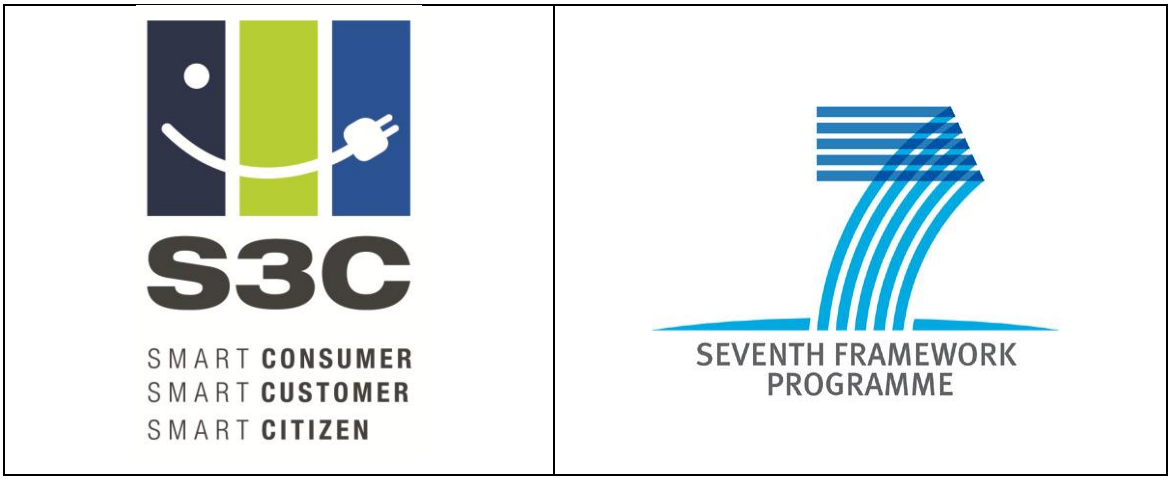


# FI.Energy-2012- 308765 S3C

# D1.2 FINAL

## *Final list of research questions and action plan for WP3-5*

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**Abstract:**

Drawing on the literature review of Deliverable 1.1, Deliverable 1.2 develops a common research protocol to be used in the evaluation of end-user engagement practices used in a selection of smart grid projects.

**Keyword list:**

Niche project, practices, affordances, learning

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# Executive Summary

Task 1.3 leads to the definition of a 'common approach' for investigating the performance of end-user interaction schemes drawn from the selection made in WP2. Task 1.3 is therefore like the soil the other parts of the project can grow upon. It has to provide the first conceptual building blocks helping us to address the fundamental research question underlying the whole of the S3C project: "*How can active (or 'smart') energy-related behaviour be fostered by active end user engagement in smart grid projects*?".

The 'common approach' developed in this deliverable forms an orienting framework, which allows the project partners to make reference to and use of when investigating practical active demand cases. It is meant to assist the S3C researchers in the act of observing what is going on in smart grid projects and to streamline the emerging consensus between the S3C researchers as they try to make common sense of what they have observed in their separate investigations. In this pragmatic approach to social science research, empirical "reality" is seen as the on-going interpretation of meaning produced by individual researchers engaged in a common project of observation. This 'common approach' is not meant to provide in the end the 'definite answers' concerning how active demand can be fostered in smart grid projects. It is rather meant to elicit fresh understandings about the patterns arising in the relationships between the actors engaged in smart grid projects; and how these relationships and interactions actively construct the reality of active end-user behaviour in such projects. In other words, the 'common approach' should help us in understanding how actors make sense of the reality of being engaged in a smart grid project, and how this 'sense of reality' (or in other words, meanings attributed to the experiences acquired in the course of such projects) influences 'dealings' with reality (or in other words, agency). This understanding will be translated in preliminary hypotheses and/or models concerning the relationship between particular end user engagement strategies and active demand behaviour which will be tested further in WP5.

The development of the 'common approach' relies upon the overview of the theoretical literature on end-user involvement and sustainable consumption. It is used for the direct questioning of experiences with end user involvement in ongoing smart grid projects. Since direct participatory observation of householders engaged in smart grid projects is beyond the scope of S3C, it takes the form of an interview protocol to be used in conduction semi-structured interviews with both social actors involved in setting up smart grid projects (e.g. research institutes, DSOs, utilities, ICT firms, etc.) and the end users from households and SMEs taking part in in these projects. Semi-structured interviews allow people to express their experiences in certain areas without being guided to strongly by the interview protocol (by using more or less 'open' questions and a certain flexibility on the part of the interviewer to go more into details when deemed necessary and possible, based on an assessment of the interviewee's responses). This approach is particularly fruitful when covering a topic that is still in an experimental phase (such as smart grid projects). It is also very relevant to separately cover the experiences of those involved in setting up the smart grid projects and the end users actually engaged in those projects. The projects are 'designed' based on many assumptions and suggestions on how consumers might behave or might be willing to take up new technological options. However, the actual knowledge with regard to the attitude of consumers towards smart grids and how the end user interaction schemes that are part of this novel infrastructure will influence daily life is still very limited and does not necessarily correspond to the 'design' of the project developers. Therefore, the interview protocol will address both perspectives separately.

The interview protocol is derived from the 'sensitising concepts' stemming from the literature review. We draw upon the literature review to gradually develop sets of relevant research questions, starting from a conceptual understanding of smart grid projects as 'niche experiments' (Section 0), energy-related behaviour as embedded in energy practices (Section 4), the new 'affordances' offered by end user participation in smart grid projects (Section 5), and finally, social learning in the course of project (Section 6). In Section 7, a semi-structured interview protocol is developed consisting of main questions around which the interviews are to be conducted. During the interview, the research questions developed under Sections 3-6 are used as a 'pool of questions' S3C researchers can draw upon when inquiring further on the various facets of the smart grid project.

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# 1 Introduction

## 1.1 Objective of Task 1.3 according to DOW

Based on the literature review (Task 1.1), WP1 will develop a list of in-depth research questions for the characterisation, analysis and assessment of the projects in the 'Family of Projects' (FoP). The research protocol will focus on:

- From the 'design perspective': how the end user has been 'scripted' in the set-up of the cases;
- From the 'end-user perspective': how the end users involved in the cases have experienced the applied end-user interfaces.

## 1.2 Scope of Task 1.3

Task 1.3 leads to the definition of a 'common approach' for investigating the performance of end-user interaction schemes drawn from the selection made in WP2. Task 1.3 is therefore like the soil the other parts of the project can grow upon. It has to provide the first conceptual building blocks helping us to address the fundamental research question underlying the whole of the S3C project: "*How can active (or 'smart') energy-related behaviour be fostered by active end user engagement in smart grid projects*?"[1]. In other words, S3C is aiming at a better understanding of the relationship between the design, implementation and use of particular end-user interaction schemes[2] and the promotion of 'smart' energy end user behaviour (i.e. behaviour that promotes the active participation of domestic and small commercial consumers in the power system markets and in the provision of services to the different power system participants).

Despite the idea of a 'smart grid' (or components thereof) being around for several years now, the actual implementation at the level of households or SMEs is still in its infancy and there is still little hard evidence on what 'smart' end-user interaction schemes and technologies can actually achieve in terms of fostering 'smart' energy end-user behaviour (Darby, 2010). S3C therefore combines a theoretical and experimental learning approach. There is a constant interaction between both lines of research as theoretical concepts and hypotheses are further refined along the course of the project in confrontation with experimental material. The theoretical approach starts from a survey of theories drawn from the broad disciplinary field of approaches relevant for understanding sustainable consumption patterns (cf. Task 1.1). The empirical results come from the evaluation of a selection of on-going or recently finished smart grid projects (WP3) (selection criteria are determined in Task 1.2), as well as pilot tests and experiments within a 'Family of Projects' (FoP) to maximise learning and minimise risks of failure in practice (WP5). Guidelines on 'good practices' arising from this interaction between theory and practice are formulated along the way (WP4). This way, S3C will go beyond the 'state of the art' of knowledge on user involvement in active demand programs by using this existing FoP to improve their programs and introduce new means and methods for the user participation in active demand side management.

The 'common approach' developed in this deliverable forms an orienting framework, which allows the project partners to make reference to and use of when investigating practical active demand cases. It is meant to assist the S3C researchers in the act of observing what is going on in smart grid projects and to streamline the emerging consensus between the S3C researchers as they try to make common sense of what they have observed in their separate investigations. In this pragmatic approach to social science

[1] The notion of a 'smart grid project' refers to projects with an experimental set-up that includes at least one part of a set of socio-technical interventions that could lead in the future to the full deployment of a smart grid (i.e. a grid able to carry out load control at high resolution - i.e. the remote and real-time control of individual electricity consuming, producing or storage technologies – in order to cope with fluctuations in supply as well as in demand). This set of socio-technical interventions is commonly held to include 'advanced' (i.e. meters which automatically send out consumption data to the utility) or 'smart' meters (i.e. advanced meters that identify consumption in more detail than conventional meters and allows for two-way communication between the end user and the utility), in-home displays, smart appliances, home energy management systems, distributed generation, electric or thermal storage systems, etc.

[2] Collection of tools and methods adopted to facilitate the interaction of end-users with the project partners, the electricity grid, and the energy market. Tools and methods can be technical (smart metering, automatic control, …), financial (monetary incentives, business models, new types of contract, …), and engagement oriented (e.g. customer awareness initiatives, marketing, …) (cf. Deliverable 1.1).

research, empirical "reality" is seen as the on-going interpretation of meaning produced by individual researchers engaged in a common project of observation. This 'common approach' is not meant to provide in the end the 'definite answers' concerning how active demand can be fostered in smart grid projects. It is rather meant to elicit fresh understandings about the patterns arising in the relationships between the actors engaged in smart grid projects; and how these relationships and interactions actively construct the reality of active end-user behaviour in such projects. In other words, the 'common approach' should help us in understanding how actors make sense of the reality of being engaged in a smart grid project, and how this 'sense of reality' (or in other words, meanings attributed to the experiences acquired in the course of such projects) influences 'dealings' with reality (or in other words, agency). This understanding will be translated in preliminary hypotheses and/or models concerning the relationship between particular end user engagement strategies and active demand behaviour which will be tested further in WP5.

The development of the 'common approach' relies upon the overview of the theoretical literature on end-user involvement and sustainable consumption; reference to theoretical insights used in the development of the 'common approach' will be only cursory in the context of this deliverable (D1.2). For more in-depth information on the relevant theoretical frameworks discussed in this deliverable we refer the reader to deliverable 1.1 (D1.1).

# 2 Methodology

The 'common approach' is gradually developed starting from a number of 'sensitising concepts' emerging from the theoretical overview (Task 1.1). The main function of these 'sensitising concepts' is to make us attentive to certain aspects of smart grid projects. These concepts do not yet provide an answer on how to influence energy-related practices by end-user participation in smart grid projects. Nor do they arise from the typical scientific approach of 'hypothesis testing'. What most differentiates our approach in S3C from much other research is that it explicitly takes into account the emergent character of the research process. We set out to find whatever theory (or combination of theoretical fragments) accounts for situation under investigation as it is. The aim in other words is to discover the theory **implicit** in the data. Hence, our main concern is that the 'common approach' should be responsive to the particular smart grid projects under investigation. It should enable a search for data in such a way that the final shape of the theory or model used to explain the interlinkage between end-user interaction schemes and their influence on 'smart' (active) energy behaviour is likely to provide a good fit to the situation. In fact, two main criteria for judging the adequacy of our 'common approach' emerge:

- that it helps to find the theory/model that fits the situation; and
- that it works – i.e. that it helps the actors engaged in smart grid projects (the project managers as well as the end users) to make sense of their experience and to manage the situation better (in view of their main motivations for participating is such projects).

How to ensure that these quality criteria are met? In order to effectively pinpoint theoretical insights emerging in the course of our empirical investigations, we rely on a research 'trident':

- selection criteria for smart grid projects are defined so that we include in our sample i) end-user participation approaches that at first sight (from the literature review) seem to be promising; ii) novel approaches that have not yet been covered in literature; and iii) approaches with the potential to disconfirm 'received wisdom' in the field of 'smart' energy behaviour (WP1 – Task 1.2);
- a 'common approach' for questioning and analysing 'smart' energy behaviour experiences in the selected smart grid projects (WP1 – Task 1.3);
- a view on what constitutes a 'successful' smart grid project based on 'key performance indicators' (KPIs) derived from the main motivations of social actors participating in smart grid projects (WP1 – Task 1.4).

This deliverable relates to the second 'tooth' of our research 'trident'. Since direct participatory observation of householders engaged in smart grid projects is beyond the scope of S3C, it takes the form of an interview protocol to be used in conduction semi-structured interviews with both social actors involved in setting up smart grid projects (e.g. research institutes, DSOs, utilities, ICT firms, etc.) and the end users from households and SMEs taking part in in these projects. Semi-structured interviews allow people to express their experiences in certain areas without being guided to strongly by the interview

protocol (by using more or less 'open' questions and a certain flexibility on the part of the interviewer to go more into details when deemed necessary and possible, based on an assessment of the interviewee's responses). This approach is particularly fruitful when covering a topic that is still in an experimental phase (such as smart grid projects). It is also very relevant to separately cover the experiences of those involved in setting up the smart grid projects and the end users actually engaged in those projects. As Verbong et al. (2013) point out, smart grid projects have so far mainly been defined with the objective of technological or economic learning in mind (i.e. learning about the technological performance of end-user interfaces, learning about new business opportunities and business plans). The projects are 'designed' based on many assumptions and suggestions on how consumers might behave or might be willing to take up new technological options. However, the actual knowledge with regard to the attitude of consumers towards smart grids and how the end user interaction schemes that are part of this novel infrastructure will influence daily life is still very limited and does not necessarily correspond to the 'design' of the project developers. Therefore, the interview protocol will address both perspectives separately.

The interview protocol is derived from the 'sensitising concepts' stemming from the literature review. In what follows, we draw upon the literature review to gradually develop sets of relevant research questions, starting from a conceptual understanding of smart grid projects as 'niche experiments' (Section 0), energy-related behaviour as embedded in energy practices (Section 4), the new 'affordances' offered by end user participation in smart grid projects (Section 5), and finally, social learning in the course of project (Section 6). In Section 7, a semi-structured interview protocol is developed consisting of main questions around which the interviews are to be conducted. During the interview, the research questions developed under Sections 3-6 are used as a 'pool of questions' S3C researchers can draw upon when inquiring further on the various facets of th smart grid project.

# 3 Introduction of smart grid infrastructure as a niche experiment

Our first set of question relates to the specific experimental character of most smart grid projects so far. Following Verbong et al. (2013), the development of smart grid technologies can be considered as a 'niche experiment'. In the peripheries of incumbent systems ('regimes' in transition management parlance – cf. D1.1), 'niches' are the loci where (more or less) radical novelties are created and tested as a co-evolution of an entrepreneurial impulse in heterogeneous socio-technological networks. These novelties can be all kinds of combinations of new technologies, new rules and legislation, new concepts, new policy settings and policy attitudes, new organisations, etc. – in a setting that essentially is a potential new societal system-in-the-making, and of which the culture, structures and activities deflect to some extent from the dominant system. Often these niches are the incubators for experimentation and proofs of the concepts of (more or less) radical innovations or 'transition experiments'. Defined as "*practical experiments with a high level of risk (in terms of failure) that can make a potentially large contribution to a transition process*" (Rotmans, 2005), transition experiments are real-life developments of drastically alternative ways of working and/or thinking, fitting into envisaged new system approaches. Such experiments are characterised by (Van Buuren and Loorbach, 2009):

i) their connection to a societal challenge (e.g. in the case of smart grid projects, integrating large amounts of renewable electricity generation into the energy provision system);
ii) illustrating a (radical) change of practices and/or culture and/or structures (e.g. in the case of smart grid projects, energy end-use practices); and
iii) their inherent relation to learning (as an interactive process of obtaining new knowledge, competences or norms and values).

As shown by many historic examples, transformation of regimes often starts from innovations in particular market niches (e.g. the application of solar cells for space travel; the development of mobile phones for business people). Sometimes however, a specifically created 'protected' niche needs to be created in order to experiment with socio-technical innovations (i.e. protected from normal market dynamics because the innovations tested in the niche cannot yet compete with existing technologies/practices in the market). By actually using an innovation in these 'niches', users create or learn about new needs, policy makers create regulatory frameworks that fit the innovation and business learns to improve the innovation and reduce costs. Apart from explicit 'transition' initiatives (embodied in niches and experiments, specifically set up more or less following the ideas, guidance and/or inspirations elaborated in transition management theory), there is also an amount of 'emergence': bottom-up grassroots initiatives arise spontaneously, even with a touch of serendipity, but essentially contributing to the body of a societal undercurrent of alternative settings for systemic change towards sustainable

societies. Such existing dynamics could very well be enlisted when setting up innovative (community) smart grid projects.

'Niche experiments' have in the past been analysed using the 'strategic niche management' (SNM) approach. SNM focusses on processes going on inside the 'niche' to understand the success or failure of particular socio-technological innovations. Three steps are to be followed when setting up niche experiments (Geels and Schot, 2010):

i) selection of appropriate (i.e. promising) technologies for experimentation;
ii) identification of the most appropriate settings for experimentation (sometimes involving the creation of particular 'protective mechanisms');
iii) formulating clear goals, aims, expectations, rules of interaction, etc.

From the discussion so far, we can already develop the following research questions:

**From the 'design' perspective**

- In your opinion, what were the most important factors allowing us to understand why this particular smart grid project was started up?
  - at a particular moment in time
  - at (a) particular place(s)
  - drawing on the combined resources of a particular research alliance
- What were the main motivations for your organisation to participate in this particular smart grid project?
  - Expectations w.r.t. future of the smart grid (including vision on what precisely constitutes a 'smart grid')
  - Expectations w.r.t. market for smart grid technologies
  - Expectations regarding the benefits for end-users
- What did you hope to learn initially from your participation in this particular smart grid project?
- What could for your organisation be qualified as a 'successful' project outcome?
- How do you think that smart grid technologies will benefit the end user?
- What (if any) could be the new role of end users in the future smart grid
- Was learning about the interaction of end users with smart grid technologies an explicit objective of this particular smart grid project?
  - Which 'experimental protocols' were used to record end-user behaviour (e.g. questionnaires, monitoring of energy use, focus groups, …)
- If so, what did you hope to learn about end-user behaviour from this particular smart grid project?
  - What (if any) were the (implicit) theories used to set up end-user experiments
  - How to set up the project in such way that the lessons learned are not too 'bound' to the end users participating in the project so that the lessons learned can be 'diffused' to other target groups

**From the 'end-user' perspective**

- How did you first learn about the possibility to participate in this particular smart grid project?
  - Via which channels did they first become aware of the existence of the project
  - Who was responsible for the day-to-day contacts during the project (installing required technologies, helpdesk, etc.)
  - Did the participant initially know these organisations and what did he/she think of them
- Would you describe yourself as 'energy-conscious' before the start of the experiment? Why (not)? Did that change during the course of the experiment?
- What were your main expectations when you decided to participate in this particular smart grid project?
  - What did you hope to learn for yourself by participating in the experiment (e.g. lowering bills, realising more sustainable lifestyles, general curiosity about new technologies,…)
  - What main benefits did you expect?

- Did you have any other motivations to participate?
- Did you have any concerns prior to the project as well? If so, which ones?

- Are you concerned with our long term energy supply? How do you think the future energy supply and demand will look like (or should look like)?

# 4 The concept of 'social practices'

Having established smart grid projects as niche experiments, the next question of course is to adequately characterise the 'stuff' these projects are experimenting with. The main purpose of smart grid projects (from the project managers' point of view) is to enable a shift in behaviour of householders so that the energy end-use patterns associated with these behaviours are more in line with the overall demands of efficient and effective energy system management. The question is: which 'factors' can be 'manipulated' (further extending our 'experiment' metaphor) to induce the necessary behavioural changes; in other words, what are the 'independent variables' causally related to the 'dependent variable' – i.e. energy-related behaviour ? Here, we propose to use the concept of 'social practices' for understanding energy-related behaviour (more on practice theory can be found in D1.1). As many studies have shown by now, actual end-user knowledge of energy use in buildings is often very patchy (at best), while energy use is strongly connected with different kinds of practices that are almost not influenced by knowledge of the energy use involved in these practices (Gram-Hansen, 2010; Guerra-Santin and Itard, 2010). *A fortiori* this seems to be true for awareness and understanding of smart grid technologies (see SGCC (2013) for information on the U.S. situation, where awareness is very limited – despite the fact that more than 33 million U.S. customers already have a smart meter installed in their homes).

'Practice theory' is precisely based on the premise that energy is 'invisible' in everyday life: we do not consume energy consciously, but this consumption is a side-effect of other activities and drivers such as the need for warmth, comfort, entertainment, mobility, hygiene etc. Practice theory conceptualizes these activities as 'practices' or 'ways of doing', e.g. cooking, washing, showering, working, commuting, watching TV, socialising, travelling. In the enactment of a practice, 'materials' (e.g. technological devices), 'competences' (e.g. knowing how to operate the technical device) and 'meanings' (i.e. the symbolic significance of the practice) come together. Instead of targeting directly people's energy consumption, practice theory proposes to target people's 'ways of doing'. Householders or SMEs are considered as 'carriers' of (bundles of) practices. Much of these practices are habitual and many of the energy-use routines implicated in these practices are consolidated as social conventions or norms: for instance, socially-shaped expectations about appropriate levels of cleanliness (showering, bathing and washing), comfort (use of air-conditioning and heating) and convenience (using the car for leisure, having multiple telephones, TVs and computers per household). These socially-shaped expectations translate into norms and rules that people mostly conform to avoid the risk of being 'expelled' from a social group. Hence, peers can be an important barrier to behavioural change, but they can also become a catalyst, when they are involved in changes in practices and behaviours. In addition, these norms and rules become embedded in a broader system encompassing technologies, infrastructures, social and cultural norms, policies, economy, politics and institutions.

Changing practices (and their related impact in terms of energy end-use patterns) therefore requires restructuring the existing links between the materials, competences and meanings that constitute the practice as such. In smart grid projects, the assumption is often made that the introduction of feedback mechanisms (e.g. smart meters, home energy management systems, etc.) will lead to enhanced or new competences ('more control') for households or SMEs over the energy-related aspects of the practices they are engaged in. The awareness-raising impact of domestic energy consumption feedback has been documented in relation to learning and behaviour change in a number of reviews and has been shown to induce some energy saving behaviour (at least in the short term) (e.g. Darby, 2006a; Faruqui *et al.*, 2009). However, as Darby (2010) points out, these review studies say nothing about *how* such savings are realised, since they render the household something of a black box. For our purposes, we need to understand what is going on inside the household or the SME when confronted with novel end user interaction schemes. Investigating how these interaction schemes relate to existing energy practices is a good starting point.

This short overview on energy-related practices leads us to emphasise two aspects of the experimental set-up of smart grid projects:

- Does the smart grid project target particular energy-related practices (e.g. those deemed to be more responsive to energy feedback)?; and if so
- How (e.g. through which end user interaction schemes) is this targeting achieved?

From these aspects, the following research questions can be derived:

| From the 'design' perspective |
|---|
| • Did you target certain household practices (e.g. showering, doing the laundry, heating, etc.) as potential 'candidates' for active demand management? If so, why and how?<br>• Did you work with different segments of end users in your particular smart grid project? Why (not)?<br>  ○ What were the criteria to decide on consumer segmentation<br>  ○ Why this particular segmentation<br>  ○ How would you describe key differences among segments<br>  ○ Was segmentation useful (or could it have been useful)? |
| **From the 'end-user' perspective** |
| • Before the start of the project, were you generally aware of the amount of energy you use when doing different things in your household?<br>  ○ What did you do to monitor your energy use<br>  ○ Which practices are considered to be 'problematic' by the end user (e.g. because of high contribution to overall energy bill, impact on the environment, wasteful behaviour, etc.)<br>• At the start of the project, which practices did you think you could easily change in order to have more control over your (timing of) energy use or energy bill? And which ones not? Why?<br>  ○ Probing the overall association between practices and related conceptions of comfort, convenience, and cleanliness<br>• Did the project set-up help you to realise the changes you had in mind?<br>  ○ Did the end users have a chance to raise issues/questions/potential solutions themselves, and where these issues/questions/potential solutions taken into account in the project set-up |

# 5 The concept of 'affordances'

How can energy-related practices change as the result of the introduction of novel end user interaction schemes (e.g. smart meters, smart appliances, home energy management systems, new contracts, etc.)? To understand how householders can be engaged in redefining energy-related practices, Darby (2010) introduces the concept of 'affordances'. Affordances are defined as 'action possibilities' latent in the environment (in a broad sense) of an actor. Just like the concept of 'social practices', they bring together physical materials and properties (e.g. a smart meter with predefined functionalities), agency (e.g. the possibility to adapt daily consumption practices to real-time pricing signals) and meanings (e.g. the possibility to realise a more sustainable lifestyle). It is useful to look at such affordances again from the design and the end-user perspective, as there might be a gap between the designed (or intended) affordances of a smart grid project, and the affordances actually perceived by the end user, which tend to determine the final outcome of the project in terms of actual (physical) affordances.

## 5.1 Affordances from the design perspective

Affordances can be 'designed' and in this sense they exist independently of whether they are recognised by an actor; but of course, it is important that this 'design' takes into account the abilities of an actor[3]. The design of affordances thus always (implicitly or explicitly) takes into account the '**ontology**' of the

[3] Darby (2010) gives the example of a ball of wool, which represents different affordances to e.g. a cat, a child or an adult.

target audience – fundamental assumptions about the abilities a certain actor (or group of actors) possess making a meaningful relation to the new affordance(s) possible in the first place. For instance, diverse social scientific disciplines have by now provided useful insights into the question of how to change behaviours towards more 'desirable' outcomes based on different 'ontologies' of the individual. Starting from assumptions about rational behaviour (i.e. rational goal-oriented optimisation of means), *economists* have proposed instruments that correct market failures (e.g. information provision, new institutions, incentives) so that individuals will become less hesitant in taking up more active energy behaviours like e.g. dynamic pricing. *Psychologists* have emphasised that it is difficult for end users to track and understand their own energy consumption, and that energy experts often do not succeed in making things more understandable or meaningful. Providing understandable information and feedback in combination with (both social and economic) incentives are suggested as useful interventions. *Sociological approaches* stress the importance of understanding end users' needs and drivers and creating benefits of active demand that resonate with the target group, for example they do not only concentrate on economic benefits but also on identifying increased levels of comfort, convenience and cleanliness (cf. practice theory). To complicate matters further, (experimental) interventions in social reality are never neutral as they have the potential to change the "reality" they are trying to enlist for their purposes (Fiske and Tetlock, 1997). Hence, designed affordances not only 'reflect' a certain social reality (**ontology**), but can also do performative 'work' by introducing new affordances as a social reality that should be strived for (**teleology**). Hargreaves (2012) gives the example of real-time display monitors providing instantaneous feedback to householders on how much carbon is being emitted through household electricity consumption at any moment in time. These devices not only measure the effects of a certain social reality, but they are also aimed at encouraging the formation of new 'low-carbon identities' more in line with certain rationalities of government (the 'territorialisation' of climate change at the household level and the individual responsabilisation this entails).

Hence, it is certainly relevant to understand from the design perspective if (and how) the intended affordances in a particular smart grid project were influenced by a (combination of) theoretical insight(s). However, despite the fact that many ideas, concepts, and theories from the above-mentioned literatures have long been recognised as powerful means to improve the effectiveness of interventions targeted at influencing energy demand, actual interventions are most often not designed based on systematic reviews of theory and evidence. All too often such interventions are not systematically developed and/or not well-described which impedes program replication or larger scale dissemination beyond the intervention trial (Kok et al., 2011). In a recent review of such intervention studies, Kok et al. (2011) suggest that methodological and theoretical limitations and little consideration of the situational context have limited the practical use and generalisability of any research findings arising from such interventions.

## 5.2 Designed affordances and the possibility of resistance

It is important to realise however that 'designed' affordances almost never turn out to work in the way they were planned. Not only is the type of feedback given to make end users more aware of new affordances often perceived wrongly, in some instances end users even actively resist the 'scripted' changes in practices implied by the new affordances. Drawing again on the example of the real-time display monitors with instantaneous information on carbon footprints, Hargreaves (2012) points out that understanding household energy use in terms of carbon was too confusing for most householders engaged in the trial he discusses. Not only did householders not understand how much a kilo or a tonne of carbon actually was, they were also unable to grasp whether they were performing 'well' or 'bad', and had nothing meaningful to compare their instantaneous carbon footprint data to. In order to move from 'designed' to 'perceived' affordances, the quality of the feedback could turn out to be an important factor. The most important thing to take away here is that in order for households or SMEs to 'distance' themselves from their current energy-related practices (i.e. constituting these practices as an 'object', becoming aware of their energy-related implications instead of being unreflexively 'immersed' in them) **new and actionable information on consumption** that **makes sense to the end user**, should be made available (Karjalainen, 2011). Insights on this matter should be used for the careful design of feedback mechanisms, with numerous possibilities: frequent meter reading by the householder, through the efforts of researchers informing the householder about their consumption (and possibly the relation to benchmarks – e.g. the 'average household'), through a more frequent and informative bill, on dedicated websites, on an electronic in-house display, etc.

However, even if correctly perceived, it is still possible that householders or SMEs actively resist to (certain aspects of) the new affordances. Drawing again on Hargreaves (2012), such resistance can for instance be based on household ethics or aesthetics that the new affordances appear to threaten. This can be the case for instance when the new affordances appear to threaten established comfort levels (e.g. by

prompting the need to lower the thermostat). In addition, Hargreaves mentions cases where resistance was based on a rejection of the carbon responsabilisation implied by the in-home displays (where people argue that "they have already done their bit" for the climate, while "the government" and "big business" could do much more). There are however also more positive examples; Marres (2009) for instance describes many examples of how green living experimental set-ups (including smart metering) are able to draw people into playful engagement and interaction with their immediate environment (for instance, through the pleasure of seeing the electricity meter turn backwards when photovoltaic panels feed electricity into the grid). The different reactions to new affordances can be explained in terms of diverse motivations and capabilities. The integration of new technologies into current household practices is not straightforward. To be correctly used, instruments have to be appropriated, i.e. contextualised in daily routines. Householders integrate objects into an existing network of objects, practices and meanings. This interaction between consumers and new technologies is reciprocal and at the basis of the coevolution between technology and its social use: technology is produced and stabilised only if it is integrated into social practices. Objects can change the time schedule of the family, it can change the way users interact, can modify their symbolic network, and so on. Whether new affordances are seen as an opportunity (provoking active demand response) or rather as an intrusion (provoking resistance) hence depends on the alignment of the new affordances with existing practices, capabilities and motivations of end users.

The concept of affordances thus leads us to question smart grid project experiences along the following lines:

**From the 'design' perspective**

- When setting up your particular smart grid project, was some kind of end-user 'training' foreseen (e.g. on the use of smart appliances, reading and interpreting in-home displays, etc.)?
- Were the end users involved in the design of the end-user interfaces used in your particular smart grid project?
- How did you communicate with the end user in the course of the project?
- How are the end users supposed to engage with the end user interaction schemes used in your particular smart grid project?
    - (How) did you make benefits clear to the end-user?
    - (How) did you try to adapt the interaction scheme according to the needs of the end-users? Did you apply segmentation of some kind?
    - (How) did you take an effort to educate end-users in dealing with the new technology?
    - (How) did you try to make the technology as user-friendly as possible?
    - (How) did you try to increase the commitment of end-users with the project, for example by involving them in the early project phase?
    - (How) did you try appeal to the social environment of end-users, for example by working with role-models?
    - What type of marketing and outreach strategy did you adopt?
- How did you deal with potential bottlenecks, like privacy or other…

**From the 'end-user' perspective**

- What do you think of the new devices installed in your house?
- Were you given any instructions on the use of the new devices (interfaces, smart appliances) installed in your home?
    - What did you think of these instructions?
    - Were these instructions helpful?
- In your opinion, were the new devices installed in your home easy to use? Why (not)?
    - How did you learn to use them
    - Did you look for additional information? If so, where?
- Is the information you get on your energy consumption useful and easy to understand? Why (not)?
    - Did it help to 'make sense' of his/her energy use
- How did you interact with the new devices installed in your house when going about your daily activities?

- For which practices did they provide useful new affordances, and for which practices was their use ignored or actively resisted
- Were benefits made clear to you? Etc.

# 6 Learning

In order to move from 'affordances' enabled by (parts of) a smart grid infrastructure to 'realised affordances' (i.e. actual changes in end-user practices with an impact on the timing and magnitude of energy demand), a measure of learning will always be needed. Practical knowledge, both tacit and explicit, needs to be acquired. The importance of social processes in acquiring new knowledge has to be acknowledged (Marres, 2009; Hargreaves, 2012). As Darby (2006b) points out, end users create meaning for themselves from their *experiences*: they 'construct' knowledge, making it their own, rather than imbibing it 'ready-made'. Their learning therefore has subjective and affective (emotional) elements that come from interpreting data from their environment in the light of their own experience. In addition, there is a strong link between action and the development of both explicit and tacit knowledge. Actually, according to Darby (2006b) this connection works in both ways: from knowledge to action (intuitively the most 'normal' sequence), but also from action to knowledge. For the latter case, Darby gives the example of people who have chosen to install solar water heating, who as a result of this action consider themselves to be more energy conscious and then conserve energy more actively than previously. In any case, the tight connection between learning (developing practical knowledge) and action prompts us to take a closer look at the social learning processes taking place in the context of smart grid projects. Such learning involves both the project managers (allowing them to redesign previously designed affordances in view of end-user feedback) and of course the end users themselves.

## 6.1 From designed affordances to continuously redesigned affordances

All interaction moments and channels related to project monitoring or research purposes with a participant or consumer can help in the learning process of smart grid project managers, i.e. when considering the design and redesign of project affordances. Research communication should be actively utilised to improve existing systems and procedures within the smart grid project by adopting the end user's view. Thus, research communication provides a strong learning potential for the smart grid project managers. This research communication can be based on:

- *End user monitoring data*: the registration of user data statistics. This delivers valuable information for utilities concerning their roll out process, and their customer program options.
- *End user evaluation feedback:* This can create moments of engagement with end users, and can produce valuable feedback for companies. This feedback can be integrated into the project or roll out, thereby creating end user involvement and enhanced service towards this target group. Several evaluation methods exist for initiating contact with the end user, all of which can provide valuable insights in end user interaction with smart meters and smart grids (e.g. interviews, questionnaires, focus groups, etc.).

In this regard, probably a lot can also be learned from the practice of user driven innovation (von Hippel, 2005). User Driven Innovation (UDI) is a product development approach that is user-centric, in the sense that the prototype of a novel technology is simply the starting point where users become part of improving and refining the innovation to obtain a higher user value, as opposed to commercial innovations. Early involvement of end users in the design of feedback mechanisms to be used in their homes is also advocated in a recent report by the European Consumer Organisation (BEUC) (Klopfert and Wallenborn, 2011).

## 6.2 From continuously (re-)designed affordances to realised affordances

Supporting communication can help advance the social learning of end users involved in the coevolution of (re-)designed and actually realised affordances. Supporting communication refers to all forms of continuing communication by the project managers aiming to inform and engage the end user and to offer support to end users to make optimal use (i.e. according to their capabilities, motivations and needs) of the smart equipment supplied in the project. As working with innovative technology devices may lead to

many questions, remarks and complaints among end users, sufficient supporting communication is a crucial aspect in the deployment of smart grid projects. Different forms of supporting communication can be used:

- **End user training during instalment of smart devices:** Pilot reviews show that active and extended training or explanation of the smart meter and its possibilities can contribute to active monitoring of energy consumption by end users and thus improving their energy efficiency. Besides more frequent use of the smart meter and its feedback systems, this may lead to a considerable reduction of demand for customer support. The amount of questions/complaints is lower when end users received training or instructions at the time of installation. It is also a potential 'protection' against end users inactivity, end user complaints, and it can possibly prevent a negative attitude of end users towards smart meters/smart grids.
- **Customer service and support:** Working with a new innovative instrument can raise questions, complaints or general remarks from end users. For the acceptance of new technology, it is vital to invest a certain amount of time and effort in customer service and support. A central point for end users, e.g. a service centre or help desk, with the ability to listen, react or solve the issue of the end user, will enhance the acceptance of end users considerably and will likely improve the enthusiasm or engagement for the project.
- **Continuing communication with participants throughout the project:** In order to generate long-term end user involvement – necessary to actually change people's energy consumption routines – it is important to engage and inform end users continuously about the project. The communication tools and media channels to realize this are numerous. One can think of weekly or monthly newsletters (paper or email), social media (Twitter, Facebook), organising monthly gatherings or information meetings, website availability or a project magazine. If there is no continuous information or engagement with end users, people most likely will lose interest or will not gain full potential, which is a possible negative outcome for the project. Therefore, end user should preferably have an active and on-going role in the project.

In addition to these communication mechanisms installed between the project managers and end users we also need to account for the possibility that end users use their own channels for learning – e.g. informal exchanges of information with 'peers' (neighbours, friends, family, colleagues), using social networks, use of social media,…

These reflections lead us to question smart grid project experiences along the following lines:

| **From the 'design' perspective** |
|---|
| • Which type of data on end user behaviour in terms of drivers, motivations and barriers to behavioural change did you collect in the course of the project? Why?<br>  ○ Meter reading, consumer feedback, …<br>  ○ Privacy issues (who has control over the data, was this accepted by the end user)<br>• How would you evaluate your end-user engagement process? What do you consider main success factors? Why?<br>• What were key bottlenecks, like privacy issues or others? |
| **From the 'end-user' perspective** |
| • Looking back on the project in which you were involved, what have you learned?<br>  ○ What do you do differently now compared to before the project<br>  ○ Did you continue to learn even after the project was finished<br>• In hindsight, were your expectations fulfilled? Were there additional benefits / concerns you did not expect beforehand?<br>• Did you have the opportunity to give feedback on your experiences with using the new devices in your |

home?
    - What type of feedback was given
    - Was this feedback taken into account
- How do you look back at the whole project? Did you feel committed to the project? Did you find communication adequate? Etc.

# 7 Interview protocol

The following steps should be taken when approaching a smart grid project for analysis.

1. Contact the project manager by phone using a standard introduction on S3C, explaining the purpose of the contact (cf. project flyer). Probe willingness to participate as 'passive partner' in S3C. Ask for suggestions for other project partners to interview. Ask specifically whether it would be possible to interview end users who participated in the project.
2. Following the phone contact, send an e-mail summarising the agreements made in the phone call and providing a link to the database to be filled in by the project manager (with assistance from S3C consortium member if needed). Ask for contact details of other partners involved in the passive project (it would be good to have interviews with 4-6 people for each project). Also ask specifically if there was a journalist who reported frequently on the project (if so, a 'must have' for an interview). Keep track of the contacts for your smart grid project using the specifically designed contact template.
3. When the database is completed, familiarise yourself with the project set-up. In particular, look out for the details and the results (in the result section) of the end-user interaction schemes used in the project.
4. Make an appointment for a telephone interview with the project manager.
5. Carry out the interview using the interview protocol.
6. Repeat step 5 for any additional interviews, adapting the interview questions to any further insights gained.

The interview approach is developed based on the work of Fischer (1980) and Grin *et al*. (1997) on action theory. In describing the rationality informing a particular actor's judgement, these authors distinguish between first order notions, which are specific for a situation, and the more generic second order convictions underlying them. First order notions include two layers: assessment of the means to achieve given objectives (solution assessments), and problem definitions that contextually vindicate these objectives. Second order notions consist in the background theories that an actor prefers on the one hand, and the deeper preferences that he wishes to realise on the other (dependent on his value system, preferred social order, etc.). The ensemble of first and second order notions is called an 'action theory' (Grin *et al.* 1997, pp. 38-39).

To summarise:

*First order notions*

- How does the actor evaluate costs, effects, and side effects of different solutions for a given problem – as he defines it?
- What is for the actor, in the given situation, precisely the problem (or opportunity)?

*Second order notions*

- Which background theories (habitual ways to reflect on the world) does the actor employ?
- What are the deeper preferences that the actor wishes to realise?

At first glance, the concept might appear very abstract. However, it can be made operational by drawing up an interview scheme in order to probe the link between a person's assumptions and their judgement in a concrete situation. First order notions can be identified relatively easily. One may directly inquire into solution assessments (what are, for that actor, the costs, effects and side effects of a particular solution?). Similarly, one can directly inquire into problem definitions (what does the actor consider to be the problem or 'challenge', what criteria does he use to judge the situation and how are they weighted?). Although one may also be able to inquire directly into second order convictions, this may be more difficult, if only because such underlying assumptions may be hidden from the actor himself. Herein lies a major challenge for the analyst. In Grin *et al.* (1997, pp. 38-44; 66-71), it is argued that one way to tackle this problem is to complement direct inquiry about the specific content of a first order notion with asking 'why' questions. By asking why somebody considers a particular aspect an advantage, or why he gives more weight to the claimed advantages than to the admitted disadvantages, his problem definition may be revealed. Similarly, by asking why the problem is defined in a particular way, one may identify the relevant elements of the worldviews and value systems underlying them. And asking why these values and causalities are considered important is likely to yield an answer in terms of 'because they guide actions so that we get closer to the world I prefer.'

These considerations will be reflected in the design of two interview protocols – one aimed at smart grid program managers (from the 'design' perspective), one aimed at the end-user participants in these projects (from the 'end user' perspective).

### 7.1 From the 'design' perspective

How these considerations influenced our interview protocol is explained in the table below. Each question is formulated in a generic way, and is to be followed up by the more in-depth questions developed in sections 3-6 for the design perspective:

- Q1-4 can be further explored using questions from Section 3 (niche experiment);
- Q 5 can be further explored using questions from Section 4 (social practices);
- Q 6-8 can be further explored using questions from Section 5 (affordances);
- Q 9-11 can be further explored using questions from Section 6 (learning).

Interviews will be half-structured, meaning that the interview protocol will only be used as a broad guideline (ensuring that at least the same questions were posed in each interview), and not as a scenario that should be followed slavishly. For instance, particular interview subjects could be developed in more detail in the course of an interview, or the order of questioning could be adapted to the line of argumentation of a particular respondent. Since the time for a personal interview should usually be limited to 1-1,5 h (max.), researchers should first familiarise themselves with the particular project under review and select the most interesting topics (in view of learning potential for developing ‚good practices') ahead of the interview session so that enough details on particularly promising approaches can be gained.

| *Question* | *Comment* |
|---|---|
| **1.** According to you, what is (or will be, or could be) the main contribution of [smart grid project x] to the development of the smart grid of the future? | *Focuses on evaluation of opportunity offered by a particular project* |
| **2.** Why does your organisation choose to play an active role in this project? Which goals does your organisation pursue? | *Focuses directly on the preferences of the organisation.* |
| **3.** Activating the energy end user in terms of energy consumption or production patterns is generally considered to be a crucial element in the transition to a smart(er) grid. According to you, what are the most important opportunities and barriers for such active end-user engagement? | *This question searches for a judgement on a (broadly defined) solution to a commonly perceived problem. Further question seek to explore how the actor evaluates benefits, barriers and drawbacks of end user engagement.* |
| **4.** Can you think of new and as of yet untested end-user interaction schemes which might be interesting to test out in the future? | *Direct input to Task 3.3* |
| **5.** Was learning about the interaction of end users with smart grid technologies an explicit objective of [smart grid project x]? If so, what did you hope to learn? | *Question probes into the implicit or explicit theories used to set up end-user interaction experiments. Further question seeks to address the issue of ‚translating' results to other contexts.* |
| **6.** Did you work with particular segments of end users in [smart grid project x]? Why (not)? | *Direct follow-up to question on learning about interaction of end users with smart grid technologies.* |
| **7.** Could you please describe how end users were recruited to participate in [smart grid project x]? What were the main problems you faced in recruitment? And how did you address these problems? | *Ask for as much details as possible. Further question probes into problem definition/perception and practical solutions.* |
| **8.** In [smart grid project x] you used the following end-user interaction tools (sum up from characterisation structure): … Why did you choose those particular tools to experiment with? | *Question probes into implicit or explicit theories used by the actor to ‚explain' consumer behaviour* |
| **9.** Could you please describe to us how each of these interaction tools were introduced to the end users participating in your project? | *Ask for as much details as possible (how were these tools implemented?). Look out for end user training, involvement of end users in design of particular tools, possibilities for feedback by end users, privacy issues, etc.* |
| **10.** What type of data (quantitative and qualitative) did you collect on end user engagement in the course of the project? Why? | *Probes into the link between implicit or explicit theories used on end user behaviour and supporting evidence sought after. Look out for inconsistencies!* |
| **11.** What are the main insight you gained on drivers, barriers and motivations of active end user engagement in [smart grid project x]? | *Look out for supporting evidence !* |
| **12.** What are the main lessons you learned about end user engagement in smart grid applications? What would (or did) you do differently w.r.t. end user engagement in | *Summary statement* |

| | |
|---|---|
| follow-up applications? | |

## 7.2 From the end-user perspective

End users can be contacted by telephone interviews or by organising a group session (focus group). Again, each question is formulated in a generic way, and is to be followed up by the more in-depth questions developed in sections 3-6 for the end-user perspective:

- Q1-3 can be further explored using questions from Section 3 (niche experiment);
- Q 4-5 can be further explored using questions from Section 4 (social practices);
- Q 6-8 can be further explored using questions from Section 5 (affordances);
- Q 9-10 can be further explored using questions from Section 6 (learning).

The same guidelines as developed in section 7.1 apply to the end-user interviews. In particular, it is very interesting to contrast the end-user perspective on the interaction schemes employed in the smart grid project with the design perspective as voiced by the managers of the smart grid project.

| ***Question*** | ***Comment*** |
|---|---|
| **1.** Could you describe in your own words how you were approached to participate in [smart grid project x]? | *Focuses on perception of recruitment strategy, raising the interest of the consumer. Get as much details as possible* |
| **2.** You decided to participate in [smart grid project x]. Could you describe in your own words what this project was about? | *Focuses on perception of the smart grid and the role that end users could or should play.* |
| **3.** What were your main expectations when you decided to participate in [smart grid project x]? | *Focuses directly on the preferences of the end user. Why did he/she participate?* |
| **4.** Energy is used for a lot of different things in your household. Before the start of the project, were you generally aware of the amount of energy you use when doing different things in the household (e.g. washing dishes, washing clothes, …)? | *Probes into level of 'energy-consciousness' before start of the project.* |
| **5.** Did you change any of these energy-consuming practices in the course of the project? If so, why (not)? | *Probes into link between energy practice and easiness to change (e.g. because of perceptions of comfort, cleanliness, convenience).* |
| **6.** Can you give a description of the new devices that were installed in your house in the course of [smart grid project x]? | *Probes into the perception of the new devices. Look for clues on the appreciation of these devices (complicated or easy to use, attractive or ugly, intrusive or appealing,…)* |
| **7.** What did you think of those new devices? How did you interact with those devices when going about your daily business? | *Were the new affordances really translated into new practices?* |
| **8.** Did you have the opportunity to give feedback on your experiences when using the new devices? | *Probes into the quality of communication between end user and managers of the project* |
| **9.** In hindsight, were the expectations you had at the beginning of the project fulfilled? Why (not)? Did the overall project set-up enable you to realise those expectations? Why (not)? | *Directly links into question 3 (if needed remind the end user of his previous statement). Overall assessment of the participation experience.* |
| **10.** Looking back on your participation in the project, what are the main lessons that you have | *Summary statement* |

learned? Will you continue to learn even after the project is finished?

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