a.> originally have? (It belongs to a housing cooperation, it is rented, it is self-owned, other:, I don’t know)
c. What type of ownership do *you* have for your <household type from a.>? (I own it , I rent it, I rent it in second/third hand, I am lodger, other: freetext)

<your/the building> =
if(a = apartment && b = housing cooperation) -> “your housing cooperation”
else if(a in (apartment, student room) && b != housing cooperation)) -> “your building”
else -> “your closest neighbors”

2. Group identification, social sustainability

2.1 Group identification, social sustainability

Group identification (building)

1. How important are the people in <your building> to you?

1= not important at all / 7=very important

2. How much do you identify with your neighbors in <the building>?

1= not all at / 7=very much

3. How strong are the ties with your neighbors in <the building>?

1= very weak ties / 7=very strong ties

4. How much do you see yourself as belonging to the people in <your building>?

1= not all at / 7=very much

Group identification (neighborhood)

5. How important are the people in <your neighborhood> to you?

1= not important at all / 7=very important

6. How much do you identify with the people in <your neighborhood>?

1= not all at / 7=very much

7. How strong are the ties with the people in <your neighborhood>?

1= very weak ties / 7=very strong ties

8. How much do you see yourself as belonging to the people of <your neighborhood>?

1= not all at / 7=very much

2.2 Further variables on social sustainability

Trust

9. Do you feel that you can trust people in general, even those that you don't know?

1= no, not all at / 7= yes, completely

10. Do you feel that you can trust people in <your building>?

1= no, not all at / 7= yes, completely

11. Do you feel that you can trust people in <your neighborhood>?

1= not all at / 7= yes, completely

Safety

12. Do you feel safe in and around <your building>?

1= no, not all at / 7= yes, completely

13. Do you feel safe in <your neighborhood>?

1= not all at / 7= yes, completely

Social bonds/network in the neighborhood

14. Is it common at the place where you live that neighbors talk to each other when you meet?

1 = not common all at / 7=very common

2.3 Questions with different scales

Social bonds/network (continued, with different scale)

15. Take a stand for the following statements of how you think it is in the place where you live?

Where I live...

a. ... care about each other
b. ... are you prepared to help each other
c. ... you have "insight into each other's life"
d. ... you take responsibility for each other's children
e. ... you are expected to be engaged in questions concerning the area

1 = Too much / 2= Moderate / 3 = Too little

16. What people do you think you have a good social relationship with, i.e. which persons belong to your social network?´

a. The family
b. Relatives
c. Friends
d. Neighbors
e. Work/peers
f. Others: *free text*

Please motivate your response:

1=yes / 2=no / 3=has none/not current to me

17. How many neighbors do you think you know where you live?
Give an exact number, or pick a range:

1 = none / 2 = 1-3 / 3 = 4-6 / 4 = 7-10 / 5 = 11-15 / 6 = more than 15

18. How often do you hang out with any of your neighbors?

1=daily/almost daily / 2=some time/week / 3=some time/month / 4= some time/year / 5=never

2.4 Place attachment

On a scale from 1 = I completely disagree / 7 = I completely agree, answer the following questions:

19. <My neighborhood> is the best place for what I like to do.
20. I feel like <my neighborhood> is part of me.
21. Everything about <my neighborhood> reflects who I am.
22. I am more satisfied in <my neighborhood> than in other places.
23. I identify myself strongly with <my neighborhood>.
24. <My neighborhood> is not a good place for what I enjoy doing.
25. There are better places to be than <my neighborhood>.
26. <My neighborhood> reflects the type of person I am.

2.5 Sharing economy

27. Has your household lended/rented out or borrowed/rented to/with your neighbours, or used a sharing pool to get hold of, any of the following items during the last 12 months?
1 = lended/rented out, 2 = borrowed/rented, 3 = used a shared resource, 4 = no.

a. Clothes
b. Toys
c. Tools
d. home appliances
e. computer/tablet/mobile
f. tv/video/dvd/stero
g. bicycle
h. car or other motor vehicle

3. Part 2 – Energy

<u>Predict energy savings (connect TpB & social identity theory)</u>

Attitudes

28. I feel that saving energy at my household is
- *Good (1=extremely bad to 7=extremely good)*
- *Wise (1= unwise to 7=wise)*
- *Beneficial (1=not at all beneficial to 7 =very beneficial)*
- *Pleasant (1=unpleasant to 7=pleasant)*
- *Satisfying (1=unsatisfying to 7 =very satisfying)*
- *Favourable (1=unfavourable to 7=very favourable)*

3.1 Social norms, group norms, TPB

Subjective social norms

29. If I save energy at my household people who are important to me would

1 = disapprove, 7 = approve

30. Most people who are important to me think that saving energy at my household would be

1= undesirable, 7 = desirable

31. Most people who are important to me think that I <*variable*> save energy in my household

1= should not, 7 = should

Perceived group norms building

32. How many of the people in <your building> would think that saving energy in your household is a good thing?

1=very few, 7 = most

33. How likely is it that people in <your building> save energy in their household?

1=very unlikely, 7 = very likely

34. How much agreement is there in <your building> that saving energy in the household is a good thing to do?

1=very little agreement, 7= a great deal of agreement

Perceived groups norms neighborhood

35. How many of the people in <your neighborhood> would think that saving energy in your household is a good thing?

1=very few, 7 = most

36. How likely is it that people in <your neighborhood> save energy in their households?

1=very unlikely, 7 = very likely

37. How much agreement is there in <your neighborhood> that saving energy in the household is a good thing to do?

1=very little agreement, 7= a great deal of agreement

Perceived behavioral control

38. How much control do you have over saving energy at your household?

1= very little, 7 = a great deal of control

39. For me, to save energy at my household is

1=very difficult, 7 = very easy

40. My knowledge about possible ways to save energy in my household is

1=very low, 7 = very high

Past behaviour

41. How much effort have you been putting in saving energy at your household?

1= none at all, 7 = a lot

42. How much time and labour have you been putting in saving energy at your household?

1=none at all, 7 = a lot

3.2 Self-reported behaviour, behavioural intention

Self-reported behaviour t0

43. To what extent do you save energy in your household?

1=not at all, 7=a lot

Behavioral intention

44. I plan to save energy in my household over the next 6 months.

1=strongly disagree / 7=strongly agree

3.3 Further information on energy behaviour

Energy use in the household

45. Has your household ordered environmentally certified electricity from your energy company?

Yes/no/don't know

46. Have you done any actions to save energy in your household? If so, which actions, and how often do you carry them out? *often / occasionally / never*

<Let the respondent answer in freetext first to capture what options he/she is aware of. Then list those of the following options that the respondent has not already mentioned>

a. Turned off lights when not needed
b. Turned off the TV instead of using the standby mode
c. Bought energy efficient home appliances
d. Set a correct temperature in fridge/freezer and defrosted them regularly
e. Lowered the indoor temperature
f. Added insulation to windows or walls
g. Lowered the consumption of hot tap water
h. Other: *free text (if respondent has got inspired by the given options and remember other versions)*

often / occasionally / never

Load-shifting

47. Assume that you own a washing machine and usually wash your clothes during the afternoon when the electricity consumption is high in your area. Would you instead wash your clothes during the night if you knew that it would…

a. … save you money due to a cheaper electricity price?
b. … be good for the environment due to less polluting electricity production?

1=extremely unlikely, 7=extremely likely

Why / Why not? <freetext>

LocalLife

48. Do you use

4. Demographic questions

1. Which year are you born?
2. What is your gender: M/F/O

3. How many other people (excluding yourself) are living in the household?

a. How many small children (0-6 years)
b. How many children (7-12 years)
c. How many teenagers (13-17 years)
d. How many young adults (18-29)
e. How many adults (30-39)
f. How many adults (40-49)
g. How many adults (50-64)
h. How many adults (65-)

4. How large is the floor area of your household (m2)
5. Which is your highest completed education (grundskola, gymnasium, universitet/högskola)
6. What is your main occupation (employee, self-employed, student, retired, sick leave, parental leave, searching for job, home/taking care of household, other)
7. In which country were you born?
8. In which country have you mainly grown up?
9. How would you describe your household's current income?
   1. Finding it very difficult to live on current income
   2. Finding it difficult to live on current income
   3. Coping on current income
   4. Living comfortably on current income
   5. Living very comfortably on current income