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D3.4

Report on case analyses, success factors and best practices

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Abstract:

This deliverable describes the outcomes of the assessment of cause-impact relations, best practices, success factors and pitfalls, based on the case studies of the S3C Family of Projects described in deliverable 3.2.

Keyword list:

smart energy behaviour, smart grid projects, end user engagement, target groups, products and services, incentives, pricing schemes, end user feedback, project communication, stakeholders, smart energy communities, market structures, scalability, replicability

Executive Summary

S3C (Smart Consumer, Smart Customer, Smart Citizen) belongs to a new 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 end user interaction schemes and the promotion of smart energy end user behaviour. In WP1, the fundamental research question underlying the S3C project was formulated as follows: *How can active (or 'smart') energy-related behaviour be fostered by active end user engagement strategies in smart grid projects?*

The objective of Deliverable 3.4 is to establish an understanding on whether and how the design, implementation and use of certain user interaction schemes (as part of a smart grid pilot/test) contribute to the formation of new 'smart' end user activities and behaviours in their different roles as consumers, customers and citizens. Based on the selection criteria developed in WP1, 32 European smart grid pilot projects – engaged as passive pilots in the so-called S3C 'Family of Projects' (FoP) – have been investigated through in-depth case study analysis.[1] These pilots are among the most promising smart grid projects in Europe, since they display a potential for learning with respect to end user interaction. The FoP mainly consists of smart grid projects, but projects that focus on engaging end users without implementing smart grid technology are also included. For the purpose of consistency the term 'smart energy projects' is used in this report, this broader term including both projects that do and projects that do not include smart grid infrastructure.

This deliverable reports the outcomes of the analysis of the FoP, including the assessment of cause-impact relations, the identification of cross-cutting success factors and pitfalls, as well as best practices from data gathered in in-depth case studies. The outcomes from this task will serve as input for WP4, which will translate the research findings into actionable guidelines and a toolkit for practitioners in the field of smart energy.

Project selection

The investigated projects include a wide variety of smart energy projects in 15 different European countries, stretching from Portugal to Finland and from the UK to Slovenia, with many differences with respect to project goals, project design, target groups, tested interaction schemes, etc. The participant group ranges from one single household to as many as 30,000 and these households could be vulnerable groups (low income, low education), but also significantly more highly-educated groups with higher income than average. Most projects focussed on households, but some also involved commercial parties. Some projects were designed from a top-down perspective (what services can the increased flexibility of energy end users offer to energy market participants, e.g. lowering peak demand?), whereas other projects took the perspective of the end user as the starting point (what new products and services can deliver added value to the end user?).

Methodology

In this task, a meta-analysis was performed on the case study data of Deliverable 3.2. As the case study reports contain qualitative in-depth information about how each pilot project deals with end user engagement, with in-depth descriptions of promising practices, success factors, pitfalls and (preliminary) achieved results, the case study reports provide insight in the *what* and *why* of an individual project. Hence, the identification of success factors and cause-impact relations was predominantly a qualitative research process. Nine research questions were formulated based the key principles (*the do's and don'ts*) and the key challenges (*the don't knows*) for end user engagement as defined in the literature review (Deliverable 1.1) and the first version of key performance indicators (KPIs; internal report 1.3) in WP1. Following these research questions, the cross-case analysis aims to reveal insight in *what works under which conditions*.

[1] Initially the S3C FoP consisted of 33 passive pilots. Before the meta-analysis, however, it was decided to exclude one project, because after conducting the case study it became clear that this project did not fit well in the project objectives of S3C.

A staged research methodology was created. First, a thematic analysis of cause-impact relations was conducted to formulate a tentative answer on each research question. In order to identify interventions and to clarify the reasoning based on which success factors, pitfalls and best practices have been attributed, the data analysis process made use of the Toulmin Model of Argumentation. Next, a cross-case analysis was carried out to identify interdependences, contradictions and congruencies between the outcomes of the thematic analyses and to assess cross-cutting cause-impact relations, success factors and pitfalls. However, it is important to realise that a project often applies multiple incentives combined with several other interventions, such as clear communication, the appropriate type of end user feedback, and so forth. It is therefore difficult to make a clear cut judgement about the performance of individual interventions. And due to the diversity of projects that were investigated – in terms of project design, scope, scale, timeframes, objectives and target groups – it is also difficult to compare them in the cross-case analysis and assess what exactly the causes are for success or failure of certain interventions.

Conclusion

The meta-analysis reveals that knowledge and expertise on how to successfully engage end users in smart energy projects is still partly uncharted territory. Nevertheless, the case studies provide numerous insights that contribute to answering the overarching research question.

The main conclusion from the assessment of the case study data is that there is not one typical end user and therefore there is no single (set of) end user engagement strategies that can or should be applied to foster smart energy behaviour. However, the end user is not a black box: the case studies provide insight in the effects of the interventions identified under the nine respective research questions on the engagement of end users in smart energy projects. Hence, context-sensitivity is the key to successful end user engagement. It is crucial for smart energy project managers to investigate the end users' needs, expectations, worries and desires and the social, cultural, geographical contexts in which they find themselves.

The findings of the cross-cutting analysis are presented in the form of drivers and barriers and opportunities to enhance the active engagement of end users in smart energy projects.

The following drivers for active end user engagement (cross-cutting success factors) are identified:

- *Addressing end users as human beings instead of as points of electricity demand*. To engage end users in smart grid infrastructures, it is of key importance to tailor the project as a whole to the everyday life and the social practices of end users. Instead of providing end users with (experimental) smart grid infrastructure and accompanying products and services without investigating the potential added value for end users themselves, their needs, demands and expectations should be taken into account.
- *Obtaining a thorough understanding of target groups*. Generally, learning about attitudes and expectations takes place through often-applied methods, such as surveys and other forms of self-reports, but these have their limitations. A more detailed, close-up picture could be obtained to discover how end users actually interact with new technologies, what their attitudes and perceptions are towards the project and the products and services introduced to them. The case studies reveal several innovative and effective methods to get an in-depth understanding of target groups, such as qualitative contextual inquiries, the use of culture probes, home visits, and co-creation and gamification-based workshops.
- *Emphasizing sense of place: underscoring the local character of a smart energy project*. Whenever applicable, smart energy projects should address a regional scale: regional topics and stories have to be picked up and regional multipliers should be pursued – for example by involving mayors, business associations and stakeholders with a solid reputation into the project and by making use of local festivities and cultural events.
- *Drawing upon community dynamics*. A sense of community can be a powerful driver to engage end users. This is most likely the case in local or regionally-oriented projects. Once in place, community dynamics can greatly facilitate end user engagement in smart grid projects in all stages of project development: from the recruitment of participants over the design, adaptation and instalment of technologies and end user interfaces, to the actual demonstration phase. The investigated case studies offer inspiring best practice examples how community dynamics can be harnessed and enhanced.

- *Testing before roll-out.* The use of friendly-user trials or so-called pre-trials with a positive, energy knowledgeable test group can be helpful in order to detect technological issues or flaws in the overall project design before the actual technology rollout starts. Furthermore, exploratory qualitative interactions with end users have shown to be beneficial for the development of end user friendly smart grid products and services. Therefore both activities should be considered mandatory prior to roll-out.
- *Creating personal relations and build trust over time.* Giving personal attention – i.e. listening to participants and helping them on an individual basis, according to their needs and expectations – is an effective way to reinforce active end user engagement. Trust is also of key importance in smart energy trials. Without a trust relation between the end users and the project management, on which open and honest discussions can be based, it can be challenging to keep end users committed and engaged in the course of the project. This can be done in several ways, for instance by creating a good support system, organizing live meetings and home visits.
- *Motivate end users with fun and good news.* In general, people are driven by positive incentives. Due to the primarily technological approach of the majority of investigated smart grid projects, the use of fun and gaming elements was fairly scarce, but projects that did include playful challenges and competitions managed to harvest success. On a micro-level, easily understandable historical usage feedback information and social comparison feedback can be considered a success factor.

The following barriers for active end user engagement (pitfalls) are identified:

- *Non-viable business cases for end users.* A number of projects in the FoP refer to the creation of business models as one of their project objectives, but there are virtually no indications that these business models turned out to be economically attractive. Thus, for the vast majority of projects, the business case for pricing schemes seems not to be very viable. Generally, the price spread between high and low peaks is too small to be a valid (financial) incentive for participants, and for DSOs they do not reflect economic reality. Without the development of solid business models for residential and commercial consumers full-scale rollout is not likely to be feasible.
- *On-going technical problems and unreliable technology*. Approximately 40% of the investigated case studies reported technical problems that caused delays in the installation phase and/or the execution phase to such an extent that it had negative impacts on the engagement of end users. In several projects this resulted in a loss of engagement or even a drop out of participants. In these cases, it became evident that it is a tough challenge to repair a damaged reputation. Hence, the importance of adequate expectation management combined with allowing time for a phased roll-out, with thorough testing and troubleshooting among friendly users, should not be underestimated.
- *Inadequate expectation management.* Expectation management is of key importance to keep end users committed and engaged, both regarding the outcome dimension (technology, products and services) and the process dimension. For instance, if the design of the equipment does not meet end user’s expectations, e.g. because it is very big or aesthetically unattractive, the end user might refuse it. On the process dimension, a long waiting period until the actual instalment of the equipment, as well as malfunctioning equipment has shown to be a disappointing factor for end user participants.
- *Engaging end users without sharing decision power.* A potential barrier for engagement of end users in active demand projects lies in the actual opportunities for end users to influence the design of specific aspects in the project (e.g. project communication, service concepts, procedures). Generally there should be some leeway for end users to bring up ideas and take initiatives within the project, without putting the project goals, the research design and the time planning at risk. In this respect, a trade-off needs to be made by project managers between active participation and empowerment of end users and staying in control of the project.

In addition, eight opportunities for future smart energy projects are presented to further enhance active engagement of end users:

- *Reinforce the end user perspective in the project design***.** Large scale smart energy innovations are only likely to succeed if they manage to adapt to the everyday social practices of end users. A vital challenge for future smart grid developments is to design projects in such a way that the end user perspective cannot be overlooked. This implies to underscore the sense of place, to achieve a sense of ownership and to provide added value for the end user: what’s in it for them?

- *Develop viable business models.* The absence of obvious, viable business cases is one clear barrier for active end user engagement in smart grids. Therefore the challenge to develop economically solid smart grid business models should be high on the agenda of energy companies, because an engaged end user is the key to long-term success of the smart grid.
- *Co-creation.* A promising way in which products or services can be adjusted to fit the wishes of the participants and thus improve its chance of successful use, is by applying co-creation with end users. Although it might be difficult for them to voice what they want, it is possible to gain very valuable feedback from the end users about the proposed product or service when co-creation methods are applied adequately. Products and services rooted in co-creation are more likely to succeed in future roll-out of smart grid infrastructures, as their added value for the end user is more evident.
- *Gamification.* A rather novel and non-intrusive way to engage with end users and simultaneously collect data, is to incorporate gamification in products and services or in research and development activities. The experiences with gaming interfaces and competitive elements in the case studies are promising and inspiring, both in terms of engaging end users in the project and in terms of outcomes. However, a challenge regarding gamification is to capture the interest and attention of end users in the long run.
- *Roll out smart grids towards the general public.* In many case studies the end user base consisted of friendly users and energy insiders. However, the opinions and insights into consumer behaviour detected in these projects can rarely be considered representative and used as reference when interacting with the general public. Since many business cases will only become viable if there is a large enough customer base, gaining better understanding of the needs, expectations and concerns of the general public is a precondition for future expansion of smart grid infrastructures.
- *Develop novel stakeholder coalitions.* The case studies show that the current generation of smart grid projects is predominantly run by the ‘usual suspects’ from the energy business. In order to introduce smart grids to the general public, novel stakeholder coalitions with stronger societal involvement are indispensable. A few projects successfully managed to involve civil society stakeholders. To better connect with everyday social practices of end users, it is recommended to establish such coalitions with civil society and other non-energy stakeholders.
- *Connect smart grids to smart cities, smart living and sustainable lifestyles.* The smart grid is a very abstract concept that focuses on the ‘low interest topic’ electricity. Coupling the topic with other thematic areas that are known to raise more interest and appear less abstract is a promising strategy to overcome obstacles such as false perceptions or no perceptions at all. Therefore, it is vital to explain the interconnectedness between topics such as smart grids, smart cities, smart mobility and sustainable lifestyles to unaware end users.
- *Develop an overarching storyline to achieve a sense of urgency about smart grids.* For the future expansion of smart grid infrastructures, it can be beneficial to create a consciousness about the unsustainability of the contemporary energy system. When the advantages of renewable energies and of smart grids are in the foreground, end users may be more likely to adopt a sense of urgency that increases their motivation to participate actively. An easy understandable, overarching storyline can be helpful to educate end users and to improve their energy awareness, which can lead to a stronger motivation to act accordingly.

Refined KPIs for smart consumers, smart customers and smart citizens

The assessment of cause-impact relations, the identification of cross-cutting success factors, pitfalls and best practices has rendered a more detailed view of the preliminary KPIs developed in WP1. Using the assessed knowledge and understanding, the first version of KPIs for end user engagement was modified and refined. This report concludes with the presentation of 16 refined KPIs, based on the three end user roles of smart consumers, smart customers and smart citizens.

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List of acronyms

AD: Active Demand

ADR: Automated Demand Response

BRP: Balance Responsible Party

CBP: Consumption Based Pricing

CCP: Critical Consumption Pricing

CEMS: Central/Community Energy Management System

CPP: Critical Peak Pricing

DER: Distributed Energy Resources

DR: Demand Response

DSM: Demand Side Management

DSO: Distribution System Operator

D*x.x*: Deliverable *x.x* of the project

EVs: Electric Vehicles

FoP: Family of Projects

HEMS: Home Energy Management System

IHD: In-House Displays

IT: Information Technology

KPI: Key Performance Indicator

RTP: Real Time Pricing

S3C: Smart Consumer, Smart Customer, Smart Citizen

SMEs: Small and Medium-sized Enterprises

ToU: Time of Use tariff

TSO: Transmission System Operator

T*x.x*: Task *x.x* of the project

VPP: Virtual Power Plant

VPS: Virtual Power System

WP *x*: Work Package *x* of the project

1. Introduction

A smart grid cannot be *smart* without smart end users. With more and more renewable energy being fed into the grid and a projected electrification of energy use, one way to ensure grid stability is through demand side management, an option made easier with the help of a smart grid. Although smart grid infrastructures are fairly well understood from a technical perspective, relatively little is known about the social aspects yet: how can active (or 'smart') energy-related behaviour be fostered by active end user engagement in smart grid projects?

1.1 Background and rationale

The objective of Task 3.4 of S3C (Smart Consumer, Smart Customer, Smart Citizen) is to establish an understanding on whether and how the design, implementation and use of a certain user interaction scheme (as part of a smart grid pilot/test) contributes to the formation of new 'smart' end user activities and behaviours in their different roles as consumers, customers and citizens. To this end, 33 European smart grid pilots that were engaged as "passive" pilots in the so-called "S3C Family of Projects" (FoP) have been investigated through in-depth case study analysis in T3.2. Based on the selection criteria that were developed in WP1 (Internal Report 1.1), these passive pilots are among the most promising smart grid projects in Europe, since they display a potential for learning with respect to end user interaction.

In this task, a meta-analysis has been conducted on the data gathered in 32 in-depth case studies.[2] The detailed case study reports contain predominantly descriptive information about how each pilot deals with end user engagement, implying that the case study reports provide insight in the *what* and *why* of a single project and – if available – in the (preliminary) results. The meta-analysis provides insight in cause-impact relations and cross-cutting success factors, revealing *what works under which conditions*.

In addition, the contributions of these findings to the various Key Performance Indicators (KPIs), developed in T1.4, have been assessed. The outcomes from this assessment will serve as inputs for WP4, which will translate the research findings into actionable guidelines and a toolkit for practitioners.

1.2 Structure of the report

This deliverable reports the outcomes of the assessment of cause-impact relations, the identification of cross-cutting success factors and pitfalls, as well as best practices from the case study data that was collected in T3.2.

The process of data collection and the assessment of cause-impact relations, best practices, success factors and pitfalls is based on a staged research methodology, which is elaborated in section 2 of this report. This section also lists the research questions. Section 3 provides a broad overview of the case study data that was gathered in the 32 passive pilots. Section 4 is the cornerstone of this deliverable: the results of the in-depth analysis that was performed to generate answers on the research questions. Throughout this section, best practices derived from the case study data are presented in boxed texts (please refer to Appendix C for the full list of best practices).

In section 5, the outcomes of the in-depth analysis are translated into overarching conclusions, revealing the key drivers (cross-cutting success factors) and key barriers (pitfalls) for end user engagement in smart energy projects. This section concludes with a refinement of the preliminary KPIs based on the outcomes of the case study data analysis.

[2] One project did not enter the cross-case analysis due to an insufficient match with the S3C project objectives (see sections 2.4 and 3).

2. Methodology

2.1 Research approach

S3C aims to obtain insight in the ways and means to strengthen end user engagement in smart energy projects. The project objectives of S3C (as formulated in the Description of Work) are twofold. Firstly, to foster the 'smart' energy behaviour of energy users in Europe by assessing and analysing technology and end user-interaction solutions and best practices in test-cases and pilot projects. Secondly, to provide a better understanding of the relationship between the design, implementation and use of particular technology and end user-interaction schemes and the promotion of smart energy behaviour. In order to meet these broad project objectives, S3C aims to:

- In WP1, **investigate** the theoretical and empirical findings in the academic and 'grey' literature concerning the topic of smart energy behaviour and derive from this investigation a list of do's, don'ts and don't knows (i.e. major uncertainties). The latter category has been 'translated' into a set of specific challenges for understanding end user involvement in smart grid projects (cf. D1.1);
- In WP2 and WP3, **understand and evaluate** how smart energy behaviour has been promoted in a number of 'cases' (the so-called S3C 'passive partners' from the 'Family of Projects', FoP) (described in D2.2); and derive from this evaluation a set of **practical guidelines** to be followed, as well as **pitfalls** to be avoided, for end user involvement in smart grid pilots;
- In WP4 and WP5, **develop the guidelines and tools** for end user engagement further based on the need for practical interventions in ongoing smart grid pilots (the so-called S3C 'active partners' from the FoP).

Since these project objectives comprise a broad range of aspects that relate to the concepts and experimental practices of smart grids, a pragmatic case-study research approach was developed in D1.2 in order to investigate performance of end user interaction schemes in the S3C FoP. In this pragmatic case-study approach, empirical "reality" is seen as the on-going interpretation of meaning produced by individual researchers engaged in a common project of observation. There are at least three such "realities": the "reality" of the stakeholders engaged in the smart grid pilot; the "reality" of the end users engaged in this pilot; and the "reality" of the S3C 'case investigator' trying to build a theoretically informed 'reconstruction' of the two previous "realities". This 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.

What most differentiates our approach in S3C from the majority of 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 the situation under investigation as it is. In other words, the aim is to discover the theory *implicit* in the data. Hence, our main concern is that this 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 approach emerge:

- that it helps to find the theory/model that fits the situation;
- 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 in such projects).

2.2 Research questions

The formulation of research questions is a central element of both quantitative and qualitative research, because it explicates theoretical assumptions in the conceptual framework. In D1.2, the fundamental research question underlying the whole of the S3C project was formulated as follows: *How can active (or* *'smart') energy-related behaviour be fostered by active end user engagement strategies in smart grid projects?*

Of course, in order to formulate the right research questions we should then have some means to identify 'smart energy-related behaviour' in our cases if and when it occurs. To that end, in Task 1.4 a list of Key Performance Indicators (KPIs) for end user engagement in smart grid projects was created (Internal report 1.3). These KPIs are organized in three sets, in order to assess what would be a successful end user engagement strategy respectively from the perspective of smart consumers, smart customers and smart citizens. For evaluations covering multiple cases, quantifiable KPIs that clearly link 'causes' to 'effects' are preferable in order to clearly substantiate claims regarding the success or failure of particular interventions. However, the majority of the identified KPIs for fostering smart energy behaviour and active end user engagement are difficult to measure or quantify – and in that sense they do not concur with the typical way KPIs are being deployed in (quantitative) research projects.

The reason for developing 'soft' (qualitative) KPIs in S3C, is that the availability of project data was expected to vary largely between individual projects, because each project in the Family of Projects has been developed and implemented in its particular (local, organisational, technological, cultural) context. Preliminary investigation of possible FoP-partners during the selection process (WP2) in 2013 made clear that several projects that turned out to be highly relevant for the S3C project objectives, were not (yet) able to supply thorough quantitative research data.

As a consequence, the identification of success factors and pitfalls, as well as the assessment of cause-impact relations relies heavily on qualitative data. Therefore, it was decided to conduct extensive case study research on the selected projects in the FoP. An evaluative case study, primarily based on qualitative data, has been carried out for each individual project. Since the identification of success factors and cause-impact relations in the FoP is predominantly a qualitative research process, a set of clear and focused research questions was developed based on the KPIs and the key principles (*the do's and don'ts*) and the key challenges (*the don't knows*) for end user engagement as defined in the literature review in WP1 (D1.1). The outcomes of the assessment are then used to refine the KPIs originally defined.

Table 1 contains the nine challenges and the accompanying research questions. The answers to the nine research questions should provide insight in *what works under which conditions* to foster smart energy behaviour of end users.

Table 1: Research questions

	S3C challenge	Research question
1	Understanding the target group(s)	Which instruments or approaches contribute to achieving better understanding of the needs and desires of target groups?
2	Products and services	What innovative products and services contribute to fostering smart energy behaviour?
3	Incentives and pricing schemes	Which (monetary or non-monetary) incentives and pricing schemes contribute to fostering smart energy behaviour?
4	End user feedback	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	Smart energy communities	Which instruments or approaches contribute to the development and support of smart energy communities?
8	New market structures	Which features of the interaction between end users and energy market structures or business models contribute to end user engagement and smart energy behaviour?
9	Scalability and replicability	Which issues hamper and/or facilitate up scaling or replication of smart energy projects?

2.3 Data collection

The qualitative case studies conducted in T3.2 provide insight in how each passive pilot in the S3C FoP deals with end user engagement. The case study methodology is based on triangular data collection, extracted from project documentation and interviews with project representatives and/or implementers. In some case studies these sources were complemented with (group) interviews with end user participants in the project and/or interviews with stakeholders involved in implementation and/or monitoring.

Each case study was performed by the consortium partner who established contact with the respective 'passive pilot', based on a predefined case study format that was jointly developed by RSE (task leader for the analysis of passive pilot projects in T3.2), ECN (task leader for the assessment of cause-impact relations in T3.4), VITO (task leader for the development of KPIs in T1.4) and SP (work package leader for WP3). To assure quality and consistency, each case study was thoroughly reviewed by another consortium partner. D3.2 (Restricted) contains 33 case study reports that have been produced in smart energy pilot projects from all over Europe. For a full list of S3C case studies, please refer to Appendix A.

In addition, factual project information about each case study was entered into an online database that was created based on the 'Defining characterization structure of interaction schemes' (D3.1).

2.4 Data analysis

The research questions served as a guidance to obtain insight in cause-impact relations and cross-cutting success factors: *what works under which conditions*? To this end a meta-analysis has been conducted on the data that was gathered. The detailed case study reports contain predominantly qualitative in-depth information about how each pilot project deals with end user engagement, with in-depth descriptions of promising practices, success factors, pitfalls and (preliminary) achieved results. Hence, the case study reports provide insight in the *what* and *why* of a single project and – if available – in (preliminary) results.

The S3C database was designed to host complementary quantitative data about the pilot projects, but due to the large diversity between the investigated projects (in terms of scope, target groups, timeframe, etc.), the information collected in the database turned out to be somewhat scarce and inconsistent. Many of the investigated projects had few quantitative research data available, and the data that had been collected turned out be largely incomparable (due to different units of measurements, timeframes, tested variables, variety of target groups, incentives, etc.). Therefore, opportunities to perform a thorough quantitative analysis on the database were limited to straight counts and it was not possible to calculate correlations or perform statistical analysis. It was thus decided to use these data for the first exploratory analysis, but not for the in-depth analysis phase, which was based on the qualitative information in the case-study reports. For the meta-analysis a staged research process was designed, consisting of the following steps:

Step 1: Exploratory data analysis

An exploratory analysis of the full case study data in D3.2 was performed to identify recurring topics and to check overall coherence of the gathered data. In this step, it was decided to exclude one case study because it did not sufficiently match with the S3C project objectives (see section 3) – resulting in 32 case studies for further investigation.

Step 2: Exploratory quantitative database analysis

Exploratory quantitative analysis of the S3C project database to identify potential cause-impact relations and success factors that can be explored further in-depth in the qualitative analysis process. As mentioned above, the database contents turned out to be rather inconsistent and thus represent little added value to the case study data. However, a concise report was produced to provide an overview of the gathered data in 32 case studies, which served as a basis for section 3 of this report.

Step 3: In-depth thematic analysis of cause-impact relations

A thematic analysis of cause-impact relations was conducted to formulate tentative answers on the individual research questions (one or two research challenges were assigned to each consortium partner). For each research question, data packages were assembled from the case study reports, drawn from the respective sections in the case study template.

In order to identify interventions and to clarify the reasoning based on which success factors, pitfalls and best practices have been attributed, the qualitative data analysis process was based on the Toulmin Model of Argumentation.[3] Toulmin's model enables to rigorously think about backings, warrants and countervailing factors for recommendations, thus making the argumentation and findings solid. For each intervention that was found in the case studies, the claim (thesis) was made explicit, followed by the warrants (hypothetical statements) that serve as backing and the rebuttals (counter-arguments) deriving from the case study data.

Step 4: Cross-cutting analysis

Based on the outcomes of step 2 and 3, a cross-cutting analysis was performed to assess overarching and cross-cutting cause-impact relations. Again, the Toulmin Model of Argumentation was used to identify interdependences, contradictions and congruencies between the outcomes of the in-depth analysis of individual research questions.

Step 5: Synthesis and refinement of the KPIs

The outcomes of the research steps described above were integrated into a synthesis of results and generic conclusions from the meta-analysis and the innovative interaction schemes described in D3.3. This rendered a more detailed view of the preliminary KPIs that were developed in Task 1.4. Using the assessed knowledge and understanding, the first version of KPIs was modified and refined.

[3] Toulmin, S., A. Janik & S. Rieke (1984). *An Introduction to Reasoning: 2nd edition.* Prentice Hall.

3. Overview of case study data

Thirty-two different projects have been evaluated as case studies within the S3C Family of Projects (FoP). In the next chapter the outcomes of the analysis of the case study data will be presented, but first this chapter will shed some light on our sample of projects, so as to give some context within which the research has taken place. In the following sections, key information about the projects will be presented. This information was gathered from two different sources: the database and the case study reports. The design and detailed explanation of the database can be found in D3.1 'Defining characterization structure of interaction schemes'. Mostly the data in this section will be presented at an aggregated level, broadly distinguishing the three categories of project management, participants and project features.

3.1 Project selection

The projects engaged in the FoP were selected based on the selection criteria that were developed in WP1 (Internal report 1.1). The FoP mainly consists of smart grid projects, but projects that focus on engaging end users without implementing smart grid infrastructure are also included. For the purpose of consistency the term 'smart energy projects' will be used in this report, as this is the broader term that includes both projects that do and do not include smart grid technology.

For example the *UppSol 2020 (SE)* project concentrates on engaging end users by working with engaged participants that interact with interested followers who might want to install solar panels. The *eueco (DE)* project should be mentioned here as well, as this case study describes a consultancy approach to facilitate the foundation and maintenance of local and regional energy cooperatives. To this end, they try to involve the members of the cooperatives into the project and they actively communicate with local stakeholders to engage them into these projects. The *OSCAR (CH)* project offers a customer portal called "OSCAR's world for saving energy" to private customers of the Energy supply company BKW Energie AG in Switzerland. Customers are invited to enter their metering data manually into an online platform on a weekly basis and learn about their own consumption and conservation possibilities in a playful manner. Overall, this project has a strong focus on end user motivation.

Initially there were 33 projects to be analysed; however, one project was excluded from further analysis, because after careful examination it did not fit within the project objectives. That project, SPES, was an initiative that after conducting the case study seemed to focus more on the use of modern equipment for medical use (telemedicine), and not on the energy use that was inherited in the use of these devices. Since no energy awareness was created in this project, it has been decided to eliminate this project from further analysis and thus the sample analysed will only contain 32 case studies.

3.2 Project organisation

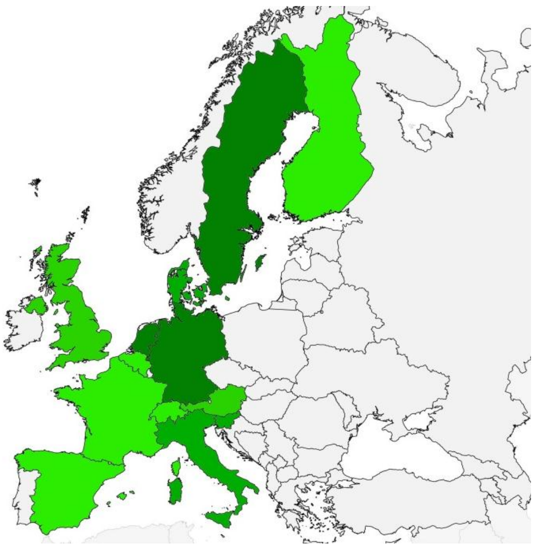
Location of projects

The analysed projects have been conducted within 15 European countries, which are listed in the table and geographically presented on the map of Europe, see figure 1. Most projects have been conducted in Sweden (6), Germany (5) and The Netherlands (5). The list includes all the different countries per project, so if a project had different pilots in different countries, all these countries were listed, but if multiple pilots were organised in one country, this country was only listed one for that project. There is no correlation between the actual amount of smart energy projects present in an EU country and the S3C selection of case studies, nor is there a relation with the development of smart grids nationwide.

The locations vary from projects being in rural areas, urban areas or in cities. There are projects that have all combinations of these three types of locations present as well. Most projects are located in urban areas. The amount of international projects is very small, only *3e-Houses (DE/ES/UK),* and *BeAware (FI/IT/SE)* have pilots that have taken place in more than one country.

Figure 1: Location of pilot projects

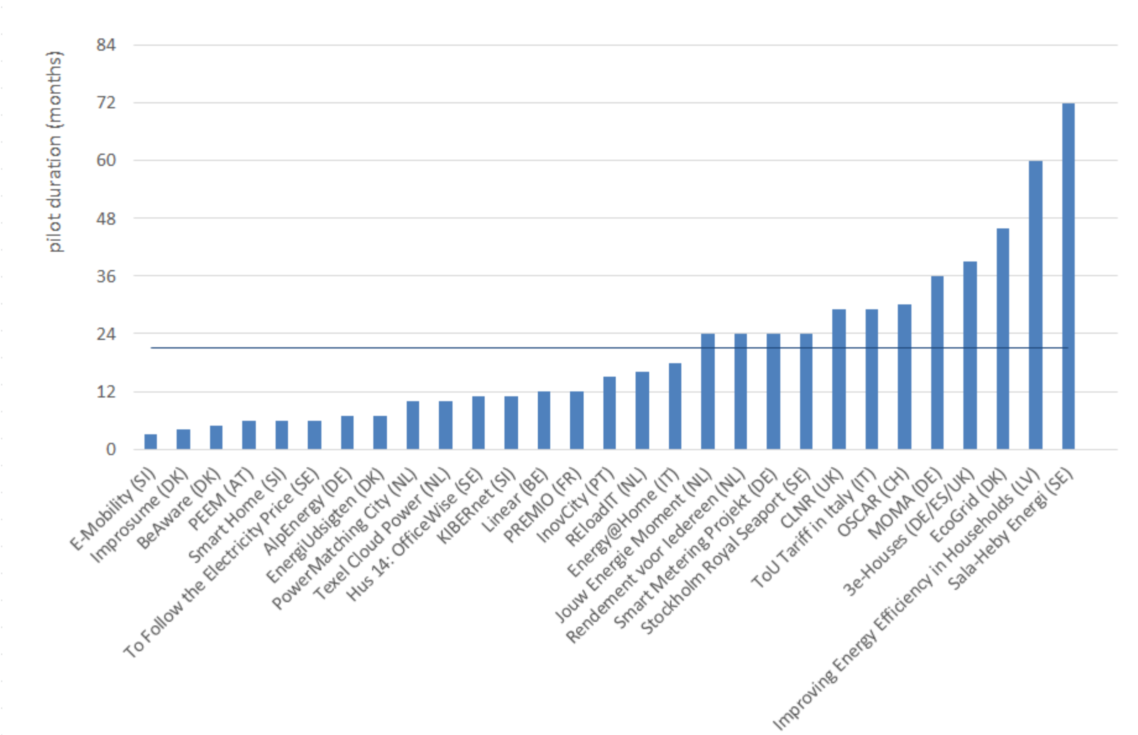
ID	Country	Frequency
1	Sweden	6
2	Germany	5
3	The Netherlands	5
4	Denmark	3
5	Italy	3
6	Slovenia	3
7	Austria	2
8	UK	2
9	Belgium	1
10	France	1
11	Finland	1
12	Latvia	1
13	Portugal	1
14	Spain	1
15	Switzerland	1



Timeline of projects

The graph below, figure 2, presents the duration of the pilot testing phase within a project. The average duration of testing has lasted 20 months, although some field tests are still ongoing and have not provided the information on the predicted duration of the test. One project was not used for this graph. This project describes the workings of an organization, and not a specific project from this organization *(eueco, DE)*. Half of the 32 case studies that we have examined had already been finished before our research started. Most of the ongoing case studies are in the execution phase.

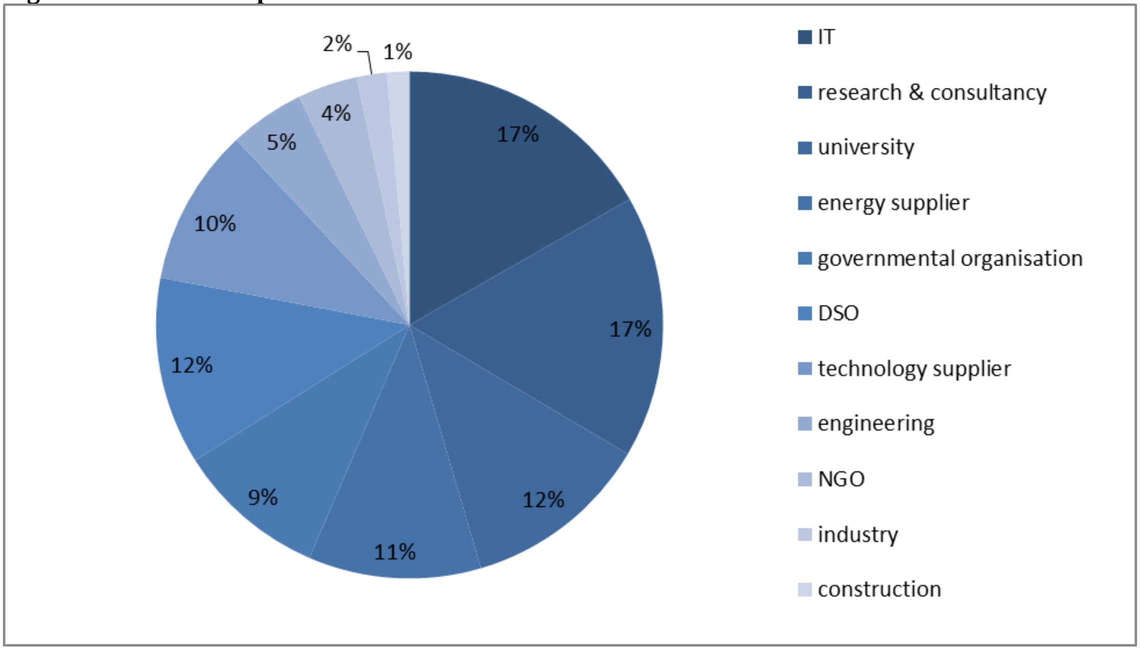
Figure 2: Duration of investigated projects



Consortium partners

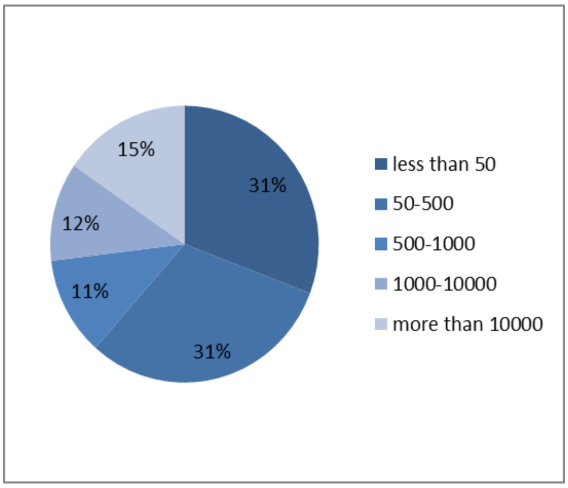
The vast majority of projects (78%) have at least one energy related partner in the consortium (25 projects). In total, the 32 projects combined 209 different stakeholders from different industries and with different specialities. A division among the different types of consortium partners can be found in figure 3. Because this concerns the total amount of organizations throughout the projects, and not the presence per type of partner per project, some stakeholder types are somewhat overrepresented. This is because many consortiums include more than one IT company, university, research institute or consultancy firm. However, for example, although IT companies are among the largest represented type of stakeholders, they are involved in only 69% of the projects.

Figure 3: Consortium partners



3.3 Participants

Figure 4: Number of residential participants



In total 26 projects have been focusing on residential consumers. Vast differences have been found in terms of the total number of participating households within the projects, see figure 4 and table 2. The largest recruitment of 30,000 participants has been conducted in the project *InovCity (PT)*, while in the project *Stockholm Royal Seaport (SE)* only one smart apartment had been analysed so far (although additional "smart" apartments are being built will be included in the analysis in the future).

Note that part of the large variety in sizes is also related to the set-up of the projects; the larger projects (*InovCity, PT; ToU Tariff in Italy, IT; and OSCAR, CH*) included so many participants because they asked relatively little input from them, whereas projects such as *PowerMatching City (NL), PEEM (AT), BeAware (FI/IT/SE)* and *Stockholm Royal Seaport (SE)* had much more intensive participation. The spread is almost equally divided between projects with a small, medium and large number of households. Projects with less than 50 households amounted for 31%, an equal percentage of projects analysed 50 to 500 users, while projects with more than 500 participating households accounted for 38% of the projects. The latter group is again quite evenly distributed between projects of 500 to 1000 participants, 1000 to 10,000 participants and projects bigger than that.

In total 8 projects concentrated or had a participant group with commercial partners. This can be SMEs or industrial organisations: *KIBERnet (SI),Hus 14: OfficeWise (SE), Salzburg SME DR Study (AT), CLNR (UK), UppSol 2020 (SE), AlpEnergy (DE), EcoGrid (DK), PREMIO (FR).*

Table 2: Number of residential participants per project

	Project name	Total number of households in the project
1	InovCity (PT)	30,000
2	ToU Tariff in Italy (IT)	28,000
3	OSCAR (CH)	24,000
4	CLNR (UK)	10,794
5	PREMIO (FR)	8,000
6	Sala-Heby Energi (SE)	5,000
7	EcoGrid (DK)	2,000
8	MOMA (pilot 2, DE)	882
9	EnergiUdsigten (DK)	558
10	Improving Energy Efficiency in Households (LV)	500
11	Jouw Energie Moment (NL)	420
12	Texel Cloud Power (NL)	300
13	Linear (BE)	239
14	Rendement voor Iedereen (BE)	200
15	MOMA (pilot 1, DE)	104
16	AlpEnergy (DE)	70
17	Energy@Home (IT)	50
18	Smart Home (SI)	50
19	To Follow the Electricity Price (SE)	41
20	PowerMatching City (NL)	40
21	Smart Metering Projekt (DE)	35
22	PEEM (AT)	24
23	Improsume (DK)	17
24	BeAware (DK)	8
25	Stockholm Royal Seaport (SE)	1

3.4 Project features

There are many features that define a smart grid project, including the interventions introduced to the end user. In this section two of those are highlighted: the level of automation and the type of tariffs that are used. We have specified before that the FoP consist of smart energy projects, which is subdivided in a large group of smart grid projects (that include a smart grid infrastructure) and some miscellaneous projects that cannot be considered smart grid projects, because they do not include smart grid infrastructure, but aim to foster smart energy behaviour in other ways. These smart energy projects are *E-Mobility (SI), eueco (DE), OSCAR (CH), Salzburg SME DR study (AT)*, and *UppSol 2020 (SE)*. The rest of the projects in the FoP are thus considered smart grid projects.

Level of automation of the system

Within the smart grid projects a division can be made according to the so-called smartness of the system, meaning how much of the smart(er) energy behaviour is automated and how much is dependent on a (conscious) behaviour change in the end users? To this end three categories were defined: full manual control, combined automated and manual control, and fully automated control, see table 3. In this way the projects are distinguished from each other from the perspective of the end user, i.e. do they need to change their behaviour themselves or will they be supported by technology? However, even in the case that there is technological support that controls the appliances, this often still requires the input of the end user with respect to the use of appliances and their flexibility.

The first of these categories include all the projects that rely on the manual control of the end user to consume energy in a smarter way. This could happen because the end users are informed of a clear dynamic tariff, such as in *Sala-Heby Energi (SE)* or *ToU Tariff in Italy (IT)*. But also by informing the end user of their consumption, and possibly providing incentives, to generate a behaviour change. This is done, for example, in *Improsume (DK), Smart Metering Projekt (DE)* and *Promoting Energy Efficiency in Households (LV)*.[4]

In the category combined automated and manual control, projects can be found that make use of HEMSs that control smart appliances or conventional appliances through smart plugs. This still requires interaction with the end user that needs to give input e.g. with respect to flexibility or comfort settings; a behaviour change is thus still necessary. The end user is also informed about their energy consumption in order to change energy consumption behaviour manually in other practices as well. This is for example the case in *Linear (BE), PowerMatching City (NL)* and *MOMA (DE)*. On the other hand this category also includes projects that have different pilots with different levels of automated control. For instance in *To Follow the Electricity Price (SE)* there is a group of participants that falls under direct control and another group that has full manual control.

Lastly the automated control category holds the projects that make use of automation to control energy consumption. This could mean that the end user is unburdened, such as in *REloadIT (NL)*, where the charging system automatically calculates the best time to recharge the EV batteries based upon the reservations made by the end users, but also that the control of the appliances is automated and that end users have to change the use of their appliances in order to remain within the set limits, as in *Smart Home (SI[5])*. If the system is automated, this does not mean that no end user interaction is required. In *KIBERnet (SI)*, an algorithm was created that could create offers for modifying the energy consumption of the end user. These loads were not directly controlled; it is up to the end user to accept or reject the offers. the The difference with the last category is that end users are not directly asked to change their energy behaviour to align with goals such as peak demand reduction, electricity demand reduction, etc.

Table 3: Manual vs automated control over energy consumption

Full manual control	Combined automated and manual control	Automated control
Improsume (DK) Sala-Heby Energi (SE) ToU Tariff in Italy (IT) Hus 14: OfficeWise (SE) PEEM (AT) BeAware (FI/IT/SE) Rendement voor Iedereen (NL) Promoting Energy Efficiency in Households (LV) Smart Metering Projekt (DE) Texel Cloud Power (NL)	3e-Houses (DE/ES/UK) Jouw Energie Moment (NL) Linear (BE) To Follow the Electricity Price (SE) PowerMatching City (NL) Stockholm Royal Seaport (SE) EcoGrid (DK) AlpEnergy (DE) CLNR (UK) MOMA (DE) Energy@Home (IT) InovCity (PT) PREMIO (FR)	KIBERnet (SI) REloadIT (NL) Smart Home (SI)

Types of Tariffs

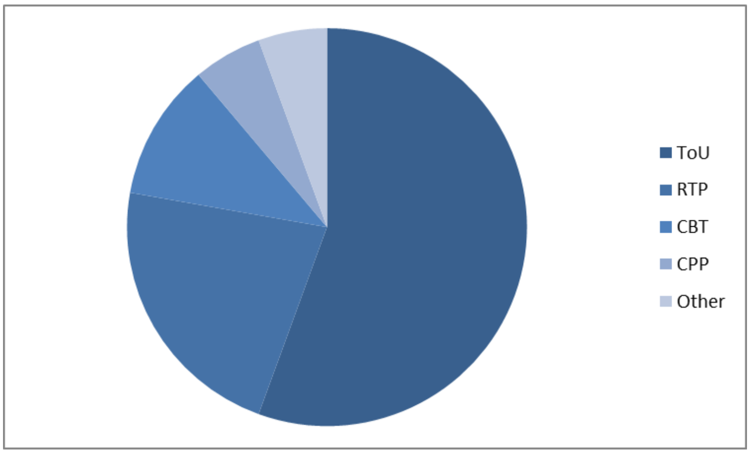
In thirteen projects one or more different dynamic tariffs were introduced to (part of) the participants, resulting in 18 different tariff schemes. In total 5 different types of tariffs were used; the Time of Use (ToU) tariff, Real Time Pricing (RTP), Consumption Based Pricing (CBP), Critical Peak Pricing (CPP) and one which is a combination of a fixed and a variable tariff based on the spot price market. The total amount of tariffs what was used can be found below in figure 5. Clearly the Time of Use tariff was used most.

[4] In *Rendement voor Iedereen (NL)*, however, a subgroup of the participants is planned to take part in a service that will remotely control some appliances, but at the time of conducting the case study it was not yet certain how and when this would be introduced. Moreover, as this would most likely only include a small sample of the participants, this project was grouped under full manual control.

[5] This project also provided the end users with feedback, but because the automated energy control box had the control over the maximum power that could be consumed at any one time, this project is considered an automated control project.

An elaborate explanation on the meaning of the different tariffs can be found in D1.1 "Report on state-of-the-art and theoretical framework for end user behaviour and market roles". The price update frequency differs throughout the projects from every 5 or 15 minutes, to daily updates, but also every three months, or twice a year updates are present in projects.

Figure 5: Different types of tariffs used



4. Analysis

This section reports the findings of the in-depth analysis of the case study data. The analysis is structured according to the nine research questions presented in section 2.2, that were based on the nine challenges for end user engagement in smart grids identified in D1.1 and the first version of the KPIs. Under each research question the relevant information from a multitude of case studies has been evaluated for their ability to their potential to positively affect the energy consumption behaviour of end users. Throughout this section, best practices derived from the case study data are presented in boxed texts.

4.1 Understanding the target group(s)

In order to engage the participants in smart energy projects, it is important to find out what their desires and needs are and what drives and motivates them to become and to remain actively engaged as end users. The following research question is addressed in this section: *Which instruments or approaches contribute to achieving better understanding of the needs and desires of target groups?*

Learning about end users in smart grid trials can be done by using different interaction schemes and approaches. In many projects, this is strongly related to the overall evaluation activities. The analysis of the case studies has led to deduce 21 different methods/instruments, which range from the traditional quantitative and qualitative surveys via interviews or questionnaires to contextual inquiries and cultural probes (see table 4 on page 31). In this section these different methods will be discussed, including the features that make them successful or might limit their success (each method is underlined). Unfortunately often the effectiveness of the methods are often not described in the case study, as are the lessons learnt by the project management from the individual interventions. This limits the possible depth in this analysis.

Overall, three key motives to achieve an understanding of the needs and desires of target groups can be identified. In this section the most suitable interventions are discussed for each motive: (1) getting to know the target group(s), (2) obtaining in-depth knowledge about the target group(s); and (3) to evaluate and to learn how the project is experienced by the target group(s).

4.1.1 Getting to know the target group(s)

The first question the project management needs to have answered about their participants is: who are they? This question primarily relates to the planning phase of the project. In order to recruit them, engage them, inform them and eventually change their attitude and behaviour, it is necessary to obtain a basic understanding of who the (potential) participants are. Gathering general data about the participants can also help decide how to pursue further communication or research into their wishes and desires. For instance, in the *3e-Houses (DE/ES/UK)* project, it was quickly figured out that phone calls and home visits were preferred over written communication, as many of the participants were illiterate.

Existing knowledge

Some interventions can already be effective to get to know target groups without having to organize interaction with them. <u>Desk research</u> is a common starting point for research and development projects. Results from former studies in the same research field and results from relevant scientific disciplines can be analysed to obtain an understanding of how a project might be perceived by potential participants and what might drive or hamper them to sign up for the project. An example of how this can be done comes from *InovCity (PT)*, where several desk studies were carried out to understand the attitude and behaviour of consumers towards smart grids. Public reports from smart meter organizations, from the regulator in Portugal and from consultancy companies were also studied. Furthermore, international benchmarking studies regarding smart grids were investigated and a national segmentation study was used to get an understanding of the needs of end users and their attitudes toward smart energy solutions. <u>Consulting ongoing (sister-)projects</u> to find out which assumptions for customer behaviour may be applicable, can be considered another intervention to get to know the target group when designing a smart grid project. This method was used by e.g. *PEEM (AT)*.

Learning from existing literature and from other projects helps to develop projects more efficiently, as they need not to reinvent the wheel when it comes to getting to know general desires, wishes, what works and what doesn't in relation to smart energy projects. However, in order to tailor the project better to the specific target group, most projects pursue different or additional ways in which they can learn to better understand the end users.

Surveys

Perhaps the most straightforward way to characterise the target group is to obtain basic information about them via the use of surveys (usually distributed online). This has been done at the start of almost all projects involving households. In some projects, for instance in *Linear (BE)* and *EcoGrid (DK)*, survey questions were based on underlying (psychological) theory in order to obtain an understanding of people's willingness to change their energy consumption behaviour. These surveys often touch upon a variety of topics. In *CLNR (UK)* questions were asked about demographics, attitude towards energy use and smart grids and the use of appliances and energy. For *MOMA (DE)* the survey included topics such as installation of the system, socio-demographic facts, living conditions, electronic devices owned, electricity consumption and willingness to pay for smart grid technologies. In *Linear (BE)* the coverage of the survey was even broader, including attitude towards smart appliances, socio-demographic factors, characteristics of their houses, environmental attitude and behaviour, energy use, appliances present in the house, use of IT, energy saving behaviour, heating practices and occupation patterns.

Surveys need not to be limited to the group of (potential) participants. In fact, for *Linear (BE)* a large scale survey was conducted in order to find out the distribution of attitudes towards smart grids in Flanders. A similar approach was found in the project *InovCity (PT)* where a quantitative study has been conducted to characterize the population of Évora and to inquire their interest to participate in the *InovCity (PT)* project. Neither do surveys have to be conducted through the use of questionnaires. In the online-based *OSCAR (CH)* project, the project management obtained a lot of information about the participants by making the survey a part of the challenges and assignments that the participants could take up.

Exploratory field inquiries

In addition to the desk research and the quantitative characterisation research mentioned above, some projects conducted exploratory field inquiries to find out whether the designated products and services would match the intended target groups.

InovCity (PT) organized focus groups with potential participants to evaluate energy management solutions that were under study for possible implementation in the project. A series of focus groups were conducted with a group of clients whom identified, discussed and voted different energy related services for further testing. In *Texel Cloud Power (NL)*, a focus group was organised before the recruitment started in order to get an understanding of the motivations, concerns and expectations of the participants. With this knowledge in mind, the project set up a recruitment strategy that included the right type of information for the end users; what they needed to know before they could decide whether or not to participate. *Jouw Energie Moment (NL)* performed a needs assessment among individuals and households, to find out under which conditions they would be willing to participate in the project. First of all they do not want to engage in such a project on their own, but they need to feel that others join as well. Secondly, although it is not necessary to save any money, it should definitely not cost them compared to not participating. And lastly they wanted the technology to be reliable and not cause too much inconvenience. A comparable but somewhat different approach was taken in *3e-Houses (DE/ES/UK)*. There a study was conducted to comprehend the end users' energy consumption habits.

Projects that worked with SMEs and other commercial parties as participants conducted feasibility studies to better understand the end user. In *KIBERnet (SI)* a feasibility study was conducted with each of the four industrial participants. As a result of this study, by taking the technological process and operation margins into account, the loads that could be shifted were identified.

Segmentation

Segmentation models can be used in the planning phase to get a general understanding of the needs, desires and attitudes of target groups. In several case studies, e.g. *BeAware (FI/IT/SE)*, *Salzburg SME DR Study (AT)*, *InovCity (PT)*, *Linear (BE* – see boxed text) and *EnergiUdsigten (DK)*, a segmentation approach was listed as means to take specific characteristics of target groups into account when designing the project (e.g. age, income, education, living situation, attitudes, regional characteristics, high consumption end users, owned technologies or a combination of several factors, etc.). Based on such a model, the needs and characteristics of the separate target groups can be discounted in the development of incentives and pricing schemes as well as communication, recruitment and feedback strategies. In addition, it can be used to identify end user groups that may need to be excluded from the trial (e.g. end user with low potential for load shifting in a demand response project).

However, the segmentation models that were applied in the investigated projects primarily focused on demographic characteristics and not so much on attitudes and values or on actual energy practices. Moreover, these projects abandoned the segmentation approach after the planning phase, because it turned out to be rather complicated to collect and process the end user data needed for further implementation in the project. This finding indicates that segmentation models can be a valuable tool for scoping and inception, but in order to fully incorporate them in the design of a smart grid project, dedicated effort and expertise is required.

Using a segmentation model to identify attitudes towards smart appliances (*Linear, BE)*

Linear had the ambition of working in the field trials with a target group of households that would be representative of the overall Flemish population. To that end, a large-scale survey was conducted, involving a total of almost 2000 users, with about 500 people responding. The results of this social investigation were linked to the consumption profiles of these end users. Sampling techniques were used to guarantee the representativeness of the consumption profiles. A segmentation was performed by Iminds, one of the consortium partners, on the basis of people's attitudes towards smart appliances. The segmentation used the 'Technology Acceptance Model' developed by Davis (1989) and Davis et al. (1989), which probes into attitudes of potential customers to new technologies before these technologies enter the market. Attitudes are questioned on 4 dimensions: 'perceived ease of use', 'perceived usefulness', 'attitude towards using' and 'intention to use'. In addition, attitudes towards perceived safety, comfort, control, environmental friendliness, and costs of smart appliances were probed. The following end user types were distinguished:

- *'Adherents':* having a very positive attitude towards smart appliances (w.r.t. their perceived ease of use, impact on comfort, safety, possibilities to control appliances, etc.) – representing about 35% of the Flemish population;
- '*Proponents':* also in general having a positive attitude towards smart appliances, but being a bit more sceptical w.r.t. safety and possibility to control smart appliances – representing about 27% of the Flemish population;
- *'Doubters':* have not yet formed a firm opinion on the use of smart appliances; their scores on perceived ease of use, impact on comfort, safety, possibilities to control appliances, etc. are mostly rather neutral – representing 25% of the Flemish population;
- *'Recusants':* having negative attitudes towards smart appliances – representing about 12% of the Flemish population.

However, in the course of the recruitment for phase 2, it became clear that the end users willing to participate in the field trial were almost exclusively made up of 'adherents' and 'proponents'. This means that extrapolation of the Linear results (e.g. in terms of flexibility provided) to the whole of Flanders needed to be done with carefully selected statistical techniques. Hence, the segmentation approach in Linear was mainly used to get an idea of attitudes towards smart appliances.

Live events

Another way to get more insight into the perspective of the participants, which also allows the project management to get some pointers as to what they need to focus on, is to organize live meetings with participants. Many projects – e.g. *EcoGrid (DK*), *eueco (DE), Jouw Energie Moment (NL), MOMA (DE), Rendement voor Iedereen (NL)* and *Texel Cloud Power (NL)* – have organized an information event of kick-off meeting either before or after recruitment. Such events allow end users to ask questions about the project and its implications to the management. In this way, the points of concern that are brought up are not guided by questions originating from the project side, but instead are those things that the participants really worry about. For instance, if many questions are asked about privacy issues and data collection, the project management learns that this is a topic of concern among the participants and can adjust communication to suit their needs. On the other hand, in many projects it seems as if these concerns are hardly present, and since they are quite controversial and difficult to explain, it might then be better not to confuse people with too much or for them irrelevant information.

An open and informal interaction does not necessarily need to happen at an organized event. Some projects set up a physical space where the project infrastructure (i.e. home energy systems and in-house displays) were put on display. Here (potential) participants can always walk in to ask questions and to receive further information about the project. In *EcoGrid (DK)*, a test site called VillaSmart was launched and *InovCity (PT)* created an exhibition shop.

4.1.2 Obtaining in-depth knowledge about the target group(s)

In this section is it discussed what projects in the S3C Family of Projects (FoP) have done to answer the question: what are the end users' actual needs and how do they perceive and experience the products and services offered in the project?

In-depth knowledge about drivers, barriers, needs and expectations of end users in smart grid projects can either serve the outcome dimension of a project (tailoring and optimizing technology, products and services) or the process dimension of the project (engaging end users in the project and keeping them engaged in the course of the project). Creating close interaction seems to be the key to gathering in-depth knowledge about target groups. This can be done in several ways.

Contextual inquiries

In order to gain an understanding about what the desires and needs of the target group are, it is very helpful to interact in a close and personal way with them through contextual inquiries. For the *CLNR (UK)* project held 250 interviews with both participating households and SMEs were conducted to find the answer to what needs and wants the participants have. They did home visits in which they set up the interview in a semi-structured way: first they would interview the participants about their energy use and attitudes, then they would make a tour through the premises together to focus on the energy practices of the household or SME, after which they would conduct another interview focussed on flexibility and peak consumption. This provided the project management with detailed information regarding energy behaviour of participants, thus allowing them to gain a deeper understanding of their needs and wants. On a much smaller scale, employees in the *Hus 14: OfficeWise (SE)* project were asked by the office to describe their working day in detail through the use of culture probes (see boxed text). A similar approach was found in in the *BeAware (FI/IT/SE)* project, where participants were asked to film themselves while performing tasks on the feedback device.

Contextual inquiry through culture probes (*Hus 14: OfficeWise, SE)*

The use of a culture probe is a fairly new method. It was used in the *Hus 14: OfficeWise (SE)* project where the respondent documents for example his or her working day by use of a mobile camera, texts and drawings based on some given questions. Questions were for example: 'What does a working day at SP look like?'; 'How is identity communicated at the workplace?'; 'How are issues concerning energy use communicated?'. This manner of gathering information has the advantage of receiving 'real time' feedback from participants, and is non-intrusive because e.g., a mobile phone is used frequently and easy to use for (most) participants. It does not interfere with the daily lives and routines of the participants, and is relatively easy to fill in the required information.

Focus groups

Creating close interaction can also be done in focus groups, which have been organised within many projects in the FoP. *InovCity (PT)* organised multi-stakeholder workshops that aimed to bring down the differences and communication gaps between technology developers and providers and their actual customers. Thus, the project established a direct contact between end users, local officials, IT-experts, communication experts and the project marketing and customer service staff prior to the field trial. Basically, such workshops offer an opportunity for an informal information exchange in which end users can address concerns directly to the responsible parties. Generally, such a workshop creates a win-win situation that not only takes end user needs into account, but can also offer the experts and technical staff direct access to the end user.

PowerMatching City (NL) developed an innovative approach that focused primarily on the outcome dimension of the project, by coupling end user workshops with a gamification approach. Data collection through gamification is a rather playful method that is not considered intrusive by the end users. In *PowerMatching City (NL)* a card game was used to learn about end users' needs and priorities regarding smart solutions that could be offered to them (see boxed text). Based on the outcomes of the card game, two propositions for energy services were developed in co-creation with the participants. The framework of a game offers participants a 'safe' environment, where they feel free to speak honestly about their real drivers and motivations. This can avoid socially desirable answers and supports the dialog among end users. In the workshop, people started talking about norms and values, which in turn became valuable input for the developed solutions. The number of participants should be limited for a successful outcome.

Gamification workshops (*PowerMatching City, NL)*

In a workshop setting, a card game was used to research opinions and attitudes of the participants in a playful manner. The aim was to learn about end users' needs and priorities and to develop propositions for energy services in co-creation with the participants.

First, a workshop session was organized for exploring and imagining the energy supply in the future. *Metaphors* (such as peak hour rates at trains) were used as a tool to allow end users to imagine and grasp new concepts of matching supply and demand, and working with variable rates. Working with metaphors was useful, both for the more and less technology minded participants. For each metaphor, participants were asked to reflect upon *hopes*, *worries* and *solutions*, concerning the future energy supply. These results were narrowed down to five key drivers.

Next, a *card game* was initiated to 'play out' different possible options end users could take. The cards had four categories: energy generation and storage (e.g. 'sharing a wind turbine'), managing energy streams (e.g. 'smart appliances reacting to energy price'), monitoring and advice (e.g. 'advice about energy investments'), and services (e.g. 'leasing smart appliances'). The full set of options was developed by the project team, based on what were considered relevant future options, and based on the input (key drivers) from the previous workshops. Each option was attributed a price, and end users had to decide in groups which options they would like to buy, given their limited allocated budget.
The project management mentioned the following reasons for choosing a game:

- To force people to really make a choice among different options (considering a limited budget in the game);
- Fun and low threshold;
- To avoid socially desirable answers;
- To support dialogue among end users.

Workshops can also focus on the design of the feedback device, such that a direct insight is given into how end users would like to receive the feedback. The office-based project *Hus 14: OfficeWise (SE)* organised a series of co-creation design workshops. In these workshops participants were offered a set of scenarios and had to design solutions for a visualisation of the feedback in groups by drawing, cutting, pasting and describing their solutions to the other participants. The events were successful, because the employees appreciated the different shape of the design workshop compared to the daily activities. Another side effect of the workshop was keeping end users engaged in the project. According to the project manager, this creative event was very appreciated by the participants and led them to be more engaged with the project.

Several projects conducted specific studies to optimize the design of feedback information, because they learnt from desk research that there is not one best way of providing participants with feedback information. What works largely depends on the context and the characteristics of the target group. Therefore, it is important for the project management to learn how end users perceive the feedback information, how they work with the feedback device and how they interpret the information that is given to them. Some projects developed novel ways to present feedback information and have used different methods to obtain insights into the experiences of the participants with this. In *Jouw Energie Moment (NL)*, a project were the participants come from a wide variety of backgrounds, two different types of interfaces for an in-house display (IHD) were designed. When the prototypes of these designs came out, they organised individual interviews with a number of end users in order to gain understanding on how the information presented was understood by them. The project management specifically chose to work with individuals here, although it was a more time-consuming method, in order to make sure that also the voices of the more insecure and self-conscious when it comes to such innovative products, such as the elderly, were heard. As their goal was to create a feedback channel that was easily understandable for the end users, they used this information to improve the display design. In the *PEEM (AT)* project a focus group was organised with a part of the sample of participants in order to gain more insight into which type of feedback would be more persuasive; what feedback would be most effective in changing energy behaviour. In this project the participants did not come from a very wide variety of backgrounds but rather all were employees at the utility company in the consortium and as a result had more knowledge on energy than the average citizen. There was thus less need for a focus on a safe environment for the end users to voice their opinion.

Intermediaries between end users and the project management

On the process dimension, a couple of interventions have been applied to build up a trust relationship between the end users and the project management, on which open and honest discussions can be based. The project *Rendement voor Iedereen (NL)* stands out from other projects by appointing an intermediary between the project management and the community of end users, who is simultaneously participating as an end user in the trial. This intermediary was part of the community that the end users had formed. Such an intermediary can be of great value when building up a relationship of trust with the end users. Also, the end user will be more open with the intermediary in knowing that, as active participant of the trial, the intermediary himself may well have similar experiences, difficulties, etc. Furthermore, an intermediary gives the project a 'face' and prevents the end user from having to deal with an unfamiliar and perhaps less trustworthy stranger at each of the different interactions.

Similar approaches were implemented in *AlpEnergy (DE)* and *Salzburg SME DR study (AT).* They tried to address the most knowledgeable employees in the firms they were surveying that were considered the energy expert by their colleagues. By involving them as 'gatekeepers', the project management was not only able to obtain important information, they also mobilised an intermediary who could provide support when surveys were conducted. This approach was also found in *UppSol 2020 (SE)* where an independent third party (STUNS) was involved to organize the workshops.

Focussed studies

Several projects conducted specific studies that helped them to better understand the end user. The knowledge obtained through such focussed studies is used for further development and optimization of technology, products and services deployed in the project. In *3e-Houses (DE/ES/UK)* a socio-economic evaluation of the proposed IT-solutions was conducted in terms of their social, psychological and economic potentials and barriers. Insights were collected on the effect of age and education of end users and the level of comfort with technologies, revealing that vulnerable end users (social housing residents) have less access to new technologies. This also impacted the incentives provided and the technical support required by tenants and end users. Additional data were collected face-to-face from workshops, home visits or by telephone call. This was found to be very useful in developing a deeper understanding of several variables, such as the level of engagement within the project, the perceived physical and intellectual comfort with the technologies, the usability and perceived reliability of the IT-solutions and the reasons behind any observed behaviour changes.

4.1.3 Learning how the project is experienced

This section focusses on the question: what are the experiences of participants? Since most projects included in the S3C FoP are research projects, it is the experimental part of the projects that is focussed upon; it includes the obtaining of information from participants on how they perceive the smart energy project from their perspective. This can be information on how they work with and understand the feedback (information), but also generally what their thoughts are on participating in the project.

Gamification

Data collection through gamification is a rather playful method that is not considered intrusive by the end users. The customers do not necessarily realize that they are being surveyed in projects like *OSCAR (CH)*, which applied a promising practice in considering end user needs by integrating questionnaires and interview tactics into an overall concept of playful learning and gamification instead of applying them as individual interaction schemes. As a consequence, questionnaires and interviews are generally not perceived as time-consuming or as invasive as regular online surveys or face-to-face interviews. Qualitative as well as quantitative data about the end user was gathered directly via the online portal in several manners: end user can fill out an online user profile, a round of introduction (including questions about attitudes, practices, etc.).

Insight in the use of feedback information

Very insightful and detailed information about how end users interact with the feedback device and information was sought in the *BeAware (FI/IT/SE)* project, where participants were invited to perform tasks on the feedback device and film this. This is a rather resource intensive way of trying to gain an understanding of how the participants work on the feedback device, but it does provide the researchers with very detailed information. Other projects have used simpler ways to obtain information about how the end users interact with the feedback device and what they think of the information presented to them. Many have included questions about the feedback channel(s) and information in the surveys that were conducted among end users. The *Smart Metering Projekt (DE)* carried out specific surveys about this topic (see boxed text).

Learning how end users experience feedback channels and information (*Smart Metering Projekt, DE)*

In the German Smart Metering Projekt, a telephone survey was conducted with the participants of the field test in Kiel, in which they could provide information on their direct experiences with the feedback system. This had the goal to gain further insights about how feedback about electricity consumption data must be presented and converted for the user and what kind of additional functions must eventually be provided so that, both the environmental objective of energy conservation can be achieved and an added value is produced for the end users. This was useful to learn which requirements and suggestions the users have and also to find out which goals and subjects the users pick out as a central theme while using the web portal. In addition, a semi-structured interview was conducted with 12 employees of Stadtwerke, which lasted between 5 and 20 minutes The interviews were recorded with the consent of the subjects and were subsequently transcribed and analysed.

During an interactive workshop with participants of the 1st field trial in Mannheim, various feedback-offers were discussed and then contents of the discussion were analytically evaluated. In preparation for the workshop, the 24 ‘friendly users’ of the trial in Mannheim were invited by mail and phone to participate. The discussion, recorded on tape, was moderated by the social science team of Fraunhofer ISE, while the sales manager of MVV Energie acted as a co-moderator. There was an atmosphere open for discussion and the participants were engaged and interested. The group discussed several feedback-options; for every option, the most important statements were recognized and then conclusions were gathered.

Some projects have tried to learn about the experience of end users with feedback information in less intrusive ways. The participating end users of *OSCAR (CH)* receive information on their consumption via a web portal and are also offered a forum and an email contact as a feedback channel where they can voice their wishes and concerns. Also, the participating end users receive general tips for saving energy on the web portal, which they can rate as ‘to do’ or ‘not interesting’, thus generating input on which measures end users think are interesting and applicable to their own situation.

Analysing the use of the feedback device is also monitored by web tracking in some of the projects. In *Jouw Energie Moment (NL)* this is done on a very detailed level, providing insight into what pages within the IHD the participants look at most often. One lesson learnt from this is that many participants looked at the non-energy information on the display, e.g. the weather forecast, rather frequently, but that once they were interacting with the display, they also checked their energy feedback. From this detailed monitoring it also became clear that after a while most participants developed a routine to checking the display on set times, for instance before they go to bed. In *MOMA (DE),* tracking the use of the web portal was considered very useful by the social research team in charge of the project’s customer and participation evaluation. Tracking the most used features, e.g. the time spent at specific sites, was used to receive information about which areas and topics of the project should be explained in-depth. Other projects kept it simpler and only monitored how often the participants checked the display.

Insight in attitudes and behaviour change

Surveys are the most often used ways to gain an insight into the attitude or behaviour change of participating end users. A lot of projects make use of pre- and post-trial surveys to document any change in attitudes of participants towards energy consumption and the smart grid and its accompanying technology. Some projects with highly engaged participant groups, such as *BeWare (FE/IT/SE)* and *PEEM (AT)*, repeated such surveys more often during the field study. Not all participants might be willing, however, to put in the repeated effort of filling out questionnaires. The participants from *PEEM (AT)*, however, were allowed to fill these out during work-time and this resulted in very high response rates. In some projects, such as *EnergiUdsigten (DK)*, the results from the questionnaires were accompanied with more detailed information regarding the change in attitude or behaviour that was sought after in interviews.

The information gained about attitudes and behaviour changes from self-reporting methods such as questionnaires and interviews is not necessarily reflected in actual energy consumption data. In surveys conducted in the *PEEM (AT)* project, the participants reported that they changed their behaviour, however, this did not show in the metered consumption. Also in the *MOMA (DE)* project, the self-evaluation of the end users was more positive than the actual usage data that was obtained through web tracking did suggest. This reveals that participants in smart grid trials might suffer from a social desirability bias, which results in over-reporting of 'good (socially desirable) behaviour', under-reporting of 'bad' behaviour or in case of observations pretending a different than usual behaviour. Hence, caution is required when interpreting evaluative data gathered with one single methodology.

Satisfaction of participation

Other than learning how the project participant experience the feedback channels and information, it is often also insightful for the project management to gain an understanding into how the participants have experienced being part of the field test. This does not directly need to provide the project management with information about the (smart) energy side of the project, but is of importance for next projects to be able to organize the project in a for the participants most convenient way. To this end group interviews were conducted with the participants of *BeAware (FI/IT/SE)*, where they could give their opinion on how they liked being part of the project and give feedback on its process.

In the project *To Follow the Electricity Price (SE)* phone interviews were conducted with those end users that decided not to participate in the second trial, to gain understanding on their experiences. The participants had seen the project as an opportunity to earn money and at the same time do something good for the environment. Not signing the contract for the second trial had a combination of factors as reasons: some were disappointed when they found out they weren't installed a new control system (because some households did not have a suitable heating system), others thought it was too much of an inconvenience to adjust the temperature manually. Generally there was a lack of information and understanding about the project; the end users did not understand the offer and could thus not estimate their personal savings. Insights like these are very important for improving the way smart energy projects are organised and managed.

4.1.4 Conclusion

The case studies illustrate that there is no single best method to learn about the target group. Analysis of the case study data results in a list of 21 methods that have been applied in the FoP to obtain an understanding of the target group (Table 4). The extent to which each of these methods is effective depends strongly on the learning goal, which can range from a first acquaintance with the target group, obtaining in depth knowledge about the target group, and understanding how a smart grid project was experienced. Also given a certain learning goal, different methods might be adequate depending, for example, on the types and number of end users, and the societal context at hand.

Even when the context is largely known, selecting the most appropriate methods remains a challenge. Often it did not become clear how exactly the different methods have helped the project management to understand the target groups. Those methods that do seem successful in creating a better understanding of the participants are likely only successful because of a combination of factors and specific details (e.g. wording of questions, set up of and ambiance during the workshop) and precise contextual characteristics (goal, target group and project phase) which are inherently difficult to assess. In this light, the case study data underscore the importance of triangular data collection. When relying on one single data source, the risk is that certain important nuances are not captured in the analysis. Furthermore, when using self-reporting methods the social desirability bias can result in severe misinterpretations.

As a general recommendation, it can be concluded that interaction with participants is very important in order to develop a thorough understanding about them. With the initiative coming from the side of participants, the project management can find out what they really find important and focus further communication and research on. Personal communication in workshops or focus groups that concentrate on certain issues can provide a very thorough, in-depth understanding of the participants desires, hopes and worries. We have not found evidence indicating that participants perceived contact moments as too burdensome, something which can possibly not be said about the filling in questionnaires. A gamification approach may lower the inconvenience that participants feel, because due to the playful approach, they usually do not perceive the gaming environment to intrude with their privacy.

In D3.3 innovative interaction schemes were analysed. These untested interaction schemes can give an outlook on future developments and innovative products to better understand target groups. For example blogs, which focus on non-energy related topics like design, fashion or health, can be a useful tool to reach target groups which may perhaps be interested in energy issues. Energy related topics will only be presented in small portions, to engage specific target groups, thereby also considering and understanding the specific target group. A more end user centred approach are energy clubs, where interested people can exchange their ideas and meet others with a common interest. The common topic of the club has not necessarily to be an energy topic. Other commonly shared interests can cultivate the club as a social meeting point. Furthermore, local ambassadors for energy companies can establish a more close and personal contact to the consumers, support them within their neighbourhood and thereby learn about the end user's wishes and needs.

Table 4: Overview of methods to understand the target group(s)

	Getting to know the target group(s)	Obtaining in-depth knowledge	Evaluating project experience
Desk research	x		
Consulting (sister-)projects	x		
Feasibility study	x		
Surveys	x		x
Exploratory field inquiries	x		
Focus groups, workshops, group interviews	x	x	x
Interviews (face-to-face and telephone)	x	x	x
Needs assessment	x		
Segmentation models	x		
Contextual inquiries	x	x	
Culture probes		x	
Co-creation design workshops		x	
Live meetings	x	x	x
Set up a physical space	x		x
Home visits		x	
Gamification	x	x	x
Appointing an intermediary		x	
Socio-economic evaluation	x	x	
Forum and email contact		x	
Rateable energy saving tips on web portal		x	
Web tracking		x	x

4.2 Products and services

The question answered in this section is: *what innovative products and services contribute to fostering smart energy behaviour?*

New and innovative products and services can have the power to enhance smart energy behaviour in end users; they can make energy consumption easier to understand, simpler to adjust or more exciting to think about. It is necessary that valid business models can be found for products and services that enhance this more sustainable energy behaviour. Only if valid business models can be found for these products and services, then the effective roll-out of smart grids can take place; with effective meaning that there will be a change in the electricity consumption pattern of end users.

In many projects a combination of multiple products and services related to smart energy has been implemented. This makes it impossible to draw conclusions on the effect of individual interventions on the energy behaviour of end users. However, because similar interventions take place in a multitude of projects some indications on their individual performance might be distilled.

In the analysis of the S3C case studies many different products and services have been distinguished, which can be grouped under smart meters, energy management systems, smart plugs and smart appliances, feedback devices and feedback services, and non-energy services. Following this categorisation the different products and services and the underlying success factors and possible pitfalls that have been documented in the case study data will be discussed. Offering dynamic tariffs can also be considered a new service related to the smart grid, however, as this will be thoroughly discussed in the paragraph on incentives and pricing schemes (section 4.4.3) it will be left out of the discussion here.

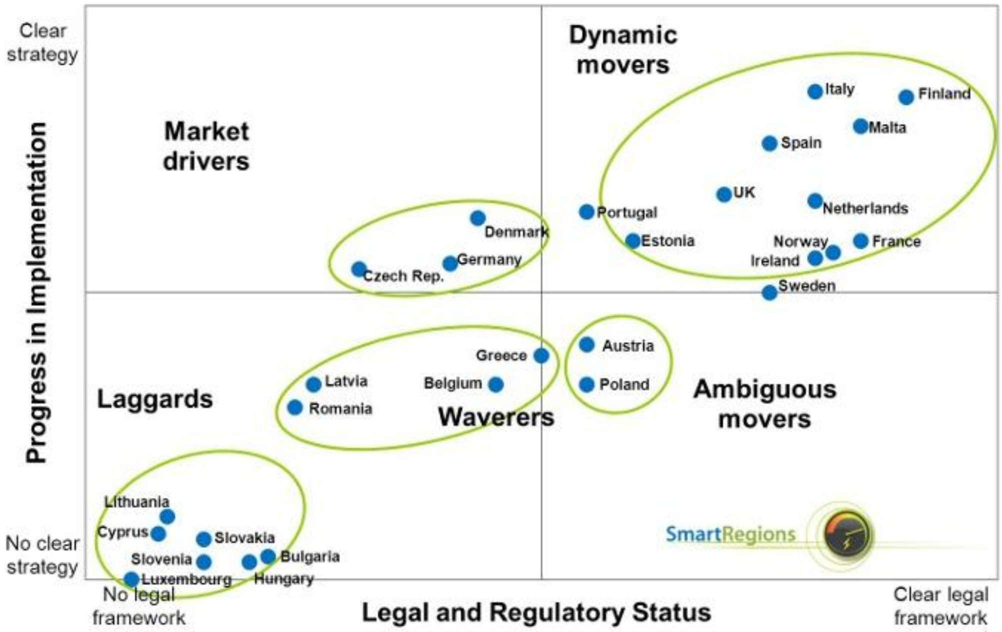
4.2.1 Smart meters

Although not all smart energy projects depend on the installation of smart meters, e.g. *OSCAR (CH)* and *UppSol 2020 (SE)*, the majority of the projects within the S3C Family of Projects (FoP) does. The smart meter generates the general information about the end user's consumption and production, and will therefore play an important role in smart energy systems that rely on such information. A smart meter is a consumption meter for electricity (and sometimes also for gas) that sends consumption information to the utility for monitoring and billing purposes. This information can be used in order to give the end user information feedback about their energy consumption pattern; the data of the meter can for example be used to generate load profiles, make a historical comparison of consumption levels and report instantaneously the price of current consumption.

Smart meters enable two-way communication between the meter and the central system, to transfer data for remote reporting. Data are sent to the central system at the Distribution System Operator (DSO) and/or energy company and can also be sent directly to the local interface (e.g. an in-house display or thermostat) at the customer's home. They usually involve real-time or near real-time sensors, power outage notification, and power quality monitoring. The smart meter records consumption of electric energy in intervals of an hour or less. The smart meter itself is, however, not a device that will change energy behaviour; it merely collects data about energy consumption and does not give any feedback about consumption itself – but instead gathers the data on which feedback can be based. It is hard to draw conclusions about the effectiveness of the smart meter itself, since it is not something that is directly visible to the end user.

Products and services related to the smart grid are often based upon the data obtained by the smart meter – smart plugs, discussed in 4.2.3, can have the same function. Whether or not these meters are already installed on the premises is thus vital for the business case. In some European countries, such as Italy and Sweden the smart meter has been successfully rolled out on a national level. Other countries opt for full smart meter roll-out (Austria) or for non-mandatory roll-out for specific types of customers (Germany), see also figure 6 for an overview of the current status of smart meter implementation versus its legal and regulatory status. Within Europe the viability of the business case of smart products and services is thus likely to be country dependent.

Figure 6: Overview of the smart meter landscape within Europe[6]



4.2.2 Energy management systems

In many of the smart energy projects some form of smart system is installed. This system automates the use of electricity, mostly in order to match supply and demand, which can be done in many different ways as described below.

Community/central and home energy management systems

Such systems can work on a variety of levels, e.g. within a community; the system is the often referred to as a community or central energy management system (CEMS) and is often used to direct the flow of electricity between a group of users. On a smaller level, in residential smart grid project this system is often referred to as a home energy management system (HEMS), which controls the energy consumption within the household.

In different projects the regional energy demand and supply is controlled via a CEMS. This is for example the case in *AlpEnergy (DE)*, where a Virtual Power System (VPS) combines the different sources for electricity generation and the different hubs for electricity demand in order to facilitate a maximum integration of distributed renewable energy generation capacities. A similar CEMS is also in place in the project *Texel Cloud Power (NL)*. There the electricity generation and demand on the island of Texel is managed via the cloud system, a product developed by Capgemini. Generally the central energy management system has no control over individual household loads and therefore end users will not be directly affected by this system.

Home energy management systems

The HEMS, on the other hand, does directly affect the energy consumption of the household. There are many things that can be included into such a system, which determine the level of automation possible within the household. In some pilots the main function for the HEMS is to (remotely) control the smart plugs and smart appliances via the IHD. However, for example, in the *Stockholm Royal Seaport (SE)* project the HEMS includes is a system measuring consumption for the different rooms and appliances, with motion- and temperature sensors in all rooms, dimmers, regulators on all radiators and “away”-buttons decreasing the consumption when the family is not at home.

[6] Hierzinger, R. et al (2013). *European Smart Metering Landscape Report 2012 – update 2013. D2.1 of the Smart Regions Project*. Vienna.

In the *To Follow the Electricity Price (SE)* project, the employed HEMS was commercially available at the time and was developed for heating control of larger properties: such loads were controlled by varying the resistance which the system uses to interpret the outdoor temperature and which determines the power level of the heating system. End users' reactions were mostly positive and led to an acceptance of the system which led to a modification of end users' behaviour in accordance to the initial goals of the project. The automated management of the heating units was even more successful that initially thought: their flexibility was increased more and more, since no complaints were received by the project management. Some even claimed that the higher flexibility resulted in a more constant temperature in the house, which was in fact more comfortable.

One very important condition that determines the success of the HEMS is whether people trust it enough to use it; e.g. In the *MOMA (DE)* project technical difficulties early on in the project with the energy management system, which was called the Energie Butler, made people lose their trust in it. These difficulties in the early phase of the project led to the installation of a very well working support unit, which was able to persuade many participants staying to stay in the project anyway. Nevertheless, as a result the willingness to use it among participants was very low, preferring manual response over the automatic control of their appliances by the Energie Butler.

Commercial energy management systems

Even more important for commercial than for residential end users is the amount of control that is left with the consumer. As we have seen in *Smart Home (SI)* it was considered acceptable, although perhaps inconvenient, that if the amount of power usage at any one time was higher than the set limit, the system would automatically shut off some loads in the household. This was done according to an algorithm based upon personal preferences regarding the order in which to shut off devices. Nevertheless, it could happen that sensitive devices, such as desktop PCs were shut off, meaning any unsaved information was lost. After a while, as the participants gained some experience with the system, the residential end users generally set the limit – they could determine the height of the limit themselves – at half of their installed power and were able to prevent most interferences.

However, it seems highly unlikely that many residential and commercial end users would accept an automatic system like this, especially for commercial users if it would interrupt the primary process of the company without any notification. This does not mean that automated control will never be accepted by commercial parties; simply that they might have different demands than residential end users. The projects that were included in the S3C FoP and that included commercial consumers, either in the form of SMEs or industrial firms, are *AlpEnergy (DE)*, with 33 commercial customers in the Immenstadt region; *KIBERnet (SI)*, four different industrial partners; *Hus 14: OfficeWise (SE)*, the office of the energy department of a technical research institute; *CLNR (UK)*, around 50 SMEs and small businesses; *EcoGrid (DK)*, which included approximately 100 commercial parties; and the *Salzburg SME DR study (AT)*, which includes 21 different SMEs in the region.

Experience with these projects has shown that commercial parties can be open for demand side management, but only under certain conditions. From *Salzburg SME DR study (AT)* it has become clear that the most important requirement for the businesses is that the energy management system cannot interfere with their primary processes. Furthermore, it is important to look into the regulations that are in place for businesses. Processes such as cooling and drying are often very well suited for control by a demand control system, because they have a storage capacity – e.g. for a cooler this means it will remain at a low temperature for a while and will not immediately become warm when the machine is shut off. However, in many industrial sectors there are regulations in place that place demands on such processes and it needs to be taken into account that the need to adhere to these requirements is a point of worry for potential participants. Furthermore, for commercial end users in particular it is very important that they always have the option to overrule the system and thus remain in full control of their business.

Business cases

Other projects have experienced similar problems to *MOMA (DE)* during the roll-out of automated energy management systems. The extra costs caused by extensive customer support (as experienced by e.g. *AlpEnergy, DE;* and *MOMA, DE)* also have to be calculated within a business case for CEMS or HEMS, in order to account for capital and operational costs alike. Currently, the amount of load shifted (usually below 5%) in residential households does not exceed the attributed installation and process costs in most cases; in other words, there is no viable business case. Therefore the mass roll-out of home energy management systems for individual households cannot yet be justified. However, energy managements systems optimizing the overall energy use in entire apartment blocks, i.e. of several households, can help to enhance the flexibility potential and render CEMS and HEMS more beneficial (*PEEM, AT).* Furthermore, commercial end users – especially those with thermal storage potentials – offer a greater flexibility and saving potential that can be tapped with energy management systems. They are considered the low hanging fruits in energy management at this point and the first customers to be included in flexibility based business cases (*AlpEnergy, DE; Salzburg DSM study, AT; MOMA, DE).*

4.2.3 Smart plugs and appliances

Other than the more general energy systems that are employed in some projects within the S3C FoP and that operate on a more general level, there are also ways to include automation and control on a lower, more detailed level. This is often done with the use of smart plugs and smart appliances. Smart plugs are usually inserted in the socket before the appliance is plugged in, and the device allows for monitoring of the electricity consumption by the appliance. Other than this passive function of the smart plug, there are also active versions that can be remotely controlled by the smart system to turn the appliance automatically on or off. This, however, depends both on the type of smart plug and the appliance it is attached to. Smart appliances on the other hand, are appliances that themselves can be fully controlled by the smart system. Because the smart plug and smart device register the energy use of an appliance, more detailed insight into an end users consumption can be given. Furthermore, active smart plugs and smart appliances both permit the automatic shifting of demand to periods of lower prices or to match the generation of renewable energy. In this sense they could thus make it easier for households to shift their energy demand to more favourable times.

We have seen an example in the *MOMA (DE)* project, where it has become clear that the use of automation, in combination with a dynamic tariff, can make it easier for the end users to change their energy consumption as it does not require them to actively think about shifting their energy consuming activities to other periods, but rather have this done automatically. In fact, the price elasticity that was calculated to be at -0.106 on average, i.e. if the price of electricity was raised by 100%, the customers reacted with a decrease of consumption by 10.6% on average. The max price elasticity in some of the households that reacted to the tariff signals manually was measured with - 19.5%, the automatic support through the energy butler even helped the consumer to achieve a price elasticity of up to - 23.6% (not significant). The price spread between the overall 31 price levels was at most 7.75 ct/kWh and the distribution of the time blocks and prices was changed on a daily basis and announced day ahead. The over 700 test households realized savings between € 0.83 to € 44 per month. Discussion within and around the *MOMA (DE)* project included the search for a sound business model around the grid-friendly home automation. One idea focused on the integration of a complete Smart Home management system that includes various other functionalities beyond the management of energy. The costs for the different functionalities would decrease, if they can be embedded within the same system and the acceptance for the components as well as the willingness to pay for devices could by increased, as other functionalities perceived to be more pressing by end users such as home security could be added to the package.

However, the automation also holds a limitation as while it makes it easier for the household to adjust the energy consumption of appliances connected to the smart system by active plugs or because they are smart appliances, they will not create a mind-set that is focussed on shifting energy consumption, and the effect will thus be limited to the appliances under automated control. This was experienced for example by *To Follow the Electricity Price (SE)*, where knowledge about energy consumption and behaviour change was more apparent in the indirect control than in the direct control group. Manual interventions might be fewer when automation is introduced, unless a focus is also put on these. In *EcoGrid (DK)* it was found that including smart appliances in the smart household is a good option, because it allows more freedom for the user by taking over some of the thinking and thus makes their life easier.

In the project *Jouw Energie Moment (NL)* the participants received a smart washing machine. However, from the field test, which was conducted among a wide variety of different household types, it has become clear that not every end user makes use of the smart functions of the appliance, which allow flexibility by letting the HEMS plan the timing of when the appliance runs. It seems as if highly educated, young professionals are most interested in the smart technologies, but at the same time there are also households in which the smart functions of the appliance are hardly ever used – for example because there is always someone present at the household and they have learnt to manually turn the washing machine on when the sun shines.

In the same project it was studied which devices and appliances will offer most flexibility and they have come to the conclusion that the dishwasher, washing machine and dryer have the most flexible consumption. This trend can also be spotted in other projects, such as *MOMA (DE)*. On the other hand, it has become clear that there is little flexibility with entertainment devices, such as TV, radio, PCs.

Furthermore, many people (irrationally) feel uneasy if the cooling cycle of the fridge is influenced, their food will go bad quicker and it will have health impacts. Some end users also voiced concerns over the flexible use of washing machines and dryers (*MOMA, DE;* and *AlpEnergy, DE*) since the end users feared that their clothes would remain wet for too long, if the start of the washing machine becomes flexible.

4.2.4 Feedback devices and services

The concept of feedback as a method to change energy consumption behaviour in end users will be discussed more elaborately in section 4.4. This section and the next focus more on how the accompanying products and services can be used to engage end users with their energy consumption and in this way facilitate a behavioural change.

New products that might have an effect on the energy behaviour of end users are the feedback devices that are used to communicate the feedback. Most projects that work with residential end users make use of webpages or apps on tablet and smartphones, but others make use of in-house displays (IHDs) to give the end user information about their personal energy consumption. Such IHDs can come in different shapes and forms. There are displays that replace the thermostat (*Texel Cloud Power, NL*), ambient devices (*EnergiUdsigten, DK*), but also more innovative devices, such as the Watt-Lite Twist projector (*BeAware, FI/IT/SE*), or the SuperGraph chandelier (*Hus 14: OfficeWise, SE*).

Regardless of what information is presented by the feedback devices, if they are to be installed in households they need to be well integrated into the life of the residents. It is not unlikely that this is the reason that many projects have opted for communication feedback information via smartphones and tablets, as these are technologies owned by the majority of the population in most countries. With the emerging trend of electronic gadgets that becoming more and more aesthetically attractive, it is not unlikely that end users demand a certain level of aesthetics in the IHD when purchasing them. The SEE1 ambient display used in the project *EnergiUdsigten (DK)* was designed to be particularly attractive and with an appealing design.

Innovative devices have the power to spark a greater awareness of energy consumption through being more than merely a visualization of consumption. They represent a growing category of new products: they are able to catch the interest of people triggered by their design and less interested in their details; thus, particular attention must be paid to such details which might raise more interest in the end users. We can see for example that with the SuperGraph chandelier that was put up in the lunchroom of the office in the *Hus 14: OfficeWise (SE)* project. The workers in the office talked about the device a lot and even showed it to visitors. Thus the SuperGraph became part of an image building towards their clients.

The feedback information that the participants of many projects receive can also be considered a service offered by the project. If a viable business case can be created for this it will facilitate the roll-out of smart grids. For this to work, end users need to be willing to pay for the information, and their investment in the smart equipment and services should be less than the savings they are likely to make on a relatively short time scale. From the project *MOMA (DE)* it has become clear that 30 % of the participants would be willing to pay between €1 and 2 per month extra for the service of feedback information. This is very likely not enough for a self-sufficient business case.

Other than simply historical consumption information, participants in different projects (Hus 14: OfficeWise, SE) have asked for hints and tips to be introduced. This will be implemented in the next phase of the project. In *PEEM (AT)* the participants voiced an appreciation for the hints and tips they received as part of the feedback. This is mainly the case, because the participants seemed unsure of what actions would have a significant effect on their energy consumption behaviour and the hints and tips can guide them in this.

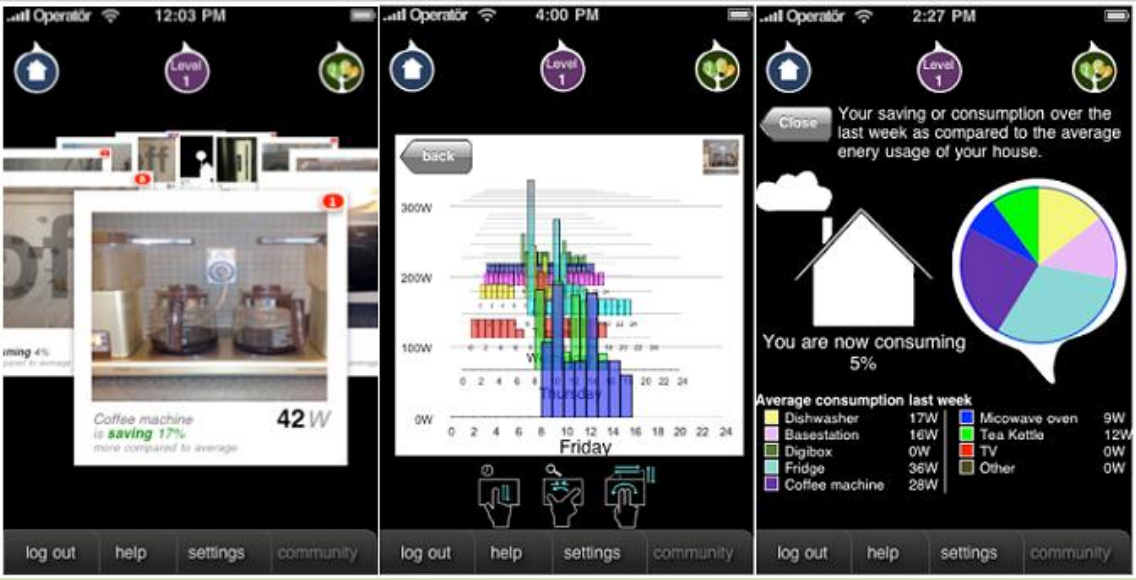
Receiving feedback information by phone and by 'flashlight' (*BeAware, SE/FI/IT)*

- **Energy Life** –a wireless system connected to a smartphone that turns the users into players. As a system that is wirelessly connected to the house, Energy Life keeps track of electricity consumption and builds a historic baseline. This application was conceived as an active game. End users play this game through different levels on their smartphones and are able to pass them by achieving certain objectives and answering correctly to quizzes related to energy efficiency. Furthermore, end users are given awareness tips in order to increase their knowledge regarding electricity consumption as well as feedback on whether they are efficient or not. The application works also as a community enabling the users to communicate among each other and compete with other households in the game. This turned out to be part of an effective way to change energy consumption behaviour, as

- **Watt-Lite Twist** –an instrument similar to a flashlight. When twisting it (like turning on a flashlight), this instrument projects pie-charts on the wall, showing the end user its actual consumption in kWhs per equipment or division. The underlying rationale is to provide the households with an intuitive way of understanding what a kWh is by showing them in real time the consumption levels. All this is made possible because of Watt-Lite Twist which is a wireless receiver connected to home appliances.

Those two practical applications provide real time information because they are connected to a Service Layer and a Sensor Layer platform that enable the whole process of collecting information from home appliances consumption and providing feedback.

Figure 7: The EnergyLife iPhone app from *BeAware (FI/IT/SE)*



4.2.5 Related non-energy services

There are also other services that have been introduced in the pilots within the S3C FoP. These can be directly related to the energy use, but also be more indirectly related. More directly related is for example the weather forecast that is shown on the IHD in the *Jouw Energie Moment (NL)* project. This is an extra service offered by the feedback device that has a positive effect also on the energy behaviour: because people look at the weather forecast on the display regularly, e.g. before going out, this makes them also check their energy feedback more often. The weather forecast gives them information that immediately satisfies their needs and reduces the hurdle they might feel towards undertaking the action of checking their energy consumption feedback, because they were already using the device.

Related to this weather services that lower the hurdle that end users might feel regarding getting involved with more sustainable energy use are the electric vehicle (EV) programmes set up in the *REloadIT (NL)* and *E-Mobility (SI)* projects. Although there are many types of EVs that are commercially available, there is often still a certain anxiety present in many people regarding this more innovative type of transport. In the *REloadIT (NL)* project, the employees of the municipality are offered the possibility to drive with EVs for work-related trips. By reducing the options to make use of other modes of transportation, the employees are stimulated towards making use of these cars. In *E-Mobility (SI)* the service of renting electric vehicles, such as scooters and motorbikes has been set up in the region. This allows people to make use of clean, electric transport in the region. Allowing people to gain experiences with electric transport, makes them more familiar with it and this may take away irrational fears such as range anxiety (the fear that the batteries will not make it to the destination, thus stranding the passengers).

Lowering hurdles to engage with smart sustainable energy; combining ecotourism and innovation (*E-Mobility, SI*)

The Slovenian Rural Development Centre (SRDC) is a social oriented organization. The organization is supported with the governmental financial funds called LEADER, which is intended to support the development of the rural area. The SRDC noticed that electric vehicles can bring additional services and development opportunities on the suburban and rural area. They were inspired by the good practices where closed areas – e.g. nature reservations such as Natura 2000 sites - have limited access with motor vehicles and allows the use of electric vehicles instead to preserve the natural habitat. This approach is usually strongly connected with the local tourism and guaranties the development of the rural areas. Therefore they had the idea to set up a promotional project, which would join the local touristic interests with promotion of the “green” technology of electric vehicles. The propagation of the new technology may serve as an opportunity for the generation of new services for the local community, provide the promotional effect and contribute to the overall development of electric vehicles.

SRDC decided to involve the five communities – Jezersko, Preddvor, Bled, Bohinj and Kranjska gora – which all have attractive touristic activities and programs. The beautiful country mountain countryside seemed the right base for the promotion of the “Gorenjska E-mobility journey”. The charging stations located close to the town lakes are just close enough to each other so that even less efficient EV’s would manage to make the 100 km long journey. In general electrical vehicles can be quite far away from practical every day long range usage. Driven mostly by the technical enthusiasts it is difficult to provide practical experience, which would encourage a wider range of end users to use them. The idea of visiting interesting touristic sights with environmental preserving technology fits with its technical barrier – the time necessary for charging may be fulfilled by touristic programs and tours. This could be one of the introductions of the electric vehicle technology to the general population.

4.2.6 Conclusion

A number of innovative products and services that contribute to the engagement of end users in smart energy projects have been presented in this chapter. The information contained in this report show that there is a huge variety of products and services available to offer to end users. The most effective ones are those providing direct feedback to end users in a simple and user-friendly way: technology is important because it allows the products and services to be integrated in end users’ daily lives and routines – this will be further elaborated in section 4.4. Products offering smart grid services, such as feedback, seem to be promising, because they create a direct link between the individual end users and the different actors in the grid; however, in order to prove their level of success, they still need to be tested in a larger number of projects.

One thing that many of these products have in common is that they give information about personal energy consumption to the end users, which enables and thus empowers them to take action themselves. We can also see this in *BeAware (FI/IT/SE)* as consumption reduction has been most visible in the appliances with the smart plugs, because then participants are made well aware of the effect of that particular appliance on their total consumption. The service of giving hints and tips is also very important in changing energy behaviour. From multiple projects, such as *Hus 14: OfficeWise (SE)* and *PEEM (AT),* it has become clear that end users are unfamiliar with the concept of energy and what they can to do reduce of shift their demand. It has been shown in *InovCity (PT)* that those participants that were offered products and services had a higher consumption reduction than those that were only offered smart metering and the billing of real energy usage data.

One major drawback of the use of the products and services that have been introduced to project participants is that most of them do not (yet) offer a viable business case. The willingness to pay for smart grid services is low among end users. In D3.3 new and untested products and services have been presented. Perhaps these innovative products and services will offer the end user an added value that makes them more willing to pay, which would be favourable for the business case. These untested products and services have a wide range. There are services which are targeting end users who are not interested in energy topics, but who can be triggered by other (lifestyle) topics. Apps for end users can help them to optimize their energy consumption even with limited knowledge. Smart home appliances can reduce the complexity for the end user and automated tariff finders can ease this task. Prosumers within the same contribution grid can organize themselves as one big virtual prosumer to act on the energy market. These business and service ideas described in D3.3 (54ff) are potential areas of business opportunities for utilities or energy and IT related companies.

4.3 Incentives and pricing schemes

The following research question is addressed in this section: *Which (monetary or non-monetary) incentives and pricing schemes contribute to fostering smart energy behaviour?*

An incentive can be defined as a stimulus aimed to motivate end users to change their behaviour by offering a reward as a compensation for a certain action that they would otherwise not have undertaken. Incentives offered in smart grid projects can have different goals: to get potential participants to join the project, to steer the participants towards the desirable energy consumption, maintain interest in and loyalty for the project, purchase related products, etc. There is a wide variety of incentives that have been used within the S3C Family of Projects (FoP). Generally these can be grouped under monetary incentives and non-monetary incentives, although sometimes a provided incentive can have characteristics of both.

Pricing schemes can provide an incentive, but do not exclusively belong to the group of incentives; a pricing scheme as such is just a billing instrument which can be combined with several different types of incentives. There are 13, out of 32, projects that have been evaluated that have made use of pricing schemes. The implementation of pricing schemes and its effect on smart energy behaviour will be covered in 4.3.1. The monetary and non-monetary incentives that have been used in the projects within the S3C FoP will be discussed in section 4.3.2 and 4.3.3, respectively.

Based on the results of the investigated smart grid pilots, an impression of the successfulness of certain incentives and pricing schemes will be given. However, it is important to realise that a successful project often uses multiple incentives combined with several other factors, such as clear communication, the right type of feedback, etc. It is therefore hard to make a clear cut judgement about the performance of individual incentives, but instead we will provide a comprehensive overview of which incentives seem to have a positive effect on end user behaviour under which circumstances and conditions.

4.3.1 Different billing structures or tariffs

Many smart energy projects make use of a dynamic pricing scheme as a means of providing the end user with an economic incentive, for example, to reduce consumption or shift energy demand. Within the S3C FoP these are *Linear (BE), InovCity (PT), PowerMatching City (NL), CLNR (UK), Sala-Heby Energi (SE), ToU in Italy (IT), Energy@Home (IT), Smart Metering Projekt (DE), EnergiUdsigten (DK), MOMA (DE), AlpEnergy (DE), To Follow the Electricity Price (SE)* and *EcoGrid (DK).*

In table 5 below a basic summary is given about five often used pricing schemes: time of use tariffs (ToU); real time pricing (RTP); critical consumption pricing (CCP), including critical peak pricing (CPP) and critical peak rebate (CPR); and consumption based pricing. A similar overview with the details of which pricing scheme has been used in which project can be found in appendix E.

As has been stated before, a pricing scheme is not an incentive per se. The same product offered within a smart grid project, e.g. a TOU tariff with two pricing zones and three price blocks a day, can be linked to different incentive packages. The incentives could be bonuses or maluses on the monthly electricity bill depending on whether more or less energy was used in peak pricing periods (most of the projects within the S3C FoP that introduced a dynamic tariff, see also section 4.3.2), but also score points in a game environment (not actually introduced in any of the projects included in the analysis).

Table 5: Summary of five frequently used pricing schemes

	Time of Use	Real time pricing	Critical consumption pricing		Consumption-based
			Critical peak pricing	Critical peak rebate	
Goal	Change routine behaviour of end users to improve base load (e.g. to increase RES uptake)	Adapt consumption to external variables (e.g. spot prices, prognoses, excess power from RES, grid overload)	Reduce critical peak demand (e.g. in case of grid overload)	Increase demand when electricity is abundant (e.g. in case of excess power from RES)	Energy saving and a general load reduction or consolidation at a certain level
Rationale	Time of use	Time of use	Time of use	Time of use	Load level/overall consumption
Applicable to following cost components	Generation T&D	Generation T&D	Generation T&D	Generation T&D	Generation T&D
Cost driver	Energy	Energy	Energy	Energy	Energy
Dynamics					
• **Number of time blocks /day**	Limited (3-6)	Hourly, Quarter-hourly (24, 96)			2-x tariff blocks based on share of consumption or based on overall currently used load
• **Price update frequency**	Reflect average cost of energy (weekly, monthly, seasonally,…)	Reflecting system costs (Daily)			static
Events					
• **Type**			Peak price	Rebate	
• **Duration**			Short	Short	
• **Occurance**			A few times a year	A few times a year	
Price spread[7]	Considerable (typical ratio 6-8)	Considerable (dependent on the external variables)	High (typical ratio 6-8)	High (typical ratio 6-8)	Prices change by load level[8]
Advised AD option	Manual (or automated)	Automated	Manual or automated	Manual or automated	Manual or automated
Often combined with	CCP		TOU	TOU	

[7] According to (Stromback et al., 2011), TOU pilots tend to have peak prices two to four times higher than off-peak prices, whereas CPP pilots tend to have peak prices between six and eight times higher than off-peak prices.
[8] In case of consumption based tariffs the rate(s) will increase with consumption. In this case the number of thresholds, the rate per threshold and the timeframe needs to be fixed (e.g. month, week, day).

Dynamism of the tariff structure

The dynamism of the tariff structure relates to the number of time blocks within the tariff scheme and the frequency with which the prices are updated. In the *AlpEnergy (DE)* project, two different pilots were organised; one in which the participants tested a static ToU tariff consisting of 2 blocks that were the same on an interday basis and another ToU tariff which was more dynamic and complex, consisting of five time blocks that shifted in time between days. The price spread between the highest and lowest price was the same for both pricing schemes (5ct/kWh) and those in the more dynamic tariff group were supported by a smart home starter kit to allow for automatic control of two or three household appliances. Nevertheless, the more static group achieved a 2% demand shift into the saving zones, while this was only 1% for the participants in the dynamic group.

Complexity of the scheme

These pricing schemes that have been introduced can range from a simple two or three phase time of use (ToU) tariff as were introduced in the Sala-Heby municipality in Sweden (*Sala-Heby Energi, SE*) and Italy (*ToU Tariff in Italy, IT*) respectively, to a complex dynamic tariff that is based on the spot price market and which was offered to the participants of *To Follow the Electricity Price (SE)*. The first two are based on the idea that by increasing the price of electricity during peak hours and reducing it during off-peak hours, end users can save on their electricity bills if they move their energy demand to hours with low prices. In *To Follow the Electricity Price (SE),* the participants received a contracted amount of electricity for a fixed price and could buy or sell additional electricity from or to the DSO that would offer spot market prices for this energy. This tariff is thus only partly variable – for energy below the predetermined hourly demand the fixed price will be paid; while for the amount above this the spot price will be paid and when less energy is used, this is 'sold' back to the grid also for the current spot price. Shifting energy demand so that the end user can sell electricity in high price periods and buy in in low price periods, will result in lower energy bills. These spot market prices were communicated via a web portal.

Although the scheme by *To Follow the Electricity Price (SE)* is more innovative and might therefore be thought of as more effective, it turns out that the complexity of the scheme does not always lead to better results. In fact, the end users do not necessarily need to understand how exactly the tariff works in order to understand how to make use of it. Both in *Sala-Heby Energi (SE)* and *To Follow the Electricity Price (SE)*, positive results have been achieved after the introduction of dynamic tariffs, but in both case studies is it was reported that although consumers had relatively little knowledge of how the tariff was calculated, they clearly understood that they could lower their energy bill by moving electricity use towards periods of low prices.

Automatic vs manual control

From the S3C FoP experiences it has become clear that if the tariff structure is more complex, it helps the end user if part of the control of the energy consumption is automated. For example one lesson learnt from *EcoGrid (DK)* is that if a highly dynamic tariff structure is introduced to the participants, in this case with prices changing every 5 minutes, keeping up to date with the feedback information is too cumbersome and automated control of demand will ease the burden on the end users. Next to this it might also serve to increase the overall flexibility of residential customers.

In several projects, such as *AlpEnergy (DE)* and *Jouw Energie Moment (NL)*, it was recognised that in order to manually show flexibility with demand the participants need to be at home and take the time to consciously decide whether to turn an appliance on or off, which is not always possible. An energy management system might help tackle this issue by switching appliances on or off when the residents are not available to do so themselves. However, in this case the flexibility is limited to the appliances under control by the energy management system. Manual control schemes can be seen as a first step of a learning process to increase the acceptance for smart consumption solutions. In fact, manual options should not be neglected and automated schemes should not be preferred per se.

4.3.2 Monetary incentives

From many different projects it has become clear that one of the main drivers for end users to participate in a smart grid project are the potential economic benefits that they might be able to draw from their behaviour change. In *Jouw Energie Moment (NL)* 95% of the participants stated that they find saving on their energy bill a good motivation to change their energy consumption behaviour. The different types of monetary incentives that will be discussed are energy bill incentives, commodities, and a category of other financial stimuli.

Some of the investigated projects lack economic incentives to motivate end users. Although the absence of economic incentives does not mean a project will not be successful, some will argue that this means the project is economically unrealistic as the business case for the end user will not be viable; this is criticism that the *PREMIO (FR)* project received. However, considering that *OSCAR (CH)* did not rely mainly on economic incentives, but managed to motivate a large number of people to join, it is possibly more adequate to say that incentives should reflect how much input from the end user is needed in the project.

Electricity bill incentives

One of the most frequently attached incentives to dynamic pricing schemes are electricity bill incentives, which translates into the possible savings (bonuses) or higher costs (maluses) that participants can make by consuming more energy in low price and high price periods, respectively.

The results of the energy behaviour change in different projects in which a dynamic tariff was incentivised by possible savings or higher costs onto the electricity bill of the end user are quite different for different projects. In *CLNR (UK)*, the ToU tariff participants consumed 3% less electricity on average than the control group, and their peak consumption was 10% lower. With less consumption in peak periods and more in off-peak periods, the consumers seem to have shifted their energy consumption to benefit from the ToU tariff. In the *Smart Metering Projekt (DE),* which also has a time dependent tariff, the peak consumption reduced by approximately 5%. This was approximately 2.3% in the project *Sala-Heby Energi (SE)*. In *EnergiUdsigten (DK)* the spot price participants reduced their energy consumption compared to the non-spot price customers.

In many European countries existing regulation does not allow for the billing according to a dynamic tariff (see also section 4.8). As a result some projects decide to simulate the dynamic tariff; i.e. the participants received feedback according to the dynamic tariff but were billed as per existing tariff. This will be done in the near future in *Rendement voor Iedereen (NL)*. However, this incentive does lack a monetary basis and as such might lack an encouragement to change behaviour.

For many people one of the conditions for participating in a smart grid project would be that they were guaranteed that they could not be worse off than without the applied dynamic tariff. In the *Linear (BE)* project the participants were assured they would not suffer any losses as a result of participation by being guaranteed that any extra costs made, e.g. as a result of additional electricity consumption by the smart appliances or the HEMS, were reimbursed.

Rather than monetary savings on the energy bill itself another option that has been implemented in several projects is that the participants were billed according to the existing tariff, but that any savings that they made by moving demand from high to low price periods were reimbursed. In *InovCity (PT)* this was done through giving the participants vouchers worth their monthly savings of a well-known supermarket branch. In this case the financial incentive might not be as strong as when the dynamic tariff would have been billed, because no change in behaviour would not lead to any consequences, even if they consumed a lot during peak hours, but does provide an incentive to generate savings by temporally shifting demand.

One of the impairing characteristics of the incentives created by dynamic tariffs that have been introduced in many projects is that the price difference between the different periods is not large enough to be a proper economic incentive. For example in the *AlpEnergy (DE*) project the savings generated by shifting demand to another time resulted in savings of approximately €10 per year, which may not be an incentive worthwhile enough for households. This can also be seen in the *ToU in Italy (IT)* project, where the price difference between the peak and off-peak hours was very little, resulting in only a shift of 1% of total energy consumption from peak to off-peak hours. It is important to realise though that in quite a number of projects the participants sample is not a good representation of the population as a whole. For example in the case study report of *MOMA (DE)* it was mentioned that the savings of €10 a month were not enough of an incentive for the participants, who mostly had higher than average incomes. However, perhaps if the target group is of low level of education and income, such as in the *3e-Houses (DE/ES/UK)* project, these savings would be enough of an incentive to change behaviour.

Examples of additional monetary incentives *(CLNR, UK)*

Three different pricing schemes were tested (with different variations):

3-rate Time of use tariff (see below)

Restricted hours tariff: Time of Use Tariff with appliance automation (e.g. on heat pumps and washing machines) to help avoid peak hours as a default option, but always with override possibility.

Direct control: Remote appliance automation to avoid peak usage at times of network constraint. No monetary incentives are given for peak shifting (flat rates), but always with override possibility.

The tariff structure reflect two different rationales. The TOU tariff (on the one extreme) is intended to offer added value to end users by allowing them to save costs. The direct control tariff (on the other extreme) is intended to assess how far a network operator can go in 'creating' flexibility from end users without end users becoming resistant an dissatisfied. Although allowing direct control was rewarded with a financial incentive reflecting average costs saving of peak shaving, the amount of this incentive appears unrealistically small (interview).

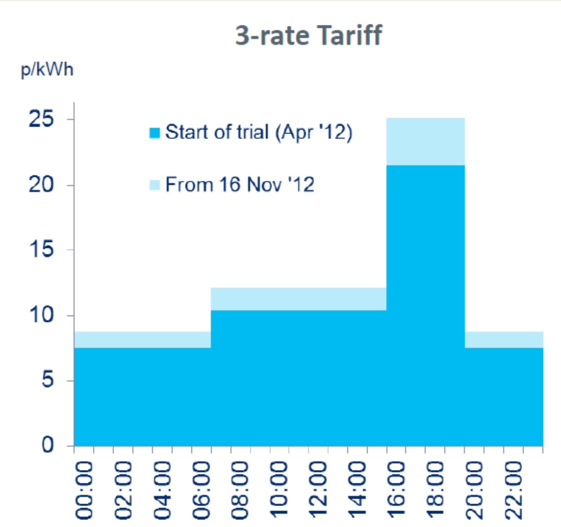
The following additional incentives were offered (CNLR, 2013a):

The CLNR project offered a £100 incentive to all test cells apart from test cell 1a (basic monitoring) paid in Marks & Spencer vouchers, to all households in two instalments.

Heat pumps and micro-CHP technologies were subsidised by the project to match the cost of a conventional boiler to encourage uptake.

Regular smart meters and an IHD were supplied by British Gas, although in most cases they were already available. For some trials, IHDs were supplied (Solar PV in trial 20) for example.

Figure 8: The basic ToU tariff applied in *CLNR (UK)*



Regarding the attractiveness of the different rates and incentives, the following observations were made (CNLR, 2013a):

The prospect of a smart meter proved to be a strong incentive for TOU test-cell recruitment. Recruitment rates among customers without a smart meter were 11% higher than amongst those that already had a smart meter.

The Time of Use tariff (TOU) was well received by residential customers in terms of trial recruitment,

The direct control and restricted hours tariffs are new customer concepts and have proved less attractive so far, in terms of trial recruitment (unclear whether this was because of the offer itself, or the marketing and communication surrounding it).

SMEs are less open to up-take of TOU and also to restricted hours and direct control. Despite initial keen interest in the prospect of lower bills, firms contacted were not amenable to remaining involved with the trial for restricted-use or direct control tariffs.

Commodities

Apart from giving the participants the possibility to save money on their energy bills through a dynamic tariff, there are also other ways for participants to directly save money. Incentives that were used in order to get participants aboard the project by reducing their costs (rebates) were for example rebates on internet use (*Linear, BE*) or even a free internet subscription (*3e-Houses, DE/ES/UK*). This is an example of a service that is offered to the participants and which is also beneficial for the project as an internet connection is necessary for the data transmission. In *CLNR (UK)*, the end users in all participating pilot groups (except for the control group), received £100 in vouchers from a well-known department store.

In *Linear (BE)* the participants were also offered discounts on the purchase of smart appliances. However, this was not as effective as was expected, as many participants were unwilling to trade in their appliances that were still working fine for new ones, even with a discount. This was tried to be overcome by offering the possibility to take back old appliances after the field test. The participants had the option to choose between different brands for the appliances and the prices were comparable or lower than conventional appliances. In the end on average participants joining the project invested € 2000 in smart appliances.

Not every monetary incentive needs to lead to immediate monetary gains. Many pilots have supplied the end users with different types of commodities as incentives (gifts). Often these commodities are related to energy practices, such as free smart washing machines that allow the automatic scheduling of the washing to the best time. They can also include the devices that will provide the end user with feedback, either as in-house displays that substitute the thermostat, or the smartphone or tablet on which the feedback app is installed.

Among the projects within the S3C FoP that focussed on residential smart grids, there were projects that provided the participants with all of the necessary equipment. This often included a smart meter, an IHD, a few smart plugs and sometimes even smart appliances. Among these are *Rendement voor Iedereen (NL)*, *Texel Cloud Power (NL)*, *Energy@Home (IT)*, *Jouw Energie Moment (NL)*, *PEEM (AT)*, *MOMA (DE)*, *AlpEnergy (DE)* and *InovCity (PT).*

Gifts are powerful incentives because they motivate potential participants to join the project under the stimulus of receiving these items for free. This can, however, also be a drawback, as people might just be interested in the free appliances and then lose interest in the project once they have received them and e.g. no longer fill out surveys. However, the positive side of offering appliances as incentives to participate is that the functionality of these new household devices is tested within the daily lives of participants, while they might not be willing to purchase such equipment (yet), as there is little experience with it among the general public. This for example shows from the study Improving Energy Efficiency in Households (LV), where only 35 out of 500 participants decided to buy the smart home kit. This was mainly because on the one hand participants felt unsure how much benefit it would bring them financially and otherwise because they could not imagine what involvement with the equipment would be necessary. It can also be in the advantage of the suppliers to provide the appliances or equipment, as in several projects they were still in their pre-commercial phase and their inclusion in the project allows for their testing outside of a laboratory environment.

It is of course also possible to offer participants non-energy related commodities. Some projects offered the end users tickets to (local) events if they signed up to become a participant, such as *MOMA (DE).* In *OSCAR (CH)* a monthly lottery is organised. Those participants that fill out their metering data regularly are eligible to take part in this lottery in which they have a chance at winning tablets, smartphones, etc. This serves as an extra incentive for the participants to keep coming back to the website on a regular basis and is in line with their focus on gamification. An incentive within the same project that has both a monetary and a non-monetary side are the virtual points that can be collected by the participants, which can be traded in for discounts in the online shop (payback system), see box.

Virtual bonus points for real discounts *(OSCAR, CH)*

In the *OSCAR (CH)* project, end users' activities were rewarded through a bonus point system and these earned points can be used as a currency in an online shop and exchanged for (discounts on) products like LED lamps and other energy related products. These points were collected by filling in the metering data regularly, by completing quizzes, etc. This is therefore an incentive that has both a monetary and a non-monetary side. First of all the participants are encouraged to be active on the web portal and thus learn about energy. An increased knowledge of (their own) energy consumption has in many projects shown to be an important step in changing behaviour. Also, the mere collection of bonus points might be an incentive for people to engage more actively. Then these earned points can also be traded in for a financial benefit, enhancing their strength.

Miscellaneous

Complimentary energy efficiency analyses are indirect monetary incentives, which have the double effect of engaging end users and, at the same time, stimulating the rising of an environmental awareness. An example of this can be found in the *Salzburg SME DR study (AT)*, where the participants were offered a free energy check of their company worth € 400 by the consultancy services of a regional information and consultation institution for enterprises. This energy efficiency analysis did not only provide the participants with more knowledge about their energy consumption etc., but also provided the project with the necessary information in order to be able to determine the load shifting potential of the participating SMEs. In the *AlpEnergy (DE)* project, commercial end users are offered a twofold incentive for participating in the study: a complimentary energy efficiency analysis and a CO_2-analysis, which both had a role in increasing end users' participation and commitment in the project.

Another last resort option is to present the project as an investment at the beginning, showing only the economic analysis and trying to keep at a minimum level all the energy related aspects, which might arise end users' suspicion; the former aspects can then be introduced at a later stage, thus softening the impact with end users who are not familiar with such topics. In *eueco (DE)*, different cooperatives and sustainable energy projects are set up, and the investors in those projects sometimes started off with only economic reasons for participation, whereas they later stated that they were now also convinced of the more environmental and societal aspects of participating in the projects.

4.3.3 Non-Monetary Incentives

Monetary incentives are crucial for many end users and the different options should be considered carefully in any smart grid project. Non-monetary incentives, such as the ones deployed in *OSCAR (CH)* have not been trialled extensively, but have so far led to promising results. In fact, the different types of non-monetary incentives possibly connected to smart grid projects will be described and supported by actual experience from the FoP.

Access

Another option to increase people's awareness and rewards their actions are to render them access to opportunities and offers they could not receive otherwise (exclusive offers). One such exclusive offer that has been implemented in a project within the S3C FoP is the service of free use of EVs during 10 weeks that was offered to the participants of one pilot in *Linear (BE).*

Gamification

A smart grid project does not necessarily have to impose itself upon end users, but they have to be incentivized by one or several of the already described dimensions. The projects can be developed in a way that it is fun for the end users to participate in it, while maintaining their interest without receiving further incentives. One way to make end users enjoy the project is by giving them a sense of achievement. This can be done if the field trials are coupled e.g. with quizzes or competitions. These can be developed in numerous ways for numerous target groups. In fact, they can also be applied to include previously inactive end user groups such as children into the trial.

For example in *Rendement voor Iedereen (NL)* the feedback app shows a red line with the target consumption on the graph with the consumption profile. In another Dutch project, *Jouw Energie Moment (NL)*, a game was introduced on the IHD which allowed the participants to gain bonus points in the form of stars when they completed a challenge. These challenges were aimed to reduce or shift demand and available in different levels of difficulty. The reactions to the game were split: some participants find earning stars a good incentive to change their behaviour, while others find it childish.

Another feedback related incentive can be found with the *OSCAR (CH)* project. The end users who were capable of reducing their energy consumption most compared to the previous month receive an 'Energy-OSCAR' award and these monthly winners were also featured online with their names and names of their municipality. This stimulates competition among all participants in the project if the virtual prize and being named on the web portal are considered an honour.

Inclusion

Furthermore, the project can be designed in a way offering end users a sense of inclusion. This is different to the "Club-Membership" in the access-category, since it refers to a community that is being build up for every participating end user regardless of their success, see section 4.7 for more about community building. End users can get a sense of "togetherness" and of not only working and changing for themselves, but, through their participation in the project, they are able to be directly involved in and contribute to solve community problems and contribute to a sustainable and environmentally friendly future for next generations, such as the management of the local grid and lowering GHG emissions. The community can be extended on multiple levels, by applying a strong regional integration of the project or by including entire neighbouring regions, introducing actual or virtual regulars table (user-blogs) or various other options.

The *Texel Cloud Power (NL)* project was presented both as a local pilot, explicitly addressing the social cohesion, the sense of place and the local identity of the community and as an initiative that is both sustainable and innovative. In the *InovCity (PT)* project, for example, a partnership with a municipality and other local entities like universities and consumer associations was helpful in building the whole smart grid environment: end users' reduction in the energy consumption, in fact, was significantly higher in a certain group with respect to a control group in another city in which the smart grid environment was not present. In the *eueco (DE)* project, end users who participated in the energy cooperatives due to purely financial incentives, later changed their minds and developed more idealistic reasons to join such energy cooperatives.

In the *Rendement voor iedereen (NL)* project the idea was to implement a bottom-up approach and therefore create a community around the theme of sustainability. To this end, a community coach was hired to support the community of residents and he acted as intermediary platform between the project management and the participating households. One major positive experience so far, is that once end users are engaged and involved in the community, they seem more likely to participate actively and help the project management with the planning, installation and co-creation of service concepts.

Making use of the projects' surroundings: strong sense of community (*Texel Cloud Power, NL)*
This project is situated on the island of Texel, in front of the coast of the Netherlands. The project accommodates 300 households in a smart grid pilot. The overall goal of the pilot is to contribute to an energy neutral Texel, meaning that with the help of renewable resources the electricity demand of Texel can be served by local production. This is also a policy aim of the municipality of Texel for 2020. In other words, the island has the aim of becoming self-reliant. Considering the down to earth mentality of the islanders, they don't try to push the project too hard, as this might put people off. Lineke used the Dutch expression: "doe maar gewoon, dan doe je al gek genoeg", which literally translates into: "act normal, and you'll be acting weird enough already". Brendan de Graaf mentioned that due to the geographical boundaries, being surrounded by sea, there is a strong sense of place and the Texel residents are sharing a distinct local identity. This can serve as a solid basis to engage end users into this very locally oriented pilot project. However, Brendan points out that at the same time this can also be a possible barrier because people's expectations are sky high so they will not easily accept mistakes or system failures.

Disincentives

Using disincentives, such as the loss of an economic privilege, can also be a successful strategy to discourage a certain end users' behaviour, as the experience of some smart grid projects have shown. This is, however, a double-edged weapon and must be employed with caution in order to avoid end users' protests. This is especially the case when participation in the project is voluntary but can be effective if the disincentive applies to a larger group, as in the case of *REloadIT (NL)*. In this project all employees of the municipality were no longer reimbursed for their commuting if this took place by car among other reasons to stir their employees away from taking their car to the municipal building, where very few parking spaces were available. However, for work related trips in and around the municipality a car is often the most comfortable mode of transportation. Not being able to use their own cars therefore increases the demand for the EVs.

4.3.4 Conclusion

The financial benefits that can be obtained by end users represent a key driver to get engaged. However, they are not the end of the line; they seem to be important for the end user mostly when making strategic decisions, e.g. whether or not to participate in a smart energy project. To maintain engagement, combinations of different types of incentives are necessary. Looking at the different projects within the S3C FoP we can see that almost all of them use a combination of monetary and non-monetary incentives in order to convince the participants to actively partake in an adjustment of their energy consumption behaviour.

In the *PEEM (AT)* project, participants remarked that they missed monetary incentives and would only continue to adapt their behaviour to the guidance of the IHD if they were rewarded in some other way. However, they did react to the trophy-icon that was shown with regard to their success in implementing the signals and also pronounced their interest in social comparisons, in order to be benchmarked against others or an average. In fact, the conclusion that financial benefits are the most decisive factor falls short of the differentiated opinions voiced by the *PEEM (AT)* end users. The same was indicated in Smart *Metering Projekt (DE)* where the majority of the participants affirmed that they would find the feedback system more interesting if it would bring a larger financial benefit.

However, other factors (such as benefits on the environments for future generations or the curiosity for new technologies) should always be mentioned to end users in order to give them a comprehensive picture of the overall benefits of the project itself and create a common awareness about energy related problems. They can be seen as good non-monetary incentives, as feeling included in a community or stimulated by a game can lead to more engagement as well. This is shown by the success of some projects, which appeal to the emotional side of the involved end users while applying, at the same time, a good mixture of non-monetary and monetary incentives.

In D3.3 different untested innovative interaction schemes are described, which are all motivating end users through economic incentives and have traits of individualisation. Pre-paid electricity accounts (e.g. for holiday homes) foster reducing of energy consumption and make it more flexible. End user behaviour classification can be used to give end users an incentive to switch to another electricity package by changing their consumption behaviour. Tariffs can be constructed in a way, that before the consumption takes place, the specific price, consumption patterns and the volume of electricity traded between the energy provider is determined (flexibility management with closed contracts), which forces the end user to change his behaviour.

4.4 End user feedback

End user feedback refers to all processes in which information about past or present energy use is sent to end users with the aim to influence their behaviour in the present or future. The following research question is addressed in this section: *What feedback information and which feedback channels contribute to fostering smart energy behaviour?*

The analysis of the 32 case studies reveals 16 types of interventions (tools or methods for providing feedback to end users): providing feedback through different feedback systems, carrying different information and on different formats. The majority of case studies consist of two or more different end user feedback interventions. Therefore, drawing conclusions of the effects of individual interventions is not possible. This is in line with findings from literature and meta-reviews: empirical studies on feedback in demand response experiments show no clear, consistent or undisputed do's and don'ts for effective end user engagement through feedback systems, because effects and results differ from project to project since the results are affected by the context and other factors (e.g. target groups).[9]

Although this implies that a context-sensitive approach, in which feedback interventions are tailored to fit a project is most likely to succeed, the case studies do provide some general indications of what interventions or incentives work and what can be considered less successful. This section first addresses the concept of feedback systems (4.4.1), followed by an elaboration of the various types of feedback information (content) that can be displayed on these systems (4.4.2).

4.4.1 Feedback systems

Current knowledge about the influence of the design of the feedback devices on energy behaviour of end users is rather limited. The conclusions from literature and meta-reviews about feedback systems do not contain a balanced view. The case study reports offer some convincing indications of what should be considered key elements of end user feedback systems. In general, end users the investigated projects in from the S3C Family of Projects (FoP) receive feedback on their energy consumption through two channels:

1. **Energy displays.** The term "energy display" is used in this report for all devices providing graphic visualization of energy consumption data on a screen such as an in-house display (IHD), an app for smartphone or tablets, a web portal etc. Most of the projects that offered end user feedback involved some kind of display to provide (near) real-time feedback of energy consumption and/or costs.
2. **Informative bills.** The term "informative billing" refers to all interventions that aim to inform end users of their energy consumption and costs on paper, preferably by providing additional information such as comparison data or visualizing graphics. Although the informative bill is usually printed on paper or distributed as a pdf-document, it is treated here as an energy feedback system because it delivers graphic visualizations of energy consumption data – just like energy feedback display.

It is not the intention of this analysis to differentiate or to draw conclusions for specific feedback systems, devices or billing products available on the market, but to provide insight in what factors or aspects of interventions can contribute to engagement of end users under specific circumstances. S3C case study data reveals the following apparent factors that can positively affect end user engagement in relation to end user feedback displays: *easy access*, *attractive and intuitive design*, *functionality* and *use of mixed feedback systems* of the display.

Easy access

Quick and easy access for end users is a very important feature that feedback systems should facilitate. For instance, information can be given via a tablet, smart phone or IHD instead of via a computer. End users tend to perceive apps and ever-present displays as more accessible and they require less effort to open than a website for which the end user must log in on a computer and receive various numbers and data – something that was appreciated and favoured by the end users in the *PEEM (AT)* project: the FORE-watch offers an attractive, easy understandable graphic display presented on a tablet in their home.

[9] Faruqui, A. & Sergici, S. (2010). Household response to dynamic pricing of electricity: a survey of 15 experiments. *Journal of Regulatory Economics*, October 2010, Volume 38, Issue 2, pp 193-225; Stromback, J., Dromacque, C., Yassin, M. H. (2011). *Empower Demand. The potential of smart meter enabled programs to increase energy and systems efficiency: a mass pilot comparison*. VaasaETT Global Energy Think Tank, Helsinki, Finland.

In *EnergiUdsigten (DK)*, the SEE1 ambient display that visualizes the real-time electricity price in three colours was offered to a group of end users. It had a clear impact on their energy behaviour, whereas other information sources (such as the website) had no significant effects, because it required too much effort for participants to gain access to those sources.

Similarly, it was perceived as a barrier by end users in *MOMA (DE)* and *Alp Energy (DE*) that the app was not available for smartphones but only for computers. The barrier to use the computer (turning it on, waiting, starting the app) was probably too high for many end users. A smartphone app allows checking the electricity consumption and future tariffs from wherever you are. It is always turned on and can present reminders and hints directly on the display. Furthermore, smartphones and apps can have an acceptance advantage as most end users own smartphones. However, this is not the case everywhere, as the participants in the *Smart Home (SI)* project mainly used the web portal for feedback, as they felt to be unfamiliar with smartphone apps.

However, easy access can also cause negative feelings among end users: In the *PEEM (AT)* project, end users felt that at times the FORE-watch rendered them a “guilty conscience”. Especially during quiet evening hours, in which the end users wanted to enjoy their entertainment appliances, they disliked the consumption display in the FORE-watch turning red, when they ignored the guidance to use less energy. They somewhat felt judged and felt treated unfairly.

Attractive and intuitive design

Even though empirical research on feedback and demand response does not offer clear and undisputed finding, the potential effects of feedback devices seem to depend for a large part on design-related factors, such as aesthetics, ergonomics, ambience and intuitiveness.

The benefits of an appealing feedback solution became evident in the *PEEM (AT)* project. The FORE-watch was designed so that end users should like to have a look at it and not perceive its involvement as being forced on them. Rather, it should appeal to emotions and create interest. One success factor lies in designing an aesthetic device that is integrated into the household and that people like to look at. It has to be located in a place where its information and guidance is easily accessible for everyone in the household. A continuous presence of information is an important step in the learning process of end users and helps to raise consciousness for the own consumption – but the challenge here is to attract their attention in the long run. In the *PEEM (AT)* project, most end users decided to place the tablet with the FORE-watch app in the kitchen, where it served as a kind of “kitchen-clock-substitute”.

In *Jouw Energie Moment (NL)* two different display designs were developed for the different pilots. They have put in a lot of effort to ensure that the design of the display matches the expectations and wishes of the participants and that the information that is presented is understandable for the end user. Based on design prototypes for the feedback device, personal interviews were held with participants to obtain an understanding of their perception and experiences, after which the design was improved.

Appealing feedback solutions as integrated household appliance: The FORE-WATCH *(PEEM, AT)*

The aim of the project was to design and test a persuasive ambient display called FORE-watch. FORE stands for “Forecast Of Renewable Energy”. The field test participants were equipped with an ‘ambient display’ which is a smartphone app that is running on Android tablet devices and is connected to the internet. The FORE -watch only offered guiding information for the end users, it did not provide further e.g. financial incentives or social comparisons on the information level.

The technology was supposed to be persuasive, i.e. it seeks to change or adapt behaviour and attitudes without imposing on or manipulating the subjects or enforcing the change. The project was designed on the results of previous studies and projects that revealed that feedback on consumption can be highly useful to create awareness and serves to adapt consumption patterns

The design follows an analogue clock. The outside ring of the clock displays favourable and unfavourable time periods for energy consumption in the next 60 minutes. The time bar below the clock displays the forecast of favourable and unfavourable time periods for the next 24 hours. The forecast is displayed in different colours (green: good; yellow: neutral; red: bad) which indicates whether it is a good or bad moment to consume energy. Favourable and unfavourable times of consumption were defined differently for the two field test groups. In one group, the forecast of renewable energies and in the other group the forecast of the net load were displayed. If the display is touched, an overview of historic consumption patterns is displayed: the average daily consumption for the last week and the amount of energy (in kWh) and the consumption within the different phases.

Smart meters were installed in all participating households, in order to obtain the real-time consumption data of the households that was displayed on the FORE-watch as well. The app shows a “trophy-icon”, in case the consumer managed to adapt their consumption the information they receive from the FORE-watch, i.e. if they consumed more during green times and less during red times. In the surveys, customers stated they really liked the trophy and felt encouraged by its appearance. However, they also explained that the feedback by the FORE-watch lacked a “social dimension”, as they did not only wonder, how well they did, but also how well they did in comparison with others.

Figure 9: Images of the FORE-watch display in *PEEM (AT)*

The display on the left shows in the outside ring of the analogue clock whether it is favourable to consume energy in the next 60 minutes (top) and the forecasted favourability for the next 24 hours (bars below). The display on the right shows the average consumption of the last week (top) and the consumption within the different price levels (bottom).[10]

Functionality

Another factor that can help increase the frequency end users check an energy display is to extend the information supplied on the display beyond the low-interest topic energy. If the display is based on an open system, able to integrate other information, it is more likely to provide added value and enhance consumer acceptance. In addition to the *PEEM (AT)* project this became clear in *Jouw Energie Moment (NL)* that offered participating households a multi-purpose display that not only provides information on energy consumption but also shows weather forecasts and expected production of solar power. Due to the multiple purposes of the display, some participants use it for more than just to improve their energy behaviour, but also e.g. to check this information before going out or before going to bed. Thus, many participants watch their display more often than necessary to stay informed of their energy consumption.

Mixed feedback channels

Several demand response studies have shown that mixed feedback channels are best suited to address a heterogeneous end user population.[11] An example of this is found in *Inovcity (PT)*, where participants could receive feedback by an IHD and through SMS and email alerts. Within *Rendement voor iedereen (NL)* feedback could be accessed by PC, smart phone or tablet. Although results were not available yet,

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[10] Schrammel, J., Gerdenitsch, C., Kluckner, P., Weiss, P. & Stutz, M. (2012). Persuasive End-Users Energy Management - Publizierbarere Endbericht.

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

the project managers state that it seems as though the participants have become more energy efficient. *AlpEnergy (DE)* used mixed channels, although the energy bill was considered by end users to be a more efficient measure compared to the web portal that was also tested in the project. Registration at the web portal was lower than wished for and the activity at the online feedback tool showed definite fatigue effects. However, web portals have a high potential for success if they are combined with the right incentives for joining, marketing structure and features to 're-motivate' the end user constantly. The portal and app in *OSCAR (CH)* achieved in attracting more than 24.000 users and applied weekly updating content as well as other incentives such as lotteries (that end users could only take part in if they were active users) to keep up the interest.

4.4.2 Feedback information

Feedback information relates to all energy consumption data that is presented to end users, and comprises the translation of end user consumption data read from the smart meter into information which enable end users to influence and control their energy consumption patterns. The amount and type of feedback information that can be delivered is extensive and can be classified in different ways. There are some examples from the S3C FoP where different types of information are mentioned as contributing to changes in end user behaviour.

Graphic visualization

The vast majority of end user feedback systems include some type of graphic visualization to give end users insight in their energy consumption. In the *MOMA (DE)* project, the visualisation of the consumed electricity and the ability to control their own electricity consumption was rated high by end users and one third of the participants of the experimental group stated in the final survey that they are willing to pay for a visualized feedback of their electricity consumption. There are generally three approaches towards graphic visualization of energy consumption:

1. **Multi-signal visualization**. The display shows the effects of consumption through more than one measure (for instance environmental impact/economy/renewables/grid load). These features were present in the energy management equipment of the *InovCity (PT)* project, which showed evidence to have a positive effect on energy efficiency. However, the use of a multi-signal approach requires a certain level of understanding from end users. Participants in the *PowerMatching City (NL)* project stated that the information on the monitor was relevant, but that the understanding needed to be improved.

2. **Different indicator options.** Some visualisations can offer the end user different statistical info and/or different visualisation manners. The *Jouw Energie Moment (NL)* project stands out by letting end users choose how to display different modes of indicators showing the effects of their energy consumption (financial mode or environmental mode), which has led to smarter energy behaviour in the participants' routines.

3. **Use of symbols and colours.** Data can be visualized through symbols and colours, thus providing an extra dimension than just displaying numbers and graphs. Some examples from the S3C FoP are leafs, wallets or different colour codes for consumption levels:

   - *PEEM (AT)* tested an app where a 'trophy-icon' is shown in case the consumer manages to adapt their consumption to the information they receive from the feedback device. The trophy was appreciated by end users: they felt encouraged by its appearance.

   - Traffic lights systems for IHDs show some indications for success: *CLNR (UK)* reports that households in the trial were particularly responding to the traffic light system of the tested IHDs. Households further reported that the device was easy to understand and prompted them to make further changes to their practices.

   - Another type of symbols considered to be very effective was used on the in-house display of *Jouw Energie Moment (NL):* a depiction of the house, the PV panels and the electricity grid. Within this image arrows moved in the direction the energy was flowing at that moment, where the speed of the arrows indicates how much electricity is either bought from or sold to the grid. Many end users check the display at set times, such as before going to bed. They do this for example to check whether any appliances are still turned on.

Creating easy to understand information on IHD's: use of symbols and colours (*Jouw Energie Moment, NL)*

Participants receive information via the IHD. Two designs of this have been introduced and for either setting (financial or sustainable) the information provided within both designs is the same.

Although the prices are recalculated every 15 minutes, they are grouped in two hour blocks in order to avoid information overloading. Then these prices are split in three categories (with solid boundaries): cheap, cheaper, least cheap. In the case of Zwolle these categories are depicted by wallets. Either there is none (least cheap), a wallet with one coin (cheap), or a wallet with two coins (cheaper). In Breda the design is very different as colours are used to give time blocks different values: green is used when the price is cheaper, light blue when it is cheap while the darker blue/purple indicates least cheap periods. The same colours are used for the sustainability setting, where green is most sustainable and dark blue least sustainable. If households have the IHD set on the sustainability setting they will receive information on how sustainable their energy use is. They are most sustainable if they use their self-generated solar power. In Zwolle this feedback is similar to that of the financial setting, but instead of showing little wallets for the prices, they will be shown little leafs. No leafs on the screen means not sustainable, one means sustainable and two means very sustainable.

The display in Zwolle also has a stand-by screen that gives direct information about how the household is doing regarding its energy use. This is a bit more of an ambient display, where the stars depict how well the family is doing currently and the colour indicates how well they have been doing recently.

One part of the IHD that was considered to be very effective according to Charlotte Kobus was the depiction of the house, the PV panels and the electricity grid on the home page. Within this image arrows moved in the direction the energy was flowing at that moment, where the speed of the arrows indicate how much electricity is either bought from or sold to the grid. This is updated every 10 seconds.

Figure 10: Image of the display of *Jouw Energie Moment (NL)*

First home screen: Second home screen:

Dynamic information and real-time consumption

Feedback information is preferably close-to-real-time and dynamic, which is shown in the *PEEM (AT)* project where two different feedback setups have been compared. One group got a visualization of the grid load (static information which doesn't change much from day to day) while the other group got a visualization of availability of renewable energy (a more dynamic type of information, varying over the day). As the feed-in from renewables is dynamic, these users had to react to ever changing information that they could not "learn by heart" and achieved a greater adaption of consumption than the group receiving static information. The renewables-signal can be compared to real-time display of consumption, which also varies with time and stimulates the end users to act quickly on the feedback signal.

Historical comparison

Providing end users with comparisons of their own consumption during previous periods of time was frequently found in the S3C FoP. As an example, in *Jouw Energie Moment (NL)* residents for Zwolle could see how they were doing by the colour of their IHD. So it is an example of an ambient historical comparison. It is likely this contributed to the positive results of the participants shifting their energy use, and saved energy as well within the project. *InovCity (PT)* showed that the energy management equipment, which provided historical comparison of energy use, had a positive effect on energy efficiency. The same is valid for the project *Jouw Energie Moment (NL)*, as the participants have incorporated smart energy behaviour in their routines after participating in the project.

Social comparison

Social comparison feedback provides insight in how an end user fares in comparison to others. The case study *OSCAR (CH)* indicates that social normative feedback is a successful tool. However, in some cases a combination of feedback systems has to be used to counteract negative consequences; e.g. neighbourhood comparison of consumption (descriptive normative feedback) has a positive effect on those end users that have a higher consumption than their neighbours, but can cause end users who consume less than their neighbours to increase their consumption. Therefore, it is imperative to combine the social normative feedback with a feedback tool on their own behaviour (injunctive feedback). In *OSCAR (CH)*, injunctive feedback was offered as a ranking of the end users behaviour on the energy efficiency scale. Comparison to the neighbours (‘Am I doing better or worse than my neighbour?’) has shown to be an important motivation for end users to make use of an energy efficiency portal. In the project *3e-Houses (DE/ES/UK)*, end users were provided with feedback on their use of energy comparing with similar households and their neighbourhood, resulting in the higher reduction of energy consumption than average user.

The end users in the *PEEM (AT)* project field trial explained that they would also like to be “benchmarked”. Besides being compared to own earlier achieved results, end users also considered comparisons to results of efforts of other households in the field test and/or an average household etc. as interesting and motivating. The consciousness for energy and the own consumption was raised through the field test. Participants in some other projects of the S3C analysis claimed to have lacked the social comparison: For instance, end users in the *MOMA (DE)* project stated that the feedback lacked a “social dimension”, as they did not only wonder how well they did, but also how well they did in comparison with others.

Visualisation of local production versus consumption

Visualization of the relationship between local production and household consumption can provide a sense of proximity and relevance for end users and that may appeal to prosumers in particular. For instance, the IHD in *Jouw Energie Moment (NL)* contains an element that the project management found out was considered to be very effective by the participants: the depiction of the house, with PV panels and the connection to the electricity grid on the home page. Additionally, the *CLNR (UK)* project states that the visualization of PV electricity for direct use has an effect on end user behaviour, especially with adequate feedback.

Gaming

Gaming and/or competitive elements in feedback information seem to appeal to and motivate certain end users. An example from the S3C analysis can be found in the *OSCAR (CH)* portal, where end users could compete and earn bonus points. The level of success among registered users in reducing their energy consumption correlated with how active they were on the web portal/how many bonus points they had, and in general, participation on the web portal did affect the behaviour of the registered end users. Reference customers (who did not participate in the project) used 0.7% less energy over a time frame of one year, whereas participants in *OSCAR (CH)* decreased their consumption by a mean of 2.4%.

4.4.3 Conclusion

The answer to the question posed at the beginning of this section, *what feedback information and which feedback channels contribute to fostering smart energy behaviour?*, cannot easily be answered. The conclusion that should be drawn first and foremost from the case study data on end user feedback is that the design of feedback systems and the development of appropriate feedback information requires a context-sensitive approach. Feedback interventions are most likely to succeed if tailored to fit a project and the respective target group.

Although the use of the feedback information seems to decrease over time – which was specifically concluded for *OSCAR (CH), PEEM (AT),* and *AlpEnergy (DE)* – the case study data do provide some general indications of what interventions or incentives can help improve the effects of end user feedback systems in smart grid projects. First of all, feedback should be easily accessible for end users. Designers and project developers should seek integration into daily household patterns and routines. For instance, having to log in to a web portal is perceived by many end users as a barrier. Feedback displays should also meet basic design requirements such as attractiveness and intuitiveness in order to stay relevant for end users in the long run. In order to attract end users, the information provided on the feedback system should be easily understandable, preferably adapting to their frame of reference, and provide actionable information. If a smart grid project does not manage to provide easy accessible and easily understandable feedback information (preferably through an attractive in-house display and/or smartphone app), this is may well lead to a decreasing use over time.

The insights of the analysis of untested innovative interaction user schemes as described in D3.3 give an added value to the discussion about end user feedback. Different ideas and business models are described there, addressing mobile apps with easy-to-grasp, easy-to-access information for end users, social comparison for single end users respectively social comparison on aggregated levels for neighbourhoods or communities, which visualizes the effects of energy use among large groups. Apps, competitions and games can be a fruitful way to present end users the desired feedback and motivate them to change their energy behaviour.

4.5 Project communication

Since ‘communication’ is a broad term, the different aspects and ways of using it vary greatly. What are the most efficient actions and channels of communication to reach different goals? All investigated projects in the S3C Family of Projects (FoP) make use of at least one communication channel (e.g. website, e-mail, phone, visit). In total, 26 different interventions (communication channels) have been identified. Each of these channels has its advantages and disadvantages and suitability of a communication channel to specific goals may vary between project phases (e.g. recruiting participants or keeping them engaged throughout the project). This section describes the communication strategies used in the S3C FoP and their effectiveness, by addressing the following research question: *Which communication channels, information and marketing techniques contribute to the recruitment and engagement of end users in smart energy projects?*

In this section, three types of communication channels (each consisting of several interventions) are distinguished: offline media channels, online media channels and face-to-face communications. Most projects in the FoP make use of ‘traditional’ offline media channels such as radio, newspapers, letters, leaflets, and phone. This group of communication channels is called ‘offline media’, as opposed to all ‘online media’ such as websites, email, social media, online forums, smart phone apps, etc. Although more and more communication takes place online, the case studies show that online media do not phase out the offline channels. Additionally, there are several face-to-face communication channels, such as workshops, exhibition events and interviews.

This inventory shows the wide range of opportunities when it comes to communicating with end users. Section 4.5.2 draws focus on recruitment communication: how to effectively engage end users? The following section contains the key findings for on-going project communication: how to keep end users engaged by communication throughout the project?

4.5.1 Recruitment communication

The case study reports from the FoP offer indications of what should be considered to be key elements of effective communication in the recruitment phase. This paragraph provides insight in what interventions can contribute to engagement of end users under specific circumstances. Although in this section (elements of) interventions in the recruitment phase are discussed, this does not disparage the effectiveness of these interventions in the course of a project.

Involving local stakeholders in project communication

Cooperation with local stakeholders can be effective when communicating with end users (see section 4.6). *CLNR (UK)* developed partnerships with local communities to approach potential participants, which was helpful to reach recruitment targets. *InovCity (PT)* cooperates with the municipality of Evora in their project communication. *Texel Cloud Power (NL)* made a clear distinction between the partner producing the project communication and the partner sending it: all project communication is coordinated and prepared by DSO Liander, but it is delivered to participants on corporate stationary of the local energy company Texel Energie.

UppSol 2020 (SE) is based on the idea of forerunners and followers, where a group of end users follow the installation process of a specific energy technology (in this case PV systems) made by an end user within the same target group (forerunner). So the owners of a PV system are communicating with potential end users. According to the project manager it should be seen as structured dissemination of experiences from the installation process. The use of a forerunner from the target group in question is meant to instil security and informal authority. Having a forerunner showing and discussing examples and results from their own business are making it more credible, the project manager claims.

Energy@home (IT) displays the importance of choosing a credible project partner – preferably locally known –to deliver the message. In this project a telecommunication company called potential participants to offer them a technologically advanced washing machine if the signed up for the project. By some people, this was seen as ‘very strange’ and some thought it would be a rip off. According to the project manager this led to a ‘trust or reliability problem’.

Combinations of online and offline channels

Although online media channels offer vast opportunities to attract potential end users, simply emailing an invitation is not deemed a guaranteed success, as it can be interpreted as not trustworthy or even as ‘spam’. Several projects (e.g. *EcoGrid, DK; AlpEnergy, DE*) reached a high participant rate by primarily using offline local media channels in the recruitment phase, but the vast majority of investigated projects combined online and offline communication channels. Depending on contextual factors, some projects took off with an offline communication strategy and gradually shift towards online channels, whereas other projects started with an online campaign supported by offline follow-up activities.

After selecting the target group, some projects deployed a ‘two-step approach’, combining online and offline communication channels. *AlpEnergy (DE)* was successful with first organizing a large regional campaign that was followed by individual phone calls. *Jouw Energie Moment (NL)* first sent out personalized invitation emails. People who had not responded within a certain timeframe were contacted by phone to inquire if they received the email and if they were interested to join. The project was situated in newly built neighbourhoods and people had just moved into their new homes. This was referred to in the recruitment telephone call: ‘You must be busy unpacking and organizing your new home, so perhaps you missed the invitation we sent you last week?’ This way the message sympathized, which contributed to an open attitude towards the project. Furthermore, *Jouw Energie Moment (NL)* took part in a local event where the project was one of the neighbourhood-oriented activities present. This contributed to an open, informative atmosphere in which there was time to personally inform interested residents in order to invite them to register.

Another ‘two-step’ approach was found in the recruitment for the large-scale *EcoGrid (DK)* project. Firstly events were organized on the island, in combination drawing attention to the project through the utility’s website and local radio and TV ads. The second steps was to ‘wait and see’, if people would sign up, and if necessary approach them with personalized letters and calls. This approach was very successful, so they created a waiting list with in case participants would drop out.

Rendement voor iedereen (NL) launched a local communication campaign mainly through offline channels, such as flyers and advertisements. The project distinguished its communication from glossy advertisements to attract people and make them actually read it. Shortly before the information event was held, they placed a text car in the neighbourhood. Once participants had registered and the project had started, communication shifted primarily to online channels: in addition to the project website, emails and newsletters, a community of end users runs their own website to exchange knowledge and information. Another example of using local offline media to engage people is *OSCAR (CH)*. A broad advertisement campaign was launched with the local mascot of the bear Oscar, which included posters, billboards, mailings and trade fairs to make people familiar with the internet-based project. In the course of the project the use of email was highly successful, but these emails were personalised and the channel was used in combination with other online channels.

Emphasizing local character in small scale projects

Besides using local project partners or stakeholders to communicate your message, it can also be effective to emphasize the local character of a smart energy project. Particularly in small-scale projects in geographically defined areas, projects tend to take a personal approach, underscoring ‘couleur locale’ in their project communication (e.g., *AlpEnergy (DE) Rendement voor iedereen (NL).* In the latter project, flyers/leaflets were clearly distinct from glossy advertisements.

Texel Cloud Power (NL) chose to present itself in a no frills manner: the tone of voice is down to earth and not as commercial as is common in the energy business. To better connect with the local identity, the project is named ‘Texel zelfvoorzienend’ (to be translated as ‘Texel self-sufficient’) in all communication with end users, stressing once more the desire for independence. Participants were recruited for the smart grid trial through advertisements in the local newspaper and email newsletters from Texel Energie. There was also a leaflet distributed among the islanders. The project presented itself as a local pilot: something the Texel people do together. It explicitly addressed social cohesion, the sense of place and the local identity. The recruitment was quite successful as they quickly reached 320 potential participants of the project.

In *Sala-Heby Energi (SE)* local patriotism has shown to be an important driver, in addition to the economic incentive. The company slogan “The local power” directly communicates a sense of civic pride to end users. The company has a relatively small distribution area, which fosters a feeling of proximity to end users – both from a geographical aspect and from the ability to establish relations. Individual end users have the feeling that their actions actually do have an effect on the system.

Even more personal is the door-to-door approach that *3e-Houses (DE/ES/UK)* used in addition to distributing leaflets and newsletters and displaying posters in common areas of apartment buildings. Many end users stated they preferred home visits over printed information materials. This personal approach was chosen because of the high illiteracy rate among the targeted social housing residents. The personal approach created an informative personal atmosphere, of which apparently enhanced end users' confidence in the project.

Selecting communication channels that suit the target group *(3e-Houses, ES/DE/UK)*

3e-Houses is an energy efficiency project aimed at helping social housing residents to reduce their energy costs. The main objective of the project is to provide innovative solutions on energy efficiency through real time monitoring, renewable energy, smart metering, among others. Due to the high illiteracy rates in the areas where the project took place, face-to-face recruiting was a major contributor. Many end users stated that they preferred a personal approach rather than having to understand reading material by themselves. Also they could take the chance to clear out some questions regarding the installation or the project as a whole. Home visits providing technology support or resolving problems resulted in the development of a good relationship between partners and residents. Especially elderly users who were not so confident with technology mentioned face-to-face visits mentioned as their favourite mean of support during the project. Another effective method of maintaining engagement with end users was the use of phone calls or SMS text messages. Calls were used to conduct the initial and final surveys, to invite participants to workshops and to perform follow-ups. These interactions were found out to have a direct impact on the use of the web interface.

Communication channels for large scale recruitment

In large, regional or even nationwide recruitment campaigns, some projects made use of large-scale events to draw attention. The project *MOMA (DE)* presented itself under the topics smart grid and renewable energies at the Hannover Messe 2012. Making use of well-known larger sentiments or appealing topics that relates one-on-one to your project can be helpful with recruiting. The project made use of the tendency of the German energy consumers of installing their decentralized energy units. This relates to the "cellular" approach of the project. Although this resulted in good visibility and many participation applications were received during the fair (up to 30 per day) for the project, it did not result in the desired number of participants with the desired profile. This shows that such interventions can work well for the visibility of a project, but does not necessarily mean the right target group will respond. For larger customer groups, an opt-out model can be deployed. *CLNR (UK)* used this approach to recruit people for the control group of the project and less than 1% opted out.

A large scale multi-channel recruitment campaign (*AlpEnergy, DE)*

The *AlpEnergy (DE)* project worked with a strong focus on regional integration. In order to raise awareness for the topic in the regional and supra-regional public, a large-scale campaign was initiated, consisting of reports in the AÜW-customer-magazine 'AllgäuStromMagazin', information events, articles in regional newspapers and magazines about the field test, coverage on regional and Bavarian television, support from the mayor, the organisation of an international (scientific) conference 'AlpEnergy meets E-Energy' (May 2009), presentations at fairs, a series of lectures and coverage within the framework of the Association for Electrical, Electronic & Information Technologies in Germany.

An additional communication feature was the interactive simulation and visualization that was published on the Internet. The visualization offers the opportunity to the Allgäu's citizens and the interested expert audience to gain an understanding of the abstract term Virtual Power System. The visualization consists of an overview function that explains the transition from the current energy system to the energy system of the future and an analysis-mode, which can access the actual generation and consumption data of 2009 to simulate the operation of the VPS Allgäu at a given point in time. In autumn of 2010, the AÜW held an information event (with catering) on the online portal and the new tariff structure. 80 of the 260 customers attended and could directly choose a tariff. The rest of the customers received an information letter where they could choose 'their' tariff. Thus, the end users themselves were able to choose which customers group they wanted to join/ which tariff structure they preferred.

With the support from local organisations, B.A.U.M. Consult GmbH and the AÜW wrote to the 53 companies that were identified as eligible for the study on commercial end users. Similarly, the AÜW wrote to a local network to ask for participation in the project and offer either tickets for the Bigbox (local event location) or the mountain cableway as an incentive. 206 households answered the letter and indicated interest in participating. The acquisition of pilot customers proved to be easier in the new development area than in other areas, because the owners of the newly build houses gave a lot of thoughts about energy efficiency. Especially tenants were sometimes unsure whether they were allowed to install smart meters without the approval of their landlord. Finally, a regional large-scale campaign and individual (e.g. telephone) contact with the customers enabled another breakthrough. The project parties thoroughly and individually informed the customers about the purpose and consequences of the project. Finally, 258 of AÜW's customers agreed to be a part of the AlpEnergy field test.

4.5.2 Ongoing project communication

Once recruitment has been successfully completed, it is key to keep these participants engaged. If this is not taken into account, a project may fail in many ways. The devices that need to be tested may be hardly used or not at all, the data that is needed will not be delivered, the project participants might develop a negative view on the project, they may lose interest or even drop out. The case study data reveals the following insights that can positively affect the engagement of end users once a project is ongoing: clear and easy access to information, expectation management, continuous interaction and addressing gaps and delays in project communication.

Clear and easy access to project information

At the start of a project participants are usually enthusiastic; they have high expectations and are eager to learn about their new equipment in their homes. But this enthusiasm is known to fade away over time. The most commonly used way to sustain it is the use of online channels that create the sense of being taken seriously as a participant and customer.

End users in *OSCAR (CH)* receive information on their consumption via a web portal and are offered a forum and an email contact as a feedback channel where they can voice their wishes and concerns. Also, the end users receive general tips for saving energy on the web portal, which they can then categorize into a "to do" and a "not interesting" category, thus generating input on which measures end users think are interesting and applicable. In general, the web portal was designed to be easily understandable. The use of the portal is developed to be intuitive so that workshops or additional long explanations of the portal's features were unnecessary.

An online forum had success in *InovCity (PT)*. Dr. Energia services contained real-time analyses and advice, as well as customized energy efficiency counselling with an interactive online platform. The concept of Dr. Energia platform was developed by EDP to fulfil the needs of consumers to have an online community to compare "me and others". The existence of a figure also established a social relationship between the supplier and the consumer. The platform joined all those elements and allowed consumers to learn from the learning section with energy efficiency guide, to share their doubts, issues, tips etc. in the forum, to compare with the average community consumption, to rate others´ ideas online, and to have a personalized interaction with Dr. Energia through a chat format or email. *EcoGrid (DK)* launched a Facebook page that was meant to function as an online forum for end users to share ideas and experiences, but in practice this is used not as frequent as the project management had expected.

Another example of the importance to provide easy access to information comes from *MOMA (DE):* participants clearly stated they preferred smartphone access to information over PC's. In current times the functionality and use of smart phones becomes of high importance. Not communicating through these channels in the near future will surely disappoint potential enthusiastic end users.

Keeping participants engaged *(InovCity, PT)*

The online forum had success in *InovCity (PT)*. Dr. Energia services contained real-time analyses and advice, as well as customized energy efficiency counselling with an interactive online platform. The concept of Dr. Energia platform was developed by EDP to fulfil the needs of consumers to have an online community to compare "me and others". The existence of a figure also established a social relationship between the supplier and the consumer. The platform joined all those elements and allowed consumers to learn from the learning section with energy efficiency guide, to share their doubts, issues, tips etc. in the forum, to compare with the average community consumption, to rate others´ ideas online, and to have a personalized interaction with Dr. Energia through a chat format or email.

Besides the online forum, several ongoing communication activities were deployed: several communication campaigns (organized by EDP with the cooperation of the local community) took place in order to inform consumers about the benefits of smart meters (letters, leaflets, local press, local schools, public institutions), provide energy efficiency information and specific efficiency tips for home consumption (mailing), provide information on how to take the best use of the energy management system installed (leaflets, e-mail, showroom), get information from the end users (only for the users of energy management systems, tariffs and energy alerts) by regular telephone interviews.

Managing expectations

Communicating expectations and realistic results is essential to keep end users engaged in a project. In *Jouw Energie Moment (NL),* it was made clear from the start that the project was working with new innovative technologies, and technical flaws and drawbacks could occur along the way. At the information event for potential participants, people were hesitant at first, but when the project manager was honest about possible technical flaws and uncertainties, people did sign up. If transparency is lacking at the start of the project, this can lead to strong feelings of disappointment, which can cause a negative attitude among participants. In *PREMIO (FR)* participants were not sufficiently informed about the demand side management scheme offered in the project. For some households, the electricity consumption turned out to be too low to represent added value, so they decided to drop out.

Managing expectations is also an important role of the community coach in *Rendement voor Iedereen (NL).* He for example makes it clear to participants that businesses will not use their feedback for improvements tomorrow, and at the same time taps the businesses on their shoulders to remind them they should let the participants know what they are doing with their feedback and how that process is going.

In this light, SMEs seem to be less flexible than household consumers: if problems occur in the project that may impact their business, they are more likely to drop out. An example of this can be found in *CLNR (UK)* where businesses were not sufficiently aware at the beginning of the project of what was to be expected from the different pricing schemes. Only during the course of the project, a number of SMEs started to perceive the direct control tariffs as a threat for the service quality to their customers, leading to a significant dropout rate. Two complete test groups of SME's dropped out because of this.

Creating continuous interaction

Another key to keep end users engaged is to invest in continuous communication during the project. *EcoGrid (DK)* made use of a local TV show to keep participants interested and informed about the project. Several projects (e.g. *Jouw Energie Moment, NL* and *Rendement voor Iedereen, NL)* organized structural meetings for interested participants who have questions or ideas regarding the project. That events can create successful engagement as is also shown in *Sala-Heby Energi (SE),* in which SHEEAB (the local network operator) continuously arranges information meetings to meet end users and inform about all their work, not only the new tariffs. These "SHEEAB-days" are considered to be a successful concept by the company interviewees, as up to 600 people show up at these events.

Underscoring the regional character in ongoing project communication has been successful in the *AlpEnergy (DE)* project. Important regional decision makers and opinion makers (supply organisations, mayors, etc.) were integrated into the projects and its research activities. *3e-Houses (DE/ES/UK)* states it is valuable to keep engaging participants by calling or texting them, seeing the higher use of the web interface afterwards. And conducting home visits during the project was a very valued contact, especially among elderly participants. *Hus14: Office Wise (SE)* is based on the idea is to design interaction strategies in collaboration with both employees and the company management to create new routines and interaction situations to keep the project alive.

Smart grid TV show *(EcoGrid, DK)*

In the EcoGrid project, the actual day to day experiences were communicated on the local TV network. This can be a valuable communication channel when there is a strong sense of community in the project location.

Figure 11: Screenshot of website hosting TV show in *EcoGrid (DK)*

Address gaps and delays in project communication

After the start of a project, delays can occur between communication moments due to technical flaws, organisational problems or externalities. If these communication gaps are wide, participants may lose interest or even drop out. Delays happen in almost every project, but contain a high risk potential of losing participants if not dealt with carefully.

At *PowerMatching City (NL)*, it took a while before the process of co-creating services with participants really took off. As a result, the project has been somewhat invisible to participants for a while. They were to some extent disappointed (as indicated by their feedback during the recent kick-off workshop), although this did not result in any dropouts. In *PREMIO (FR)* end users actually dropped out due to a lack of communication. In the community-volunteering phase, a lot of communication efforts were spent in order to motivate enough people to host the devices. However, as time elapsed between the volunteering process and the actual installation, there were not enough suitable candidates anymore. A new recruitment campaign was launched to 're-recruit' participants. The campaign included the advertisements in a local newspaper, an internet website, public communications (newsletters) including best practices for energy savings, and distribution of energy-efficient light bulbs for all inhabitants of Lambesc. In this case, the project management did not take into account from the start that social acceptability is an ongoing effort over the different project phases.

4.5.3 Conclusion

Key in engaging end users through project communication is to adopt a personalised approach. This section discussed ways and means to personally address end users throughout a smart energy project. The case study data show that a combination of online and offline communication channels is most likely to be effective when engaging with end users. Not only an integrated approach contributes to reaching all potential target groups, a message is also more likely to resonate when delivered through various channels.

In the recruitment phase, a two-step approach (first getting in the surroundings of potential end users, and secondly approach them personally) has shown to work well, although the exact elaboration of such an approach should take contextual factors into account. It is vital to get the project on top of mind when engaging participants, and to stay on top of mind by continuously providing easily accessible information when the project is on its way. Tailoring project communication contents and channels to the local context and the sense of place has shown to be very successful in many projects, e.g. *Sala-Heby Energi (SE), EcoGrid (DK), Texel Could Power (NL)* and *Rendement voor Iedereen (NL).* Involving well-known local stakeholders in communication strategies can contribute to building trust.

In ongoing project communication it is vital to manage expectations. Communication gaps due to project delays should be avoided at all times, as they may well underpin end users' motivation and commitment to the project and it can eventually lead to dropouts. To this end, it can be helpful to visualize the project timeline from the end user perspective to obtain a comprehensive overview which communication messages end users receive at which moment. Particularly SMEs have shown to be less flexible in dealing with unexpected developments that may impact or hamper their business, so it is quite important to keep them well informed and engaged.

A further option for project communication is to appoint a local ambassador for energy companies to connect the end user in personal and close relations with the project (as described in D3.3). The ambassador can enhance the trust and loyalty between the project and the participants. Energy clubs/associations can also emphasize involvement of end users alongside close and personal relations (D3.3). Bloggers, which are focused on topics like fashion or music can additionally inform about energy to reach other target groups.

4.6 Cooperation between stakeholders

In virtually all investigated project consortia, energy companies – e.g. utilities, DSOs, TSOs – are involved as a (lead) partner (see section 3 for detailed information about stakeholder coalitions in the S3C Family of Projects, FoP). This chapter explores the possible benefits of working with non-energy related stakeholders.

As the perspectives and interest of non-energy stakeholders differ from the traditional views of energy companies, it can have several benefits to establish a partnership. In this section the following research question is addressed: *Does involvement of non-energy stakeholders contribute to end user engagement and smart energy behaviour?*

4.6.1 Involving governmental stakeholders

Several project consortia engaged in partnerships with governmental stakeholders. Particularly local governmental bodies (municipalities or regional bodies) can help make potential participants enthusiastic to join a project, or to emphasize the local character (‘sense of place’) of a project. In *PREMIO (FR)* local administrative bodies (PACA regional government, the municipality, the mayor of Lambesc) fulfilled an important role – not so much in the day-to-day management of the project, but in communication and securing social support for the project. In some projects, governmental bodies also contribute to project funding, such as the *Rendement voor Iedereen (NL)* project, that was co-funded by the province of Utrecht and the municipalities of Amersfoort and Utrecht. Municipalities can also prove to be important in case a project impacts local policy issues (e.g. urbanization plans). *E-Mobility (SI)* actively involved the local communities that aided in minor financial participation and they adapted their urbanization plan for the project. This involvement and cooperation of political stakeholders shifts the possible end user perspective for a project from realizing individual gain for a commercial organization, towards a project that benefits the community.

In *3e-Houses (DE/ES/UK)* the Bristol City Council was the main facilitator and coordinator of the replication pilot implemented in Bristol. They were involved in the engagement of end users and the dissemination of the activities performed within the project framework. Because the organization and workforce were familiar to local partners they ended up being the projects eyes and ears during the course of the pilot. In *InovCity (PT)* the municipality played an important role in communicating the project to all the inhabitants in Évora. They also organized conferences about smart grids for the community. Involvement of local government bodies contributes to a sense of trust towards the project and its associated products and services. This can be further enhanced by engaging political stakeholders; they can act as mobilizers of the population, the local media and of other stakeholders. Several projects in the FoP were endorsed by the mayor or by other local politicians. It is thus a well-used method of creating trust and a community feeling.

However, cooperation with governmental stakeholders is not guaranteed to be beneficial. The *PREMIO (FR)* project suffered from a rather strong division between the ‘social’ and ‘technical’ partners in this project: the one hand to the municipality that had the task of engaging participants and on the other hand to Capénergies, who was responsible for the installation of the smart grid equipment. Because of communication issues between the two parties, the project ran into many difficulties once the installation phase of the project began, such as problems with old electrical installations, IT systems, etc. The project management has proposed that for future work it such projects should also include partners with experience in IT solutions, for better communication within the smart grid system, and a regulator, to ensure a fair distribution of burdens and benefits stemming from the smart grid.

Involving local communities to secure social support for the project (*PREMIO, FR)*

The PREMIO project (PREMIO stands for "Production Répartie, Energies Renouvelables et MDE (Maîtrise de l'Énergie), Intégrées et Optimisées") originated in Capénergies, a working group in which most of the project partners were already active. When the opportunity of financing by the PACA region presented itself, Capénergies seized the opportunity. Reuniting the goals and wishes of the PACA region with the goals and wishes of Capénergies, it was decided to develop an *in vivo* demonstration project on the neighbourhood scale (total load of max 1 MW) and to maximize the potential of local distributed generation, demand response and local storage in order to shave peaks thus contributing to grid management.

The target groups included actors present in a real neighbourhood – i.e. both SMEs and households. Once the project set up was defined and financing by the PACA region secured, local communities could offer themselves up as volunteers for hosting the demonstration project. The community of Lambesc was chosen because local people really showed their motivation to take part in the project (by signing a petition in favour of the project, by turning up very numerously at a meeting organized to present the project) and furthermore, the major of Lambesc was highly in favour of the project, because he was elected on a platform promising more sustainable development for the community.

4.6.2 Involving non-governmental stakeholders

Similar to government bodies, non-governmental organisations can be involved in the project because they are usually more familiar to end users than energy companies and are often perceived as trustworthy. If there is another partner who explains the benefits of a projects' products or services, this attributes to the credibility of the benefits.

Civil society organisations

In the *3e-Houses (DE/ES/UK)* project the Knowle West Media Centre (KWMC) in Bristol played an important role. KWMC is a registered charity and company limited by guarantee that performs a wide social, cultural and educational role in the community. The core element of this function is that the location of the organization is in South Bristol. They were an important partner in terms of user engagement, providing support, providing feedback of the experience to other partners and elaborating the main audio-visual contents for the project consortium. This is a well-known and trusted organisation within the community, which had already created strong connections with local people and had run several credible environmental projects in the area. This facilitated the acceptance of the UK replicator in the Knowle West community.

Rendement voor Iedereen (NL) involved local primary schools in the recruitment communication, in order to inform residents about the project through their children. Another example of a civil society stakeholder that communicates project benefits comes from *Jouw Energie Moment (NL)*. The housing association SWZ (involved in the pilot in the city of Zwolle) aims to educate tenants that they can lower their energy bills by taking better control over their energy consumption. Because in social housing the energy bills take up a large share of the total income, reducing the uncertainty for the tenants will also reduce uncertainty for the housing association. As energy norms increase, more sustainable houses will also increase the value of their housing stock. With this motivation they clearly favour the benefits from this project and the associated innovation. This helped with the recruitment of social housing participants.

In *E-Mobility (SI)* the tourism association provided suggestions about the charging station locations. They were also involved in the project execution, by leading all marketing activities and organizing a series of events. This caused for a different perspective and message for the project compared to a technical approach and received publicity within and outside Slovenia.

The *UppSol 2020 (SE)* project derives from discussions between a governmental body (the county administrative board) and a non-governmental organisation (STUNS). The county administrative board is on daily basis responsible for giving advice and information regarding rules to the inhabitants in their specific region within a wide range of areas, and is therefore not a pure energy stakeholder, but rather one focusing on information dissemination. STUNS is a foundation for cooperation between the universities of Uppsala, business and society. A small group of people at STUNS is working with energy-related matters. The forerunners around which the different workshop series are built are non-energy stakeholders. Their main interest is rather on a well-functioning building stock or fulfilling the requirements and wishes of residents and the economy of their organizations. The forerunners interact strongly both with the project managers and with the followers, where the latter ones are also non-energy stakeholders. The project also makes use of housing associations: in particular the use of the forerunners' network of contacts within other housing associations in combination with targeted invitations to housing associations in the neighbourhood of the test bed. The project manager stresses the importance of a true understanding of the end user, something that can only come from close and personal contact and an open and responsive atmosphere.

Research organizations

Due to the experimental design of many projects in the FoP, many have incorporated research institutes and academia in the project consortium. Research institutes, universities and consultancy firms can first of all be useful to conducting the necessary studies to prove the level of achievement of the project goals. Additionally, they can perform roles such as defining frameworks and timelines for workloads and retrieving and analysing project data. This was found in the *MOMA (DE)* project; through the field tests (conducted by the research company), they gained insight into the opinions and needs of the end users that they can translate into future products. These stakeholders can also support and/or conduct activities that help understanding target groups (see section 4.1). In *PowerMatching City (NL)* and knowledge institutes and an IT company are the most relevant 'non-energy' actors, providing additional expertise to the project by e.g. cost-benefit analysis and customer evaluation. Putting a research organization in the lead of a project, this can underscore the 'common good' aspect of a smart grid project, rather than giving the impression of testing another commercial product. Because of their independent status, it can add a trustworthy character to a project consortium, which can have an effect on the expectations that the participants have about the project. The presence of a research organisation might be a good reminder for the participants of the experimental character of a smart grid trial.

Partners with retail experience

Usually, energy companies do not have the same experience in dealing directly with the general public as parties that work in the retail industries do. This knowledge might give such partners an important role in the projects to bridge the gap between the individual households and the complex energy system. With their knowledge of how to deal with customers, they might be the first to understand how economically attractive business models around the smart grid can be created.

An important partner in many project consortia are IT companies. Since the technological infrastructure of smart energy projects is strongly based on IT-solutions, these partners are important for the success of a project. Not only because they introduce the innovation into someone's home, but also because it has to be understandable and according to the expectations of a household. If they don't understand the product, or it doesn't work, or even causes irritation (noise, invasive, black outs) the effects on the project and the innovation can be negative. Because they have experience with working with clients directly, it might be easier for them to understand better what the end user wants, expects and tolerates.

However, the role of a commercial partner should always be made very clear. In the *Energy@Home (IT)* project, which was organised by an Italian telecom company, the project found it difficult to find enough participants as people seemed weary to join an energy project organised by a non-energy partner, as they feared it might just be another way for the telecom firm to make money.

The messenger matters (*Energy@Home, IT)*

There were specific selection criteria used for the recruitment of the subjects of the sample: a flat ADSL contract with Telecom, an electrical contract with Enel Distribuzione (default service market) and a specific type of electric meter were mandatory. These selection criteria, together with the difficulties of recruitment, have led to a limited sample of subjects. The first attempt to recruit end users for the projects have initially been done by the customer service of Telecom Italia (the largest Italian telecommunication company) in the Ancona area, in the central part of Italy. This resulted in having half of the sample, but it proved to be unsuccessful (or less effective than expected) even though end users were promised to be given a smart dishwasher and other smart equipment for free. The devil was in the details; customers didn't believe the telecommunication company that called and offered a washing machine by phone; why would a telecom company offer a washing machine?

The second way of recruitment, was the recruitment by word of mouth trough colleagues from Telecom. This proved to be successful instead and some people even complained, because they were not able to participate because they had not been informed of the trial by their friends who were aware of the project.

This method was more effective because it inspires more confidence than less personal methods. This trust made end users willingly to accept some minor inconveniences, such as the quite cumbersome smart plugs in their homes.

4.6.3 Conclusion

A well-organised consortium lies at the basis of every project and including the right partners and ensuring clear communication between them, can ease the engagement of participants. Many projects in the FoP bring together a variety of stakeholders to cooperate in the management and operations of smart grid pilots. Often this is a good thing, because each partner brings in specific skills and competences. In theory, combining the expertise of the different partner could result in a synergy within the project. However, with an increasing number of partners, the flexibility within the cooperation might decrease, as was recognized in the European project *Stockholm Royal Seaport (SE)*. In this project some delays were caused because it can sometimes be difficult to reach agreements when many different partners from different backgrounds are involved.

4.7 Smart energy communities

This section addresses how to engage end users as initiators, co-creators and co-owners of smart grid projects. Bottom-up initiatives can either relate to individual consumers taking the role of smart customers by feeding their own micro-generation into the electricity grid, or to community initiatives in which consumers turn to smart citizens. In this section, the key focus lies on the development and support of smart energy communities. This section addresses not only how a particular smart grid project can facilitate the formation of an 'energy community', but also how community dynamics can influence end user engagement in a project. The research question addressed here was formulated as follows: *Which instruments or approaches contribute to the development and support of smart energy communities?*

First, we investigate what exactly is meant by the notion of an 'energy community' (4.7.1). Next interventions to tailor the design of smart grid projects to community dynamics are discussed (4.7.2). Section 4.7.3 elaborates on community-based engagement strategies, not only to recruit end users but also to keep them engaged during the project.

4.7.1 Two dimensions of community dynamics

It is rather difficult to define what counts as a 'community project' – the term has a largely positive ring to it so it is usually advantageous to label a project as a 'community project' in external communication. There is however an agreement that 'community dynamics' can either refer to the *outcome dimension*, meaning that the outcomes of the project are distributed socially and geographically so that 'the community' as a whole benefits from it (i.e. benefits should be spread more or less evenly over all members of the community); or the *process dimension*, implying that the project is developed and run by 'the community' (i.e. 'the community' participates in setting up the project and influences and/or shapes the project's contents and progress).[12]

The analysis of the S3C Family of Projects (FoP) shows that current experiences with smart energy communities in the 32 case studies primarily focus on the process dimension. The vast majority of community-oriented interventions found in the case studies aim to involve residents or local communities through participation in the design and implementation of the project. There are a few exceptions: *EcoGrid (DK)* on the island of Bornholm and *Texel Cloud Power (NL)* on the island of Texel, both strive for local energy generation and distribution in such a way that the community becomes less dependent of the electricity grid. Also the *eueco (DE)* project should be mentioned here, as this case study describes a consultancy approach to facilitate the foundation and maintenance of local and regional energy cooperatives. To this end, they try to involve the members of the cooperatives into the project and they actively communicate with local stakeholders to engage them into these projects.

4.7.2 Tailoring the project design to community dynamics

In the planning phase, several activities can be undertaken to facilitate engagement of smart citizens and smart energy communities already at an early stage of project development. The case studies reveal the following interventions relating to consortium building and project management design.

The local energy company initiates and/or manages the project

Especially in areas that are relatively isolated from the main grid (e.g. an island or remote rural areas) and thus may rely stronger on locally produced electricity, the local energy company can probably enlist support for a project that aims to solve a problem of common community interest, especially if this company is highly visible (e.g. owner of a lot of wind mills) and a trusted partner. When a local energy company initiates and manages a smart grid project, this emphasizes a sense of place and a 'community feeling' which is usually already present in rather isolated areas. It can lead to a win-win situation: for the company, because they can potentially offer new services (and generate new business) to clients based on smart grid applications; and to the end users themselves, who help solve a community problem (which for some people can be enough in terms of motivation) and/or gain financially from this.

This can be seen in two S3C case studies. The *EcoGrid (DK)* project is led by Oestkraft, the local power producer and distributor operating power plants, the distribution grid, wind turbines and a biogas plant on

[12] Walker, G. & P. Devine-Wright (2008). Community renewable energy: What should it mean? *Energy Policy, 36,* 2, 497–500.

the island of Bornholm. Furthermore the company trades energy, produces district heating, erects and maintains streetlights and broadband. *Texel Cloud Power (NL)* was initiated by the local energy utility Texel Energie and implemented in close cooperation with the regionally operating DSO Liander. However, in the latter, the project manager stated that such close ties with the local energy company could also result in critical consumers. As people tend to trust the familiar faces in these local companies, expectations are very high and people may be easily disappointed in case of delays or technical problems.

Involving local non-energy partners with a solid reputation

It can be advantageous to delegate project management tasks to local, preferable non-profit organisations. In these cases, an energy company and/or DSO is still a main financial contributor and is responsible for technical support, but by delegating the project management to the local non-energy players the whole project is taken out of the commercial sphere and can be enlisted for the purposes of contributing to the local 'common good' – e.g. contributing to the environmental performance of the local community, stimulating 'eco-tourism', etc.

The advantage of this approach is that specific energy-related issues can be connected to community issues in a search for common ground. In this way, a smart grid project can gain more 'added value' in the perception of end users, than would be the case in a purely technical experimental set up. The *Rendement voor Iedereen (NL)* project is coordinated by a project manager from the regional Taskforce Innovatie (English: Taskforce Innovation), but locally known non-energy parties lead the pilots in two Dutch cities. A local internet provider company is in charge of the pilot in Utrecht (which follows a top-down approach), whereas the bottom-up based pilot in in Amersfoort is led by a community coach: a consultant specialized in community support. Furthermore, as an intermediary between the community and the project management, his task is to facilitate communication and to manage expectations.

The selection of the localisation of the *PREMIO (FR)* project was based on a volunteering approach: the community, in which the motivation to accommodate the project's experimental infrastructure was highest, was selected (Lambesc). This was evaluated by a jury installed by the regional authorities. Securing bottom-up support hence was a primary condition for the project to take place. The project made extensive use of the social network of the municipality administration and of the participants that had volunteered to be part of the project in the selection phase. In *E-Mobility (SI)*, local communities were involved from the early beginning. The municipalities have selected locations for charging stations close to the tourist attractions or spots like lakes, tourist offices, souvenir stores, and the local tourist organisation contributed to marketing and promotion material.

A promising way to involve local partners with a solid reputation is to enlist the mayor in the smart grid project. Several projects, such as *PREMIO (FR), EcoGrid (DK)* and *E-Mobility (SI)*, have involved the mayors of the municipalities to endorse the project. In these cases the mayor is a respected and stable political factor in the local community (e.g. no major electoral shifts over time). It can be especially effective if the mayor has been elected on a platform promising sustainable development for the community, as was the case with *PREMIO (FR)*. In *Linear (BE)* the mayors of two municipalities played an instrumental role in securing enough participation in the local field tests (e.g. by co-signing invitation letters sent out to potential participants, by being present at the project's networking events, etc.). The strongest sense of commitment will be communicated if the mayor is actually participating as an end user in the smart grid project, as the mayor of Bornholm did in *EcoGrid (DK)*. A similar effect is found in *Rendement voor Iedereen (NL)* where the community coach in the Amersfoort pilot also participates in the project as residential end user.

Building a business model to facilitate and support community initiatives

By building a business model around energy community initiatives, the steps to facilitate and support citizens' participation – recruitment, communication, PR, administrative and financial aspects – can become standardized. This can lead to a reduction of administrative costs.

Eueco (DE) implemented a business model in which a commercial partner takes care of all aspects of community engagement to set up energy cooperatives investing in RES. The business model offers financial incentives to citizens for participating in a cooperative irrespective of e.g. their attitudes to renewable energy. It turns out that participants (i.e. prosumers) have only limited time to participate in the smart grid community and are therefore happy to 'outsource' management tasks to a professional partner specialising in community initiatives. The project manager of *eueco (DE)*, explained that attitudes among end users regarding their acceptance of RES changed along the way. Many members of the cooperatives started their engagement through financial reasons. The cooperative is a safe investment with safe return rates. But throughout the process, members of the cooperatives have changed their attitude towards RES.

Causes can be seen in the communication and education proposed in the cooperative and in the fact to participate in the energy turnaround. Based on these findings, it is very likely that the acceptance of the projects will increase, if the concerned people are interested in the success of the projects due to the fact that they gave their own money to the cooperative. *Eueco (DE)* shows that the whole process of bottom-up citizen participation can be facilitated by a third party: starting from administrational and financial consulting, IT-solutions (websites, blogs, social media, etc.) to the organization of the recruitment process and local events for future members of the cooperatives.

The community coach in *Rendement voor Iedereen (NL)* was hired to professionally organize and facilitate the community of end users in the planning, installation and execution phase based on a dedicated methodology, developed by Icasus consultancy. The ICA-method (Interaction, Commitment and Activation) does not follow a standardized roadmap, but is tailored loosely to the project objectives and the target group. The method contains an entire engagement 'package', ranging from smart recruitment techniques using multiple channels to organizing community involvement through co-creation. It is based upon the idea that people should be activated in relation to issues in their direct living environment (e.g. street, neighbourhood or village) and their personal interests. The incentive for people to get involved (Activation phase) draws upon something people actually want to achieve themselves, rather than a business offer that provides a solution. Using the ICA-method, people are triggered to actively participate by trying to get across the message that they can actually 'make the difference'. Next, people are empowered to achieve the goals they set out for themselves. The community coach states that when people manage to achieve what they are striving for, this generates civic pride and people will spread the word within the community.

In these projects, people are continuously informed about energy related topics and get in touch with forerunner topics very early. This can have an influence on their attitude toward sustainability and renewable energy. Furthermore, the comprehension of the background and necessity of smart grids and RES can be established. Although this approach has only been tried out on a commercial scale in the context of setting up energy cooperatives, the business model will be applicable in later stages for smart grid technologies. Of course, such a business model is most likely to succeed in a context where local citizens' initiatives are in high demand (e.g. Germany and The Netherlands) and it should always be adapted to the local (cultural, organisational, geographical) context.

Fostering a sense of ownership through tailored project communication

Many smart grid innovations projects carry non-descriptive project names based on acronyms or technical solutions that are embedded in the project. These projects do not ring a bell for outsiders in the energy industry. To promote a sense of proximity and a sense of ownership among end users, and to raise community awareness about these projects several of the investigated case studies have chosen a project name that would (hopefully) attract end users. For instance, the project *Texel Cloud Power (NL),* implemented on Dutch the island of Texel, decided to present their project in the communication to end users to 'Texel Slim Zelfvoorzienend' (translated as 'Texel smart and self-sufficient'). DSO Enexis that initiated the *Jouw Energie Moment (NL)* project chose this project name because it explains that that it offers demand response incentives to put households in control of when they consume energy (translated as 'your energy moment'). In the bottom-up pilot in the city of Amersfoort in *Rendement voor Iedereen (NL),* a contest was organised for participating end users to find an appropriate name for the community. They came up with the name 'AmersVolt'. This contest was a means to get people actively engaged in the community, and it was immediately a way to show them that they were in charge, that the community was their own.

4.7.3 Community-based engagement strategies

The investigated projects reveal the following community-based interventions that have been applied to recruit participants and to keep them engaged in the course of the project.

Creating a local hype

Several projects, such as *PREMIO (FR), EcoGrid (DK), eueco (DE), Rendement voor Iedereen (NL)* and *Jouw Energie Moment (NL),* managed to create a local hype around their smart grid pilot project. In most cases the recruitment and communication followed a marketing approach for end user participation, in effect combining the insights of Cialdini (1984), such as creating a sense of 'scarcity' and building up a 'socially acceptable norm' with community dynamics. The first step is trying to get everyone informed (e.g. local TV, local radio and local newspapers can be used to "create news or a hype"). This is usually the first opportunity to sign up for the project. After the reactions slow down, a direct mailing can be launched to invite people to join the project. Direct individual phone contacts have also been applied in some projects, as well as having dedicated project representatives answer the questions of potential participants.

Projects initiated by local trusted partners using multiple communication channels (addressed to different types of audiences) are most likely succeed in creating a ‘hype’ around the project – see the boxed text about *Rendement voor Iedereen (NL)*. Knowing and understanding the people, being part of the local community makes the service you want to provide to participants more valuable and of high quality. Being asked by a trusted and respected member of your community to help in a project of community interest is likely to be a factor that facilitates initial recruitment especially. Acting in a socially accepted way in your community is generally known to be a motivator for behavioural change.

However, it is important to note that a local hype can also fade away rather quickly. The *PREMIO (FR)* project relied strongly on community support and community dynamics, but it seems that the implicit assumption was that the volunteering approach used to select a site would secure social acceptability ‘once and for all’. But as time elapsed between the volunteering process and the actual installation, many potential participants lost their interest in the project, due to a lack of follow-up community activities, eventually leading to a situation that were not enough suitable end users anymore.

Creating a neighbourhood hype *(Rendement voor Iedereen, NL)*

In October 2012, recruitment started for the smart grid pilot in Nieuwland, a neighbourhood in the city of Amersfoort. The first step was to distribute a leaflet about the project. Following the ICA-method this leaflet was strongly differentiated from slick and glossy advertisements by printing it in greyscale on a green sheet of (normal) paper, and it contained a spelling mistake (to attract the reader’s attention). To directly addresses the residents, the question “have you heard of the new residents’ collective?” was printed on top. The community coach stressed that to attract attention of a potential participants, project communication in the recruitment phase should appeal to a sense of ‘civil disobedience’. In addition balloons were handed out (low cost, nice for kids) and primary schools in the neighbourhood were involved to spread information about the project (in order to reach busy parents) and advertisements were published in local newspapers. A ‘text car’ was placed in the neighbourhood to draw extra attention. After people had been exposed to the project a couple of times through different channels, an information event was held. At this event over 85 people showed up (representing over 70 households), and soon after the recruitment communication stopped because there was room for only 100 households and more than that had already signed up.

Organising community events

Organising events where end user participants can meet face-to-face with fellow residents are an effective means to reinforce community dynamics. Community-oriented events to inform people about the project were held in several projects, e.g. *EcoGrid (DK), eueco (DE), Linear (BE), Rendement voor Iedereen (NL)* and *Texel Cloud Power (NL)*. In most cases, this event was also the first opportunity for participants to sign up for the project. To reach potential participants in the newly build neighbourhoods where *Jouw Energie Moment (NL)* was implemented, the project management jointly organized events with other parties such as the municipality, housing associations, energy utilities, internet providers and primary schools. According to the project manager, moving into a new house is by far the most important thing on people’s mind, so future residents were invited to visit an information event where they could meet their future neighbours and receive information about the new neighbourhood.

To strengthen community dynamics after recruitment and to carry participants over to the instalment and demonstration phases, community events can also be organised in the course of the project. This make the abstract 'sense of community' much more tangible and real for participants, especially when the local hype and initial feelings of enthusiasm and have slowly faded along the way. They allow members from the community to meet each other face-to-face and talk about project experiences. Some projects provided fun and entertainment to attract participants. For instance, *EcoGrid (DK)* organized a performance by a local comedian on their event. To celebrate the start of the installation phase, *Linear (BE)* organized an event for participants where they received the tablet that served as their in-house energy display. In the office based project *Hus 14: OfficeWise (SE)*, all employees in the building were invited for an installation and inauguration event to inform them about the project and the present status. This event was also the used to have all office workers that showed up help to finish the SuperGraph ambient visualization that was designed to display energy consumption in the office building.

In addition to organizing community events, providing a physical space or meeting point for participants can be beneficial to support and strengthen community dynamics, such as *EcoGrid's (DK)* VillaSmart and the demonstration space at *InovCity (PT)*. Another possibility is to creating a virtual forum (website) where end user participants can ask each other advice and/or interact with a technical support team (*InovCity, PT; EcoGrid, DK*).

Appointing a board of participants

To keep communities engaged as the project progresses, it can be beneficial to install a board of participants that represent the end user community. After recruitment of 100 households was finished, the community coach in the Amersfoort pilot of *Rendement voor Iedereen (NL)* took the initiative to form a board of 12 participants to represent the AmersVolt community to the project management. Perhaps the *PREMIO (FR)* project would have been able to sustain the strong community dynamics that emerged in the phase of site selection if a systematic representation of the end users had been organised – e.g. in an end user group that regularly meets with the technical people to discuss the project progress.

It can also be helpful to have virtual interactive platforms in place for the end user community. For *InovCity (PT),* EDP developed the Dr. Energy platform (www.drenergia.pt) to fulfil the needs of consumers to have an online community to compare "me and others". The existence of a figure also established a "humanized" relationship between the supplier and the consumer. The platform joined all those elements and allowed consumers to learn from the learning section with energy efficiency guide, to share their doubts, issues, tips etc. in the forum, to compare with the average community consumption, to rate others' ideas online, and to have a personalized interaction with Dr. Energy through a chat format or email.

Board of ambassadors representing the AmersVolt community *(Rendement voor Iedereen, NL)*

In the Amersfoort pilot of *Rendement voor Iedereen (NL),* a board of 12 participating end users was formed to represent the end users that had united in the AmersVolt community. This was not at all a top down process: board members offered their help voluntarily, because they were motivated to get involved more actively than just participate as an end user. It soon turned out that the board members rather portrayed themselves as project ambassadors, so it was agreed upon to name them accordingly. These ambassadors fulfil different roles, for example some of them are technical experts that will be the first to try out new products while others are responsible for the communication within the community. Each ambassador brings in professional expertise and know-how from his or her job or education, thus empowering the project with a rich knowledge base. As a consequence of the community approach, communication between the project management and the group of participants is multilateral. The ambassador meetings take place once or twice a month, depending on activities in the project.

Tasks were divided informally between the project ambassadors, with support from the community coach, who challenges ambassadors to take up specific assignments. Some engaged in technological aspects of the project, for example by organizing a brainstorm meeting about the design of feedback information, others got involved in legal issues (revising the contract for participants) or in the project communication, such as delivering content for the community's website. They also turned out to be helpful when it came to the problem solving in the installation phase. A few members were taught how to (re-)install the equipment and how to run firmware updates, and they approached participants who experienced troubles with the installation and helped them out.

Co-creation interventions to shape community dynamics

Both during and after recruitment, community co-creation approaches can be deployed to better tailor a project to local community dynamics and to develop community-based products and services. In *InovCity (PT),* co-creation workshops with end users and engineers were organized to collect community feedback on the design and operation of technologies and interfaces. The board of participants in *Rendement voor Iedereen (NL)* turned out to be an effective way to organize community co-creation. For instance, members of the board got involved in contractual issues when several participants did not want to sign the contract because they had a feeling of distrust (related to privacy and data protection). The project management proposed to redevelop the contract in cooperation with a group of participants, resulting relatively quickly in a reworked, condensed version of the contract to everyone's satisfaction. All participants signed the contract without further ado. The board was also involved in the development of service concepts, such as the design of the feedback information. This was valuable for developers of the app and the supplier of smart meters, because they received elaborate information about end users' needs and expectations.

In *PowerMatching City (NL)*, end users' hopes, worries and priorities were elicited through workshops based on a card game that was developed specifically for this purpose. This led to the identification of two prototypical energy services:

- 'Together More Sustainable', involving optimising the usage of locally produced energy within the energy community of choice;
- 'Smart Cost Reduction', involving lowering end users energy bills by empowering them to use energy when prices are lowest.

Furthermore, it was possible to broadly distinguish two different end user groups; one mainly driven by cost reductions and one driven by motivations of self-sufficiency, both from an individual and community perspective. This finding lends some empirical support to the S3C distinction between 'consumer' and 'customer' motivations on the one hand, vs. 'citizen' motivations on the other.

Hus 14: OfficeWise (SE) deployed a co-creation approach for concept development and design of the community feedback device to visualize energy consumption. First, workshops on visualization were held with employees. The workshop focused on preferences regarding how the employer should pay attention to energy efficient employees, visualisation and presentation, as well as what data the participants found interesting and wanted to get access to. Next, employees worked out various solutions for a visualization screen in a design workshop, in which they were drawing, cutting, pasting and describing their solutions to the other participants in working groups. In the installation and inauguration event that organized to finalize the ambient visualization (the SuperGraph), every participant was invited to contribute to the chandelier by mounting an avatar.

Co-creation: forerunners and followers (*UppSol 2020, SE)*

UppSol 2020 (SE) makes use of a method based on the idea of forerunners and followers, where a group of end users follow the installation process of a specific energy technology made by an end user within the same target group. The method is built on test beds within different target groups. A group of approximately 15-20 followers (individual followers, usually at least two attendees from each follower organization) are invited to a workshop series following the hand-picked forerunner. Workshops are held before, during and after the installation. The workshops contain both knowledge raising activities and activities where the forerunner presents experiences and results, as well as answers questions. An informal network of contacts is built through the workshops and the project leaders try to create a "culture" and an open atmosphere where any type of question can be asked. By repetition and follow-ups they want to create a longer-lasting awareness among the followers. The (technical) information given at the workshops is adjusted to the level of knowledge and relevance to the attendees. Some issues are for example very important when dealing with municipalities, but not at all with housing associations. The starting point is always the end users (target group) in question.

4.7.4 Conclusion

Community dynamics – once in place – can greatly facilitate end user engagement in smart grid projects in all stages of project development: from the recruitment of participants over the design, adaptation and instalment of technologies and end user interfaces, to the actual demonstration phase. Contributing to the good of the community can be a powerful motivator, and learning from the experiences of peers can be more effective in acquiring new behaviours than top-down education efforts.

*Which instruments or approaches contribute to the development and support of smart energy communities?*It appears that such community dynamics – if not more or less in place already – are hard to form from scratch. Once in place, they should be nurtured throughout the entire process (once the energy community is formed, participants expect to be involved in all project stages, and even carry over the community thrust to other ways of experimenting with sustainable lifestyles). If the community dynamic is not maintained during the instalment and demonstration phase, the project is likely to suffer from backlash in terms of drop-outs. A community dynamic is not something which can be 'turned on and off' at will, e.g. in certain project phases. Community smart grid projects can thus be resource intensive, and this could be a significant hampering factor for a full-scale roll-out of the smart grid of the future.

4.8 New market structures

Which features of the interaction between end users and energy market structures contribute to end user engagement and smart energy behaviour? This research question is asking us to think about the larger market that the end user is acting within. More specifically it forces us to think what effects the consumer feels of the way the energy market is organised. Some aspects of the energy market situation that each project finds itself in - characterised e.g. by laws and regulations – can have a significant impact on how the smart grid project is set up, and thus also on how it influences the energy behaviour of end users.

Because most smart grid projects focus on electricity and very few on other forms of energy, such as natural gas for heating, only the electricity market will be taken into further consideration. Not only will the influence of the current electricity market on end user energy consumption be discussed, also the influence we can see from new market structures that are simulated in some of the case studies within the S3C Family of Projects (FoP) will be taken into consideration.

First we will look at the market structure where end users become part of the market by offering flexibility in return for a monetary reward; this will result in viable business models only if the value of the flexibility is high enough. Then different new roles of incumbents or the introduction of new players in the market will be discussed. Lastly, we will have a look at a possible future change: how the focus shift towards local grids might affect the end user.

4.8.1 Financial benefits for consumers by offering flexibility

There are many different ways in which the end users can be engaged to offer flexibility and thus play a more active role in the energy market. In the project *Smart Home (SI)* the end user was free to limit their own maximum load power, i.e. the amount of energy they can use at any instant in time. Its purpose was to prevent peak power consumption, which could incur high electricity costs for the households as part of the (existing) tariff was based on the capacity of the connection and would enable the distribution company to use existing grid capacities, postponing investment in grid expansion. The feature was tested in an existing price tariff, but because this tariff is partly based upon the capacity of the connection, households could lower their costs by restricting their capacity. Behavioural changes have been achieved; the users have learnt when to switch-off certain devices in order to prevent the forceful disconnection of the loads. Results show that majority of users set their power limits to 50% of the installed power. In *EnergiUdsigten (DK)* a spot price contract was presented to the participants, which directly makes them aware of how the prices on the electricity market behave.

The *Salzburg SME DR study (AT)* analysed through interviews and equipment and process data the theoretical availability for positive and negative flexible loads (the potential to switch off or on, resp.) for the participating SMEs. Although experimental tests have not been performed, the analytical data suggest that the top 5 participants (out of 21) were responsible for 60-70% of the overall value for flexible loads in this study; especially the food retailer had a high potential. All five top participants voiced a definite interest to participate in a follow-up pilot.

Creating business models for SME's; what questions need to be answered? (*Salzburg SME DR study, AT*)

The declared goal of the Salzburg SME DR study was to analyse potentials for load shifting in small to medium sized enterprises in the Salzburg region. The study was charged with answering which measures in the demand response category could benefit the realisation of smart grid solutions and which kind of framework conditions would be required. The focus was on SMEs, municipal buildings as well as local utility service providers and encompassed technical and economic potential and mobilising those potentials through interaction measures.

The survey of the SMEs in the Salzburg area was charged with answering the following questions:

- Which potentials for demand response can be expected in SMEs?
- How open are the contact persons and decision makers for the topic of load shifting?
- Which approach to the decision makers and which incentives work to promote the implementation of load shifting?
- What are the barriers for implementing load shifting?
- What would a central load management have to look like?
- Which conclusions can be drawn from the survey for an ICT strategy?

- What are the next steps to take with interested end user to realise their potential?

Based on the theoretical and on-site research the study proposes a customer approach strategy, 8 different reward models and additionally suggests several possible business models.

The flexibility offered by the end user also has value for other parties. *KIBERnet (SI)* and *Smart Home (SI)* were both designed to increase the flexibility of the end user in order to reduce peak demand on the long term, such that future investment in infrastructure could be limited. For *AlpEnergy (DE)* the end users' flexibility was used to improve the uptake of distributed renewable energy sources in the local grid. In *Linear (BE)* four business cases were tested; two of these are designed to create added value for the retailer/balance responsible party (BRP), the other two are of concern for the DSO. The project will calculate the value of the flexibility per household for each of the cases (the project is still ongoing).

4.8.2 Regulatory Situation

In Europe most electricity markets have been liberalised in the past, but simultaneously have become reliant on much heavier regulation. As a result, in some places there are regulatory constraints to introducing a dynamic tariff scheme, which is often used as one of the main motivators for end users to adapt their energy consumption. In some projects, e.g. *Rendement voor Iedereen (NL)* and *InovCity (PT)*, this has tried to be overcome by simulating the energy price; the dynamic price was given as part of the energy feedback, but would not actually be charged on the customers' bill. This might have an effect on the behaviour of the end user, who might find the incentive now lacks a monetary value and is thus less inclined to follow the feedback.

Another regulatory situation that some projects find themselves in which is not supportive of smart grids is the net metering of local production. This allows prosumers with privately owned electricity generation technologies – often PV panels – to feed their net production into the grid. Although this improves the business case of buying these technologies, it does not stimulate the use of electricity at the moment of generation. This does not provide the end user with any incentive to change his energy consumption to match the generation and thus does not stimulate smart energy behaviour.

4.8.3 Shifting the role of existing market parties

The energy market is at the moment a very technical market not initially designed for the interaction with small parties as individual households or SMEs. Nevertheless, sometimes parties within this impersonal market do manage to hold close relations with their customers. The DSO Sala-Heby Energi Elnät AB (SHEEAB) in the *Sala-Heby Energi (SE)* project finds the continuous involvement of end users very important for its business. They regularly organise special SHEEAB-days when they invite the local community to inform them about their work and these days are very well visited with a turn up of 600 visitors (>10% of the customer base). This close relationship with the energy company might have played a role in the smooth acceptance of the ToU tariff by the end users.

The traditional role of grid operators lies with supplying the load - per kWh, along with maintaining the safety of the grid within technical restrictions. The transformation of the grid to include more distributed generation capacities opens the possibility for the conventional energy parties to expand their range of services to the end users. DSOs could for example offer demand side management programs, such as the DSO Enexis did for the project *Jouw Energie Moment (NL)*, which could focus on improving the grid stability and thus lowering investment costs in return for a financial benefit for the end users.

From supplying to interacting (*Sala-Heby Energi, SE*)

Sala-Heby Energi Elnät AB (SHEEAB) is the network distribution part of the energy company Sala-Heby Energi AB, owned by the municipalities of Sala and Heby located in the eastern parts of Sweden. They have a 100-year history as distribution system operator (DSO) and today there are approximately 5000 end users in their distribution area. The electric grid comprises rural areas, small towns and a large number of agricultural businesses. As a part of the Swedish smart meter roll-out of 5.3 million meters which was completed in 2009, SHEEAB carried out a phased installation of smart meters in their region. Before the introduction of the demand-based tariff, SHEEAB customers had a conventional distribution tariff with an annual fixed access charge depending on fuse size and a variable distribution charge. The idea of a demand-based tariff in SHEEAB derives from discussions with end users a few years prior to its implementation, and is still not a final product but rather work in progress. The main discussions in the design stage were held with farmers, who had a strong need for a new tariff due to seasonal variations affecting the electricity price and their costs.

SHEEAB continuously arranges information meetings during whole days to meet end users and inform about all their work, not only the new tariffs. These “SHEEAB-days” are considered to be a successful concept from the company interviewees, and normally, around 600 people show up on these events. The new tariff was, in all groups of end users, introduced in spring, i.e. during the low-cost period. This means a few people got to know about their new tariffs during the first winter season (through the unusually high electricity bill). Customer services reported that some calls regarding the new tariffs were made. SHEEAB had put some extra resources in customer services in beforehand, as they understood that there would be questions on the new tariffs. They had also made sure to involve staff from the DSO part of the company to provide the customer service with in-depth information and support. People generally call when there’s a new bill, and there were not many more calls to the customer services regarding the new tariffs. Also, people were not annoyed but wondered what had happened. The calling decreased when the monthly reading of meters and the web-based statistics service were introduced.

The aggregator, the party that falls between the supply and demand of electricity and offers flexibility, is often mentioned as a new role in the energy market. None of the projects within the S3C FoP includes an aggregator as a market and consortium party. Nevertheless, this role is implicitly taken up by the project management, for example by *Linear (BE)*, where the research parties perform this role behind the scenes.

With a few exceptions here and there, such as *UppSol 2020 (SE)*, which relies on face-to-face contact between forerunners that have solar installations installed and other interested parties, most smart grid projects encompass IT technology. This invites new parties into the energy market besides the traditional energy companies, for example a telecom company such as in *Energy@Home (IT)*, smart grid products suppliers – e.g. IBM and Siemens in *EcoGrid (DK)*, and the smart home appliance manufacturers such as Electrolux in the projects *Stockholm Royal Seaport (SE)*. Additionally, the consumer electronics sector can expand its reach by providing products such as the IHDs, which have been used by many pilots within the FoP.

The presence of traditionally retail oriented sectors into the energy sector should accelerate the adoption of smart energy behaviour of residents, since they bring knowledge and experience in dealing with the customers in contrast to the recently liberalised energy sector that does not have this history. A good example of this is OSCAR (CH), in which IT specialists developed an application for the energy markets based on psychological insights into customer behaviour. This might give them an advantage when it comes to understanding the needs and wishes of the end user and get them to understand smart energy behaviour ideas, such as dynamic pricing, remote access and control, DSM, etc., since much of the ideas are similar to others within the established sectors. It is, however, important to realise that the entrance of non-energy companies into the energy market might be confusing for the public. In the *Energy@Home (IT)* project, which was organised by a telecom company, there was a lot of trouble with gaining the trust from the public to participate as to them it was unclear why a telecom company would organise such a project.

4.8.4 Towards local grids

A new market structure proposition is to go from the large impersonal electricity grids towards locally produced and consumed energy on smaller grids. This can have the aim to facilitate the optimisation of the incorporation of local, distributed renewable energy sources, but it can also go a step further and try to make the local grid independent from the larger network of transmission (and distribution) lines – where the larger grid only acts as backup if no balance can be achieved in the local grid. This is the ultimate goal of the project *Texel Cloud Power (NL)*, where they have the ambition to make the island independent from the electricity cable that connects it to the mainland in 2020. The understanding that the local grid has limits, might help change the energy consumption behaviour of the islanders.

The focus on more local electricity grids and the increased deployment of local renewable generation technologies can be enhanced by so-called virtual power plants (VPPs). A virtual power plant is a cluster of distributed generation capacities, which are collectively run by one operator (also called an aggregator). In other words, different energy generating installations in one area, such as multiple solar panels, wind turbines and small hydropower installations, are regarded as if they were one power plant with a fluctuating energy output. In the case of the *AlpEnergy (DE)* project in they tested a virtual power system (VPS) consisting not only of a VPP, but also of a virtual load plant (VLP) that included the different electricity end users in the region. This VPS was developed to maximise the integration of solar and wind energy in the Allgäu region. It integrates, manages and controls the supply side of the energy and links this to the demand from consumers and the energy market. Knowing that such a system exists and helps to create a more sustainable energy system in the region could be an important incentive for end users to shift their electricity consumption to match the supply of renewable energy.

In many cases – e.g. for *EcoGrid (DK)*, *KIBERnet (SI)*, and *Linear (BE)* – the VPS includes an automated demand response system. The end users' loads are, upon agreement, (partly) remotely operated by the central control entity. By making visible the electricity generated and consumed on a distribution grid scale, it can be easier for end users to understand the idea of grid stability – which is what many of the DSOs in the project consortia are aiming to improve – which might give them extra incentive to shift demand in order to align it temporally with the production of renewable electricity. In *PREMIO (FR)* the status of the local grid was indicated with colours (e.g. red means peak demand) in the centre of the village. By focussing on the local grid, the community feeling of the end users and their feeling of personal responsibility might be enhanced, which could serve as incentives for changing their energy behaviour.

4.8.5 Conclusion

There are different features of the electricity market that have an influence on the smart energy behaviour of end users. The possibility of a new role of end users, where they can become a part of the energy market by offering flexibility, is one. But also the role of the existing market parties can shift or change, which might have an effect on the behaviour of the end user. The regulatory situation in which the end users find themselves has an effect on how the smart energy project can be organised, and can thus also influence their behaviour.

There are several ways in which projects have tried to change the way the electricity market is usually perceived by the end user. Sometimes this was done by changing the role of the end user, for example making him more active by offering a dynamic tariff, but also the role of the market parties could be developed further. However, not all of these changes can easily be implemented, as the electricity sector is highly regulated and under strict control.

There are few examples in our case studies of innovative market schemes, so there are only few conclusions we can draw. Other options for new market structures are described in D3.3. For the flexibility management it is necessary, that aggregators and service providers are allowed to act on the electricity market. New market functions for providing a real-time market for regulation power are thinkable, as well as electricity storage clouds for prosumers. Trading of locally generated electricity within the same distribution level is possible, as well as the aggregation of many prosumers. Some of these ideas described in the mentioned deliverable are already feasible, but some need changes of the market structure, foremost the introduction of an aggregator.

4.9 Upscaling and replicability

After the smart grid infrastructure has proven to be successful within a pilot, it is important to see how more end users could make use of the smart energy products and services tested in order to facilitate a roll-out of the smart grid. To this end there are two options: replication and up scaling. The replicability of a project is defined by its ability to be (easily) implemented in other places. Re-implementing the project on a larger scale (to include more participants or a higher load) would refer to the scalability of the project. Both the replicability and scalability of projects are significant qualities to take into consideration when the goal of the pilot is to facilitate the large-scale roll-out of smart grids. In this section, the following research question is addressed: *Which issues hamper and/or facilitate up scaling or replication of smart energy projects?*

This research question is somewhat different from the other eight questions answered in the previous paragraphs. In those cases we tried to distil the causal impact of different types of interventions used, but in this paragraph we will look at the project characteristics that might influence – but are not tested to have had an influence on – the scalability and replicability. In other words, this is the only chapter that focusses on project design more than on end user engagement.

Each of the projects that were discussed in the case studies has several characteristics that might be advantageous or unfavourable for the large-scale implementation of smart grids. These features of the project can be caused either by external powers or by the way the project is set up. In any case, every case study is likely to hold a combination of such aspects and therefore it is impossible from this research to conclude whether or not projects would be successful if carried out in another location or on a larger scale. Nevertheless, an attempt is made at drawing provisional conclusions of what issues facilitate or hamper the upscaling or replication of smart energy projects.

4.9.1 Participants

Thus far most smart grid projects, with the exception of some region or nationwide tariff structures that have been implemented (e.g. *Sala-Heby Energi (SE)* and *ToU tariff in Italy (IT)*), have included very small proportions of the entire population as participants. This means that in order to be able to expect the same results from the project on a larger scale, the sample must be representative of this larger group.

In almost all projects the participation in the project is voluntary, which may lead to a unrealistically high share of participants with interests in energy consumption, the environment, new technology, etc. In the *Linear (BE)* project a comprehensive study into the motivations and attitudes of the Flemish inhabitants was conducted, because the project had the ambition to include a sample of participants that would be a statistical representative of the entire population. However, after analysing the same about the actual participants, they concluded that this group was almost entirely made up of people having a positive attitude towards smart appliances, while only 60% of the Flemish population shares this opinion.

Also in other projects studied such as *MOMA (DE)* it has been noticed that the (voluntary) participants are almost all open minded towards smart grids and the accompanying technology. It is very hard to get a sample that is representative of the entire population, which limits the scalability of the project. This positive attitude can also be ascribed to a professional interest, which is the case for the participants in the *PEEM (AT)* and *Hus 14: OfficeWise (SE)* projects, where the major part of the participants were professionals in the field of energy. This implies they have more knowledge about energy, although not necessarily about their own consumption. This background knowledge might make it easier to change their behaviour, as the necessity of their behaviour change might be easier for them to comprehend.

Because many projects rely on possible participants having to reach out to the project management in order to be included in the pilot (it is communicated that a pilot will be organised, but those who are interested have to take the initiative to enrol), another way to avoid a sample that is biased towards positive attitudes towards smart grids is for the project management to actively reach out to possible participants. This was done in the project *EnergiUdsigten (DK)*, where participants were randomly selected from the customer base of the DSO in the south and south west of Jutland, Denmark, such that the sample was representative for the whole of the local population with respect to age, gender and some characteristics of their home. Another option is to use an opt-out rather than an opt-in strategy, such that the default situation for the selected households will be to participate rather than not to participate. In the *Improsume (DK)* case study it was noted that with an opt-out approach a higher share of the people reached will be participating, such that a higher share of those not necessarily initially positive about smart grids will be included in the sample of participants as well. Furthermore in this case study they also shared that they learnt that consumers were more likely to reveal their true preferences if approached with an opt-out possibility. The *CLNR (UK)* project used an opt-out strategy for recruiting participants in the control group and noticed that the rate of households actually refusing to participate was less than 1%.

Representative samples of subgroup (*KIBERnet, SI* and *EnergiUdsigten, DK)*

Nevertheless, while it may be almost impossible to get a sample that is representative of the entire population, there are certain projects that have been successful at creating a sample of participants that is a good proxy for a larger group. Among those projects is *KIBERnet (SI)*, which chose as participants companies that are good representatives of typical load profiles for their respective industrial sectors. They have focussed their research on four industries: the cardboard, paper, waste processing and foundry industry. Within these industries they have recruited companies that have a typical consumption profiles, such that the results from the pilot can also be applied to other manufacturers within those sectors.

In *EnergiUdsigten (DK)* the target group was composed of randomly selected household users located in the area where Syd Energi, the organizing company, operated. A segmentation with respect to the age, gender and other characteristic of the house was carried out and the sample resulted to be representative of the population in the specific geographical area. The sample group consisted initially of 558 households in Syd Energi's supply area: they have all been identified and interviewed.

The distribution of the 558 households in the experimental group corresponds to the costumer categories in the customer database of the DSO. However, in the experimental group there's a slight under-representation of apartments without electric heating (8% versus 13% in the customer database), whereas single-family homes are over-represented (in the test group they constitute 92% of the total, in the customer database 86%). The experimental group composition in gender and age was compared with the corresponding composition of the region. The results show that gender and age distribution of the people involved in the project corresponds very well to the distribution in the region

The local culture of the participants in a pilot can also be of influence on the ability to scale up or replicate the project. If the project has been carried out in a place that holds a very distinct local culture, such as the strong social cohesion on the island of Texel in the project *Texel Cloud Power (NL)*, it might be more difficult to replicate the project in another setting or expand the project to other include other places which have a different culture.

One way to overcome the geographical dependence of a project is to organise pilots in different locations. This was done for example for the projects *3e-Houses (DE/ES/UK)* and *BeAware (FI/IT/SE)*, who both had pilots with similar participant groups but in different countries; social housing tenants and families with underage children, respectively. Nevertheless, this does not immediately imply that the results from each pilot will be the same. In the *3e-Houses (DE/ES/UK)* project most energy savings were realised on energy consumption for heating in all pilot locations but one; in this pilot the tenants generally lived in underheated homes and thus little to no reductions could be made on their gas consumption; which is where most efficiency gains were made in the other pilots.

4.9.2 Project design

Other than the type of participants included in the pilot, which affects the scalability or replicability of the project results, there are also some project characteristics that have an influence on the feasibility of replicating and up scaling the project itself. The way the participants are approached is an example of this. In a project like *OSCAR (CH)*, where participants are approached on a large scale and the effort that is put into reaching individual end users is low. Such a line of action can with rather low marginal effort be extended to reach more end users. It might also be true that if less effort is required for the participant, more end users are willing to participate; in the same project the input demanded from the end users is rather low, which might explain why 24,000 households (8% of the total customer base of the energy supplier) were engaged in the project, by far the highest number of voluntary participants in a project among the researched case studies.

There are also projects that put a lot of resources into reaching individual participants, which will make it much harder to scale up the project. These resources can be in the form of time and effort such as the highly intensive participant engagement in the form of several face-to-face meetings and workshops organised for participants in *PowerMatching City (NL)*. It is important to realise, however, that the co-creation process was used as input for a more standardised, commercialised and easy-to-use product for a future roll-out. It can also be in the form of costly incentives, which greatly minimises the economic viability of the project. An example of this is the project *3e-Houses (DE/ES/UK)*, where incentives in the form of free wireless internet access, tablets and smartphones, domestic energy devices (energy meters, thermostat, etc.), and shopping vouchers had to be offered in order to convince end users to participate. These kind of 'high level investment projects' should be seen as possibilities to gain information and insights for further projects, but not replicable. It is an investment for other replicating and up scaling activities.

Replication and up scaling of projects is also facilitated by standardised products and equipment or modular system design of the smart grid. In *eueco (DE)* the development of a standardised website for activating participants and an IT system for managing projects reduces costs and can easily be adapted to serve the same purpose in other contexts and locations. In several projects the smart grid system was designed in a modular fashion, which promotes the expansion of the system. In *KIBERnet (SI)* the only thing that new industrial and commercial participants would have to do is install the communication interface, which makes it relatively simple to enlarge the end users connected to the system. In the *PREMIO (FR)* project, the virtual power system was created to be as generic as possible, such that it could easily be replicated or up scaled to include more or different components. Furthermore, also within the existing pilot up scaling would be easily attainable, as the system consists of separate modules that fall within one of the 9 so-called families of experiments, such as heat pumps, thermal storage units, PV panels, etc.

4.9.3 Conclusion

The case study data does not provide us with solid proof of what features of project design hamper or facilitate up scaling or replication of smart energy projects, as many of the pilots have only been held on a small scale and only on one location. However, as discussed above there are some project characteristics that are likely to aid the larger scale roll-out of smart grids and the accompanying desired behaviour change. It is important that the possible expansion of the smart grid is kept in mind, as most business cases will only become viable if there is a large enough customer base.

Related to this it is important to mention that the current research is too fragmented; research designs of the different projects have been very different and that therefore it is difficult to compare them and deduce what the causes are for the success or failure of certain interventions. It is necessary that the research community starts to talk in the same terms when it comes to setting up end user engagement projects. Then it would be easier to understand what the effect of individual aspects are on the project, such that it will also become easier to estimate whether an end user interaction or intervention can be scaled up or whether this changes the context too much for the outcome to remain the same.

5. Conclusion

The in-depth analysis of 32 smart grid case studies reveals that knowledge and expertise on how to successfully engage end users in smart energy projects is still partly uncharted territory. Although the investigated projects were selected for the S3C Family of Projects (FoP) because their approach was considered to be among the most promising in current smart grid practices all over Europe, many projects are still primarily driven by technological and/or economic objectives, aiming to test experimental infrastructure and interaction schemes (such as home automation systems an dynamic tariffs) 'in the wild' rather than investigating the interplay between end user behaviour and the smart grid. Hence, there are still significant knowledge gaps regarding attitudes and behaviour of consumers towards smart grids, and the ways end user interaction schemes in this novel infrastructure impact daily life.

That said, the case study analysis offers valuable indications of what works in order to engage end users in smart energy projects. It is important to realise that a successful project often uses multiple incentives combined with several other factors, such as clear communication, the right type of feedback, and so forth. It is therefore hard to make a clear cut judgement about the performance of individual interventions. And due to the diversity of projects that were investigated – in terms of project design, scope, scale, timeframes, objectives and target groups – it is difficult to compare them in the cross-case analysis and assess what exactly the causes are for success or failure of certain interventions. Nevertheless, the investigated case studies provide several insights that contribute to answering the fundamental research question underlying the S3C project: *How can active (or 'smart') energy-related behaviour be fostered by active end user engagement strategies in smart grid projects?*

The main conclusion from the assessment of the case study data (see section 4), is that there is not one typical end user and therefore there is no single (set of) end user engagement strategies that can or should be applied to foster smart energy behaviour. However, the end user is not a black box: the case studies provide insight in the effects of the interventions identified under the nine respective research questions on the engagement of end users in smart energy projects. Hence, context-sensitivity is the key to successful end user engagement. It is crucial for smart energy project managers to investigate the end users' needs, expectations, worries and desires and the social, cultural, geographical contexts in which they find themselves.

This section lists the key lessons drawn from the cross-case analysis: the success factors and pitfalls for active end user engagement based on the best practice examples found in the case study data. Sections 5.1 and 5.2 collect insights in what can drive and hamper successful end user engagement in smart energy projects, followed by an inventory of opportunities to enhance end user engagement (5.3). This section concludes with a reflection on the key performance indicators (KPIs) for end user engagement based on the three end user roles of smart consumers, smart customers and smart citizens (5.4).

5.1 Cross-cutting success factors: drivers for active end user engagement

1. Addressing end users as human beings instead of as points of electricity demand

To engage end users in smart grid infrastructures, it is of key importance to tailor the project as a whole to the everyday life and daily routines of end users. The current generation of smart energy projects is still largely technology-driven. Instead of providing end users with (experimental) smart grid infrastructure and accompanying products and services without investigating the potential added value for end users themselves, their needs, demands and expectations should be taken into account. To address end users as human beings applies to:

- **The interaction scheme**, i.e. the tested technical infrastructure and accompanying pricing scheme(s) and any other incentives, should adapt to end users' needs and daily routines. Surprisingly, the case studies show that this is not common practice. For instance, in *Smart Home (SI)* the participants had to set their own capacity limit, and when they exceeded this limit, some loads were automatically switched off, which could mean they were literally put in the dark. Similarly, offering complex tariff structures itself (e.g. real time pricing, RTP) is not very likely to be successful among average end users, as they tend to prefer easily understandable information that helps them to make the right choices. Bridging the gap between the two different worlds of energy experts and the general public, for instance by organizing integrated meetings with technicians and end users, or by involving project members that can speak for the end users, can enhance the relevance and value of smart grid technology, products and services.

- **End user feedback** should be accessible, understandable and provide actionable information; otherwise the use of feedback systems is likely to decrease over time. Feedback systems are most effective if easily accessible for end users, i.e. preferably on an in-house display or a smartphone or tablet app rather than a web portal. People should be triggered by feedback information when looking at it at a glance. Numbers themselves are not easy to understand as they have no meaning for most people (they generally have no frame of reference). Therefore, consumption and production information on the in-house display should be very simple to understand, e.g. with (ambient) colour indications and symbols, showing how much is currently used (compared to average) and showing import from/export to grid for prosumers. The *PEEM (AT)* project showed that end users liked the tablet carrying the in-house display because it was designed as a kitchen clock. For them, the kitchen was a very logical and practical place to manage home energy matters – the kitchen functioned as the flight deck of the house. Participants in *Jouw Energie Moment (NL)* valued highly that the energy display contained non energy-information such as the weather forecast. This made them develop a routine to check the display on set times. To tailor the design of feedback devices to end users' needs, several projects successfully applied testing sessions and co-creation workshops.
- **Project communication** should always pinpoint the everyday life of end users. For instance, naming a project in an appealing way, preferably in the native language, is more likely to attract people's attention than technocratic acronyms – see the example of *Texel Cloud Power (NL)* that presented itself under the name Texel Slim Zelfvoorzienend (English: Texel Smart Self-sufficient) when recruiting participants. The analysis shows that it is highly context dependent (project scope and goals, target groups, geography, culture, etc.) which communication channel is the most appropriate. Furthermore, as a project proceeds (from the planning phase, to recruitment of participants, installation and execution) the mix of communication channels that work best to serve and support the end users vary strongly. Therefore, the selection of communication channels in project phases requires thorough analysis and assessment.

2. *Obtaining a thorough understanding of target groups*

Generally, social science-based research on end users in smart grid projects is still in its infancy. Generally, learning about attitudes and expectations takes place through often-applied methods, such as surveys and other forms of self-reports, but these have their limitations. The social desirability bias denotes the end users' tendency to answer questions in the way that they perceive to be favoured by social norms and/or by the researchers they are facing. The tendency of over-reporting what is considered good behaviour and/or under-reporting bad behaviour is particularly problematic in terms of isolating individual differences between end users and for deducing an average tendency.

The study of pre-existing knowledge deriving from research and practical experience from previous projects should be considered a prerequisite for any project dealing with the inclusion of end users into smart grid infrastructures. To investigate how end users actually interact with new technologies, what their attitudes and perceptions are towards the project and the respective products and services, researchers and project managers should obtain a thorough, close-up picture. In the case studies several innovative and creative methods were applied to create an in-depth understanding of target groups, such as qualitative contextual inquiries, the use of culture probes, home visits and co-creation and gamification-based workshops (e.g. *CLNR, UK; BeAware, FI/IT/SE; Hus 14: OfficeWise (SE)* and *PowerMatching City, NL*). The common denominator between these innovative methods is that they all seek to establish close (in some cases virtual) interaction with end users. However, the selection of appropriate methods to get as close to the end user as possible should rely strongly on contextual factors.

The analysis of case study data shows that the more informed and educated the participants are about their energy consumption and the more engaged they are, the more likely they are to change their behaviour and manually adjust energy consumption. And although projects involving SMEs are somewhat underrepresented in the S3C FoP, the case studies shows that SMEs differ strongly from household consumers, both in terms of operations and motivations. Therefore, different business models and incentives and different strategies for recruitment and (long-term) engagement are required.

3. *Emphasizing sense of place: underscoring the local character of a smart energy project*

Whenever applicable, smart energy projects should address a regional scale: regional topics and stories have to be picked up and regional multipliers should be pursued – for example by involving mayors, business associations and stakeholders with a solid reputation into the project and by making use of local festivities and cultural events. Communication should be extensive and diverse to reach different target audiences and keep participants engaged throughout the project.

Drawing upon local partners with a good reputation is particularly suitable for projects with a clear geographical focus (e.g. a building block, neighbourhood, village or island). Due to their organization and workforce, local partners can be the most recognizable project partners; they can end up being the projects eyes and ears during the course of the pilot, thereby facilitating the acceptance of a local pilot project. These local partners can either be energy related, such as locally operating utilities, but some project also developed stakeholder coalitions with municipalities or civil society organisations.

Local stakeholders usually have extensive and detailed knowledge about the social, cultural and geographical situation, that can prove to be valuable in the implementation of a project. As familiar faces are more likely to be perceived as trustworthy than energy companies, they are often able to perform wide social, cultural and educational roles in the community without witnessing problems of access to participants or lack of trust. For instance, the locally operating DSO involved in *Sala-Heby (SE)* regularly invites customers to the company's premises to inform them about their business operations. These events are very well attended. Local partners and their networks can help to ensure a more assertive communication of the project, thus contributing to successful communication and dissemination of project activities at a local level.

4. Drawing upon community dynamics

A sense of community can be a strong driver to engage end users. This is most likely the case in local or regionally oriented projects. Once in place, community dynamics can greatly facilitate end user engagement in smart grid projects in all stages of project development: from the recruitment of participants over the design, adaptation and instalment of technologies and end user interfaces, to the actual demonstration phase. Contributing to the good of the community can be a powerful motivator for end users, and learning from the experiences of peers can be more effective in acquiring new behaviours than top-down education efforts. However, it appears that such community dynamics – if not more or less already in place – are hard to form from scratch. They should be nurtured throughout the entire process (once the energy community is formed, participants expect to be involved in all project stages, and even carry over the community thrust to other ways of experimenting with sustainable lifestyles). If the community dynamic is not maintained during the instalment and demonstration phase, the project is likely to suffer from backlash in terms of drop-outs.

A community dynamic is not something which can be turned on and off, i.e. in certain project phases, but requires support throughout the project. The investigated case studies offer inspiring best practice examples how community dynamics can be empowered and enhanced. Here, a best practice example is *Rendement voor Iedereen (NL)*, where a community coach was brought in to give shape and to support the community of end users. However, these best practice examples show that community smart grid projects can be resource intensive, and this could be a hampering factor for a future upscaling of energy community-based smart grid infrastructures.

5. Testing before roll-out

The participating end users in several projects in the FoP consisted of friendly users (such as employees from the DSOs or the utility) and 'energy insiders' that were easier to recruit than the average household consumer. These end users took part voluntarily because the project, or the technology tested, had attracted their attention. As a consequence, participants in these projects consisted of a proportionally higher amount of environmentally conscious, technically curious and also more often highly educated people with higher incomes.

The use of these friendly-user trials or so-called pre-trials with a positive, energy knowledgeable test group can be helpful in order to detect technological issues or flaws in the overall project design before the actual technology roll-out starts, but findings regarding energy behaviour can rarely be considered representative for the general public. In addition to testing and troubleshooting, some projects (*InovCity, PT*; *Jouw Energie Moment, NL;* and *PEEM, AT*) organised interactive workshops with energy insiders and/or outsiders prior to the start of the project, to gain insight in how design prototypes were understood by them and to evaluate how they perceived the energy solutions that were under development for the projects. Hence, the added value of exploratory qualitative in-depth testing is undisputed, therefore these activities should be considered a mandatory step in the process of developing end user friendly smart grid products and services.

6. Creating personal relations and build trust over time

Giving personal attention – i.e. listening to participants and helping them on an individual basis, according to their needs and expectations – is an effective way to reinforce active end user engagement. However, it is not always easy to achieve. Creating a good support system might lighten the load, as it is an important interface between the backstage of the technical infrastructure and the everyday routines of end users. The well-functioning telephone helpdesk was highly appreciated by end users in the *EcoGrid (DK)* project and the online forum Dr. Energia developed in *InovCity (PT)* has shown to foster a sense of engagement among participants: they received adequate support and felt like they were taken seriously. Adding a human dimension to online-based customer support systems may well be a prerequisite for future large scale roll-out of smart grid infrastructures.

Organizing project meetings are live events fruitful ways to create interaction with end users. The project *3e-Houses (DE/ES/UK)* shows that home visits can be very successful in projects working with target groups that go beyond the friendly users and energy knowledgeables, e.g. projects involving elderly residents or operating in areas with a high illiteracy rate. The end users stated that they valued personal attention highly and preferred it over written project information. On the other hand, organising continuous interaction with end users can be very resource intensive; therefore it is unlikely that this approach will lead to viable new business cases.

Trust is of key importance in smart energy trials. Without a trust relation between the end users and the project management, on which open and honest discussions can be based, it can be challenging to keep end users committed and engaged in the course of the project. This has been done successfully in the project *Rendement voor Iedereen (NL),* that distinguishes itself from other projects by offering its end users an intermediary from the project management that was simultaneously a participant in the trial. This intermediary was a member of the community that the end users had formed as part of an ongoing co-creation process in the project. End users will be more open with the intermediary in knowing that, as active participant of the trial, the intermediary might have similar experiences, difficulties, etc. Other projects (*Salzburg SME DR study, AT;* and *AlpEnergy, DE*) managed to involve ‘gatekeepers’ (knowledgeable contact persons) to stay in touch with SMEs that were engaged in the project. An intermediary or gatekeeper gives the project a familiar face and prevents the end user from having to deal with perhaps less trustworthy strangers at each end of the different interactions, which should be taken into account even if an intermediary that is part of the trial phase is not feasible.

7. Motivate end users with fun and good news

In general, people are driven by positive incentives. Due to the primarily technological approach of the majority of investigated smart grid projects, the use of fun and gaming elements are fairly scarce. However, those projects that did include playful challenges and competitions managed to harvest success (*OSCAR, CH; BeAware, FI/IT/SE;* and *PowerMatching City, NL*). Also the celebration of project milestones by inviting the end users to some kind of festivity, as was done in the *Linear (BE)* project, was rather uncommon in the investigated projects. Many projects introduced incentives such as tablets and smart phones to persuade people to register for the project. Such gifts received a warm welcome; they can be considered quick wins when setting up a small-scale trial, but seem not very feasible when moving towards large-scale roll-outs, because of the high costs.

On a micro-level, delivering good news is important as well. In this respect, easily understandable historical usage feedback information and social comparison feedback – that provides a benchmark of one’s performance against others or an average (e.g. of the neighbourhood, the village or a similar household composition) – can be considered a success factor. In several projects end users showed a strong interest in learning how well they performed in comparison with others. To counteract possible negative consequences (e.g. when the neighbours are doing better), social comparison information can be combined with a feedback tool on their own behaviour (injunctive feedback), e.g. by comparing current) consumption with historical data. The drawbacks of delivering ‘bad news’ became apparent in the *PEEM (AT)* project, where some end users felt that the in-house display at times rendered them a guilty conscience. Especially during quiet evening hours, when they wanted to enjoy their entertainment appliances, they disliked the ambient display turning red when they ignored the guidance to use less energy. They somewhat felt judged and felt treated unfairly.

5.2 Pitfalls: barriers for active end user engagement

1. Non-viable business cases for end users

There are a number of projects in the FoP that refer to the creation of business models as one of their project objectives. These include business models for the parties responsible for the distribution and transmission grid infrastructure, but also business models for the retail parties involved in the smart grid. In some projects the goal was to identify business models, such as the *Salzburg SME DR study (AT),* which described in its final report eight different possible smart energy business models for SMEs. There are also projects that have tested business cases, such as *To Follow the Electricity Price (SE)*, where a new business proposal based on a new tariff structure was trialled and *Linear (BE),* where different business models for the DSO or retailer/balance responsible party related to household flexibility are tested.

Unfortunately, virtually all case studies that mention business models do not report on whether these have turned out to be economically attractive. Only *CLNR (UK)* explicitly stated that the ToU-tariff could provide interesting business models. Hence, it can be concluded for the vast majority of investigated smart grid projects, the business case for pricing schemes seems not to be very viable – neither for participating households, nor for the DSO. Generally, the price spread between high and low peaks is too small to be a valid (financial) incentive for participants and for DSOs they do not reflect economic reality.

Although participants often do achieve a (small) shift in consumption, the financial benefits will retain marginal in the long run, so the smart grid infrastructure may not prove to be sustainable in the long run. The case studies show that the potential for load shifting by household consumers is rather limited: the most easily shifted loads for households are the washing machine, dryer and dishwasher, whereas people are generally uncomfortable with the idea of shifting energy consumption by the fridge and unwilling to shift consumption with devices related to entertainment and work. It would require further research to assess whether the load shifting potential can be increased by offering stronger (monetary or non-monetary) incentives. These findings indicate that for end users who run a household and a fulltime job, it may simply not be worth the hassle and the worrying to (actively) participate in the smart grid, if the benefits for them are not evident.

SMEs and commercial businesses seem to offer more flexibility when it comes to cooling, heating and drying, but it is important to keep the regulations in mind. SMEs and other commercial parties are not likely to accept remote control when it comes to their primary processes. Ensuring non-monetary incentives – besides the monetary ones – is thus a prerequisite for active and sustained participation. Without the development of solid business models for residential and commercial consumers full-scale roll-out is not likely to be feasible.

2. On-going technical problems and unreliable technology

Approximately 40% of the investigated case studies have reported technical problems that caused delays in the installation phase and/or the execution phase to such an extent that it had negative impacts on the engagement of end users. Commonly reported problems were related to the functioning of the in-house display, web portal or smartphone app, smart household appliances (washing machine, dish washer) that were ‘invisible’ for the home energy management system and delayed installation of equipment due to deliverance problems. In a significant number this resulted in a loss of engagement or even a drop out of participants. In these cases, it became evident that it is a tough challenge to repair a damaged reputation. Hence, the importance of expectation management combined with allowing time for a phased roll-out, starting with thorough testing and troubleshooting among friendly users, should not be underestimated.

3. Inadequate expectation management

Expectation management is of key importance to keep end users committed and engaged, both regarding the outcome dimension (technology, products and services) and the process dimension. For instance, if the design of the equipment does not meet end user’s expectations, e.g. because it is very big or aesthetically unattractive, the end user might refuse it. On the process dimension, both a long waiting period between recruitment and the actual instalment of the equipment and the malfunctioning of equipment have shown to be a disappointing factor for end user participants. This can quite plausibly be conceived as a potential ‘disruptor’ of a community dynamic, potentially causing some initial participants to step out of the project before the start of the actual demonstration phase.

4. Engaging end users without sharing decision power

A potential barrier for engagement of end users in active demand projects lies in the actual opportunities for end users to influence the design of specific aspects in the project (e.g. project communication, service concepts, procedures). If end user engagement is designed to play an important role in the project, there should be some leeway for them to bring up ideas and take initiatives within the project, without putting the project goals, the research design and the time planning at risk. Although this may prove to be a challenge, a trade-off needs to be made by project managers between active participation and empowerment of end users and staying in control of the project.

5.3 Opportunities to enhance active end user engagement

The case study analysis revealed several opportunities to further enhance active end user engagement and to foster smart energy behaviour that were not explicitly addressed in the nine research questions that guided the process of data analysis. In this section we present a number of opportunities that were distilled from the case study data and that deserve further elaboration and development in future smart energy projects, particularly when pursuing upscaling and roll-out for the general public.

1. Reinforce the end user perspective in the project design

Large scale smart energy innovations are only likely to succeed if they manage to adapt to the everyday social practices of end users. A vital challenge for future smart grid developments is to design projects in such a way that the end user perspective cannot be overlooked. This implies to underscore the sense of place, to achieve a sense of ownership and to provide added value for the end user: what's in it for them? Although context-sensitivity is key here, the drivers for active end users described in section 5.1 provide insight in in how this can be achieved and inspiration can be found in the best practice examples described throughout this report. For instance, a project timeline should not be solely based on a technology implementation timeframe, but should also be seen from the end user perspective. Hence, a feasible project planning incorporates thorough testing and troubleshooting, accommodates contingencies and should avoid communication gaps that can lead to participants losing their interest in the project.

2. Develop viable business models

As made clear in section 5.2, the absence of obvious, viable business cases is a clear barrier for active end user engagement in smart grids. Therefore the challenge to develop economically strong smart grid business models should be high on the agenda of energy companies, because an engaged end user is the key to long-term success of the smart grid. In this respect, the three E's-concept with a focus on the energy sector can provide guidance for the development of further strategies to engage end users that better reflect economic reality:[13]

- Educative: Statistical end user consumption information, combined with dwelling and climate data;
- Enabling: Billing and accounting date, metering information, simplified dynamic energy pricing and rate plants etc;
- Empowering: Information on current programs and rebates, tips on energy savings, calls to action, modes of engagement with utility etc.

These E's have been addressed in smart grid projects and the results have impacted the analyses. However, research designs of smart grids projects rarely focused on business model developments or the implementation of the 3E's in practice or built their research design around it. In fact, a basic research design that can result in concrete feedback for business model conceptualisations needs to be developed and applied in practice.

3. Co-creation

A promising way in which products or services can be adjusted to fit the wishes of the participants and thus improve its chance of successful use, is by applying co-creation with end users. Although it might be difficult for them to voice what they want, if the workshop is well organised and set up, it is possible to gain very valuable feedback from the end users about the proposed product or service. This involvement also often leads to a stronger feeling of attachment to the project, which might also make the participants more engaged during the field test phase. Products and services that stem from a co-creation approach may well be more likely to succeed in future roll-out of smart grid infrastructures, as their added value for the end user is more evident.

[13] Aggarwal R. (2013). The Three E's of End user Engagement. http://smartgrid.ieee.org/may-2013/867-the-three-e-s-of-end user-engagement

The project *InovCity (PT)* applied a strong approach of co-creation and interaction by conducting multi-stakeholder workshops that can help to bring down the differences and communication gaps between technology developers and providers and their actual customers. Thus, the project established a direct contact between end users, local officials, IT-experts, communication experts and the project marketing and customer service staff prior to the field trial. Basically, such workshops offer an opportunity for an informal information exchange in which end users can address concerns directly to the responsible parties. Generally, such a workshop creates a win-win situation that not only takes end user needs into account, but can also offer the experts and technical staff direct access to the end user. Similarly, *Hus 14: OfficeWise (SE)* successfully conducted co-creation workshops in order to test and optimize their feedback design prototypes.

4. Gamification

A rather novel way to engage with end users and simultaneously collect data and information that is not considered to be intrusive by end users is to incorporate gamification in products, services or research and development activities. In projects like *OSCAR (CH)*, end users do not necessarily realize that they are being surveyed because questionnaires and interview tactics are integrated into an overall concept of playful learning, instead of applying them as individual interaction schemes. Therefore, such questionnaires and interviews are not perceived as time consuming or as invasive as regular online survey or face-to-face interviews. Thus the social desirability bias as well as the Hawthorne effect (that attributes the observed results to the constant observation of behaviour rather to than the tested interaction scheme), are alleviated. The whole information gathering process is integrated into the *OSCAR (CH)* bonus point system, meaning that end users receive bonus points for answering questions. These bonus points can then be used as currency in the utility’s online shop. Thus, the end user stands to gain from volunteering information and time spent on each questionnaires or interview is minimized and distributed across a longer period of time.

Another individual and particularly outstanding method was trialled in the project *PowerMatching City (NL)*, which developed a card game-based workshop concept to research opinions and attitudes of the participants in a playful manner. The framework of a game offered participants a safe environment, where they feel free to speak honestly about their real drivers and motivations. The game’s aim was to learn about end users’ hopes, worries and priorities and to develop propositions for energy services in co-creation with the participants that were eventually implemented when the project entered the execution phase. All participants in *BeAware (FI/IT/SE)* were players in the EnergyLife game, which combined saving consumption data with feedback on this and hints and tips to increase their knowledge regarding electricity consumption. The end users could play different levels in which they had to achieve certain objectives or answer quiz questions correctly in order to pass them. Through EnergyLife the households could communicate and play against other households. This led to an overall consumption reduction of 15%.

The experiences with gaming interfaces and competitive elements in the S3C case studies are promising and inspiring, both in terms of reinforcing the engagement of end users in the project and in terms of outcomes (optimization of products and services, collection of reliable evaluative data). However, an important future challenge regarding gamification is how to capture the interest and attention of end users in the long run.

5. Roll-out smart grids towards the general public

As mentioned in section 5.1, the participating end users in quite a few projects in the FoP consist of friendly users (such as employees from the DSOs or utility) and energy insiders, that were easier to recruit than the average household consumer. However, the opinions and insights into consumer behaviour detected in such projects can rarely be considered representative and used as reference when interacting with the general public.

Although knowledge and research about environmentally conscious, energy knowledgeables and technology enthusiasts are accumulating due to the large number of relatively small-scale smart grid pilots worldwide, knowledge gaps when moving towards large-scale roll-out of smart grid infrastructure remain rather abundant. Since many business cases will only become viable if there is a large enough customer base, gaining more in-depth understanding of the needs, expectations and concerns of the general public is a precondition for future expansion of smart grid infrastructures. In terms of Rogers’ model of diffusion of innovations, future smart grid projects should thus primarily focus on engaging the 'early majority' and perhaps even the 'late majority, rather than the 'early adopters' that are fairly well understood already.[14]

6. Develop novel stakeholder coalitions

The case study data show that the current generation of smart grid projects are predominantly run by usual suspects from the energy business: DSOs and utilities, often supported by universities, research institutes, engineers and IT consultancy. Interestingly, government bodies and political stakeholders are also regularly found to be project partners. Although this may add dynamics to a project that are not undeniably beneficial (such as political issues that may suddenly cast a shadow over the project), the involvement of municipalities and regional governmental organisations generally contributes to establishing trust among end users and to foster a stronger sense of place.

In order to introduce smart grids to the general public, novel stakeholder coalitions with stronger societal involvement are indispensable. A few projects in the FoP (e.g. *3e Houses, DE/ES/UK; Rendement voor Iedereen, NL)* successfully managed to involve civil society stakeholders. To better connect with the everyday social practices of end users, it is highly recommended to establish such coalitions with civil society and other non-energy stakeholders.

7. Connect smart grids to smart cities, smart living and sustainable lifestyles

The smart grid is a very abstract concept that focuses on the 'low interest topic' electricity. In fact, customers in Europe and elsewhere are currently either completely unaware of the new possibilities a smart grid has to offer or they perceive an active energy management as a loss of comfort or even as an attack on their privacy. Coupling the topic with other thematic areas that are known to raise more interest and appear less abstract is a promising strategy to overcome obstacles such as false perceptions or no perceptions at all. Therefore, it is crucial to explain the interconnectedness between topics such as smart grids, smart cities, smart mobility and sustainable lifestyles to unaware end users.

The roll-out of smart grid infrastructure can be connected the introduction and development of holistic smart cities concepts. Thereby, the smart grid infrastructure can help to introduce different services based on IT technologies, such as smart mobility, smart data based public services. This can lead to a decrease of the infrastructure costs for the smart grid as such. Apps that are currently only trialled in smart grids project for the sake of manual or automated energy management could be used for several other smart city functionalities that offer more added value to the customers.

Furthermore, the merging of smart grid technology and known and trusted home automation functionalities in an overall smart home approach could boost the acceptance and market relevance of smart grids technologies. Different smart home functionalities can be realised by the same hardware and software application, thereby decreasing the overall costs for energy management systems and increasing the benefit for the customers. The further added value might increase the customers' interest in the newly developed solutions and offer them the added value that often appears to be missing in current smart grids business cases. In fact, it is important to capitalize on the comfort-increase factor with respect to energy management to frame the smart grid service within the concept of a smart home.

8. Develop an overarching storyline to achieve a sense of urgency about smart grids

The general public tends to perceive energy as a low interest topic. For many people, electricity is an invisible good, of which they are hardly aware. They have no clear understanding of what it is, how it works and what the costs are. For the future expansion of smart grid infrastructures, it can be beneficial to create a consciousness about the (external) costs of fossil and nuclear energy production for future generations and the missing sustainability of the contemporary energy system. When the advantages of renewable energies and of smart grids are in the foreground, end users may be more likely to adopt a sense of urgency that increases their motivation to participate actively.

Developing an easy understandable overarching storyline can be helpful to educate end users and improve their energy awareness, which can lead to a stronger motivation to act accordingly. However, it is of key importance to translate the overarching story in actionable information for end users, such as energy saving tips. Currently, the lack of detailed, factual knowledge about the energy system, leads to confusion and perhaps even apathy among end users. In everyday social practices, this can lead to undesirable results because people are unsure of what to do and how to do it. Practical hints and tips – e.g. how to

[14] Rogers, E. M. (2003). *Diffusion of innovations (5th edition).* New York: Free Press.

save on the energy bill and how to improve energy efficiency – are generally appreciated by end users. As shown in some of the investigated case studies, providing non-energy information (e.g. the weather forecast) on the feedback is a simple way to connect in-house energy management with the everyday social practices of end users.

5.4 Refinement of the KPIs

In order to evaluate the performance of particular smart grid projects in fostering smart energy behaviour (or empowering end users to take on more active roles in the energy system), well-defined key performance indicators (KPIs) should be used. Common to all applications of KPIs is that their definition rests on a thorough understanding of the goals of a particular strategy. Without a clear comprehension of the goals to be realised (and their relative importance), it becomes impossible to define the success or failure of a particular strategy. However, different stakeholders often not only have different goals they want to realise, but in addition hold different views on the relative importance of different goals. In the case of smart grids for instance, DSOs, aggregators, ESCOs, utilities, ICT companies, regulators, consumer organisations and end users all potentially have a distinct interest in the future implementation of a smart grid. The definition of KPIs is thus bound to (a) particular perspective(s).

In the case of the S3C project, we are of course particularly interested in the end user perspective – i.e. what are the needs and motivations of end users when taking up more active roles in the implementation and functioning of the future energy system. The definition of success is then tied to fulfilling these needs/meeting these motivations by facilitating their incorporation in end users' daily practices. However, as revealed in the present deliverable, we face the difficulty here that there is no such thing as *the* energy end user, but rather different types of end users who are all pursuing different goals in their interaction with the (future) energy system.

In an internal project report (IR1.3) we therefore proposed to organise the different needs/motivations of end users under the three perspectives which form the S3C project set-up: the Smart Consumer, Smart Customer, and Smart Citizen.[15] In practice, end users will assume different roles and hence hold different needs and motivations at the same time (e.g. end users could be interested both in lowering their energy bill and in decreasing their carbon footprint). The KPIs attached to the three S3C roles should thus be interpreted in an ideal-typical sense – i.e. as necessary analytical tools for the evaluation of smart grid projects from the end user perspective, but not as a tool for the evaluation of individual behaviour. Besides the KPIs attached to the S3C ideal types, a category of general KPIs (relating to issues which are relevant to all types of end users) is also included. The cross-case analysis performed in the present deliverable has revealed a wealth of new information of possible needs/motivations for end users to participate in a smart grid pilot, and on possible strategies for meeting these needs. Therefore, this section of the report includes an update of the proposed KPIs in accordance with the newly acquired insights.

In what follows we suggest a number of potentially important KPIs from the perspective of the smart consumer, customer and citizen respectively. As explained in Section 2.2, KPIs for end user engagement cannot meet the specific SMART (Specific – Measurable - Achievable – Relevant – Time-bound) requirements which allow to compare projects on a standardized basis. We suggest to use the KPIs proposed here as a more qualitative evaluation tool, allowing for a quick scan of smart grid pilots based on a scoring on the proposed KPIs by the project management. Where feasible, we do however suggest some possible ways to make this scoring more quantitative, e.g. in terms of suggesting ways to acquire the necessary quantitative data to give a more objective base to the scoring of the KPIs in question.

5.4.1 Smart Consumer

The Smart Consumer represents the most passive role an end user could take up in future smart grid functioning. This ideal-typical end user is mostly interested in lowering their energy bill, having stable or predictable energy bills over time, and keeping comfort levels of energy services at least on an equal level. The overall convenience or ease of use of the socio-technical interventions used in the smart grid project is also of major importance to the Smart Consumer (i.e. interventions requiring the least amount of active attention or change of behaviour are preferred).

The following KPIs are proposed for the Smart Consumer:

[15] Definitions for the three Cs are taken up in the following sections.

1. Lowering energy bills

Scoring could be based on the average amount of money saved per household (or equivalent, if some kind of simulated tariff with e.g. bonus points is used) in the course of the smart grid pilot, compared to a benchmark situation which does not have the smart grid equipment in place.

2. Complexity of new billing structure or tariff (if applicable)

Scoring could be based on a qualitative judgement – e.g. a new tariff based on a limited number of time blocks per day (e.g. 3) with limited price update frequency (e.g. seasonally) as compared to a new tariff based on an extended set of time blocks per day (e.g. hourly, quarterly) with a frequent price update frequency (e.g. daily, reflecting system costs).

3. Financial risk of new billing structure or tariff (if applicable)

Scoring could be based on a qualitative judgement – e.g. a new tariff based on a limited price spread between time blocks as compared to a new tariff based on a considerable price spread between time blocks. Of course, offering a guarantee to the end user that their bill will anyway not be higher than what he/she would pay before the start of the pilot reduces the risk to zero.

4. Intrusiveness of the installation process at the end user's premises

Scoring could be based on the average amount of time per household needed to install the necessary equipment for running the smart grid pilot.

5. Intelligibility of end user feedback

Scoring could be based on a qualitative judgement, where possible supported by feedback from end users, using e.g. focus groups, surveys, etc.; or supported by evidence on the use of particular interventions such as individual coaching, sharing experiences with peers, etc.

6. Ease of use of the new technologies installed at the end user's premises

Scoring could be based on the average number of information requests submitted per household in e.g. a ticketing system; or based on information acquired by using survey methods.

7. Reliability of the new technologies installed at the end user's premises

Scoring could be based on the number of malfunctions reported per household through a helpdesk (if in place).

5.4.2 Smart Customer

The Smart Customer is interested in taking up a more active role in future smart grid functioning. In contrast to the Smart Citizen, this more active role is intended to substantiate I-centred (or extrinsic) as opposed to we-centred (or intrinsic) needs or motivations. Examples of I-centred motivations include conformity (to live up to the expectations of neighbours, peers, or society in general), image (to look attractive to the outside), popularity (to be well-known and admired), financial success (to be wealthy and materially successful). Applied to end user engagement in smart grids, the Smart Customer is probably mainly interested in new market offerings, such as the possibility to:

- acquire smart appliances that provide the possibility to realise a low-carbon lifestyle (as a way to distinguish oneself from others);
- actively choose among different tariff plans (e.g. pre- vs. post-payment, monthly vs. yearly bill, etc.);
- buy into new and attractive energy service offerings (e.g. optimal home energy management, energy audits facilitated by installed feedback systems, etc.);
- become a prosumer (based on the desire to be more or less independent from utilities).

The following KPIs are proposed for the Smart Customer:

8. 'Buy in' of new products and services offered

Scoring could be based on the % of households acquiring the new products offered in the smart grid pilots (e.g. smart appliances, smart plugs, IHDs, etc) and the total amount invested during or at the end of the pilot, or alternatively scoring could be based on the stated willingness to pay for these products and services as revealed in questionnaires.

9. Freedom of choice

Scoring could be based on the number of different tariff schemes offered in the smart grid pilot, or the freedom to choose between different types of IHDs (where applicable).

10. Development of viable business cases

Scoring could be based on the viability of the business case(s) developed – measured in terms of financial profitability and/or other added value – as a result of the smart grid pilot. For example, a solid business proposition and business plan has been developed for commercial players, or, in the best case, the smart grid pilot has resulted in a marketable product or service.

5.4.3 Smart Citizen

The smart citizen sees in the development of smart grids an opportunity to realise we-centred (or intrinsic) needs / motivations. Examples of we-centred values include affiliation (to have satisfying relationships based on mutual trust and respect with others), self-acceptance (to feel confident and autonomous in relations with others), community (to be able to improve the world through community action - "Think globally, act locally!"). Applied to end user engagement in smart grids, the Smart Citizen is probably mainly interested in the community aspects. These community aspects relate to the process as well as to the outcomes of smart grid developments:

- Process: concerned with who is developing and running the smart grid project – in other words, who is involved and who has influence? From a community point of view, the ideal process would involve mainly local actors in open and participatory project development settings;
- Outcome: concerned with how the outcomes of the smart grid project are spatially and socially distributed – in other words, who is benefitting from the project?

An ideal project from the Smart Citizen point of view would therefore be one which is entirely driven and carried through by a group of local actors and which brings collective benefits to the local community.

The following KPIs are proposed for the Smart Citizen:

11. Contribution to the community's common good

Scoring could be based on the question whether the smart grid pilot has clearly shown the potential to contribute to the common good of the community – e.g. solving a local network congestion problem, lowering energy costs for the community, lowering community CO_2 emissions, etc.

12. Contribution to local identity

Scoring could be based on the % of people in a local community (e.g. municipality, island, etc.) successfully recruited for the smart grid pilot, or the extent to which the smart grid pilot successfully draws upon local partners, or connects to local topics.

13. Participation in development and implementation

Scoring could be based on the 'participation ladder', which classifies projects on their level of participation using the following criteria, ranging from 'being informed' to 'active co-creation':

a. *Information (end users are simply informed of the feedback mechanisms/incentives etc. used in the smart grid project);*

b. *Consultation (asking for opinions of end user before starting the project);*

c. *Advise (end users are continuously asked feedback on their experiences and project management takes into account this feedback);*

d. *Co-creation (smart grid project is set up and managed as a shared responsibility between end users and other stakeholders).*

14. Fair distribution of benefits and burdens in the community

Scoring could be based on e.g. the distribution of financial benefits or incentives gained in the course of the project among the project participants, compared to the burdens experienced by each participant (e.g. investment of time and money). Not only should the benefits and burdens be distributed fairly between the households participating in the project, but also between the households and the other stakeholders involved in the project (DSOs, energy retailers, ICT companies, etc.).

5.4.4 General

We conclude with two KPIs that relate to all three end user roles:

15. Overall process satisfaction

Overall end user satisfaction probes into the more 'indirect' but nevertheless important factors for engagement, such as feeling empowered, feeling motivated, having fun (gaming aspects), establishing good relationships with other project participants etc. Scoring could be based on survey results, or alternatively on observed behaviour of project participants – e.g. level of drop-out in the course of the project.

16. Willingness to participate in follow-up project (if applicable)

5.5 What's in it for Smart Consumers, Customers and Citizens?

What do the findings of the case study analysis reveal from the perspective of engaging Smart Consumers, Customers and Citizens? At the moment, the main focus of many projects is to integrate smart innovations in the end users' home environment without running into technical problems, and keeping everything working throughout the project period (and beyond). The majority of the projects focus on testing new products and services, incentives and pricing schemes. The case studies thus predominantly relate to the role of the Smart Consumer. Nonetheless, a number of projects include (small scale) renewable energy production for end users (a precondition to gain understandings of the Smart Customer), and there are some promising examples of projects that relate to the Smart Citizen through the community approaches found in several case studies. Even though the majority of the case studies focus on the integration of smart infrastructure and appliances, the insights from the case study analysis thus contribute to building a body of knowledge on end user engagement for all three prototypical roles. This indicates how traditional end users could enter into one of the S3C roles, possibly moving up from a Smart(er) Consumer, to a Smart(er) Customer and/or to a Smart(er) Citizen following the order of activities described below.

Smart Consumer

A consumer will be smarter because of the insights he will receive about his electricity use. Not only can he have convenient IHDs and ambient devices in his home he has never had before, he can also get access to information about his energy use in many ways and in many forms. All these opportunities for the consumer can create a higher awareness of his energy use and will help him to lower the energy bill. He can therefore not only be educated, well informed, and motivated to shift energy and save energy, but he also moved closer to the next step; becoming a Smart Customer.

Smart Customer

As a Smart Customer is not only aware of his energy use, but also becoming more aware of the workings of a smart grid network, he is well prepared to reap the full benefits that the smart grid network can provide. As an energy producer, he is able to sell electricity back to the smart grid when he thinks this is best for him. He can (and probably will) make use of automated controls for these interplays between generating renewable energy, using it, storing it, or selling it back to the grid. He is not only more aware of his energy use, but his understanding of what a smart grid actually does will be many times higher. The understanding about energy use and on top of that the more active role of the customer, makes it likely he will be interest in the next role: the Smart Citizen.

Smart Citizen

Once an end user is aware of his energy use and his possibilities as a producer, he can look around his street, neighbourhood, city or even region and collectively engage in a smart energy project. The findings of our case study analysis indicate that the potential of this role is high. As 'no man is an island', surely once mutual benefits can be enjoyed by context bound partners (be it neighbours, colleagues or a whole neighbourhood or island), the new group of Smart citizens can rapidly expand. The fact that people are social beings, and want to be part of a sustainable society where they can have individual benefits, makes the potential of smart energy projects even larger.

Appendix A: Short description of passive pilots

No.	Name	Description
1	3e-Houses (DE/ES/UK)	Social housing project, 2 pilots and 2 replicators in three different countries. Aimed at lowering residents' energy bills.
2	AlpEnergy (DE)	Residential, commercial and agricultural customers in south of Germany. Aimed at seeing how price incentives and improved information could adapt consumption to local generation. Makes use of VPS. Strong end user involvement. Two tariff structures, several feedback options, manual and automatic components. Strong regional ties. SMEs: theoretical study into their load shifting potential.
3	BeAware (FI/IT/SE)	Two trial with 8 (Finland, Italy) and 12 families (" " + Sweden). Goal is to reduce power consumption by 15% with the use of an online game for smartphones (1 iPhone per household as incentive) and a flashlight that projects real time consumption on the wall (second trial only).
4	CLNR (UK)	Many households and businesses in rural and urban north east England and Yorkshire. Focusses on flexibility of grid, and (used for case study) end user profiles and flexibility of consumers. 23 trials/test sites were set up.
5	EcoGrid (DK)	Different types of participants (households + commercial) on rural Bornholm island, Denmark. Goal is to see how people react to smart meters.
6	E-mobility (SI)	In Gorenjska region in Slovenia electric transport was linked to tourism by the installation of charging stations in five communities in the region such that a journey between them can be made.
7	EnergiUdsigten (DK)	In south and south western part of Jutland, Denmark involving 383 households. It focusses on the flexibility of energy use. Webpage displays energy spot market prices. Users with spot price contract received the SEE1, an ambient display that shows relative energy price.
8	Energy@Home (IT)	50 households (15 with pv) in urban Ancona or cities in northern Italy received full smart grid set (5 plugs, smart washing machine, home gateway and display). Aimed at making participating in smart grid systems easier for consumers and creating a valid business case for the equipment. Case study focusses on first trial only.
9	eueco (DE)	In rural south east of Germany the company eueco supports and facilitates the set-up of bottom-up approaches for a local sustainable energy system. Currently two cooperatives have been set up. The idea behind eueco is that people have to become active partners through financial participation. More than 1000 residential end users from the region are already participating.
10	Hus 14: OfficeWise (SE)	At the office of SP three different prototypes for energy consumption visualisation were developed. The goal is to minimise the waste energy (e.g. when nobody is present in a room) in the office.
11	Improsume (DK)	Project in Aarhus, Denmark, where prosumers are active participants in the energy market. Focus on the heating system.
12	InovCity (PT)	The whole city of Evora in Portugal was equiped with smart meters. Different products and services were tested on a group of 1200 domestic customers, such as three different tariff structures and different types of energy management systems. A smaller group of 50 customers were part of a co-creation work group for designing new products and services.

13	Jouw Energie Moment (NL)	In three neighbourhoods two cities in the Netherlands households use a smart meter, IHD and a smart washing machine to reduce and shift their energy demand. Feedback is received in the light of maximum sustainability or minimum costs.
14	KIBERnet (SI)	In this project a prototype system for automatic control of industrial loads was developed. There is a very strong focus on the technical side of DSM.
15	Linear (BE)	Households in Flanders were recruited to participate in this smart grid project. The project aims at developing required technical solutions, and looks at possible future energy market structures and business cases. There were three project phases in which four different business cases were tested; the end user was only aware of the option to either provide flexibility or to make use of a ToU tariff. The starting point of the project was not the end user perspective, but instead the stakeholders involved were interested in the question of how to get 'flexibility' from end users.
16	PEEM (AT)	This project had as goal to develop and test a new app/IHD called the FORE-watch and to research its influence on end users' consumption behaviour. Goal of this is not to reduce consumption, but rather shift it to increase the reliability of the local grid or fit the production of locally generated renewable energy.
17	MOMA (DE)	Customers were added stepwise to the pilot, such that in the last three months 700 households in Mannheim, Germany, participated. They tested a dynamic pricing tariff. The control group received smart meters only. But the test group was also equipped with a HEMS that could control the use of household appliances automatically (EnergieButler). Via an app for tablets and PCs (MOMA app) they could access a web portal with consumption and price diagrams. In addition, some households received monthly informative bills.
18	OSCAR (CH)	Participants in this project have to manually enter their metering data on the website, where Oscar the bear teaches them about their own consumption and energy saving in a playful manner. It is organised by an energy supply company in Switzerland and 24.000 (8%) of their customers are registered users. Aim of the project was to become acquainted with their private customers on a personal level and to find a cost-effective solution for offering energy efficiency consultation.
19	PowerMatching City (NL)	This project is the successor of PMC I, which involved 20 houses. For this project another 20 houses from one specific street were involved. Two prototypes of energy services were created: "Together More Sustainable" and "Smart Cost Reduction". The participants all have an IHD (the "Energy Monitor"), a thermostat with microCHP or heat pump, a smart washing machine and make use of a dynamic tariff. The goal is to see if these energy services can relief pressure on the grid and deliver added value to end users and eventually aims for .
20	PREMIO (FR)	The community in the village Lambesc (PACA region) in France was included in this smart energy project that involved 9 "families of experiments" with industry, households (both residential and apartments), commercial users and also involved public lighting and a biogas storage facility. Goal was to maximise the potential of locally generated electricity, demand response and local storage in order to shave peaks (and thus contributing to grid management).
21	Promoting Energy Efficiency in Households (LV)	The goal of this project is to evaluate whether feedback in the form of a web portal and energy efficiency advice have an impact on the consumption patterns of residential end users. There is also an in-house monitoring kit (an IHD) that can be purchased by the participants; only 35 of 500 did.

22	REloadIT (NL)	The municipality has bought electric cars for its employees to use and charges them automatically with a programme that prioritises the use of electricity from the municipalities three solar panel installations and a virtual wind turbine. Employees can reserve the cars online through a web portal and are guaranteed that they will be charged sufficiently for the planned trip. The idea behind this project is that the smart grid should make things easier for the end user, not to engage them actively in sustainable behaviour.
23	Sala-Heby Energi (SE)	Introduction of a ToU tariff in the region after the national roll-out of smart meters. Implementation was done step-wise between 2003 and 2009 - participation is mandatory. Focus more on shifting consumption than reducing consumption.
24	Salzburg SME DR study (AT)	Goals is to analyse potentials for load shifting in SMEs, municipal buildings and utility service providers in the Salzburg area. To this end a literature study was done, followed by a survey of 21 SMEs in Salzburg. On the basis of this recommendations for the energy economy and on framework requirements was done. There was strong end user involvement in the writing of these, but no active pilot.
25	Rendement voor Iedereen (NL)	Residential smart grid project with 100 households (each) in two cities in the Netherlands. The goal is to co-create and test eight service concepts for improving energy efficiency and facilitating flexibility in households that have potentially viable business cases. Through the community AmersVolt people are activated to search for a solution themselves.
26	Smart Home (SI)	Residential end users in Ljubljana, Slovenia, testing smart home innovative solutions in real-life situations. They were all friendly users; personal contacts and relatives of employees. The goal of the project was to limit consumers peak demand in order to improve the use of the electricity grid. Focus was not on the technology - existing equipment was purchased and used.
27	Smart Metering Projekt (DE)	In three places in Germany two field tests were run in order to see whether smart meters would increase EE with residential households.
29	Stockholm Royal Seaport (SE)	In a district in Stockholm smart and sustainable active apartments will be built. Currently one such apartment is finished and serves as a pilot for testing the smart appliances, new tariffs and feedback systems.
30	Texel Cloud Power (NL)	300 households on a small island close to the Dutch coast will be participating in a smart grid project that aims to work towards making the island's electricity supply fully domestic and renewable.
31	To Follow the Electricity Price (SE)	In Gothenburg, Sweden, it was tested whether it would be useful to introduce demand response programmes by comparing direct (DC) and indirect control (IC) of electricity use in two different groups. In the DC group, the system had a remote control over the waterborne electric heating. In the IC group the households were informed about an hourly spot price.
32	ToU Tariff in Italy (IT)	This case study is the monitoring of 28,000 households that fall within a mandatory ToU tariff that was introduced in Italy on residential end users. This sample is statistically representative of the Italian population.
33	UppSol 2020 (SE)	Series of three workshops are organised for five different stakeholder groups (e.g. housing associations, municipalities, property owners, farmers, and companies) about PV installations such that the rate of installation will increase in Uppsala region, Sweden. In each test bed the experiences of a frontrunner with his PV installation will be followed.

Appendix B: List of country codes

AT	Austria
BE	Belgium
CH	Switzerland
DK	Denmark
DE	Germany
ES	Spain
FI	Finland
FR	France
IT	Italy
LV	Latvia
NL	Netherlands
PT	Portugal
SE	Sweden
SI	Slovenia
UK	United Kingdom

Appendix C: Best practice examples

Understanding the target group(s)		
Getting to know the target group(s)	• Using a segmentation model to identify attitudes towards smart appliances *(Linear ,BE)*	4.1.1
Obtaining in-depth knowledge about the target group(s)	• Contextual inquiry through culture probes *(Hus 14: Office Wise, SE)* • Gamification workshops *(PowerMatching City, NL)*	4.1.2
Learning how project is experienced	• Learning how the end users experience presented feedback channels and information *(Smart Metering Projekt, DE)*	4.1.3
Products and services		
Feedback devices and services	• Receiving feedback information by phone and by 'flashlight' *(BeAware, SE/FI/IT)*	4.2.4
Related non-energy services	• Lowering hurdles to engage with smart sustainable energy; combining ecotourism and innovation *(E-Mobility, SI)*	4.2.5
Incentives and pricing schemes		
Monetary	• Examples of additional monetary incentives *(CLNR, UK)* • Virtual bonus points for real discounts *(OSCAR, CH)*	4.3.2
Non-monetary	• Making use of the projects' surroundings: strong sense of community *(Texel Cloud Power, NL)*	4.3.3
End user feedback		
Feedback systems	• Appealing feedback solutions as integrated household appliance: The FORE-WATCH *(PEEM project, AT)*	4.4.1
Feedback information	• Creating easy to understand information on IHD's: use of symbols and colours *(Jouw Energie Moment, NL)*	4.4.2
Project communication		
Recruitment communication	• Selecting communication channels that suit the target group *(3e-Houses, ES/DE/UK)* • A large scale multi-channel recruitment campaign *(AlpEnergy, DE)*	4.5.1
Ongoing project communication	• Keeping participants engaged *(InovCity, PT)*	4.5.2
Cooperation between stakeholders		
Involving governmental stakeholders	• Involving local communities to secure social support for the project *(PREMIO, FR)*	4.6.1
Involving non-governmental stakeholders	• The messenger matters *(Energy@Home, IT)*	4.6.2
Smart energy communities		
Community based engagement strategies	• Creating a neighbourhood hype *(Rendement voor iedereen, NL)* • Board of ambassadors representing the AmersVolt community *(Rendement voor Iedereen, NL)*	4.7.3

	• Co-creation: forerunners and followers *(UppSol 2020, SE)*	
New market structures		
Financial benefits for consumers by offering flexibility	• Creating business models for SME's; what questions need to be answered? *(Salzburg SME DR study, AT)*	4.8.1
Shifting the roles of existing market parties	• From supplying to interacting *(Sala-Heby, SE)*	4.8.3
Scalability/replicability		
Participants	• Representative sample of subgroups: *KIBERNET (SI)* and *EnergiUdsigten (DK)*	4.9.1

Appendix D: Refined KPIs

End user role	Key Performance Indicator
Smart consumer	1. Lowering energy bills
	2. Complexity of new billing structure or tariff (if any)
	3. Financial risk of new billing structure or tariff (if any)
	4. Intrusiveness of the installation process at the end user's premises
	5. Intelligibility of end user feedback
	6. Ease of use of the new technologies installed at the end user's premises
	7. Reliability of the new technologies installed at the end user's premises
Smart customer	8. 'Buy in' of new products and services offered
	9. Freedom of choice
	10. Development of viable business cases
Smart citizen	11. Contribution to the Community's 'common good'
	12. Contribution to local identity
	13. Participation in development and implementation
	14. Fair distribution of benefits and burdens in the community
General	15. Overall process satisfaction
	16. Willingness to participate in follow-up project (where applicable)

Appendix E: Overview of dynamic tariffs

	AlpEnergy I (DE)	*AlpEnergy II (DE)*	*CLNR (UK)*		
Name	static price model	dynamic price model	3 rate TOU tariff	Restricted hours tariff	Direct control
Tariff type	TOU	TOU	TOU	TOU	Flat rate
Goal	Adapt consumption to the availability of renewable energy from PV generation	adapt consumption to available loally generated energy and the status of the local distribution grid	Shift consumption from peak to off-peak hours		Avoid consumption during peak hours at times of network constraints
Rationale	synchronyzing time of use and generation from photovoltaic plants	time of use	Time of use	Time of use	NO
Applicable to following cost components	generation, distribution	generation, distribution	Generation Distribution	Generation Distribution	NA
Cost driver			Energy	Energy	Energy
Dynamics					
Number of time blocks /day	2	5	3		1
Number of levels	2	5	NA		NA
Price update frequency	static (same timing of saving zone between October-March and November-February)	updates of price and pricing zone distribution updates every 36 hours	static (updated once a year?)		static

	EcoGrid (DK)	*Energy@Home (IT)*	*InovCity (PT)*		
Name	Basic real-time-pricing	Tariffa bioraria	Time of use tariff	Target kWh tariff	Consumption levels tariff
Tariff type	RTP	TOU	TOU	Consumption-based tariff	Consumption-based tariff
Goal	adapt consumption to currently needed goal (e.g. providing palancing power, optimizing purchasing etc.)	consumption shifting from peak to off-peak hours	Shift consumption	Decrease consumption	Decrease consumption
Rationale		Time of use	Time of use	Overall consumption	Load level / overall consumption
Applicable to following cost components	transmission, distribution, generation	Generation Trasmission Distribution	Generation Distribution	Generation Distribution	Generation Distribution
Cost driver		Energy	Energy	Energy	Energy
Dynamics					
Number of time blocks /day	up to 288 (5 Minute intervals)	2	6 time blocks with 3 price levels (peak, normal, off-peak)	NA	NA
Number of levels	up to 140	2	3	2	3
Price update frequency	every 5 minutes	every three months	Annual	Annual	Annual

	EnergiUdsigten (SE)	***Linear (BE)***	***MOMA I (DE)***	***MOMA II (DE)***	***PowerMatching City (NL)***
Name	Spot price contract	Dynamic tariff Linear	Nova-tariff		PMCII retail price
Tariff type	RTP	TOU	TOU	RTP	RTP
Goal	Shift consumption away from peaks hours	Shift consumption to increase RES uptake / reflect system costs			Reflect wholesale prices / system costs (including grid constraints)
Rationale	RTP	Time of use	Time of Use (avoid load paks at noon and in the evening)	Time of Use and load level	Time of use
Applicable to following cost components	Generation Trasmission Distribution	Generation Distribution	Distribution Generation	Generation, Distribution, Spot Market Prices	Generation Distribution
Cost driver	Energy	Energy			Energy
Dynamics					
Number of time blocks /day	NA	6	6 on weekdays, 3 on weekend	24	96
Number of levels	NA	NA	2	31	NA
Price update frequency	every hour	daily	static (updated every 2 months/ different, easier structure for the weekend)	daily	quarter-hourly

	Sala-Heby Energi (SE)	*Smart Metering Projekt (DE)*	*To Follow the Electricity Price (SE)*	*ToU Tariff in Italy (IT)*
Name	TOU demand-based electricity distribution tariff	Stand-by tariff	fixed price with a high rate of return	Tariffa bioraria
Tariff type	TOU	CPP	Semi variable spot-market based contract	TOU
Goal	Reduce peak load	Shift consumption away from peaks hours	adapt consumption heating systems to spot market price levels	consumption shifting from peak to off-peak hours
Rationale	Load level	Real time pricing	saving electrcity, sensitizing customers for innovative tariff arrangements	Time of use
Applicable to following cost components	Distribution	Generation Trasmission Distribution	purchasing	Generation Trasmission Distribution
Cost driver	Power	Energy	energy	Energy
Dynamics				
Number of time blocks /day	2 (peak - off-peak)	3	1	2
Number of levels	NA	NA	1 + x	2
Price update frequency	static (updated 1 time /year (winter - summer))	NA	spot market prices update every hour and are different every day	every three months