Synthesis of S3C Deliverable 1.1:
Report on state-of-the-art and theoretical framework for end-user behaviour and market roles.

This document presents a short and comprehensive synthesis of the S3C Deliverable 1.1. For the full report see http://www.s3c-project.eu/Deliverables.html or click **here**. The **S3C project** belongs to a new, consumer-centric generation of smart grid projects giving centre stage to the energy end-users in households and small commercial/industrial entities. The project aims to provide a better understanding of the relationship between the design, implementation and use of particular technology and user interaction schemes and the promotion of 'smart' energy end-user behaviour. To this end, S3C Deliverable 1.1 describes a variety of insights on **end-user engagement in smart grid projects** from a theoretical and from an empirical perspective.

This synthesis aims to integrate those findings into a consistent view on what can be considered good practice for end-user interaction in smart grid projects, as currently known, and to sketch out the implications for further research. To this end, it starts with a recapitulation of the key findings in the report from a **theoretical and empirical perspective** (**Section 1**). Following, it summarizes the **enablers and barriers** for engaging in smart energy behaviour (**Section 2**) and the **recommendations or 'success factors'** for end-user interaction (**Section 3**) as reported in the current literature. Finally, it identifies a number of **key challenges for the research and development** regarding end-user engagement in smart grid projects **(Section 4)** and describes what that implies for S3C research (**Section 5**).

1. Recapitulation

Theoretical perspective

From the theoretical perspective, we found that various theories exist that can be used to frame and analyse end-user behaviour. One can roughly distinguish two schools of thought: the psychology oriented approaches take individual decision-making as a starting point, while the sociology oriented approaches draw attention to the influence of social structure. Following Giddens' structuration theory, some theories aim to bridge these two lines of thought, with practice theory and societal transitions theory as two key examples.

End-user energy behaviour is thus influenced by a broad range of both behavioural and situational factors. Behavioural factors include 'rational' factors (like financial gains), non-monetary motivators (like beliefs, values, habits, and routines), social influences (like norms and leadership), and personal capabilities (like knowledge, skills, and financial means). Situational factors, amongst others include institutional factors (laws, and regulations), culture, infrastructure and social networks that may equally influence energy behaviour. This implies that a nuanced view on end-user behaviour is required, taking both behavioural and situational factors into account.

Considerations on end-user energy behaviour must take both behavioural and situational factors into account.

Recent literature particularly highlights energy related practices as key to understanding and influencing smart energy behaviour. Practices are said to reside at the 'interface' of individual behaviours and social structure, as these behaviours are the product of, and also reinforce, social structure. According to practice theory, energy is not used consciously or rationally, but rather as the 'byproduct' of practices like cooking, washing, showering, working, commuting, watching TV, socialising, and travelling. Such practices are often driven by routines and socially shaped expectations. Smart grid programs would benefit from a thorough understanding of the energy related practices of their target groups.

Smart Grid programs must strive to understand the energy related practices of their target groups.

End-users differ on the practices they adhere to and on the extent to which the situational and behavioural factors mentioned above influence their energy related behaviour. Strategies for involving end-users should thus depart from a thorough understanding of the target group, for example by applying a segmentation approach. Current segmentation models can roughly be divided into models based on general values, preferences and opinions ('population segmentation models') and models that are tailored to specific (smart grid) products and programs and/or regions ('target group segmentation models'). They classify end-users generally on the basis of socio-demographic criteria (age, household, income and education level), behavioural factors (preferences, beliefs, values, norms) and more recently also on the basis of energy-related behavioural characteristics.

To actively engage with end-users, a number of further principles for communication and engagement apply. These are reflected in key (social) marketing models like the 4P's marketing mix (product, price, promotion, place), the AIDA model (attention interest, desire, action), Cialdini's principles of influence (reciprocity, commitment, social proof, liking, authority, scarcity), and Defra's 4E model (enable, encourage, engage, exemplify). A mix of solutions is generally recommended to 'serve' different user types. In addition, communications theory emphasises that an effective communication strategy needs to consider the following key components: the sender (make clear who is communicating), the target group (to whom is communications addressed?), the aim (make explicit why one is communicating), the message (content and form need to be adapted to the target group), the timing (when should the message be delivered?) and the communication channels (which ones are used by the target group?).

Empirical perspective

These findings are largely consistent with, and complementary to, the findings from empirical literature. Different types of incentive based programs are described to engage with end-users in demand response. These may be 'classical' or 'market-oriented', comprising monetary and/or non-monetary incentives, and which could be operated on a capacity and/or use oriented mode. End-user questionnaires reveal that financial benefits, reliability, comfort, and the level of control over appliances are some of the key factors taken into account when deciding to enrol in such programs.

Alternatively, dynamic pricing schemes may be used. Various tariff structures may be offered for which different levels of peak clipping and reduction of the energy bill have been reported. To better compare the different tariffs structures, we identified several key attributes, including the rationale of the scheme, the number of time blocks used, the price update frequency, duration of peak periods, rates and rebates offered, the price spread, the price components that are made dynamic, and whether automated or manual control is applied. Further key lessons include the need for a variety of tailored interventions to address different user segments and the need for convincing feedback mechanisms and communication and engagement strategies to make dynamic pricing 'work'.

Feedback on energy consumption forms a key component of an end-user interaction scheme. Regarding feedback channels and devices, various options can be used. Most experience has been gained with in-home displays, but also others channels like websites, ambient displays, informative billing, and smartphone apps are equally promising and rapidly developing. Considering the influence of the feedback channel (and its design) on energy use behaviour, a suite of factors play a role. As a general finding, mixed feedback channels are considered best suited to address a heterogeneous end-user population.

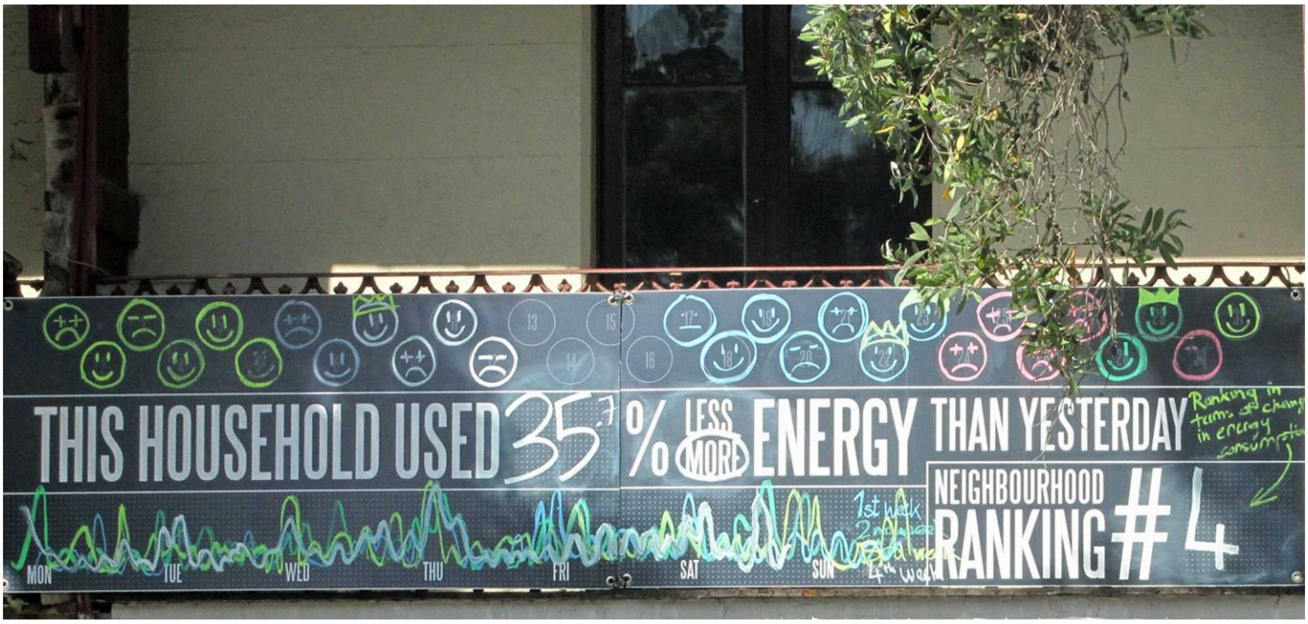

Figure 1: Energy feedback through neighbourhood comparison in the Neighbourhood Scoreboards project in Sydney ("Smart energy home" by Newtown grafitti is licensed under CC BY 2.0)

Concerning feedback content, different types of information can be delivered to the end-user, including current and expected usage rates, bill predictions, historical comparison, differentiation by appliance, unusual usage alerts, social feedback (comparison with others) etc. It tends to be difficult to assess which type 'works best' with partially contradictory empirical results. Nonetheless, direct feedback (e.g. real-time and historic usage) tends to be somewhat more effective than indirect feedback (e.g. processed via billing), and also social feedback appears relatively effective. Other general recommendations include linking feedback directly to advice on actions and ensuring that feedback is interactive and sufficiently disaggregated.

Regarding communication and engagement, training end-users and installers, innovative customer service and support (e.g. using social media), appropriate communication channels, face-to-face interaction and the need for continuous information are highlighted to generate long-term end-user interest and involvement.

Concerning data privacy, the literature stresses three important points: data minimization, transparency, and end-user empowerment (adequate information and permission requests). In addition, appropriate technical measures need to be taken to ensure data security.

Regarding energy markets, the literature describes new market structures and services that can be developed in an unbundled market and in a smart grid framework.

Although being largely uncharted territory, the concept of aggregation has emerged as a key contributor to these new energy markets. Aggregators enable small loads to participate in the market which would not be accessible for them otherwise. They typically take an intermediary role between end-users and other market players on a multi-sided platform. They commercialize the aggregated flexibility from the end-users to the other market players. This aggregated flexibility can provide a number of services to the different market players, like offering reserve capacity (for TSOs), distribution system congestion management (for DSOs), portfolio management (for BRPs and retailers), and energy usage monitoring and optimization (for end-users).

Definition Aggregator:

An actor that aggregates the flexibility of a cluster of flexible devices and/or decentralized generation and manages this flexibility. The aggregator bundles the small amounts of flexibility to qualify as grid- or market-oriented services. Depending on the market configuration, the aggregator may have different tasks and responsibilities.

Such innovative business models currently remain largely untested (partly due to uncertainties under the current regulatory framework), but they will most probably become increasingly important over the coming years. Important will be to further our understanding of end-user preferences in this context, for example, regarding what their offered flexibility is used for (e.g. balancing of the local network, balancing energy consumption and micro-generation in their own home or balancing the general, 'anonymous' energy market) or regarding the actors taking up the role of the aggregator.

Recent developments in the telecommunication and mobile phone industry provide a number of additional relevant lessons learned. These include thinking about new business models (e.g. tying arrangements) and thinking serious about usability (e.g. simple, self-learning devices), design (devices that fit into every household) and marketing (e.g. emphasising lower energy costs and more comfort, and creating 'cool' lifestyles around products that fulfil the need for distinction). Furthermore, example projects in the field of energy monitoring and management of offices show how automated systems That reduce energy consumption can be developed, while minimizing the need for behavioural change on behalf of the end-user.

2. Enablers and barriers for engaging in smart energy behaviour

So what do the theoretical and empirical insights tell us about smart energy behaviour? We first note that smart energy behaviour includes behaviours at different levels of consciousness, ranging from habitual to conscious and one-shot behaviour (Aarts, Verplanken, & Van Knippenberg, 1998). Energy related practices as such - like washing, cooking, heating etc. – can typically be considered habitual. However, behaviours towards a change of practices - like deciding whether to engage in a smart grid project and / or to buy smart appliances - are rather conscious or even one-shot.

Figure 2 presents this view in a highly stylized manner. The process of end-user engagement in smart grid programs and their consequent interaction with new technologies, feedback and pricing schemes (i.e. the ‘end-user interaction scheme’) is interpreted as a process of practice change towards a higher level of ‘smartness’. At the start of the process, it is assumed that end-users carry out their energy related practices in a rather habitual manner. As end-users become engaged in a smart grid program, they are stimulated towards more conscious decision-making. This phase can be considered rather ‘disruptive’, as existing practices need to be reconsidered and redefined, In this ‘activation phase’, end-user interaction is targeted typically at achieving active end-user participation and an explicit consideration of old and new practices. As new practices are adopted, behaviour becomes again more habitual. End-user interaction is then more aimed at supporting and reinforcing the new energy practices (‘continuation phase’).

Here, we focus on reported key enablers and barriers that seem to be of importance in the ‘activation’ and ‘continuation’ phases of end-user interaction. Literature reports on a variety of factors end-users consider when deciding whether to engage in (and continue with) a smart grid program. These factors can be classified as either enablers (reasons why end-users may be tempted to engage) or barriers (reasons why they would not)[1]. Table 1 presents an overview of the various possible enablers and barriers listed in the literature. They are grouped under the categories (in alphabetical order) *comfort, control*, *environment*, *finance*, *knowledge & information*, *security*, and *social process*. Interestingly, for most categories both enablers and barriers can be identified:

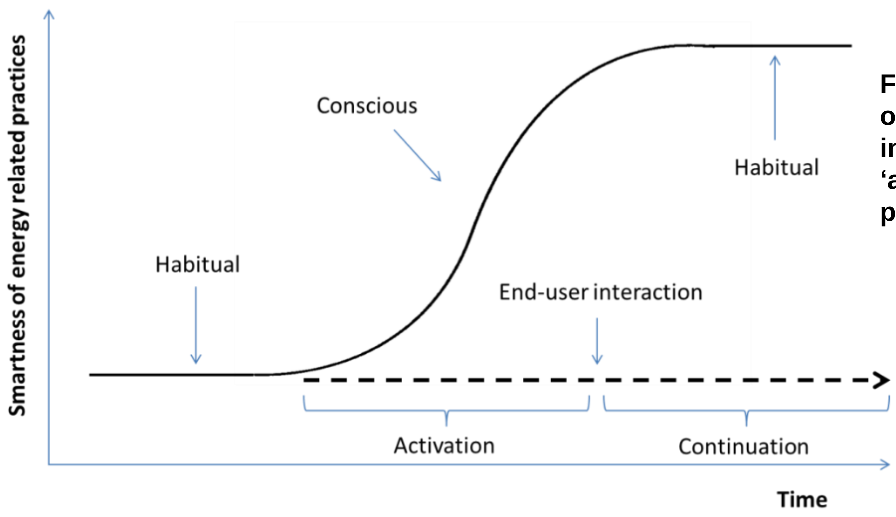

Figure 2: A stylized interpretation of the process of end-user-interaction distinguishing an ‘activation’ and ‘continuation’ phase.

[1] Although generally meaningful, this distinction needs to be interpreted with care. What can be considered an ‘enabler’ or ‘barrier’ can be context dependent, and dependent on the perspective of the end-user.

- ***Comfort*:** Possible loss of comfort is an often mentioned barrier (e.g. Prüggler, 2013). Smart grid technology may also increase levels of comfort, also mentioned as a potential enabler as such.
- ***Control*:** An often mentioned barrier to engagement is the perceived loss of control over appliances, as automated control algorithms 'take over' appliances[2] (Verbong, 2013; Bartusch 2011). Smart grid technology, however, may also extend the possibilities for control, for example, through more advanced possibilities for controlling appliances (e.g. using mobile devices), extended possibilities to participate in the electricity market (e.g. JRC, 2011) and possibilities for becoming more energy independent ('energy autarky').
- ***Environment*:** The environmental benefits of smart grid development - reducing greenhouse gas emissions by integrating renewables into the grid – is a reported key benefit end-users may strongly care about (e.g. SGCC, 2013).
- ***Finance*:** It is clear that financial or 'in kind' incentives and the expectation of a reduced energy bill may be clear enablers for engaging in smart grid programs (e.g. Verbong, 2013; SGCC, 2013;JRC, 2011; Prüggler, 2013). On the other hand, engagement may also require investment costs for smart appliances and may also lead a higher energy bill for end-users requiring electricity at peak times.
- ***Knowledge & information*:** More transparent and frequent billing information and detailed knowledge about energy use by different appliances are considered a key benefit for end-users engaging in a smart grid program (e.g. JRC, 2011). Yet, the lack of adequate knowledge and information provision about the smart grid program may act as a barrier (e.g. EEA, 2013). Additional barriers in this category are lack of competences to deal with new technologies or to negotiate with energy suppliers (e.g. EEA, 2013), a lack of awareness about the concept 'smart grid' and its potential gains (e.g. SGCC, 2013; Bartusch, 2011) and perceived risks like the (supposedly) adverse health effects of wireless signals (e.g. SGCC, 2013; Bartusch, 2011).
- ***Security*:** A typical security issue is improved reliability, often mentioned as an important advantage (e.g. JRC, 2011; SGCC, 2013). On the other hand, privacy and security concerns are reported as potential barriers (e.g. Verbong, 2013; SGCC, 2013).
- ***Social process*:** The positive stimuli social processes may provide are mostly reported as enablers of end-user engagement. This concerns, for example, the stimulating effect of role models (EEA, 2013) and customer testimonials (SGCC, 2013), and the 'community feelings' and sense of competition that smart grid programs may appeal to (Verbong, 2013), basically making participation 'fun'[3]. To some extent, social values are also reported as barriers, for example through 'free rider effects' (JRC, 2011) (creation of a sense of unfairness, because non-participants of the smart grid also benefit from peak shaving) or job losses (SGCC, 2013) (as meter readers will no longer be needed) end-users don't want to be responsible for.

[2] A basic recommendation given is to always include possibilities to interfere / overrule automatic procedures (e.g. Verbong, 2013).

[3] As was stressed by one of the members of the S3C advisory board.

Table 1: Possible enablers and barriers of end-user engagement in smart grid projects listed in the literature

Category	Enablers	Barriers
Comfort	Comfort (gain)	Comfort (loss)
Control	More energy independence (‘energy autarky’) Extended possibilities to participate in the electricity market More advanced control of appliances, e.g. using mobile devices.	Loss of control over appliances
Environment	Environmental benefits	
Finance	Financial or in kind incentives Reduction of the energy bill	Investment costs Increased energy bill
Knowledge & Information	More transparent and frequent billing Detailed knowledge about electricity use	Unclear information about the smart grid program (technologies / incentives / pricing schemes) Lack of competences, e.g. to deal with new technologies or to negotiate with energy suppliers Lack of awareness about the concept ‘smart grid’ and its potential gains Perceived risks, e.g. adverse health effects
Security	Improved reliability of energy supply	Privacy and security concerns
Social process	Role models Customer testimonials Community feelings Competition Fun	Free rider effects Job losses

3. Recommendations for successful end-user interaction schemes

This section aims to integrate the theoretical and empirical findings further into a consistent view on what can be considered successful end-user interaction in smart grid projects. To this end, we have classified the various recommendations from literature into a set of key success factors supported both by empirical findings and established theoretical insight. We thereby distinguish success factors that are applicable mostly to the **activation phase (Table 2)** and ones that are mostly applicable to the **continuation phase (Table 3)**. The column ‘empirical findings’ in these tables contains illustrative examples for the corresponding success factor drawn from the empirical section of this report. The column ‘theoretical concepts’ provides corresponding concepts from the theoretical section.

For the **activation phase**, we arrive at the following key success factors:

- ***Provide added value***: This corresponds broadly with providing clear added value on the various categories of enablers of Table 1, while relieving barriers as much as possible. This includes, for example, applying attractive financial incentives, ensure comfort gains rather than losses, providing new information services, ensuring data privacy and security, and include possibilities to overrule automatic procedures while offering new forms of end-user control. Corresponding theoretical notions include considering Product & Price (4P model), Exchange (Social Marketing), Encouragement (4E model) and Rational appeals (Breukers’ (2009) tools for change concerning energy investments).
- ***Understand end-users***: Different target groups may be susceptible to very different enablers and barriers. The challenge is thus to understand which ones are of particular relevance, and to base engagement strategies on that. Understanding the end-user is indeed strongly support in the empirical literature, for example, in the recommendations to apply segmentation (SGCC, 2013; JRC, 2011), to take into account a broad scope of behavioural determinants (EEA, 2013), to have a special focus for low income / vulnerable groups (SGCC, 2013; JRC, 2011), and to understand social practices and daily routines in a social context (Verbong, 2013). Corresponding theoretical notions include, for example, the need for ‘Customer orientation’, ‘Theory’, ‘Insight’, and ‘Segmentation’ (Social Marketing).
- ***Educate end-users***: Relieving possible knowledge & information barriers will involve some form of education as programs need to take into account consumer (non-)ability to deal with new technology (EEA, 2013). Corresponding recommendations in this context include educating end-users before deployment (e.g. explaining how to shift usage to off-peak demand hours) (SGCC, 2013) and providing training to end-users and installers (Erhart-Martinez 2010; Darby, 2006; Lewis et al., 2012; Dong Energy, 2012). Theory equally stresses the importance of education, for example, to Enable end-users’ to adopt new practices (4E model) and by providing transparent and understandable information & training (Breukers, 2009).
- ***Create commitment & appeal***: Creating commitment & appeal involves taking full advantage of social processes as important enablers. This may include ensuring trust in the whole smart grid process (JRC, 2011), involving end-users at early project stages allowing a choice of involvement level (JRC, 2011), involving role models respected by the selected group (EEA, 2013), believable customer testimonials (SGCC, 2013), and dealing with possible free-rider effects (JRC, 2011). Creating commitment & appeal also requires effective marketing and outreach (JRC, 2011) to create a ‘desire’ for new products, for

example by emphasising key benefits and creating new lifestyles around products. Corresponding theoretical notions can be found, for example, in the importance of the factor Engagement (4E model), Cialdini's principles (Social Proof, Liking, Authority, Reciprocity, Commitment, Scarcity), and the need for consequent attention, interest, desire and action (AIDA model).

Table 2: Success factors for end-user engagement described in the literature for the activation phase.

Success factor	Empirical findings	Theoretical concepts
Provide added value	Attractive financial incentives Comfort gains rather than losses New information services Data privacy and security Allow automatic procedure overruling	Product, Price (4P) Exchange (Social Marketing) Encourage (4E) Rational appeals (Breukers, 2009)
Understand the end-user	Apply segmentation Consider broad scope of behavioural determinants Special focus low income / vulnerable end-users Understand social practices, daily routines and social context	Customer orientation, Theory, Insight, Segmentation (Social Marketing)
Educate the end-user	Consider consumer (non-)ability to deal with new technology Educate end-users before deployment Provide training	Enable (4E) Transparent and understandable information & training (Breukers, 2009)
Create commitment & appeal	Establish trust in the whole process Early end-users involvement Role models Customer testimonials Deal with free-rider effects Effective marketing and outreach Emphasising key benefits Creating lifestyles around products	Engage (4E) Build trust and confidence, Emotional appeals (Breukers, 2009) Reciprocity, Commitment, Social Proof, Liking, Authority, Scarcity (Cialdini) Promotion (4P) Competition (Social Marketing) AIDA model

In the **continuation phase**, the following factors appear particularly relevant:

- ***Effective feed-back, pricing & communication:*** A lot is known about which factors need to be considered when designing effective feedback and pricing schemes. For feedback, this involves, for example, considering direct and indirect feedback, interactive and disaggregated feedback and linking feedback directly to advice on action. For pricing, this involves taking into account various attributes of tariff structures – i.e. the rationale of the scheme, the number of time blocks used, the price update frequency etc. - previously mentioned under Section 1 (Empirical perspective). Regarding communication, it is particularly important to ensure a continuous information flow to maintain high engagement levels. Moreover, it is considered promising to link dynamic pricing, convincing feedback mechanisms and communication strategies to achieve an optimal response. Related theory includes, for example, communications theory that highlights the sender, target group, aim, message, timing and communication channels as key factors to consider in a communications strategy.
- ***Variety of intervention methods***: Although understanding of the end-user is key, there are limitations on the extent to which 'tailor made solutions' can be offered, especially for a heterogeneous target group. Several studies therefore also stress the need for adopting a variety of intervention methods and techniques to serve different user types. This includes, for example, adopting a variety of feedback information and channels (Lewis et al., 2012) and adopting a variety of tailored dynamic pricing schemes to address different user segments (Breukers & Mourik, 2013).
- ***Ease of use****:* User-friendly, intuitive designs are considered important to minimize effort needed for operating new devices and schemes (i.e. to minimize knowledge & information barriers perceived by end-users). Ease of use also includes adequate and pro-active support and service, e.g. by 'anticipating and answer questions before customers ask them' (SGCC, 2013). Support and service may actually benefit from user-friendly, intuitive designs, for example by using social media for support services (Dong Energy, 2012). These practical recommendations correspond to the tool 'provide support and services' (Breukers, 2009) and also to the factor Enable (4E model).
- ***Social comparison***: It is generally considered stimulating to allow end-users to compare their (new) energy behaviours to peers. Besides setting individual energy-saving targets (EEA, 2013), this thus involves comparing those targets (and their fulfilment) to others. The case for social comparison is reflected, for example, in recommendations to appeal to the competitive nature of people (Verbong, 2013) and in the perceived effectiveness of social feedback for influencing behaviour (Lewis et al., 2012).
- ***Reflection & learning***: Smart grid innovations can be considered 'complex', involving many connections to other domains and scale levels and significant uncertainties on technical, social and other dimensions. Reflection and learning is therefore needed, starting in the activation phase and continuing throughout the continuation phase. This could involve, for example, eliciting end-users' expectations at the start of the process and evaluating their experiences later on, possibly fine-tuning interaction schemes when needed. On the project level, monitoring and evaluation cycles may be incorporated to further update, upscale and replicate project designs and offerings (see e.g. NSMC (2011). Also, letting initiatives be part of a wider programme with clear objectives can be stimulating for end-users (EEA, 2013). All in all, smart grid innovation projects may function as 'niches' (see e.g. Rotmans, 2005) in

which end-users, suppliers, designers and other actors collaborate and co-create knowledge in the further development of the smart grid.

Table 3: Success factors for end-user engagement described in the literature for the continuation phase.

Success factor	Empirical findings	Theoretical concepts
Effective feed-back, pricing & communication	Consider direct and indirect feedback, interactive and disaggregated feedback and linking feedback directly to advice on action. Consider attributes like the rationale of the scheme, the number of time blocks used, the price update frequency etc. Ensure a continuous information flow. Link feedback, pricing and communication strategies	Communications theory: take into account sender, target group, aim, message, timing and communication channels
Variety of intervention methods	Variety of feedback information and channels Variety of tailored dynamic pricing schemes	
Ease of use	User-friendly, intuitive designs Pro-active support and service (e.g. using social media)	Enable (4E) Provide support and services (Breukers, 2009)
Social comparison	Individual energy saving targets Appeal to the competitive nature of people Social feedback	
Reflection & learning	Elicit and follow-up end-users' expectations Monitoring and evaluation cycles Position initiatives within a wider programme with clear objectives Co-creation of knowledge	Societal transitions Social Marketing

A previous version of this classification of success factors was tested in a meeting with smart grid experts on the S3C advisory board. Participants were asked to brainstorm about what to do and what not to do when involving end-users. The results (see the Appendix in the full report) indicate that understanding and educating the end-user were seen as the most crucial factors for success or (when inadequate) failure. Additional attention points included creating commitment & appeal, the co-creation of knowledge, and adequate communication and feedback.

We thus arrive at a rather extensive list of suggestions for end-user-interaction. We stress that this list is not to be interpreted as a blue print, but rather as an overview of factors that need to be considered when designing or evaluating an end-user-interaction scheme.

4. Key challenges for (research on) end-user engagement in smart grids

Given what is currently known, what are the key ‘unknowns’? In this section, these unknowns are formulated as key challenges that can be identified for (research on) end-user engagement in smart grid projects. Reflecting back on Figure 2, the overall question S3C addresses may be formulated as: “how to contribute to smarter energy behaviour”? In other words, how to break ‘old’ routines and practices of energy use, and support the development and new ‘smarter’ ones? Within this scope, S3C defines a number of concrete challenges it will address in its further research:

A 1st challenge relates to **identifying and targeting specific end-user groups**. Although the overall scope of potential enablers, barriers and success factors for end-user engagement is relatively clear (see Table 1, Table 2 and Table 3), it is yet largely unclear how these should be related to the different type of end-users that may be targeted. End-user segmentation is one of the approaches that may be further developed in this respect. The challenge is thus to find instruments or approaches that contribute to achieving better understanding of the enablers and barriers of target groups and the type of end-user interaction scheme best suited to them.

A 2nd challenge relates to the **added value of smart grid related products** from the perspective of the end-user. The current energy system in Western Europe operates with few flaws. End-users are used to being able to use electricity whenever they see fit. The risk with DSM programs is being perceived as ‘demanding’ a lot from customers (in return to reduction of price), rather than a project that makes an interesting offer (for which end-users would be even willing to pay). In that sense, smart grid technology is a challenging technology to ‘sell’. The challenge is thus to find innovative products and services that provide clear added value to end-users, while contributing to fostering smart energy behaviour.

Further challenges (3-4) relate to **available knowledge on the effects of end-user interaction schemes**. Although some research has been done on for example the effect of feedback and dynamic pricing on energy use, peak clipping, empirical evidence on the effectiveness of the various engagement schemes remains weak. Notably, further research is needed to assess the effect of combinations of approaches and to identify critical success factors. The challenge is thus to understand both which (monetary or non-monetary) incentives and pricing schemes, as well as feedback information and feedback channels contribute to fostering smart energy behaviour.

A 5th key challenge relates to the **use of communication channels, information and marketing techniques**. Although a number of general recommendations on communication and information provision can be given, empirical evidence on the effect of communication and information on smart energy behaviour remains weak. Moreover, although the field of marketing has shown the added value of applying marketing techniques, actual use of such techniques in smart grid projects remains weak. The challenge is thus to better understand which communication channels, information and marketing techniques contribute to recruitment and engagement of end-users in smart energy projects.

A 6th key challenge relates to the **cooperation between stakeholders**. Current smart grid projects may include various actors other than the traditional energy players. It is as yet unclear how this involvement of non-energy players may influence end-user engagement. The challenges are thus to understand to what extent involvement of non-energy stakeholders contributes to end-user engagement and smart energy behaviour.

A 7th key challenge relates to the **end-users as initiators of projects**. Whereas the literature describes a variety of results on end-user involvement, relatively little is reported on 'bottom-up' projects in which end-users are initiators and 'owners' of the project. In S3C terms, most projects place end-users in a Consumer or Customer role and were initiated by other stakeholders than citizens usually incentivized by a European/national/regional funding opportunity. Yet, very few projects are reported on that place end-users in a Citizen role. Here, combining smart grid research with research on smart cities seems promising, as the latter does tend to place the end-user in a more central role. The challenge is thus to find instruments or approaches that contribute to facilitating end-user empowerment (from consumer to customer and/or citizen).

An 8th key challenge relates to the **new market structures and the role of end-users in those structures**. Although a number of projects have addressed this issue, further testing is needed. A specific issue is how to ensure legislation and regulation supports, rather than hamper, smart grid development. Another issue is to develop new interpretations of the role of customers, as well as the market entry of completely new actors and roles that lead to new interactions and innovative value chains in the energy system. In particular, a tailored approach to different end-user segments will require that the end-users provide a lot of information of a potential 'sensitive' nature (e.g. regarding lifestyles, values, preferences, etc.). The issue of trust is thus of particular importance when designing new market structures. All in all, the challenge is thus to understand which features of the interaction between end-users and energy market structures contribute to end user engagement and smart energy behaviour.

A 9th key challenge relates to **up-scaling and replicating pilot projects involving a diverse end-user group**. Although significant experience exists with pilot projects, little experience has been gained in larger scale roll-outs. Findings from pilot projects - often targeting specific end-user groups (e.g. 'early adopters') - can not a priori be transferred to the case of larger scale roll-outs dealing with a much more diverse audience. In particular when engaging with the typical 'indifferent', 'vulnerable' or 'stalled starters', specific criteria will apply, such as making the technology highly accessible, and working with very easy to understand messages. The challenge is thus to understand which issues hamper and/or facilitate up-scaling or replication of smart energy projects.

Key challenges:

1. Understanding the target group(s): Which instruments or approaches contribute to achieving better understanding of the enablers and barriers of target groups and the type of end-user interaction scheme best suited to them?
2. Products & services: How / in what way can innovative products and services provide clear added value to end-users, while contributing to fostering smart energy behaviour?
3. Incentives & pricing schemes: Which (monetary or non-monetary) incentives and pricing schemes contribute to fostering smart energy behaviour?
4. End-user feedback (system communication): What feedback information and which feedback channels contribute to fostering smart energy behaviour?
5. Project communication: Which communication channels, information and marketing techniques contribute to recruitment and engagement of end-users in smart energy projects?
6. Cooperation between stakeholders: Does involvement of non-energy stakeholders contribute to end-user engagement and smart energy behaviour?
7. Bottom-up support: Which instruments or approaches contribute to facilitating end-user empowerment? (from consumer to customer and/or citizen)
8. New market structures: Which features of the interaction between end-users and energy market structures contribute to end user engagement and smart energy behaviour?
9. Scalability / replicability: Which issues hamper and/or facilitate up scaling or replication of smart energy projects?

Comparing these challenges to the ‘don’t knows’ of the brainstorm with S3C advisory board members (see the Appendix in the full report), one observes that questions of how to change routine behaviour and how to understand specific target groups receive most attention.

5. **Implications for S3C research**

This section sketches how findings of this report have fed into the other research tasks undertaken in the S3C project.

5.1 Selection of projects

The findings in this report suggest key lessons can be learned from those projects that address one or more of the key challenges identified above. The challenges thus notably underpin the selection criteria (Task 1.2) of being innovative. That, together with a number of other criteria, forms the basis on which project selection takes place. As such, the key challenges may equally form a framework for finding innovative and not yet tested interaction schemes (Task 3.3) by reflecting for each key challenge on what innovative examples can be found.

5.2 Scope and research questions

The report has contributed to developing the 'common approach' described in the S3C report "Final list of research questions and action plan for WP3-5" (D1.2). In particular, it has delivered a number of 'sensitising concepts' of societal transitions, social practices, affordances and learning. It equally contributed to designing concrete research questions from the end-user and design perspective. From the end-user perspective, it highlighted research questions on drivers and barriers, expectations, evaluation and learning. From a design perspective, it pointed to relevant research questions on the adopted engagement principles, the evaluation of those principles and the match between design and end-user perspectives. The identified key challenges may be further used in the interviews, to address specific lessons that can be extracted from the investigated projects for one or more of these challenges. Finally, the overview of end-user interaction schemes reported on in the literature fed into the classification structure that together with the interviews will form the basis for the assessment of projects (WP3).

5.3 Towards tools and guidelines

Finally, the descriptions of tools and best practices given in this report – together with the findings of the analyses of projects to be undertaken - provides a basis for the development of guidelines and a toolkit for practitioners (WP4). In particular, the overview of success factors in end-user engagement (Table 2 and Table 3) may provide a first structure for such a toolkit, by highlighting factors that need to be considered when designing an end-user engagement strategy.

One particular challenge S3C will address is to link such practices to different types of end-users and end-user roles – e.g. consumers, customers and citizens - to be able to target different end-user types in the most effective way.

References

Aarts, H., Verplanken, B., & Van Knippenberg, A. (1998). Predicting behaviour from actions in the past: repeated decision making or a matter of habit? Journal of Applied Social Psychology, 28, 1355–1374.

Bartusch, Cajsa, Fredrik Wallin, Monica Odlare, Iana Vassileva, and Lars Wester (2011). Introducing a Demand-based Electricity Distribution Tariff in the Residential Sector: Demand Response and Customer Perception. Energy Policy 39, no. 9: 5008–5025. doi:10.1016/j.enpol.2011.06.013

Breukers, S., E. Heiskanen, R.M.Mourik, D. Bauknecht, M. Hodson, Y. Barabanova, B. Brohmann, V. Bürger, C.F.J. Feenstra, M. Jalas, M. Johnson, P. Maier, S. Marvin, H. Meinel, J. Pariag, M. Rask, S. Rinne, S. Robinson, S. Saastamoinen, J. Salminen, I. Valuntiene´, E. Vadovics, (2009). Interaction schemes for successful energy demand side management. Building blocks for a practicable and conceptual framework. Deliverable 5 of the CHANGING BEHAVIOUR project. www.energychange.info

Breukers, S., and R.M. Mourik (2013). The end-users as starting point for designing dynamic pricing approaches to change household energy consumption behaviours. Report for Netbeheer Nederland, Projectgroep Smart Grids (Pg SG). DuneWorks, March 2013.

Darby, S., (2006). The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays. Environmental Change Institute, University of Oxford, Oxford.

Defra (2011). Framework for Sustainable Lifestyles. Centre of Expertise on Influencing behaviours. http://archive.defra.gov.uk/environment/economy/documents/sustainable-life-framework.pdf

Dong Energy (2012). The eFlex Project, Dong Energy, November 2012. www.dongenergy.com.

EEA (2013). Achieving energy efficiency through behaviour change: what does it take? (Rep. No. 5/2013). Copenhagen, Denmark: European Environment Agency.

Ehrhardt-Martinez, K., (2010). Advanced Metering Initiatives and Residential Feedback Programs: a meta-review for household electricity savings opportunities, ACEEE.

JRC (2011). Smart Grid projects in Europe: lessons learned and current developments Petten, The Netherlands: Joint Research Centre, Institute for Energy.

Lewis, P.E., Dromacque, C., Brennan, S., Stromback, J., Kennedy, D. (2012). Empower Demand 2: Energy Efficiency through Information and Communication Technology: Best Practice Examples and Guidance. 2012 VaasaETT http://www.esmig.eu/press/publications-new/empower-demand-report.pdf/view

NSMC (2011). Big Pocket Guide to using social marketing for behaviour change London, UK: The NSMC.

Prüggler, Natalie (2013). “Economic Potential of Demand Response at Household level—Are Central-European Market Conditions Sufficient?” Energy Policy (May 2013). doi:10.1016/j.enpol.2013.04.044.

Rotmans, J. (2005). Societal Innovation: between dream and reality lies complexity. Inaugural Adress, Erasmus University Rotterdam.

Smart Grid Consumer Collaborative (SGCC) (2013). 2013 State of the Consumer Report. SGCC, available at http://smartgridcc.org/

Sütterlin, B., Brunner, T. , Siegrist, M. (2011). Who puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related behavioural characteristics. Energy Policy 39: 8137–8152.

Verbong, G., Beemsterboer, S., Sengers, F. (2013). Smart grids or smart users? Involving users in developing a low carbon electricity economy. Energy Policy 52: 117-125.