# Interaction between Customers and Smart Grid Related Initiatives

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November 2013

International Energy Agency Demand-Side Management Programme
Task 23: The Role of Customers in Delivering Effective Smart Grids

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# Summary

This report represents the output from the second Sub-Task in Task 23. It considers the interaction of customers with a range of Smart Grid related interventions (both technological and tariff/ information based). A large number of case studies and consumer surveys have been reviewed in order to understand the ways in which customers interact with different technologies/ interventions and their attitudes to them. The report specifically focuses on determining the readiness of the initiatives themselves, and the readiness of the market to accept them, levels of customer engagement with Smart Grid activities, their willingness to take part and any barriers which have been experienced. Consumer surveys have been reviewed in order to gauge customers' attitudes towards Smart Grid concepts, and other closely related subjects (e.g. climate change and sustainability).

This review of case studies and surveys has shown that there is a large amount of activity within this area and a wealth of information available, although information relating specifically to consumer attitudes is often poorly reported within the project results. Many Smart Grid interventions have been implemented, with varying degrees of success and can be considered technically mature, although the market readiness (i.e. the degree to which the market understands and accepts them) often lags behind. Ways in which this gap can be addressed will be considered as part of the next major Sub-Task (Sub-Task 4: Designing Offers and Programs).

# Glossary

| | |
|---|---|
| CPP | Critical Peak Pricing |
| DEFRA | Department for Environment, Food and Rural Affairs |
| DSM | Demand Side Management |
| DSR | Demand Side Response |
| IEA | International Energy Agency |
| IHD | In Home Display |
| IRL | Initiative Readiness Level |
| ISGAN | International Smart Grid Action Network |
| LCNF | Low Carbon Network Fund |
| MRL | Market Readiness Level |
| PTR | Peak Time Rebate |
| RTP | Real Time Pricing |
| SME | Small and Medium size Enterprise |
| ToU | Time of Use |
| TRL | Technology Readiness Level |

# Currency Exchange Rates

| | | € |
|---|---|---|
| 1 | NOK | 0.12697 |
| 1 | SEK | 0.11479 |
| 1 | GBP | 1.14581 |
| 1 | KRW | 0.00067 |

From www.xe.com on 31st July 2013.

# Contents

# 1 Introduction

Smart Grids are becoming widely regarded as an essential component of ensuring sustainable energy supplies going forwards. They enable a co-ordinated approach, whereby energy production and demand are integrated to ensure the use of renewables can be optimised whilst also minimising the use of fossil fuel fired generation and network infrastructure investment.

Whilst there is considerable focus on the technological aspects of delivering Smart Grids, little is understood of the extent to which consumers are willing and able to embrace new technologies and initiatives that enable their use of energy to be actively managed. There is a real risk that if consumers do not adopt new approaches to the way that they consume electricity, Smart Grids may not be able to achieve their full potential.

Therefore, this project has been established within the IEA Demand Side Management Implementing Agreement to focus on investigating the role of consumers in delivering effective Smart Grids[1]. The project is entitled Task 23 – The Role of the Demand Side in Delivering Effective Smart Grids. The aim and objectives of the project are described in Section 1.1.

This report considers the interaction of customers with a range of interventions designed to change energy consumption behaviour in order to support the successful implementation of Smart Grids. The primary focus of this Task is on actions that directly lead to the **active engagement** of consumers with Smart Grids. More specifically, this includes interventions that lead to the following outcomes:

- Reduced energy consumption (energy saving)
- Reduced peak demand (curtailment)
- Demand shifting (with demand shifted to a different time)

It is worth noting that the latter of these may not lead to a reduction in overall consumption, but may, in some situations, lead to an increase in consumption. However, the change in pattern of consumption may never-the-less be considered advantageous from the Smart Grid perspective.

Four types of interventions that can motivate consumers to change their energy behaviours in order to achieve the outcomes listed above are considered. These are highlighted in Table 1.1 below.

[1] An overview of the IEA DSM Implementing Agreement can be found in Appendix 6.

**Table 1.1 Interventions considered within the scope of Task 23**

| | | |
|---|---|---|
| **Time of Use Tariff** | **(T)** | A form of pricing that penalises consumers that use energy at certain times and/or rewards consumption at other times. This can include static Time of Use (ToU) tariffs, Critical Peak Pricing (CPP), Peak Time Rebates (PTR) and Real Time Pricing (RTP). |
| **Control** | **(C)** | Controls to actively manage the pattern of consumption. This can include direct load control, automatic load controls, home energy management systems, thermostats for heating / air-conditioning and building energy management systems. |
| **Feedback** | **(F)** | Feedback of energy end use information based on the actual energy end use of the individual, i.e. relying on data collected from the smart meter. This can include in-home displays of real time and historic data, web based feedback and billing information. Alternative forms of feedback also exist, such as web-based feedback or the use of smart phones or other portable devices. |
| **Advice** | **(A)** | Advice on how consumers can deliver outcomes that support the effective delivering of Smart Grids. This can include advice targeted to an individual on processes/end uses that can be managed, or general advice distributed to groups. |

Two or more of these interventions can be combined. In this case, the phrase 'initiative' is used to describe the combination (or package) of interventions that have been implemented, as depicted below using two generic examples.

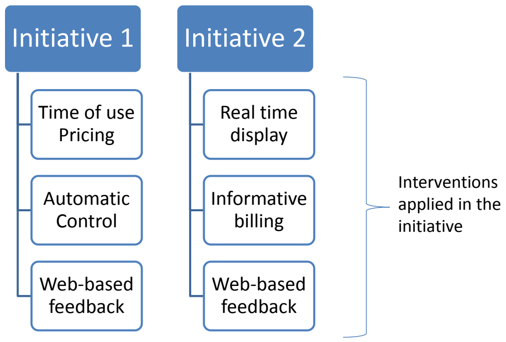



**Figure 1.1 Interventions and Initiatives explained in the context of Task 23**

## 1.1 Aim, Objectives and Scope of Task 23

The overall aim of the project is to explore the potential risks and rewards associated with Smart Grids from the perspective of consumers. The project will draw together international experiences and identify best practices to ensure the demand side becomes an integral component of a successful Smart Grid. By identifying the potential risks and rewards the Task seeks to develop best practice guidelines in order to ensure the demand side contributes to the delivery of effective Smart Grids.

The project focuses on the interaction of policies, technologies and tools with consumers, and examines the impact of these interactions on the effectiveness of Smart Grids, as indicated below.

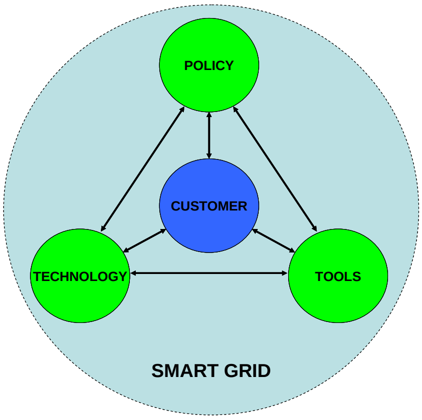



**Figure 1.2 Overview of Task 23**

There are a number of examples worldwide of Smart Grid and Smart Metering implementations. These have met with varying success and a number have experienced difficulties as a result of resistance on the part of consumers.

There are also a number of initiatives currently underway that focus on Smart Grids and Smart Metering. Examples include the International Smart Grid Action Network (ISGAN)[2] and other IEA activities, as well as country specific work such as US Department of Energy funded trials, and the Low Carbon Network Fund in the UK. These trials and initiatives are primarily focused on the technical aspects of Smart Grids, both in terms of the technology requirements needed for implementation as well as the policy measures required to facilitate the roll-out of Smart Metering. The present Task however specifically focusses on the customer perspective, rather than the more technological aspects.

Specific objectives of Task 23 are therefore to:

- Understand the impact of the structure of energy markets on the interactions of consumers with Smart Grids;
- Explore the impact of technologies on the ability and willingness of consumers to contribute towards the successful implementation of Smart Grids;
- Identify the risks and rewards associated with Smart Grids from the perspective of consumers;
- Understand the opportunity for stakeholders to influence these risks and rewards;

[2] The IEA Implementing Agreement for a Co-Operative Programme on Smart Grids (ISGAN), http://www.iea-isgan.org/

- Identify tools to minimise the risks and maximise the rewards associated with the Smart Grid from the point of view of the consumer, whilst still satisfying the needs of other stakeholders;
- Understand consumer reactions and preferences to offers and opportunities that a Smart Grid might provide (including local supply); and
- Understand regulatory options, practice and consequences.

The scope of the project is limited to those who are, or are expected to be, a participant of a Smart Grid initiative. Specifically, the scope of Task 23 will focus on consumers with Smart Meters or likely to have Smart Meters in the coming years, thus are expected to play an important part in the future Smart Grids as they become deployed. This therefore includes:

- Residential consumers; and
- Small commercial, business and local authority consumers, i.e. those that are treated in a similar way to residential consumers (for example have similar metering arrangements, or have similar access to the energy market).

Task 23 comprises five Subtasks, as highlighted below. This report focusses only on Subtask 2 (ST2 in Figure 1.3 below), and considers the interaction of customers with a range of Smart Grid related interventions.

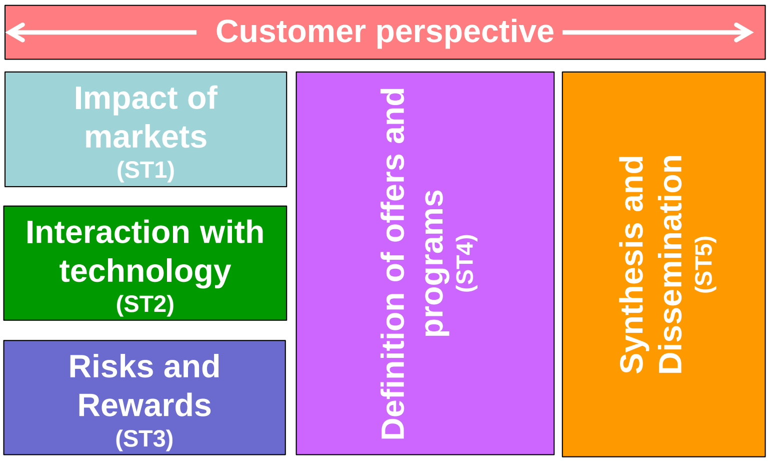



**Figure 1.3 Task 23 Overall Work Programme**

## 1.2 Report Structure

This report looks at what can be learnt from customer experiences to date with Smart Grid related initiatives. It is structured as follows:

- Section 2 describes the approach used in this task to assess the various case studies, including the concept of 'Initiative Readiness Level' and 'Market Readiness Level';
- Section 3 outlines a number of consumer surveys which were considered to gauge consumer reaction to Smart Grid related initiatives;
- Section 4 describes the results of a number of case studies from both the participating countries and a number of other international examples;
- Section 5 presents the conclusions of this reporting, highlighting lessons learnt in relation to intervention and market readiness, the willingness of customers to take up initiatives and engage with them, and any barriers which have been experienced; and
- The appendices to this report provide a more detailed summary of each of the consumer surveys and case studies which have been reviewed.

# 2 Approach

This report considers the interaction between customers and interventions. Two different methods were adopted in order to gather information from the customer perspective. Initially, a number of existing customer surveys that captured the views and opinions of customers towards Smart Grids and Smart Grid related initiatives were reviewed. Thus, this part of the project seeks to explore customer attitudes and beliefs towards Smart Grid related initiatives. The results of this review are presented in Section 3.

To supplement these qualitative surveys of what customers say and think about Smart Grids, a number of actual case studies were reviewed to assess how customers actually respond to Smart Grid related initiatives. The case study reviews attempt to capture the way that customers use and relate to Smart Grid related technologies or initiatives (e.g. tariffs) by examining the learning experiences of actual pilots and trials of Smart Grid related interventions. They also provide valuable insights into customer attitudes. The Case Study approach and results are summarised in Section 4.

The overall aim of this part of the project was to explore whether customers are willing to accept Smart Grid related interventions, and the extent to which they are able to actively engage in Smart Grid initiatives. In order to do so, an energy behaviour model is used as guidance. A description of the model is provided in Section 2.1 below.

## 2.1 Understanding Energy Behaviours

As discussed in the first report from this project[3], the factors that impact on the way that consumers behave are wide-ranging and complex. A number of models or frameworks of understanding exist and these have been used with varying success in an array of situations. Some focus on individuals, whilst others focus on the individual in his/her social environment. Some focus only on behaviour whilst others also focus on the context impacting that behaviour. Some focus on one-off behaviours whilst others focus on habitual behaviours. Where some focus on discrete actions, others focus on a complex inter-related set of actions.

Whilst no single model or framework is considered to be ideal, they are considered to be necessary tools both to assist decision makers implement policies, and to assist practitioners implement technologies and initiatives to help achieve an outcome that depends upon behaviour change.

Smart Grid initiatives endeavour to achieve energy efficiency and/or load shifting by enabling or stimulating certain energy behaviours. Once that behaviour is well defined, a behavioural model can be used to help explain the factors that influence the decision maker’s choice over whether or not to perform the behaviour.

Some energy behaviours may be best discussed using an individualistic approach, whilst others are best understood using a systemic approach. The starting point for the present Task 23 is that valuable insights can be found using both approaches, and therefore the model outlined in Figure 2.1 is used to provide theoretical guidance for this purpose[4,5].

[3] The Impact of Electricity Markets on Consumers, Task 23 Report, Version 1.0
[4] Predicting and Changing Behaviour: The Reasoned Action Approach; M. Fishbein, and I. Ajzen;: Psychology Press, New York; 2010
[5] Nothing is as practical as a good theory. Analysis of theories and a tool for developing interventions to influence energy-related behaviour; C. Egmond and R. Bruel; SenterNovem; 2007

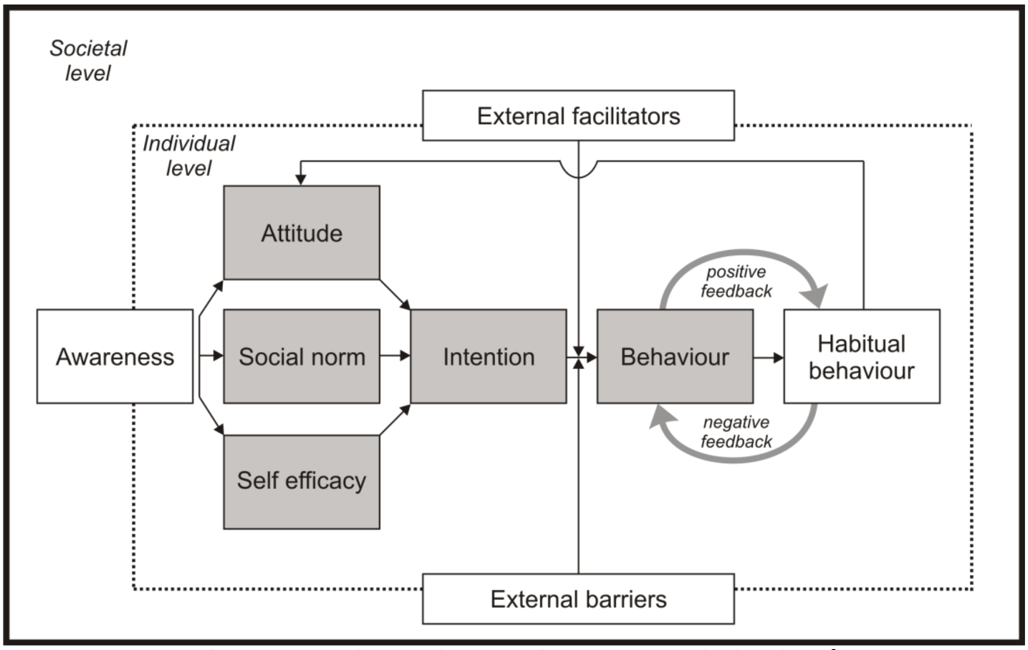



**Figure 2.1 Theoretical model of energy behaviour**[6]

This framework is particularly suited to the purposes of Task 23 because it reflects that different people will react differently to a situation because of their own attitudes, self-efficacy and the social norms relevant to them. Likewise, people with similar attitudes and subject to similar social norms will react different due to the influence of external factors. In this case, this includes the opportunities / barriers created due to the impact of the electricity market structure.

This report considers the way consumers interact with Smart Grid initiatives, and focusses on the following individual elements of the model:

***Awareness:*** This includes awareness of the behaviour itself and also of why the behaviour is desirable. For example;

- Switching off my appliances when they are not needed; and
- The cost of energy wasted due to appliances left switched on when they are not used is £90[7] per year.

***Attitude:*** This is the sum of beliefs about a particular behaviour, with overall attitude depending on the relative importance of each belief.
For example, beliefs about switching off appliances to reduce energy consumption might include:

- Switching my home computer off when I'm not using it is good way to reduce energy consumption; and
- Switching off my home computer is inconvenient because I won't be able to instantly access my computer whenever I need to.

[6] Understanding Household Energy Use Investment Decisions, Even Bjørnstad, Enova SF, Energy Efficiency and Behaviour Conference, Helsinki, 20 September 2012

[7] Energy Saving Trust estimates that a UK family could save between £50 and £90 a year by turning things off when they are not needed http://www.energysavingtrust.org.uk/Take-action/Start-saving-money

***Social norm:*** This the looks at the influence of other people, and the relative importance placed on these opinions. For example,

- Following a school project on sustainability, my children constantly remind me that it is important to switch off appliances when they are not in use; and
- My employer expects me to respond promptly to e-mails sent day or night.

***Self-Efficacy:*** This is an individual's belief in their ability to perform a task. For example,

- It's really awkward to turn off the PC and all the peripheral equipment.

## 2.2 Diffusion of innovation

Although individuals display different kinds of behaviour within a given market context, there is often a tendency for individual behaviours to develop over time, i.e. as the market develops. The diffusion of innovations model is one theory that seeks to explain how, why and at what rate new ideas and technologies are taken up by individuals.

Many of the technologies and initiatives proposed as part of the Smart Grid are relatively new to consumers. As new technologies/offerings are introduced to the market they are taken up gradually, by different types of consumers at different times. 'Diffusion of Innovations' theory (popularised by Everett Rogers, 1962[8]) seeks to explain how these new initiatives spread through a population. The adoption of a new offering is influenced by four main elements (the innovation, communication channels, time and the social system). The process of diffusion involves individuals adopting the given innovation. Individuals experience five stages of accepting a new innovation: knowledge, persuasion, decision, implementation and confirmation, and the individual may reject the innovation at any one of these stages. Once the individual has adopted the innovation it is spread via communication channels to others in the society. These stages can be defined as:

- Knowledge: the individual is first exposed to the innovation but lacks information and so may not be inspired to find out more (e.g. hearing a reference to Smart Meters on the television news);
- Persuasion: the individual is interested in the innovation and actively seeks further information (e.g. looking up Smart Meters on the internet);
- Decision: the individual takes the concept of the innovation and compares its advantages and disadvantages to decide whether to adopt or reject it (e.g. considering whether a Smart Meter would offer benefits for the individual);
- Implementation: the individual employs the innovation to a varying degree depending on the situation and learns more about its usefulness, possibly searching for further information on it (e.g. asking for a Smart Meter and then beginning to use the data to save energy); and
- Confirmation: the individual finalises a decision to continue to use the innovation (e.g. the individual either continues to use the information or ignores it once the 'novelty' has worn off).

[8] Information from: http://en.wikipedia.org/wiki/Diffusion_of_innovations#Diffusion_of_New_Technology Accessed 01/08/2013. Article based on: Diffusion of Innovations. Rogers, Everett M. (1962 and 1983 editions).

Different types of adopters will take up the innovation at different rates and the process described above will take a varying amount of time. These different types of adopters were defined by Rogers as:

- Innovators: the first individuals to adopt an innovation. They are generally willing to take risks, are often young, of a high social class, with great financial liquidity and are linked to other innovators. They have a relatively high tolerance to risk (i.e. have sufficient financial liquidity to accept the risks);
- Early Adopters: these are similar to innovators but are more discrete in their adoption choices. These individuals have the highest degree of opinion leadership (someone who interprets the meaning of media messages and content for lower end media users) among the other categories;
- Early Majority: individuals in this category adopt an innovation after a varying amount of time, but this is significantly longer than for the previous two categories. They have above average social status and contact with early adopters;
- Late Majority: individuals in this category will adopt an innovation after the average member of society. They often have a high degree of scepticism, with below average social status, low ability to absorb financial risk and are likely to be in contact with others in the late majority and early majority categories; and
- Laggards: the last group to adopt an innovation. They typically have an aversion to change, be focussed on 'traditions', of a lower social status, often older and in contact with only family and close friends.

It may be possible that customers would fit into different groups depending on the type of innovation. For example, if they have a particular interest in energy technologies they may be more amenable to any perceived risk, or more willing to experiment than those with little interest in energy.

Rogers showed this diffusion graphically (see below), where the blue bell curve shows the proportion of the market within each of five categories, and the yellow s-curve showing the market share of the innovation increasing over time as each of the different groups adopt the innovation.

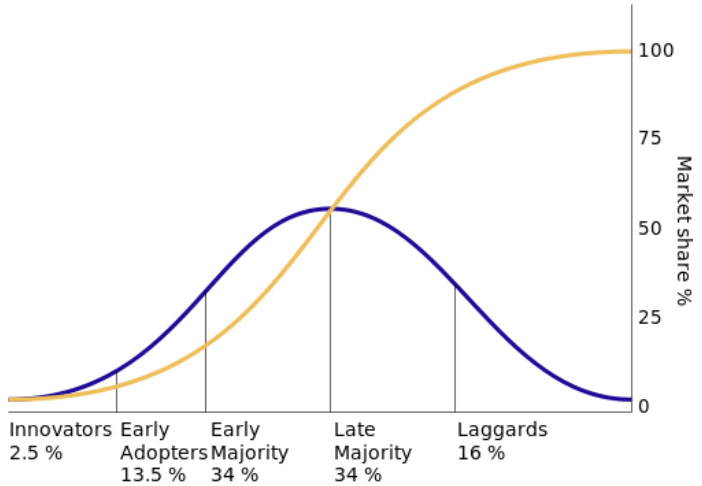



**Figure 2.2 Diffusion Curve for New Technologies/ Innovations**

Diffusion theory influences Task 23 in a number of ways, as follows:

- The type of information presented to the consumer about new technologies and offerings (e.g. tariffs) in the five stages of decision making should be considered. For example, making sure the customer is 'inspired' to find out more during the 'Knowledge' stage, and that suitable information is readily available during the 'Persuasion' stage;
- The type of customers involved in a trial will affect whether the results (including factors such as ease of recruitment, level of acceptance and drop-out rate) can be extrapolated to a whole population. For example, trials involving a very small number of customers who 'opt-in' to taking part are likely to involve 'Innovators' and 'Early Adopters' and the behaviour of other customer types cannot be assumed to be the same as they have different characteristics; and
- It may be sufficient in some cases for innovations (e.g. particular tariffs or technologies) to only be taken up by certain customer groups in order to achieve the project aims (e.g. a decrease in overall energy consumption or peak load reduction). Figure 2.2 shows that it is possible to achieve a high market share (approximately 84%) even if the 'most difficult' customer group ('Laggards') do not take part.

Many innovative technologies do not diffuse beyond the innovators and early adopters. This is referred to as 'crossing the chasm'[9], a method developed in the 1990's for marketing technology during the start-up period. The chasm is the area between the early market and the early majority (i.e. the pragmatists). Crossing the chasm is relevant for disruption technologies that require a behaviour change from individuals. As such, it is considered to be a relevant concept for Smart Grid interventions. Ensuring that the new technology provides a solution to an existing problem faced by the early majority is regarded as a key factor in enabling the chasm to be crossed. This is because innovators and early adopters will take up the technology just because it is new and innovative, whereas the pragmatists require a firmer reason for changing the way that they do something.

## 2.3 Assessing market readiness

The status of a specific concept within a given market varies. It can be in its very early stages and only trialled by a few innovators. Alternatively, it may be well established and implemented by the majority of individuals, with only a few (the laggards) excluded. The difference in the rate of implementation of any concept can be influenced by two factors – the readiness of the concept (i.e. the technology itself) or the readiness of individuals to accept the technology (i.e. the market readiness level). These concepts are further discussed below.

### 2.3.1 Initiative readiness level

A Technology readiness level (TRL) framework is used to grade technologies on a scale of 1 to 9. The upper end of the scale, 9, indicates a technology that has been qualified through prolonged operation and a number of units are in commercial operations. The lower end of the scale, 1, indicates that only the basic principles involved in a concept have been observed and reported. As mentioned earlier, this Sub-Task is focussed on the interaction of customers and interventions. As such, an equivalent Initiative Readiness Level (IRL) was used to assess the readiness of the initiative (i.e. package of interventions within a trial), using the same scale used for assessing TRLs. This is shown in Figure 2.3 below.

[9] Crossing the Chasm, Geoffrey A. Moore

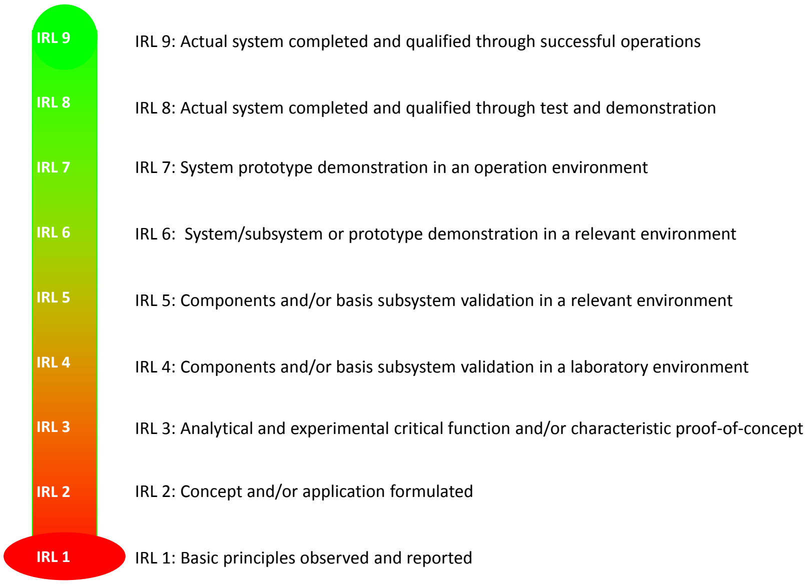
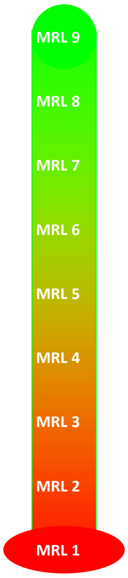



**Figure 2.3 Initiative Readiness Levels**

The Initiative Readiness Level scale shown above was used to assess the readiness of the initiatives that were implemented in the case studies discussed in Section 4.

### 2.3.2 Market readiness level

Although an initiative (i.e. package of interventions) may be sufficiently developed, the market may not be 'ready' for implementation. For example, whilst technologies might exist to allow washing machines to be remotely controlled by a third party, customers may not yet be willing to accept the intervention. The term 'Market Readiness Level' or MRL is used to describe customer attitudes towards specific Smart Grid initiatives. Unlike TRLs, there is no standard definition of a MRL scale, therefore a scale has been defined specifically for the purpose of Task 23. Again, a nine point scale has been used to ensure comparability with the TRL scale, as shown in Figure 2.4. The Market Readiness Level scale shown below was used to assess the readiness of the customers that were implemented in the case studies discussed in Section 4.




MRL 9: Approach fully understood and accepted by vast majority of consumers. (e.g. a mobile phone has become a social ‘norm’ rather than landlines for many calls)

MRL 8: Most consumers understand the principles, but only accepted as the ‘norm’ for certain groups (e.g. the use of a Smart Phone to access the internet is regarded as the ‘norm’ for young)

MRL 7: Benefits reasonably well understood by all, but may not be sufficient to drive demand except for certain niche markets (i.e. costs considered to outweigh the benefits) (e.g. iPAD)

MRL 6: General awareness of benefits, but majority of individuals unable to identify the costs/benefits to themselves. (e.g. need for a 3D TV not well justified)

MRL 5: Some customers actively attempting to find out more, i.e. there is some ‘market pull’ from early adopters, but benefits/costs not well understood by most customers.

MRL 4: Some customers aware of basic principles , but limited or no information on potential benefits/costs )

MRL 3: Some consumers starting to actively find out more

MRL 2: Some consumer awareness – but limited, small minority open minded to the idea

MRL 1: Consumers as a whole are unaware

**Figure 2.4 Market Readiness Levels**

# 3 Consumer Surveys

A number of consumer surveys were considered to gauge consumer reaction to Smart Grid related initiatives. A wider selection were also included when they provided insights into consumers views on topics that could be interest to Task 23, for example energy efficiency, sustainable behaviours and climate change.

An overview of the surveys examined is provided below:

**Table 3.1: Consumer Survey list**

| Ref. | Country | Panel Size | Title |
|---|---|---|---|
| CS1 | UK | | Retail Market Review: Domestic Proposals |
| CS 2 | UK | 100 | Consumer First Panel |
| CS 3 | Ireland(*) | 1,880 | 2009/10 research on residential and business attitudes and experience of the electricity market across the island or Ireland |
| CS 4 | Europe | | Consumer Attitudes to Electricity Disclosure in Europe |
| CS 5 | UK | | What makes People Recycle? An evaluation of Attitudes and Behaviour in London Western Riverside |
| CS 6 | UK | 1,000 | Public Attitudes towards climate change and the impact of transport, 2010 |
| CS 7 | USA | | Public Perception of energy consumption savings |
| CS 8 | UK | 56 | Motivators and barriers to successful public participation in community-based carbon reduction programmes |
| CS 9 | UK | | The Effectiveness of feedback on Energy Consumption – A review for DEFRA of the literature on metering, billing and displays |
| CS 10 | UK | 2,396 | Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters |
| CS 11 | UK | 2,159 | Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters (Wave 2) |
| CS 12 | UK | 120 | Smart Meters: research into public attitudes |
| CS 13 | UK | | Smart for All – Understanding consumer vulnerability during the experience of smart meter installation |
| CS 14 | UK | 2,704 | Role of Community Groups in Smart Metering-Related Energy Efficiency Activities |
| CS 15 | UK | 2,000 | Demand Side Management: A Discussion Paper |
| CS 16 | UK | | Demand Side Response in the non-domestic sector |
| CS 17 | Germany | 29 | Smart Homes as a Means to Sustainable Energy Consumption: A Study of Consumer Perceptions |
| CS 18 | UK | 1,000 | An Easier Life at Home? 'Selling' the Green Deal to UK households |
| CS 19 | UK | 5,914 | Customer Experiences Of Time of Use Tariffs |
| CS 20 | International | 9,108 | Understanding Consumer Preferences in Energy Efficiency Accenture end-use consumer observatory |
| CS 21 | International | 10,200 | Revealing the Values of the New Energy Consumer – Accenture end-consumer observatory on electricity management 2011 |
| CS 22 | Sweden | 3,000 | Ladda Sverige – Survey on perception of electricity and climate in Sweden |
| CS 23 | UK | 1,000 | Demand Side Response research |

(*) Northern Ireland and Republic of Ireland

## 3.1 Consumer survey findings

These consumer surveys cover a range of aspects of energy consumption and attitudes towards sustainable behaviour. None of the surveys specifically examines how consumers knowledge of the electricity industry, and their attitude towards it, translates into a willingness to participate in DSR. One of the surveys [CS12] examines public attitudes towards the electricity industry and willingness to change electricity supplier or use a Smart Meter for energy efficiency purposes, whilst another [CS22] acknowledges that the level of knowledge about electricity and the power system is low in some areas of Sweden. One survey [CS 23] asked consumers if they knew who to contact if they had a power outage. Although three-quarters of respondents indicated they did, when asked to name the organisation they would contact, many indicated a supply company not a network company.

Only one of the consumer surveys specifically explores the attitudes of vulnerable consumers [CS13]. This survey looks at their views in the narrow context of the impact of the installation of a Smart Meter and their desire and ability to interact with the Smart Meter in order to modify their energy consumption.

The majority of the surveys have concentrated on the domestic energy consumption market. Two have looked at SME's, one alongside domestic customers [CS3], and one looking at the whole of the non-domestic market [CS16].

Anecdotal evidence from these surveys [CS12, CS13] suggests that consumers with In Home Displays or Smart Meters are using these technologies to improve their knowledge of individual appliances and overall household energy consumption. There have been no surveys testing the accuracy of this knowledge, comparing it to the knowledge of those households who do not have these technologies, discovering the decisions taken as a result of this knowledge or exploring what further advice households would like to receive in order to further reduce their consumption.

The following sections provide an overview of the findings of these surveys, and describe:

- Customers knowledge and understanding of the electricity industry in general, and of Smart Grids and Smart Meters (Section 3.1.1);
- Attitudes to Smart Meters and In Home Displays (Section 3.1.2); and
- Time of use tariffs and demand side response (Section 3.1.3)

Whilst these surveys provide an interesting insight into what consumers think about energy efficiency and other Smart Grid related initiatives, it is important to bear in mind the following quotation by an anthropologist[10]:

> *"What people say, what people do, and what they say they do are entirely different things."*

One example of this relates to the tradition of 'tithing' (giving) a proportion of income. In a national study of how much money was given to faith charities, a quarter of respondents said they tithed 10 per cent of their income to charity. However, when their donations were checked against income figures, only 3 per cent of the group gave more than 5 per cent to charity[11].

[10] Margaret Mead
[11] http://blogs.thearda.com/trend/featured/parting-with-treasure-easier-said-than-done-churchgoers-give-far-less-than-they-think/ accessed 11 December 2012

### 3.1.1 Knowledge and Understanding

This section provides an overview of customer knowledge and understanding of the electricity industry in general, and also of Smart Grids and Smart Meters.

Some of the surveys show high levels of consumer scepticism and suspicion in the UK, especially towards Electricity Suppliers. The public is becoming more sceptical about the impact of climate change [CS6]. There is also evidence of a lack of understanding of and interest in the structure of the electricity industry [CS2, CS3] and a lack of trust of Energy Suppliers [CS12] in the UK. This is also a finding from a survey of 3,000 customers in Sweden [CS22], which found that knowledge about electricity production and the effects on the climate could be increased. The same survey shows that around a fifth of respondents would be willing to reduce electricity consumption to reduce their impact on the environment.

A survey from the United States of America [CS7] suggests that the public have little understanding of how much electricity household appliances consume and the best ways to consume less electricity. Public knowledge tended to focus around curtailment actions rather than energy efficiency actions. There was also a failure to recognise the relative magnitudes of energy consumption of different appliances. This study suggests that there is a requirement for accurate consumer advice to avoid public disillusionment at the scale of monetary savings achieved when householders do try to implement energy consumption reductions.

Few householders have heard of Smart Meters or are aware of the advantages that Smart Meters may provide [CS10, CS11]. Suggestions that householders may be forced to accept a Smart Meter were very unpopular [CS12].

Evidence suggested that businesses have little understanding of their energy consumption [CS3]. Many are not aware of how they consumed energy, and did not view it as a key priority [CS16].

This suspicion and scepticism of Energy Suppliers has a number of consequences. Householders are less likely to be ‘active consumers’ by changing their Energy Supplier because of the perception that all Suppliers are the same and there are only minimal savings to be made by swapping, so it is not worth the time and inconvenience involved. Smart Meters, which are provided by Energy Suppliers, are viewed with suspicion – “why would an Energy Supplier want you to use less energy?” was a common attitude [CS12].

Evidence from a survey that examined recycling habits [CS5] suggest that householders are willing to take part in sustainable behaviour if it is made easy for them, for example via kerb-side recycling rather than having to go to a recycling facility, and if they are assured that material that they sort will be recycled rather than put in landfill. The transport survey [CS6] suggests that although consumers may be willing to use public transport, they may be unable to for a variety of reasons. The messages from these surveys can be translated to energy consumption. Householders must be clear about why they are changing their consumption and wherever possible be given the means to make it easier. Although some households may be willing to change their consumption, they may be unable to due to their individual circumstances.

### 3.1.2 Smart Meters and In Home Displays

Public attitudes to Smart Meters and In Home Displays are covered in a number of the surveys. As mentioned above there is evidence that many householders are unaware of what a Smart Meter is and confused about the difference between a Smart Meter and an In Home Display [CS10, CS11].

Research suggests that householders react more positively if the In Home Display shows electricity consumption in monetary units rather that in kWh [CS11, CS12]. They also responded well to indicators that change colour to indicate if consumption was low, medium or high. These colour indicators were seen as being a particularly useful educational tool for households with small children [CS12].

There is strong evidence that when Smart Meters are first installed they can provoke interest in household energy consumption and how much energy appliances use [CS12]. Householders experiment by turning different appliances on and off to see how much each consumes, and uses the information to develop more energy efficient behaviour. Some households stop using certain appliances because they are energy intensive, stop leaving appliances on stand-by, or use appliances less frequently. The level to which this behaviour becomes routine and therefore persists is yet to be seen.

There was evidence of the use of the In Home Display as an educational tool [CS12], either for teaching children or other less energy conscious adults in the households. It could be used as an apparatus in a game, turning off all the appliances in a house and seeing the consumption falling with younger children, pointing out how the display changed colour.

The surveys are inconclusive about the long term effects of Smart Meters as an energy efficiency tool.

There is evidence that combining direct feedback from a Smart Meter or In Home Display with indirect feedback such as more regular billing or comparisons of consumption data with the previous years can be more effective than the two measures on their own. The research also suggests that that the behaviour learnt as part of the trial is more likely to persist beyond the end of the trial [CS9].

Only one survey has been undertaken into the effect of Smart Meters on vulnerable households [CS13]. This survey defined 'vulnerable' households as containing members over 65, members with chronic physical conditions, mental health conditions, children under 16, household income of less than £10,000pa, in receipt of means tested benefits or literacy issues (defined as less than 5 GCSEs or 'O' levels). This survey specifically examined the impact of the Smart Meters installation and how 'user friendly' these vulnerable customers found the experience. However, it did also investigate whether these customers subsequently used their Smart Meter and any behaviour changes that had resulted from its use. The survey found that some vulnerable customers found it difficult to understand the explanation that they were given when the Meter was installed. Some were anxious when the colour indicator on the display turned red to indicate high use. When further investigation led to the discovery that the 'red' indicator was due to certain appliances, they often altered the way that they used that particular appliance. In other cases, they considered that the use of the appliance was necessary and there was little alteration to their behaviour that they could make. There was no evidence from this survey that these vulnerable customers were altering their behaviour to a dangerous extent.

### 3.1.3 Time of Use Tariffs and Demand Side Response

There has been some investigation into public attitudes to Time of Use Tariffs and Demand Side Response. A survey was conducted into the experience of householders on Economy 7 or 10 tariffs [CS19]. This found that some households adapted well to these tariffs, changing their consumption patterns, and making savings. Other households were less sure about the terms of the tariff, usually having inherited it when they moved into the house. Sometimes the tariff was inappropriate for their requirements, and as a result left them financially worse off.

Another survey investigated more general public attitudes towards Time of Use tariffs [CS15]. It suggested that just over half of participants would be willing to adapt their behaviour to take advantage of a Time of Use tariff. Control technology was less popular. However a significant proportion suggested that they would be willing to install technology that would turn off appliances if energy prices were high.

Participants questioned as part of surveys investigating an energy management system [CS20, CS21] highlight that financial rewards are not the only benefit that they would like to receive for modifying or ceding control of their energy consumption. Popular options for enrolling in the scheme included rebates against energy bills, free installation of a home energy management system and loyalty points that could be redeemed against products of the consumers' choice.

Around a quarter of the respondents in a UK survey [CS23] had previously heard about the concept of demand side response (although less so amongst older age groups). The level of interest in the concept was also very high, especially if there was an incentive/reward scheme. When asked 'unprompted' to comment on the level of reward expected, the responses were wide-ranging. The average (mean) level of reward expected was over £2,000 per annum, but this was skewed by several respondents suggesting unrealistically large sums (2 over £1 million!). When prompted with various suggested levels of reward, around half (49%) would see participation in a DSR scheme as worthwhile if yielding rewards of up to £50 p.a. Around a quarter (23%) would be likely to participate for reward of only up to £25 p.a.

# 4 Case Studies

As discussed previously, a number of case studies were used to assess the way that customers use and relate to Smart Grid related technologies and initiatives. There are a large number of pilots and trials underway that include a wide variety of interventions. A number of these were identified as being of particular interest to Task 23. At the outset of this sub-task over fifty case studies were identified. A number of projects were at an early stage with no results available. The list was then reduced to exclude those which were still at very early stages, or which were not central to the aims of Task 23. The remaining case studies were summarised using a standard template to ensure that data and information was collated in a consistent manner. The template is presented in Appendix B.

The list of case studies considered within this project is presented in Table 4.1, which provides details of the customers involved, the intervention(s) that were implemented and the end-use load(s) targeted by the interventions.

Although a number of case studies were identified as being of significant interest to the project, some were subsequently found to be either outside of the scope of Task 23 (i.e. involving large industrial / commercial customers) or were currently in their early stages, and as such no results were yet available (beyond those which were initially excluded). As such, no template was prepared for these, and they were subsequently excluded from the study.

**Table 4.1: List of Case Studies**

| Ref | Title | Customer Type(s) | Intervention(s) | End Use Load(s) |
|---|---|---|---|---|
| INT1 | EcoWatt Trial in Brittany- Using Energy Responsibly | All customer types | Entirely voluntary initiative. Broadcasts (via SMS, Twitter and Facebook) asking customers to turn off loads. Some hints provided on saving energy | General consumption |
| INT2 | SDG&E Reduce Your Use Day | Household and businesses | The 'Reduce your Use' scheme encouraged participants to reduce their electricity consumption during critical peak periods. There were no penalties for not participating however those who did participate could earn rebates against future bills. | General consumption |
| INT3 | PG&E SmartRate | Domestic General Households | Critical Peak Pricing and Static ToU, optional automatic control of air conditioning, notification of 'Smart Days'. | General household consumption or in conjunction with automatic controlled air conditioning loads (INT6). Notification technologies used. |
| INT4 | Florida Power and Light Residential Load Control Pilot Project (FLP) | Domestic households with air conditioning | Participants' air conditioners were fitted with a remotely controllable device so that householders could program it via the internet. In return Florida Light and Power were able to control the air conditioning unit during Critical Periods, although householders were able to override this intervention. | Air conditioning |
| INT5 | Electricity Customer Behaviour Trial | Households and SME | Time of Use tariff | All electrical consumption |
| INT6 | PG&E SmartAC Program | Residential | Remote load control | Air conditioning and pool pumps |
| INT7 | ETSA Direct Load Control | Residential | Voluntary initiative with no recompense. Remote load control | Air Conditioning |
| IT1 | Impact of a mandatory ToU rate among residential customers in Italy | Residential | Mandatory ToU | General Household Consumption |
| KR1 | Jeju Island Test Bed | 2,300 residential customers and a small number of businesses | Smart meters, IHDs, PV panels, smart appliances and dynamic tariffs. | General household consumption, some control of smart appliances. |
| NL1 | ADDRESS (French and Spanish trials) | Residential | Home energy management systems, some smart washing machines, air conditioning control and smart meters | General household consumption via control of a number of appliances. |
| NL2 | PowerMatching City 2 | 40 residential households | Control of heat pumps, micro-CHP, washing machines, thermal heat storage, EVs, PV generation and an online information portal. | Space and water heating, washing machines, electric vehicle charging and general household consumption (via consumption feedback). |
| NL3 | Rendement voor Ledereen | 200 residential households | Control of loads including integration with PV generation | Tumble dryers, refrigerators, dishwashers, washing machines and use of PV generation. |
| NO1 | Malvik Norway | 40 "typical" residential households | Smart metering, remote load control of water heating, ToU tariff with hourly spot energy price. | Electric water heating (for domestic hot water and/or space heating) and general household consumption. |
| NO2 | eWave In-Home display | 91 residential households | In-home display (without Smart Meter) | General Household Consumption |

| Ref | Title | Customer Type(s) | Intervention(s) | End Use Load(s) |
|---|---|---|---|---|
| SE1 | Consumer reactions to peak prices | Residential households. | Alternative tariff structure (critical peak pricing) | General Household Consumption |
| SE2 | Consumer reactions to peak prices – continuation project to SE1 | Residential households | Alternative tariff structure (critical peak pricing) | General household consumption including 50 customers (of 75) with heat pumps |
| SE3 | Sala-Heby | Residential households who were not in fuel poverty | New tariff design- variable tariff based on the level of demand (varies by time of day and season). | General household consumption, some with electric heating. |
| SE4 | Information through digital channels and its potential to change electricity consumption patterns | Residential customers (a total of 1246 customers across three studies) | Three separate case studies all involving provision of feedback to the consumer. | General household consumption |
| UK1 | Energy Demand Reduction Trial | Domestic, Fuel Poverty and General | Static ToU, Various feedback methods | General Household Consumption |
| UK2 | CHARM | General Domestic Households | Three separate pilots focussing energy, activity and environmental awareness. Each involving feedback by email/ internet on own performance and that of peers. | General Household Consumption |
| UK3 | E.ON Thinking Energy | General Domestic Households with and without on-site generation | Home Energy Managements System, heating control, end use monitoring and feedback | General Household consumption |
| UK4 | Customer Led Network Revolution | Households and businesses | Static ToU tariff with no control and a static ToU tariff + automated load switching + manual override option<br>Direct control - short term (remote) interruptions without override | General consumption, PV, Heat Pumps, Electric Vehicles |
| UK5 | Low Carbon London | General Domestic Households with and without on-site generation | Heat pumps, small scale embedded generation, photovoltaic generation and electric vehicles. | Heat Pumps, Electric Vehicles |
| UK6 | New Thames Valley Vision | Automatic Demand Response will be deployed with large I&C customers. If this is deemed successful then the extent to which the principles can be roll-out to small business customers will be investigated | Smart Metering and Automatic Demand Response solution. | |

| Ref | Title | Customer Type(s) | Intervention(s) | End Use Load(s) |
|---|---|---|---|---|
| UK7 | Sola Bristol | 30 domestic homes, 10 schools and a section of an office all with PV generation | Shadow tariff, control technology that will decide when the battery should be charged either from the solar PV or off peak electricity from the distribution network and what the electricity demand of the property will be for the following day. | In domestic homes: up to 4.8kWh battery storage, 2kW$_e$ PV panels connected to DC network, Lighting converted to operate on DC network, Computing converted to operate on DC network, Central heating pump and controller converted to operate on DC network, Smart appliances controlled via LC Connections manager, Variable tariffs. In Schools: 19.2kWh battery storage, PV panels connected to DC network 3.6kWe, Up to 40kW$_e$ connected to AC network, lighting and computing converted to operate from DC network, three phase balancing. In Office; 19.2kWh battery storage, PV panels converted to DC network 10kW$_e$, lighting and computing converted to DC network, Three phase balancing, |
| UK8 | Domestic Demand Side Management | Domestic households (housing association) | Storage heaters and hot water cylinder that can be better controlled by householder, and DNO | New generation storage heaters and hot water tank |
| UK9 | Sustainable Blacon | General domestic households | Some participants were issued with a Wattson™ energy display unit(IHD). Another group received an on-line AlertMe™ system (computer based consumption data with limited appliance remote control). A third group received no technology. All participants were requested to submit regular meter readings. | General household consumption |

## 4.1 Review of Case Studies

Each of the case studies identified in Table 4.1 was assessed in terms of the following four criteria:

- **Initiative Readiness Level (IRL),** which provides an indication of the status of the initiative(s) implemented in the case study. The initiative(s) are represented within the societal level of the behavioural model presented in Section 2.1, i.e. the readiness of factors that are external to the customers. So, has the concept been fully trialled and developed with innovators and early adopters?
- **Factors 'internal' to the individual** that impact on customer intention, i.e. awareness, customer attitudes, self-efficacy and social norms. These represent the internal elements of the model, i.e. the elements of individual behaviours.
- **Customer behaviours**, i.e. to what extend customer behaviour changed as a result of the implementation of the initiative.
- **Market Readiness Level (MRL),** which provides an indication of the receptiveness (or readiness) of the market to the initiative being implemented, i.e. is it attractive only to innovators or has it crossed the chasm to reach the early adopters? This is based customer attitudes and the level of behaviour change. This assessment is based on the readiness of the market as a whole in the country to accept the intervention, not only the group recruited to the trial (as this will generally be higher, particularly in those small trials involving early adopters).

The results of this assessment are provided in Table 4.2. Only completed projects, or those that have published interim results relevant to this study have been included.

**Table 4.2 Assessment of Case Studies**

| Ref | Title | IRL | Internal elements impacting on consumer intention (awareness, attitude, self-efficacy, social norms) | Customer behaviours | MRL |
|---|---|---|---|---|---|
| INT1 | ECOWATT Trial in Brittany– Using Energy Responsibly | 7 | **Attitude:** Positive acceptance of the need to change behaviour, and belief that they can make a difference to their community.<br>**Attitude:** No financial reward expected in return.<br>**Social Norm:** Sense of community - aversion to building of nuclear power station within their community. | Large number of customers enrolled onto the scheme via social media (Facebook, Twitter) and enrolment for SMS messaging and other social media.<br>Evidence to suggest customers willing to change their energy behaviour, evidenced through reduction in demand in response to alerts issued during winter 2008/2009. | 5 |
| INT2 | SDG&E Reduce Your Use Day | 8 | **Attitude:** Customers were automatically enrolled onto the scheme, but were offered the chance to sign-up for alerts to earn rewards. Interest was very low (around 41,000 customers from a total of more than 1 million opted to receive alerts). | Only customers receiving the alerts reduced their energy consumption. Of those customers receiving alerts, the average saving was around $2.50 per event or $20. | 7 |
| INT3 | PG&E SmartRate | 9 | **Attitude:** Customer willingness to join the scheme is limited to a small proportion of customers<br>- The scheme was introduced in 2011, when 23,000 customers out of PG&E's customer base of around 5 million enrolled. This has now increased to around 100,000.<br>**Attitude:** Customers in the scheme seem to be satisfied<br>- The drop-out rate amongst those enrolled on the scheme is very low. | Customers do respond to alerts, and the more information they receive the larger the impact on energy behaviour<br>- While some participants provide no, or invalid contact information to be sent notification of event, evidence suggests that the more notifications a household elects to receive, the larger the saving<br>Air conditioning enabling technology contributes substantially to the size of response provided<br>- Needs to be as easy as possible. | 7 |
| INT4 | Florida Power and Light Residential Load Control Pilot Project | 8 | **Attitude:** Interest in participating in the trial was low:<br>- Of 1,000 customers on an existing demand response scheme (On-Call) which provided a financial reward were offered the chance to receive a programmable thermostat instead.<br>- Only 2.2% accepted the offer<br>**Attitude:** New technology raises interest<br>- A further 10,000 eligible customers were contacted, and the response rate was 16% higher than for previous mailshots.<br>**Attitude:** Preference for financial reward<br>- Of those new customers signing up the majority (59%) opted to enrol on the existing scheme (for a $31 reward) rather than the pilot (free programmable thermostat.)<br>**Attitude/Social Norm:** High satisfaction level of participants<br>- High proportion 'very' satisfied with technology, and would recommend to others | Relatively high proportion of customers did not actively engage<br>- Only 56% of customers programmed their thermostats.<br>Customers did not routinely override automatic curtailments (override rate was less than 1%) | 8 |

| Ref | Title | IRL | Internal elements impacting on consumer intention (awareness, attitude, self-efficacy, social norms) | Customer behaviours | MRL |
|---|---|---|---|---|---|
| INT5 | Electricity Customer Behaviour Trial | 7 | **Attitude:** There was a reasonable level of interest in in participating in the trial<br>- 30% response rate to invitation<br>Very little reported on customer attitudes. | Results show that customer did change their energy behaviour.<br>- 82% of domestic participants changed their electricity consumption behaviour<br>- 74% of households claimed to have made major changes to their behaviour.<br>- 71% claimed to have been forced to attempt to reduce usage at peak times.<br>- Not all customers managed to achieve energy load reductions / peak load reductions. | 7 |
| INT6 | PG&E SmartAC Program | 7 | **Attitude:** No evidence is available of how easy it was to recruit participants onto this trial however those on it were generally very satisfied with the experience.<br>**Attitude:** Participants experienced little discomfort during curtailment events. | No evidence is available about the number of participants who opted out of events.<br>No details available on how customers interacted with their programmable thermostats. | 7 |
| INT7 | ETSA Direct Load Control | 8 | **Attitude:** Customer willingness to become involved in the initiative increased as the trial period progressed and when the issue was properly explained to them.<br>**Attitude:** Potential participants were still worried about potential damage to air conditioning units and allowing access to homes and these issues stopped some recruits participating. | No energy behaviour change required of consumers<br>- Once the control device was installed no further customer engagement was required. | 6 |
| IT1 | Impact of a mandatory ToU rate among residential customers in Italy | 9 | **Attitude:** The tariff was mandatory so customer did not 'opt-in' to having a ToU tariff. However, no significant concerns were raised by consumers. | There has been limited shift in consumption by the population as a whole- some customers have shifted their load to off-peak periods, but some have increased peak-time consumption, leading to limited overall change.<br>The amount of 'engagement' with the tariff by consumers (i.e. reacting to the price signals) varies considerably. There have been small changes in the time when certain appliances are used, but in some cases this has actually increased consumption during peak hours (e.g. ovens, washing machines, dishwashers). | 7 |
| KR1 | Jeju Island Test Bed | 8 | **Attitude:** Preliminary results that shown that a majority of participants (86.2%) have an interest in electricity consumption reduction.<br>**Attitude:** Some customers were happy to take part in the voluntary trials before indirect financial benefits (e.g. smart appliances, PV panels and IHDs) were offered, whilst others strongly complained when they did not receive their free smart devices.<br>**Social Norms:** Customer engagement was initially not considered to be important but this changed during the project implementation. Local elders and key opinion leaders in the community were consulted in advance. | After the trial the results showed that 42.6% of participants thought their electricity consumption had changed.<br><br>Full results of the trial (amount of peak energy reduction or energy savings achieved) are not yet available. | 6 |

| Ref | Title | IRL | Internal elements impacting on consumer intention (awareness, attitude, self-efficacy, social norms) | Customer behaviours | MRL |
|---|---|---|---|---|---|
| NL1 | ADDRESS | 8 | **Attitude:** Recruiting customers into the Spanish trial involved telephone calls and follow up home visits. Reasons for not non-participation included loss of interest (between initial call and home visit), disliking the objectives of the project, and disagreement with the rights and obligations defined in the contract.<br>**Attitude:** Motivations are wide and varying. In France, 29% were motivated because ADDRESS was a new technology, 29% were driven by environmental concerns, 21% by energy security in the islands and 21% were interested in saving money. In Spain the majority (68%) were interested in saving money, 11% joined because of the use of new technology, 8% because of environmental concerns and only 3% joined due to concerns over energy security. | No results yet available on the level of savings achieved or customer satisfaction. | 4 |
| NL2 | PowerMatching City 2 | 9 | **Social Norms:** In the first phase the majority of participants were from a neighbourhood association who already an interest in 'Green projects'. In Phase 2 participants were recruited in a different area but around half lived in the same street and all were connected to a Home Owners Association. Before PowerMatching City 2 there was already an initiative to collectively purchase PV generation and heat pumps.<br>**Attitude:** Customers were motivated by sustainability and independence.<br>**Attitude:** Customers have been willing to engage with the system and have reported that they perceive a higher level of comfort with the system without experiencing any inconvenience from participating. The acceptance level amongst consumers is high. | The frequency of visits to the energy portal by consumers indicates that it provides relevant information which is of interest to the participants. | 4 |
| NL3 | Rendement voor Ledereen | 8 | **Social Norms:** Local "ambassadors" were used to recruit customers. The ambassadors also contributed to setting up the pilot (e.g. setting the requirements for the appliances and contents of contracts). | Results showing the level of engagement (e.g. via feedback from participants, or the level of load shifting achieved) are not yet available. | 4 |
| NO1 | Malvik Norway | 8 | **Attitude:** Participation was voluntary and involved 40 customers. Customers were recruited via an article in a local newspaper and email. Those customers who took part were clearly willing but it is not clear how the results would be replicated in the general population (beyond early adopters). | A demand response during the peak hours of 1kW (for customers with standard water heaters) and 2.5kW (for customers with electric space heating) was achieved, suggesting these customers engaged with the tariff. | 3 |

| Ref | Title | IRL | Internal elements impacting on consumer intention (awareness, attitude, self-efficacy, social norms) | Customer behaviours | MRL |
|---|---|---|---|---|---|
| NO2 | eWave in-home display | 9 | **Attitude:** Participation was voluntary and customers were recruited via an advertisement in a local newspaper and on a relevant web page.<br>**Attitude:** No major concerns concerning data security or privacy were received from customers.<br>**Attitude:** Customers didn't regard the display as a nuisance when questioned and were positive about the energy and financial savings made and the environmental impacts.<br><br>Only a small number of consumers were recruited (90) and so these were likely to be more engaged than the 'average' consumer. | A decision was made that customers would receive no further information once the display was installed so that the IHD alone would motivate the behavioural change. Preliminary analysis indicates energy savings in the order of 6 to 8%. | 3 |
| SE1 | Consumer reactions to peak prices | 9 | **Attitude:** In the interviews performed within the project, various reasons were given to why the consumers participated in the project. Motives included:<br>- it was economically beneficial to participate<br>- it was interesting<br>- it had a positive environmental impact | Results showed that the consumer did become more active; consumption decreased by 50% during intervals with high prices, | 5 |
| SE2 | Consumer reactions to peak prices – continuation project | 9 | **Attitude:** No information is available on the recruitment or interest of consumers to participate in the trial. | During the project, the participants managed to reduce their peak demand. The trial showed that even though very low outdoor temperatures, the consumers were willing and capable of significantly reduce the peaks. | 5 |
| SE3 | Sala-Heby | 9 | **Attitude:** A follow up survey of a sample of participants showed that households were generally sympathetic to the project.<br>**Self-efficacy:** However, many also had poor knowledge about the difference between power (in kW) and energy (kWh) and thereby also had difficulties understanding the demand based power tariff. This had a negative impact on the acceptance for the applied tariff. | Statistics of the energy consumption shows that the consumers changed their consumption to avoid peaks. The most common measures being to run various domestic appliances in off-peak periods. The system loads have accordingly decreased during peak hours and have instead increased during off-peak hours. | 6 |

| Ref | Title | IRL | Internal elements impacting on consumer intention (awareness, attitude, self-efficacy, social norms) | Customer behaviours | MRL |
|---|---|---|---|---|---|
| SE4 | Information through digital channels and its potential to change electricity consumption patterns | 9 | **Attitude**: A survey of a sample of participants assessed their views on three different services. A clear majority of the respondents answered that they felt a need for a service showing their energy consumption. Further, a majority of the respondents would also like advice on how to reduce their consumption. Overall the respondents were positive to the services. **Self-efficacy:** Many respondents felt that they needed more information and advice on how to change their consumption levels. | The results from the project show no decrease in energy consumption. In fact, for some cases, the consumption has instead increased during the project period. Hence, the services have not been able to help the consumers to reduce their consumption. Many consumers did not feel that they were in control of their own consumption and did not know what to change in order to lowering it. | 7 |
| UK1 | Energy Demand Reduction Trial (E.ON). | 6-8[12] | **Attitude:** Most people found energy savings advice useful. Energy saving advice related to cooking was not well received. Most householders found Real time Displays useful. Real Time Energy displays with 'traffic light' features were well received. Customers did not finds displays that featured usage in kW, provided greenhouse gas emissions, or had usage alarm features helpful. | When householders were asked about the behaviour change provoked by the interventions, the changes reported were similar across all user type groups however when actual change in energy consumption was measured the High Energy Users has reduced their energy consumption most significantly. The reason for this divergence is unknown.<br>None of the interventions provided to the non-smart meter group produced a significant change in their energy consumption | 5 |
| UK2 | CHARM | 9 | **Social Norms:** Participants who received Social Norms feedback downloaded the information more frequently than those who did not, suggesting that they found it more engaging. | Despite a financial incentive for completing the trial only 316 of the 400 recruited finished it.<br><br>Householders who received Social Norms feedback did not reduce their consumption any more than the control group. This may be due to the small sample size and the relatively short duration of the project. | 7 |
| UK3 | E.ON Thinking Energy | 8 | **Attitude:** Householders like the extra control and comfort that this system gives them over their appliances, heating system and energy consumption.<br>**Attitude:** Householders valued the technology for its ability to add to a householders' lifestyle rather than its energy saving abilities. | Householders used the extra control of their appliances in unexpected ways – for example to turn on the kettle as they were about to get home from walking the dog.<br>Most householders thought that they had reduced their energy use – some achieved dramatic savings as a result of running appliances more efficiently, discovering that they were faulty or not operating in the way that they expected. | 8 |
| UK4 | Customer Led Network Revolution | 6-8 | **Attitude:** Huge difficulties recruiting SME participants onto restricted hours and direct load control aspects of the trial.<br>**Attitude:** Residential customers interested in ToU tariffs with the expectation that they could save money – little interest in environmental impact.<br>**Attitude:** Financial sweeteners were available to domestic participants but were not always required. | SME's were not prepared to alter their behaviour in order to enter into restricted hours or direct control arrangements.<br>Householders on ToU tariffs were willing to modify their behaviour to help reduce the early evening peak however there is a significant payback as demand increases later in the evening. | 2-6 |
| UK5 | Low Carbon London | 8 | **Attitude:** Recruitments of participants onto some trial initiatives has been difficult | | 3 |
| UK6 | New Thames Valley Vision | 8 | **Attitude:** Difficult to attract commercial customers to participate in trial | | 2 |
| UK7 | Sola Bristol | 8 | This information is not available yet. | This information is not available yet. | 4 |

[12] The Energy Demand Research Project included multiple propositions, most of which were at a higher level of IRL but a lower level of MRL in the UK.

| Ref | Title | IRL | Internal elements impacting on consumer intention (awareness, attitude, self-efficacy, social norms) | Customer behaviours | MRL |
|---|---|---|---|---|---|
| UK8 | Domestic Demand Side Management | 6 | **Attitude:** The householders liked their new storage heaters and hot water systems. | Some of the householders did not understand how to use the new systems effectively | 5 |
| UK9 | Sustainable Blacon | 8 | | Householders were willing to try to engage with either technology.<br>Householders were able to engage with their energy consumption to a greater degree by using their IHD than computer based technology.<br>The education programme helped participants instil good behaviour such as turning off lights and appliances when they are not in use. | 7 |

The results presented in Table 4.2 demonstrate that in general, whilst the interventions implemented can be considered to be at a reasonably high readiness level (typically 8 to 9), the market readiness is wide ranging, with values ranging between 2 and 9. MRL has been assessed based on the general population, rather than those participating in trials as these are often ‘early adopters’. According to the definition of MRL (see Section 2.3.2) initiatives which are being taken up by early adopters (e.g. trial participants who opt-in) are an MRL of 5.

The following sections provide a high level overview of the findings of the review of case studies in terms of the internal (i.e. individual) factors that influence consumer intention to do something and consumer behaviours.

The Market Readiness Level reflects the internal components of the behavioural model that influence customer intention to engage in Smart Grid related activities. This includes customer attitudes, customer self-efficacy, social norms and awareness. The information obtained from the case studies indicate there are a number of common themes between the case studies but also examples where apparently similar initiatives are viewed very differently by different groups of consumers.

For example, interest in joining some Smart Grid related initiatives was very low, whilst others reported a significant level of interest. Case studies reporting low levels of interest include INT2 & INT3, schemes incentivising customers to participate in dynamic demand response via a dynamic ToU tariff. The schemes were open to large numbers of customers, i.e. ‘business as usual’. However, only around 100,000 customers enrolled onto the PG&E SmartRate scheme [INT3], representing around 2% of PG&E’s customer base. In the SDG&E scheme [INT2], all customers are automatically enrolled onto the CPP tariff, but households were asked to opt-in to receiving alerts of high price events. The number of households doing so was very low; only 41,000 households out of a total customer base of around 1 million.

Case Studies in the UK involving commercial customers [UK4, UK5 and UK6] also report difficulty recruiting participants. In these cases, customers indicated an unwillingness or inability to alter their energy behaviour. These same studies report a higher level of willingness from domestic consumers. This might suggest commercial customers may think it is more difficult for them to change their energy behaviour compared to domestic customers.

One of the Case Studies reports a significant level of interest; the Electricity customer Behaviour Trial [INT5]. In this case, 30% of recipients of a mail shot responding to an offer of more information about the prospective trial. The total number of customers involved in the trial was 5,735, which represents a small percentage of the overall population of the trial involved a relatively small number of customers (around 1.6 million households, <0.5%). Although the 5,735 participants were selected to be representative of the population (in terms of demographics), it does not necessarily mean they are also representative in terms of attitudes. However, the trial involved a relatively simple ToU tariff with three different rates depending on the time of day and day of week. No remote or automatic control technologies were deployed, and the tariffs were designed to be cost neutral, so that the ‘average’ participant who did not alter their consumption pattern would not be penalised.

The case studies provide only very limited information on customer attitudes. In particular, negative attitudes (i.e. what customers did not like) are not well reported. The following Sections therefore provide some general findings in terms of customer attitudes towards

Tariffs, Control, Feedback and Advice (i.e. the four types of Smart Grid interventions) being considered as part of this study.

Thus, an interesting conclusion of the case studies is that the same intervention can be offered in several countries but because of the level of market readiness it will be met with different responses. For example, the remote control of air conditioning units is at a high level of market readiness level in the USA. However when the technology was introduced in Australia, householders were worried that it may cause damage to their appliances [INT7]. Similarly, initiatives relating to the control of heat pumps are more developed in countries in mainland Europe [NL2, SE2, SE4] where there has been a greater deployment of heat pumps compared to the UK [UK4, UK5]. This lower level of market readiness meant that some householders were less willing to participate in the initiative, or that it was more difficult to recruit customers to the trials as they did not have the necessary appliance to provide a demand response.

The following Sections provide a high level overview of customer willingness to engage in the four different types of interventions (Tariffs, Control, Feedback and Advice), i.e. the internal elements of the behaviour model that influence an individual's intention to undertake a certain behaviour (or not).

### 4.1.1 Tariffs

Whilst there are a wide range of different types of tariff that could be offered to motivate customers to participate in Smart Grid related initiatives, those implemented in the selected case studies fell into one of the following types:

- Time of use tariff
- Critical peak pricing tariff

These are discussed in the following sections.

#### Time of Use Tariffs

New ToU tariffs have introduced in both trials and as a 'Business as Usual' activity in a number of case studies. The main example of a ToU tariff introduced outside of trials activity is from Italy [IT1], where all customers subject to the universal supply regime were subjected to a mandatory ToU tariff from July 2010 onwards. A panel of 28,000 customers where monitored to observe the change in their consumption patterns as a result of this tariff. This has shown that behaviour by customers is variable to the extent that even though 60% of customers responded in the 'correct' manner (i.e. shifting some consumption away from peak periods) their actions were negated by the remaining customers who behaved in the opposite manner. In this case the impact of the tariff has been minimal, with a reduction in peak consumption of around 1%. This is thought to be mainly due to the limited possibility for load shifting, as many large loads were already used off-peak, and a very low price signal. It is also possible that after the initial introduction of the tariff, customers have subsequently forgotten the information they received and so may benefit from regular reminders, such as the visual prompts used in other trials [NO1].

In the case of trials activity, the majority of this has occurred in the UK and Ireland [INT5, UK1, UK4 and UK5]. Despite there being some longstanding experience in the UK with ToU products such as Economy 7 and 10 tariffs, more novel ToU products have only been offered as part of trial situations with the result that participants are only on them for a finite period, and usually with some assurance that the householder will not have to pay any more than they would if they had remained on their usual tariff at the end of the trial. Pricing structures have not been representative of potential Business as Usual tariff structures, sometimes exaggerating potential off-peak savings, in contrast to the Italian example [IT1] where a lower price differential was used. Initials findings from the LCNF CLNR trial warn that this may be result in another peak, but at a slightly later time, limiting the usefulness as a network load management tool [UK4]. A finding of the EDRP trial suggested that it is more difficult to shift load when there are more members in a household [UK1]. Domestic customers who participated in the ESB Networks Smart Demonstration Trial were reluctant to use appliances overnight because of safety fears and because of a loss of convenience [INT5]. Simple aids such as fridge magnets that remind householders of the peak periods are particularly valued by participants on this type of tariff [INT5, NO1]. Participants on the ESB trial were often disappointed by the scale of reduction of their bill that they achieved when they modified their behaviour and did not seem to become more aware of general energy efficiency behaviour [INT5]. The type of loads available for control has also been shown to impact the scale of peak reduction which a householder can achieve on a ToU tariff- with larger savings for those homes with electric space heating as well as electric water heating [NO1].

The level of motivation of customers who are subject to ToU tariffs may also affect the level of load shifting observed. For example, small pilot trials have demonstrated significant savings [NO1] compared to those involving whole populations [IT1]. This may be further demonstrated in the future as results are published from trials which are currently underway involving a greater number of customers [UK4, UK5].

#### Critical Peak Pricing

Critical Peak Programs (CPP) are most common in areas with a high incidence of air conditioning or electric heating such as California, Florida, parts of Australia and Scandinavia. Especially hot or cold weather can result in a high electrical demand to power these devices, causing stresses on electricity distribution and transmission equipment. These periods can usually be predicted in advance allowing notification of a Critical Peak event to be given in advance, either to the area at large over the radio or TV, or to participating customers via email, SMS messaging or social media [INT1, INT2, INT3, SE1, SE2, SE3]. These types of tariffs are at a high level of participant and market readiness in parts of the USA. They are often most effective in conjunction with control technology, although examples have also been observed in the absence of control technology [SE2]. Results can be dependent on weather conditions, for example humidity levels [INT7]. This suggests that householders are willing to compromise their comfort to a degree, but not beyond a certain point.

### 4.1.2 Control

This section of the report focusses on customer acceptance of remote / automatic control of selected end-use loads. Here, the focus is on highlighting where customers are willing to cede control of their appliances to a third party (such as a network operator or Energy Supplier), and any concerns raised.

#### Air Conditioning

This type of appliance control is at a high level of participant acceptance in the US where it is generally used alongside CPP initiatives [INT2, INT3 and INT7]. A consumer override is usually required [INT3 and INT7]. When this technology was introduced into Australia, the market readiness level was lower. Residents were worried about it damaging their air conditioning equipment. However, they were willing to allow it to be fitted despite not receiving any financial reward [INT7]. Some testing of control of air-conditioning has been trialled in Europe [NL1] although this has limited applications due to differences in climate.

#### Heat Pumps, heating and hot water

Householders in the small trial that involved allowing automated control of their electric heating and hot water were happy to allow this and reported this as a positive experience [NO1, SE1 and SE2]. In return for allowing third party automated control they received a new heating and hot water system. They were also able to override the third party control.

#### General household consumption

UK trials that offered householders technology that increases their control of household appliances, allowing them to remotely control consumption, were oversubscribed [UK3]. This suggests that despite being at a low level of participant and market readiness householders were attracted to the extra functionality that the technology provided. No suggestions were made during or prior to this trial about ceding control of appliances to a third party. The product was popular because it gave householders visibility and control of individual appliances, allowing increased control over consumption, but also, and perhaps more importantly, increased convenience. Households have also demonstrated a willingness to cede some control of appliances in trials in mainland Europe [NL1]. Interestingly, when a product was trialled in Florida that provided householders with remote control of their air conditioning units it proved more popular than the standard product [INT4].

#### Washing Machines

Direct control of washing machines is at an early stage of market readiness. However, customers have been willing to trial the technology in both the UK and overseas [UK4, NL1]. Appliance manufacturers have stressed the need for consumers to retain an ‘override’ option [NL1, UK4]. Results for this technology are not yet available.

### 4.1.3 Feedback

#### Smart Meters and In Home Displays

Results from trials in the UK suggest that Smart Meters with In Home Displays have been an important tool for assisting householders to manage their household consumption [UK1]. Householders have shown a preference for In Home Displays that allow them to display consumption in a monetary format, and these have resulted in larger reductions in consumption. ‘Traffic light’ displays have also been valued by consumers. However, In Home Displays with audible alarms were unpopular [UK1]. Participants in a Norwegian trial did not find the use of IHD to be a nuisance [NO2]. There is evidence that they are more effective when combined with energy efficiency advice. One trial investigated the use of feedback displays without the inclusion of energy efficiency advice [NO2] and this still resulted in an energy saving of 6-8%, although the involvement of early adopters in the trial may mean that the results would not translate to the general population. Feedback devices that require householders to log onto computer systems were found to be not as effective as IHD’s [UK9] with some users finding logging into an online system time consuming and therefore ineffective [SE3]. An online portal was used as part of a trial in the Netherlands [NL2] and was received positively by participants, although they would value additional feedback in how to use the portal.

As yet, there have been no trials that have looked at the prolonged energy saving effects of Smart Meters, thus from the trials analysed here, the long term effectiveness of Smart Meters as a means to reduce energy consumption is not yet proven.

### 4.1.4 Advice

Information from the trials suggests that consumers can find energy efficiency advice useful, even if it is information that they are already aware of. Its usefulness can often increase if it is used in conjunction with some form of real time feedback [UK1, UK9 and SE4]. It has been noted in one trial that households also require a degree of interest and commitment to changing their energy behaviours, if that advice is to lead to energy saving or peak load reduction [SE4].

## 4.2 Key Learning Points and Challenges

As part of the process of summarising the case studies, the key learning points and key barriers from each project covered were identified. Although attention was paid especially to points that revealed consumer attitudes to the trial, some points have been included that provide technical learning points. Key learning points are lessons identified from the trial of aspects that were particularly popular with consumers or cost effective. Key barriers are aspects of the trial that were unpopular or too expensive at the time that the trial was run to work in a Business as Usual scenario. The barriers are also sub-divided into internal barriers, i.e. those internal to the individuals involved in the case study, and external barriers, i.e. those external to the individual, and relating to the technology or the market.

A summary of the key learning points and key barriers from the case studies examined are presented in the following Table. Only completed projects, or those that have published interim results relevant to this study have been included. Studies that upon investigation were found to fall outside the boundaries of Task 23, or had no interim results that came within these boundaries were also excluded at this point.

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**Table 4.3: Case Study learning points and barriers**

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| INT1 | ECOWATT Trial in Brittany - Using Energy Responsibly | • Brittany has a strong sense of community which has helped motivate participation.<br>• The program explained the reasons why Brittany was particularly at risk of black outs and asked for assistance via this scheme to overcome the issue.<br>• There was also strong opposition in Brittany to building a nuclear power station to overcome these problems.<br>• Consumers are willing to respond when problems are properly explained to them, especially if the coincide with issues that they feel strongly about.<br>• Financial reward not necessary in this context. | **Internal**<br>• Different attitude towards electricity and the electricity industry in other countries would make this scheme difficult to replicate. |
| INT2 | SDG&E Reduce Your Use Day | • The scheme was designed with no risk to customers (reward for positive action, but no penalty for inaction). | **Internal**<br>• Low numbers of customers sign up to receive the alerts, and those who don't receive the alerts do not change their energy behaviour. No information is available on why consumers do not elect to receive alerts. |
| INT3 | PG&E SmartRate | • The scheme was designed with no risk to customers (customer bills protected in the first year).<br>• Customers in the accepted remote control of their appliances – no information on whether this was a concern to those not enrolled in the scheme.<br>• However, not all customers on the program provided a response, some sign up but do not opt to receive notifications of events and therefore provided little demand response.<br>• Specific information regarding customer experiences is not provided but the low drop-out rate would suggest that customers are generally happy. | **Internal**<br>• Low numbers of customers sign up to join and to receive automatic alerts. No information on reasons for not enrolling. |
| INT4 | Florida Power and Light Residential Load Control Pilot Project | • Customers could choose between different rewards (financial incentive or a technology option).<br>• Customers selecting the technology option required much more support than those accepting the financial reward.<br>• The availability of technology made the scheme more attractive to customers initially, but more subsequently selected the financial reward option. | **External**<br>• The new technology failed the post-trial statistical cost effectiveness test so at the time of the trial it would be too expensive to replicate in a Business as Usual scenario. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| INT5 | Electricity Customer Behaviour Trial | **Domestic**<br>• Participants adapted their usage to the tariffs. 82% of participants made some changes to the way that they use electricity with 74% stating that their household made major changes.<br>• Simple communication methods work well and are well remembered by participants (75% found the fridge magnet useful)<br>• Participants claimed to be more aware of their energy usage (electricity monitor playing an important part in increasing awareness).<br><br>**SME**<br>• High prices during peak periods did 'force' customer to attempt to reduce usage during peak periods.<br>• Participants who regularly monitored their electricity usage also had an increased likelihood of trying to identify ways to reduce usage.<br>• The electricity monitor was found to be an effective tool to reducing overall and peak electricity use. | **Domestic - Internal**<br>• Linking behaviour change to bill reduction proved a barrier to peak load reduction. This may be difficult to address because of exaggerated saving expectations.<br>• The Overall Load Reduction incentive was not well remembered.<br>• Participants were reluctant to shift usage to night time because of safety concerns and convenience.<br>• The trial did not provoke any secondary benefits such as increased awareness of general energy efficiency or investment in energy efficiency products for the home.<br><br>**SME - Internal**<br>• The main barrier to reduction was the perception that it was not possible to move usage to other times.<br>• The web-site information was poorly-used. |
| INT6 | PG&E SmartAC Program | • It can be difficult to predict the level of response that will be provided. For example, for domestic customers, the level of response was not linked to the number of air-condition units that were controlled (the level of the response was similar for all household independent of the number of air-condition units that were controlled). However, for business units, the level of response was directly proportional to the number of units controlled).<br>• Customer satisfaction with the SmartAC program is generally high-customers were asked to rate "how satisfied they were with the program overall" on a scale of 1 to 10 (1 being "Very Dissatisfied" and 10 being "Very Satisfied"). The mean scores among residential and business customers were 8.0 and 7.7 respectively.<br>• Recommendations made as a result of the 2011 review of the program included.<br>  o Concentrating recruitment of customers to those with particularly high summer energy usage (estimated to increase per customer load reduction by 50%)<br>  o Further improvements in device communications. | **Internal / External**<br>• The cost effectiveness is better for customers with higher level of consumption. No information is available on whether these customers (as a segment) are more or less willing to participate than those with lower consumption.<br>**External**<br>• Some technical communications issued were experienced in contacting the switches to ensure a response for each test event. This has been improved via the use of a new algorithm which attempts to contact the device every half hour, rather than once only. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| INT7 | ETSA Direct Load Control Trials | • Simple and direct communication is important and valued by the community. The avoidance of technical, market and political emphasis and is prepared to respond with a strong ethos of contribution and involvement in "doing their bit" as long as they understand where the value lies in their contribution. The every little bit helps message is one the community feels comfortable with."<br>• Where customers have volunteered to take part in a trial, and require a visit by an installation technician in order to set-up the equipment involved it should be noted that "homeowners need to be given a significant level of control over the installation time. Installers cannot expect volunteers to act like customers and to be available in a schedule that suits the installer rather than the volunteer". | **Internal**<br>• Customers were more likely to drop-out when an installer required access to the inside of their home (as opposed to a 'garden installation').<br>• Customers were also more likely to drop-out if they perceived a risk for damage to either their equipment (their air conditioning unit) or the fabric of their building. |
| IT1 | Impact of a mandatory ToU rate among residential customers in Italy | • Consumption allocation during off-peak hours was high before the introduction of the ToU tariff, suggesting that there were only a limited number of loads occurring in the peak period which could be moved. | **External**<br>• Varying behaviour of consumers results in the load changes from some customers being masked by others. Therefore, should efforts focus on targeting only those likely to participate, or should emphasis be on estimating what proportion of customers will participate.<br>**External / Internal**<br>• There is little incentive for customers to make changes to their energy behaviour if the difference between prices at peak and non- peak times is too low. In this case study, the price differential is such that in order to achieve a benefit of greater than 1€/year a consumer would need to shift around 20% of their energy consumption from peak to off-peak. |
| KR1 | Jeju Island Test Bed | • The participants were not subjected to any risk in this project. The project owner ensured that the consumers would not suffer any economic losses due to participating in the trial.<br>• Even though no technical equipment was installed at the consumers, it is still possible to achieve significant peak reductions.<br>• The tariff applied in the field test included a rebate. This rebate and the economic incentives are important, but the level is not that important. It is the "symbolic value" that is of importance. Hence, it's not necessarily the financial benefit that is experienced to be the most rewarding for the consumers. | • The principle of not exposing the consumers to any risks can constitute a barrier for the distribution operator for a larger rollout. A more extensive use of the proposed tariff potentially can lower the revenue and thereby the decrease the possibilities to invest and operate the system. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| NL1 | ADDRESS | • For positive consumer engagement with AD, the usability of the technology, contracts and contextual issues are all important.<br>• User interfaces must be easy to understand, allowing users to input settings and to access the different functionalities that the EBox™ can provide.<br>• Accessing information about electricity consumption was very important to consumers in this respect.<br>• Consumers need support with the installation of AD technology to minimise technical problems and to facilitate setting the parameters of the load control.<br>• The ability to over-ride the system when needed is central to acceptance.<br>• Contracts need to be understandable, transparent and clearly set out the potential financial benefits and implications of different actions.<br>• Consumer privacy and data must be protected.<br>• Financial savings are important to consumers, although other factors such as environmental protection are important in their decision to adopt AD technology. The full range of benefits must be clearly communicated to consumers to ensure as wide a take-up as possible. | • Results are not yet available. |
| NL2 | PowerMatching City 2 | • Suppliers of appliances were involved in Phase 2 which will make it easier to scale up the results from to other locations.<br>• "It is only through the efforts of all parties along the entire energy chain that it becomes possible to fully exploit the opportunities in Smart Grids"<br>• It was identified that a "bi-directional, interactive relationship between households and technology" was required so that households can understand the consequences of their energy actions.<br>• Customers required a "learning loop" to answer their questions about the operation of the system and to help them achieve their energy goals. | • Customers couldn't use the energy portal to evaluate the payback period for investment decisions due to a lack of historical (pre smart meter installation) data.<br>• It would be beneficial if the energy portal provided a tool to help customers to evaluate investments made.<br>• Consumers would have liked to have data on appliances which are not part of the PowerMatching trial so they could make more informed choices about the use of these appliances.<br>• Customers indicated that they would like information on how to use the energy portal. |
| NL3 | Rendement voor Ledereen | Results are not yet available (pilot still running). | |
| NO1 | Malvik Norway | • Significant load shifting is possible, given:<br>  ○ motivated customers (here: small pilot group)<br>  ○ suitable economic incentives (tariff and spot price)<br>  ○ good information and "behavioural trigger"<br>• Customers were mainly motivated by economic savings, but also electricity savings mattered.<br>• Remote load control by the DSO was accepted, as long as it did not reduce general comfort.<br>• Some customers adjusted other energy behaviours to better suit the new tariff. Some also said that their interest in and awareness of own energy consumption had increased during the pilot. | **General**<br>• No specific major barriers were identified during the pilot.<br>**Internal**<br>• Participants were generally motivated, and it is uncertain whether the same positive results can be achieved in a full scale project. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| NO2 | eWave in-home display | • Customers reported behavioural changes such as:<br>  ○ Turning off appliances when not in use<br>  ○ Turing off lights when no one present<br>  ○ Reducing indoor temperature when no one is at home, or during the night<br>• Customers were able to make energy savings of 6 to 8%, even without engagement after the installation of the meter. | **General**<br>• No major barriers encountered, although it is not clear whether the results (energy saving and willingness to engage) would be replicated in the general population.<br>**Internal**<br>• A few customers discontinued their participation mainly due to technical faults of the display units. |
| SE1 | Consumer reactions to peak prices | • The participants were not subjected to any risk in this project. The project owner ensured that the consumers would not suffer any economic losses due to participating in the trial.<br>• Even though no technical equipment was installed at the consumers, it is still possible to achieve significant peak reductions.<br>• The tariff applied in the field test included a rebate. This rebate and the economic incentives are important, but the level is not that important. It is the "symbolic value" that is of importance. Hence, it's not necessarily the financial benefit that is experienced to be the most rewarding for the consumers. | **External**<br>• The principle of not exposing the consumers to any risks can constitute a barrier for the distribution operator for a larger rollout. A more extensive use of the proposed tariff potentially can lower the revenue and thereby the decrease the possibilities to invest and operate the system. |
| SE2 | Consumer reactions to peak prices – continuation project | • The learning points from the preceding project are also valid in this project. Hence,<br>  ○ Even though no technical equipment was installed at the consumers, it is still possible to achieve significant peak reductions.<br>  ○ It's not necessarily the financial benefit that is experienced to be the most rewarding for the consumers.<br>• This project also draws the conclusion that this is valid also at low outdoor temperatures. | **External**<br>• As in the preceding project, the principle of not exposing the consumers to any increased economic risks can possibly become a barrier for a larger rollout. |
| SE3 | Sala-Heby | • Many consumers have an interest for reducing their peaks if they can see the benefit for doing this. The benefits can be related to the consumer directly, but can also consist of a better operation of the distribution system or a decreased impact on the environment.<br>• Information and advice are important to facilitate the engagement of consumers. | **Internal**<br>• It was difficult for consumer to assess hourly consumption information because the information infrastructure and systems are not always adapted to report hourly metering values.<br>• The feedback to the customers through web pages is too longwinded. This implies that the users will not be able to follow their energy consumption and or comprehend the impact of various measures on their energy bill. Further, the interest for changing energy behaviour will, as a consequence, not reach its full potential due to the process of getting the feedback information. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| SE4 | Information through digital channels and its potential to change electricity consumption patterns | • There is a need for feedback and advice to the consumers. The consumers request such information in order to get a better understanding and feeling of control concerning their energy consumption.<br>• One explanation as to why certain households have an increase in energy consumption when starting to use the service can possibly be that the increase triggered their need to get further information about the consumption, and hence they started to use the service. | **Internal**<br>• The impact of presenting statistics of consumers' energy consumption through web pages has a limited impact on the actual consumption. The effects are small, or maybe not even present.<br>• One of the main reasons as to why potential users didn't use the service was "lack of time". Hence, in order to succeed to engage these consumers, the service must be easily accessible. |
| UK1 | Energy Demand Reduction Trial | • The provision of Smart Meters with IHDs was a significant tool helping householders reduce gas and electricity usage.<br>• The amount of savings achieved by a household can be influenced by how helpful they find the IHD.<br>• It is more difficult for households to manage electricity use during the peak period of Time of Use tariffs the more people are in the household.<br>• Customers preferred the immediacy of real time display based feedback compared to retrospective paper based feedback. | **Internal**<br>• Further research required into consumer preferences for In Home Displays.<br>• Household management of electricity consumption during the peak period is more difficult the more people there are in the household.<br>**External**<br>• Significant problems associated with the transition to Smart Meters including, asbestos meter boards, cut out fuse changes, faulty gas ECV's, bad wiring, lead piping, lack of customer awareness, lack of understanding of customer responsibilities and appliance fault attribution, lack of trusted customer advisory service, proximity issues.<br>• A marketing campaign at a national level and at local/community levels required, from trusted organisations. This needs to generate a broad level of interest of awareness across all customer types.<br>• Clarification of communication technologies required. |
| UK2 | Home Energy Study | • Householders who received Social Norms feedback did not reduce their consumption any more than the control group. However they did download the information more, suggesting that they found it more engaging. | **Internal**<br>• Participants may want to 'do the right thing' but other social perceptions can limit how much they are prepared to change their behaviour.<br>• The study was a relatively small sample size, which may have limited the impact on determining the impact of social feedback. |
| UK3 | E.ON Thinking Energy | • Customers valued the technology for the extra control of their energy use that this system provided them with.<br>• Many commented that they were able to achieve a higher level of control and comfort from their heating system with the new technology.<br>• The technology was valued for its ability to add to the households' lifestyle rather than its energy saving abilities per se. | • None identified. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| UK4 | Customer Led Network Revolution | • Domestic<br>• ToU proved to be very popular – householders were particularly motivated by the opportunity to save money.<br>• Useful learning can be gained from offering tariffs, even if take up is low.<br>• The supplier of a 'smart' (externally controllable) washing machine for the project has stressed the importance of the customer experience. As part of this they also note that any remote control by a third party should not be made available to the detriment of the appliance's intended functionality, therefore it was considered essential that customers have an override facility.<br>• Although there were difficulties in recruiting SME customers, those expressing interest cited the following reasons:<br>• Enthusiasm for environmental projects<br>• Wanting to save money<br>• Having an interest in the results of the monitoring trial if possible<br>• Agreeing to take part as long as it's not intrusive to the business. | **SMEs – Internal**<br>• Early indications show that SME customers who are considering adopting ToU tariffs appear to be unwilling to change behaviour to any great extent to access cheaper rates, particularly if doing so would have an impact on business operation. Reasons cited by businesses customers for not taking part include:<br>○ Previous problems with the installation of Smart Meters in their business<br>○ Don't like the idea of equipment being installed<br>○ Concerns about the size or impact of the monitoring or control equipment<br>○ They don't want overlap between trial and existing energy saving/environmental impacts<br>○ They do not have the power to make the decision to take part – for example they may have a landlord or contract for their electricity through a broker<br>**Domestic - Internal**<br>• Householders were reluctant to change their heating system to a heat pump. The main reasons for this were<br>○ They were happy with their existing system<br>○ They were not sure about the technology<br>○ They did not want the upheaval of having either their heating system or radiators replaced<br>**Domestic – External**<br>• Preliminary results suggest that ToU tariffs reduce early evening peaks, at least in the summer. However, there was a significant increase in demand after the peak rate period, i.e. the peak was moved rather than avoided. |
| UK5 | Low Carbon London | • Financial incentives were required to attract participants onto the Time of Use tariff scheme (£100 for signing up to the trial, £50 for completing the trial and final survey, and the promise that they will be reimbursed if their total electricity costs on the tariff are greater than they would have been on their previous tariff). This is unlikely to be sustainable under 'business as usual'.<br>• | **External**<br>• Conflicting and contradictory messages to electricity consumers effected recruitment rates. The media backdrop and messages from the energy regulator and Government calling for a simplification of energy tariffs made attempts to recruit participants onto a time of use tariff more difficult. |

| Ref. | Title | Key Learning Points – what aspects worked well and might be considered to be an example of 'best practice' | Key Barriers – what are the challenges going forwards |
|---|---|---|---|
| UK6 | New Thames Valley Vision | • Trial selling points that have assisted the recruitment of commercial customers include: service/benefits the company could gain, energy audit to identify potential energy savings, reduction in energy bill, local aspect of the trial, opportunity for Bracknell businesses only, link with the local council, positioning the project as a 'business in the community' initiative, asking for permission to check eligibility - thus positioning the project as selective and exclusive rather than in need of participants.<br>• A brief 'pre-audit' of a company's site was useful to enable companies to get a better understanding of the scheme and allow them to base decisions on figures relating to their own premises.<br>• A new commercial customer engagement framework helped the processing of companies interested in participating. | **Internal**<br>• Businesses did not respond well to:<br>o The source of funding for the project – the Low Carbon Network Fund, (businesses were adverse to taking Government money);<br>o The focus of the project - searching for sites to put trial kit in for a project<br>o Environmental benefits |
| UK7 | Sola Bristol | • The project is at an early stage and these results are not yet available. | |
| UK8 | Domestic Demand Side Management | • Project highlights the need for Technical Standards to support implementation. A standards paper is to be drawn up for Shetland to specify the minimum functionality and characteristics that equipment being installed on the island for Demand Side Management purposes should comply with. | **Internal**<br>• Customers did not always understand how to use their new technology, which impacted on the benefits. While some households used the new storage heaters in the way they were designed, programming them to come on in accordance with their movements, others used them more like panel heaters, using the boost function as they required heat. |
| UK9 | Sustainable Blacon | • The visual display unit was useful a prompt providing awareness of energy use.<br>• Householders reported that the visual display system helped them develop a better understanding of their energy consumption, allowing them to discover which appliances caused a spike in their electricity consumption.<br>• The education programme was credited by participants for helping to instil good behaviour practices such as turning of lights or appliances when not in use. | **Internal**<br>• Householders who received an alert system failed to utilise it to its full potential particularly the control functions that allowed the remote control of appliances. |

The case studies in different geographic areas have tended to concentrate on different technologies and methods to alter consumer behaviour. Trials in the USA and Australia have largely focussed on air conditioning; this is a major electrical load in these warmer climates. These trials usually focus on reducing electricity use during Critical Peak Periods, usually on hot days when above average use of air conditioners puts stresses on local electricity distribution networks and generation [INT2, INT3, INT4, INT6, INT7]. In Europe CPP has also been used to reduce loads due to very cold days in areas where electric heating dominates [SE1 and SE2].

In the UK, no single electricity load currently dominates household consumption. Trials have centred around the use of Time of Use tariffs to attempt to influence general consumption of all appliances, rather than a single dominant appliance [UK1, UK2, UK4(some cells), UK5]. Trials elsewhere in Europe have demonstrated that peak load reductions can be obtained from customers with electric heating (i.e. a large, single controllable load) [NO1].

In Europe and the UK, a number of schemes are investigating the potential of heat pumps or other electrical heating and hot water systems to provide DSR, usually to provide a remotely controllable resource. In the UK ownership of heat pumps is presently low but expected to increase, especially in areas that are not on the gas network. Heat pump cells were to be included in some of the UK Low Carbon Network Fund (LCNF) trials [UK4, UK5]. However, delays in government funding for the technology support mechanism have resulted in a smaller number of installations than was expected and therefore less opportunity to recruit and monitor them in trials. Opportunities to involve hot water control technologies as part of these trials has also been limited in the UK because the majority of households who heat their water using electricity are already on Time of Use profiles such as Economy 7 or 10 [UK4]. There are trials underway in mainland Europe looking into the potential of heat pumps and other electric heating and hot water technologies to be used for DSR purposes however no results are available yet [INT5, INT6, INT7 and INT8]. Positive results have been obtained from a number of trials [NO1, SE2 and NL2].

In the UK, LCNF trials are currently underway. These trials are investigating non-conventional methods of managing the electricity network. Some of the LCNF trials have DSR aspects included in them [UK4, UK5, UK6, UK7]. At the time of writing, few results had been published. These trials have the potential to provide an important source of information in the future.

Only one completed trial analysed the ability of SME companies to alter their electricity usage [INT5]. Some of the LCNF trials will be investigating this area. Early results tend to suggest that it is difficult to recruit SMEs into trials because of the perception that they cannot move their electricity consumption without compromising productivity [UK4, UK6].

Some trials have investigated participants' willingness to change their behaviour, or allow their consumption to be controlled for societal benefit, without any individual reward other than the reduced risk that they could suffer a blackout [INT1, INT7]. When the reason why the behaviour change is required has been explained, consumers have demonstrated willingness to participate, either by reducing their consumption on specific occasions, as in Brittany, or as in Australia, by ceding control of their air conditioning unit for a short period of time. Specific issues have motivated participation in both schemes – in Australia an increase in the installation of air conditioning units has put stress on the distribution network, whereas in Brittany the peninsular has limited transmission connections to the rest of France, and locals are adverse to the construction of a nuclear power station in the region. A marketing campaign was used in the Australian example to change the community attitude and was successful in recruiting customers [INT7]. The motivation for taking part in DSR initiatives has been studied in a number of the case studies. This tends not to be purely financial; with other reasons included energy security, environmental concerns, interest in new technology and seeing reducing consumption as a “challenge”.

Barriers to taking part have also been studied. Inconvenience relating to the installation of equipment (particularly where access to the home was required) has been cited in some trials [INT7].

# 5 Conclusions

This Sub-Task sought to explore customer attitudes and beliefs towards Smart Grid related initiatives via the analysis of both consumer surveys and case studies. The overall aim of this part of the project was to explore whether customers are willing to accept Smart Grid related interventions, and the extent to which they are able to actively engage in Smart Grid initiatives.

This investigation of Smart Grid research has revealed that there is a high level of useful activity in this area at the time of writing, for example the Low Carbon Network Fund Trials underway in the UK. Many useful projects were identified and investigated both within the participating countries and elsewhere. A number of the trials that were identified as part of this project are still on-going but were nonetheless able to provide interesting learning points, for example about problems or successes they experienced recruiting participants onto their propositions. These on-going trials should provide further valuable results in the coming months and years.

The results reported by trials have a tendency to concentrate on technical know-how and measured changes to consumption. Very few provide detailed information on customer perspectives, i.e. consumer interaction with and attitudes. In particular, there has been little focus on issues of concern to customers and the aspects disliked. However, the combination of case studies and consumer surveys reviewed in this project has drawn together a significant amount of information on customer opinions and behaviours relating to Smart Grid related activities.

The key learning points gained from the analysis of the consumer surveys and the case studies are summarised in the following Sections.

## 5.1 Initiative Readiness Levels and Market Readiness Levels

IRLs have been used to assess the state of the Smart Grid related initiative in terms of its *'technical'* readiness. Initiatives at the higher end of this scale have been qualified through multiple trials and may be being used as 'Business as Usual' (i.e. outside of trials). Those at the lower end of the IRL scale may only have just started to be developed, or are only being tested through very small scale pilots. However, IRLs do not assess the 'pull' from the market for any particular proposition, and so the willingness of customers to engage. A new scale has been developed to reflect this- MRLs.

The IRL and MRLs observed in the case studies are shown in Figure 5.1.

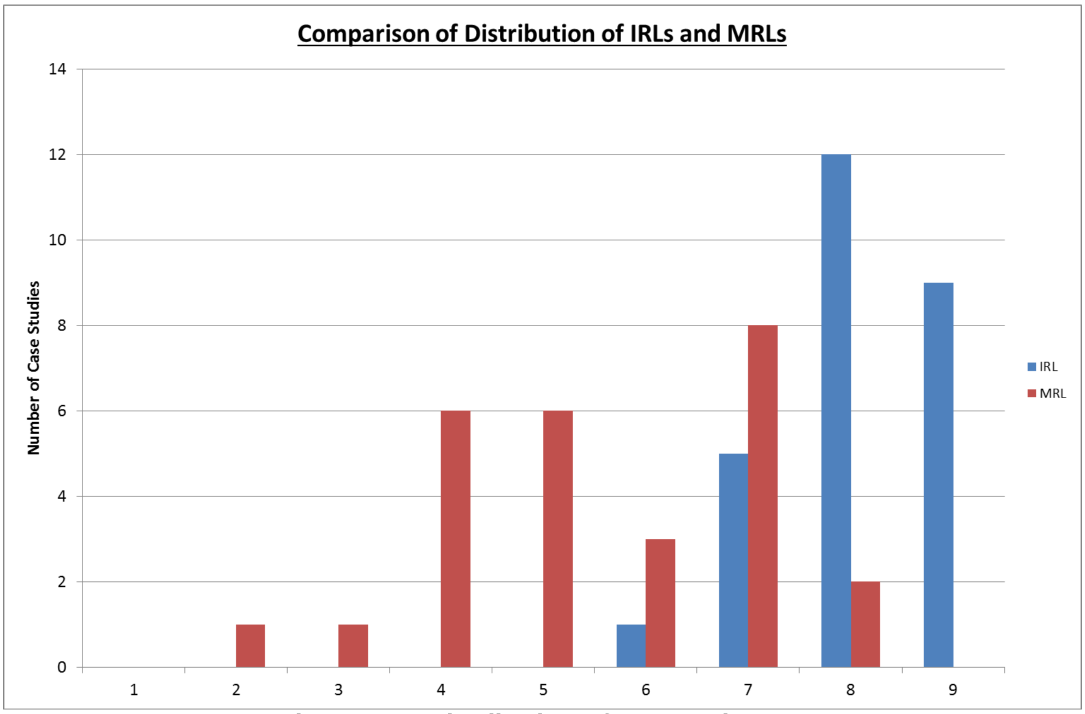



**Figure 5.1 Distribution of IRLs and MRLs**

The data shown in Figure 5.1 shows that there is a much greater range in MRL (2-8) than IRL (6-9). At a lower MRL the 'market pull' for any particular initiative is lower and consumer understanding is likely to be lower. At these lower MRL values, only 'early adopters' or particularly engaged consumers are likely to have an understanding of an initiative, or indeed have a desire to adopt the initiative.

It is important to note that a trial indicated as having a low MRL is characterised as one involving innovators and/or early adopters only. Therefore, the results of these trials will not necessarily scale if rolled out to the general population if implemented as a 'business as usual'. This is the chasm referred to in Section 2.2.

Many of the case studies investigated demonstrate that there is often a difference between the IRL and MRL, for example, technically mature technologies (which have been trialled and tested by innovators and early adopters) but which are not understood or wanted by the rest of the market (the early and later adopters). These early and late adopters tend to take a pragmatic approach, and are more inclined to follow others' behaviour, i.e. "if you have got one then I want one too" approach.

An assessment has been made of the difference between the IRL and MRL across the case studies; these results are presented in Figure 5.2.

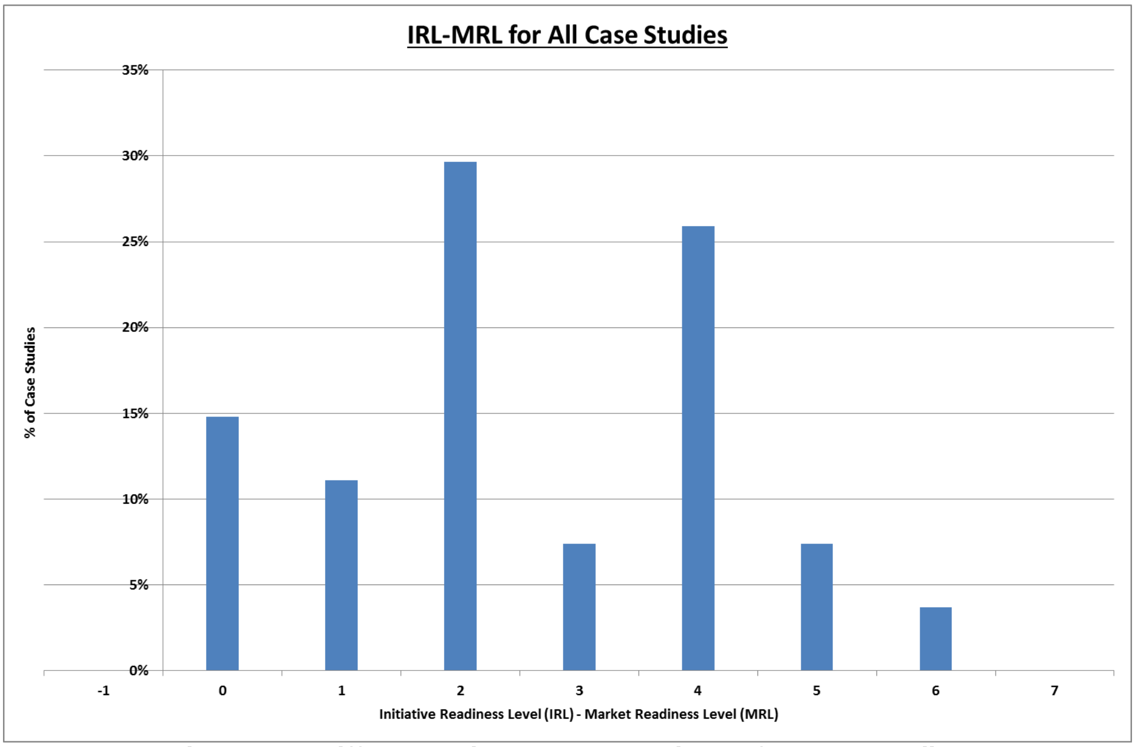



**Figure 5.2 Differences between IRL and MRL for Case Studies**

Figure 5.2 show how the difference between the IRL and the MRL varies for the case studies analysed. For the majority of the case studies (85%) the IRL is higher than the MRL, indicated by a positive value on the x-axis. There are no examples where the MRL exceeds the IRL. This is to be expected because Smart Grid initiatives are led by industry stakeholders, and are not being developed to meet a direct need for customers.

An examination of the difference between IRL and MRL for the different types of interventions (tariff, control, feedback and advice) has also been made. This reveals that case studies involving the implementation of 'Control' and 'Advice' initiatives account for all the case studies with a difference between IRL and MRL of 6. At first glance, this might suggest that customers are least ready to take up these initiatives. However, this is more likely to reflect the fact that these initiatives are regarded as key motivators for behaviour change, and are therefore being more actively pursued by industry stakeholders.

It is also interesting to note that the gap between MRL and IRL varies the most for case studies involving the provision of advice. This may be due to the methods used to provide advice, or the complexity of the information being provided, e.g. a very simple energy efficiency message in a bill vs. a complex web-based interface interacting with a ToU.

This 'gap' between IRL and MRL suggests that whilst many of the Smart Grid initiatives are well developed, and in many cases have been qualified through successful trial operations or full scale roll-out (78% either IRL 8 or 9), the market understanding of these propositions is much lower. This implies that focussing on the development of technologies alone, without addressing the needs of the market (i.e. consumers) introduces the risk that initiatives will not deliver the expected benefits.

Addressing this gap between the technical readiness of initiatives and market acceptance should be a priority in the further deployment of Smart Grids. This represents the chasm that must be crossed in order for consumers to have an active role in the implementation of effective Smart Grids. Crossing the chasm requires that Smart Grids meet the needs of consumers. If they do not, there is little likelihood that Smart Grid related initiatives will be taken up on a wide scale. This will be the focus of Sub-task 4 of this project, which will seek to identify examples of best practice to ensure that customer needs are addressed and that MRLs are increased. For example, at MRL 7 the benefits of initiatives are only sufficient to drive demand in niche markets, whilst at MRL 9 they are valued by the majority.

## 5.2 Customer Willingness

Customer willingness represents the inclination or disposition towards Smart Grid related initiatives, which depends upon a range of factors including those at the societal level (the external facilitators and barriers) and those at the individual level (awareness, attitude, social norms and self-efficacy). Whilst these influences are inevitably inter-linked, this report has focussed primarily on attitudes, social norms and self-efficacy and the resulting impact on willingness.

The different experience reported in terms of recruiting participants provides important evidence about consumer opinion of these types of schemes, and offers valuable insights into customer willingness.

Smaller trials have experienced comparatively few problems in the recruitment of participants. This suggests that they are able to tap into the resource of 'Innovators' and 'Early Adopters' who have a high level of interest and awareness of these trials and the associated background issues. It cannot be taken for granted that any roll-out to a larger number of participants would be as easy, or that the same results would be achievable. Effort must be put into ensuring that knowledge and understanding of Smart Grid interventions is disseminated across all customer groups within the market in order to increase the likelihood that mass roll-out can be achieved.

The trials have also shown that in order to recruit larger numbers of participants onto some schemes it has been necessary to provide them with assurances that they will not be financially worse off because they have participated. This is likely to be difficult to maintain in a Business-As-Usual scenario and suggests that at the moment most customers are not willing to enrol on schemes that may prove to be punitive.

Experience from some trials has shown that consumers are willing to participate in the schemes for no personal reward. In order to achieve this, the problem (e.g. requirement for additional capacity, or energy security concerns) appears to be well understood, and the participants have sympathy with the motives of the scheme. In these cases, it can be seen that the Smart Grid provides a solution to an existing problem. This is seen as an important factor in ensuring that disrupting technologies cross the chasm between the early market and the mass market.

Consumers also show a greater willingness to become involved in a scheme if there is a 'gadget' involved. Trials that offered participants devices that provide them with remote control of their household appliances and air conditioning have experienced more consumer willingness to become involved in the trial. This may be because the householders can see additional benefits to taking part, such as convenience and comfort or the kudos of having the 'latest gadget', as well as the ability to control their energy consumption to a greater degree. This may also suggest that customers are better motivated by other benefits offered by cutting edge technology rather than simply the ability to gain a better understanding of their energy consumption and potentially save money.

It may be possible therefore to conclude that there is consumer willingness to participate in Smart Grid initiatives, especially amongst 'Early Adopters'. However, the market is still at an early level (as evidenced by the MRLs described above). In order for these schemes to achieve mass roll-out it is important that thought and effort be put into information dissemination and explanation.

## 5.3 Customer Engagement

The extent to which customers were actively engaged in an initiative (i.e. the extent to which their energy consumption behaviour and their approach to energy consumption in general changed) provides a measure of its effectiveness. This includes both quantitative (e.g. reduction in total energy consumption or peak load) and qualitative elements (e.g. decision making processes, or aspects of the initiatives found most or least helpful). The level of customer engagement achieved has been reviewed in each of the case studies (where sufficient information was available) and this has been presented in Table 4.2.

It is especially difficult to extrapolate information about the degree of consumer engagement from the case studies reviewed in this project. The case study outputs (as reported) tend to focus on consumer engagement in terms of a quantitative saving or movement of load rather than the experience of consumers. For example, the percentage reduction in peak load or total energy will be reported, but participants are not asked to report *how* these savings were achieved or what was liked and/or disliked. Some of these gaps can be filled by the insight offered from the customer surveys (Section 3). For example, a number show interesting qualitative examples of household interaction with Smart Meters. Consumers have shown high levels of openness in their responses to these surveys and this provides unprecedented qualitative insights into their engagement with Smart Meters. A recommendation would be that qualitative survey work is undertaken within technological trials to understand the underlying behaviours. In addition, qualitative surveys should be commissioned to investigate householders' interaction and engagement with other technologies and schemes, or their attitudes to concepts.

Another challenge experienced is the ability to establish a causal link between changes in energy consumption behaviour and any given initiative. This often requires a larger trial involving the use of a carefully selected control group. Without suitable data showing a link between cause and effect in trials, it becomes more difficult to show the true effectiveness of initiatives.

It is also important to note that households do not always engage with interventions in the manner that is expected. Some trials have achieved a reduction in peak demand, but have then observed the creation of a new spike in demand after the original peak. Other schemes have found consumers did not engage as much as they expected. This may be because of societal or climatic reasons or just that the market is less developed in a locality than they had expected. This suggests that it is not necessarily valid to assume that the results from one trial can be automatically translated to another customer group or locality. For example, there is always the possibility of a rebound effect, where the benefits of energy saving in one area are used to increase energy use in another.

## 5.4 Major Barriers Identified

Full details of the barriers identified in each of the case studies are given in the templates in Appendix C. These barriers, which are also summarised in Table 4.3 are wide ranging. Some were due to specific elements of the trial (e.g. technology, or country-specific issues). This section, however, aims to highlight those barriers that are more common across a number of different case studies, or those that are considered particularly relevant to the aims of Task 23.

The wide range of barriers identified in Table 4.3 have been summarised in a 'word cloud' (where the size of the word indicates the frequency with which it has been used).

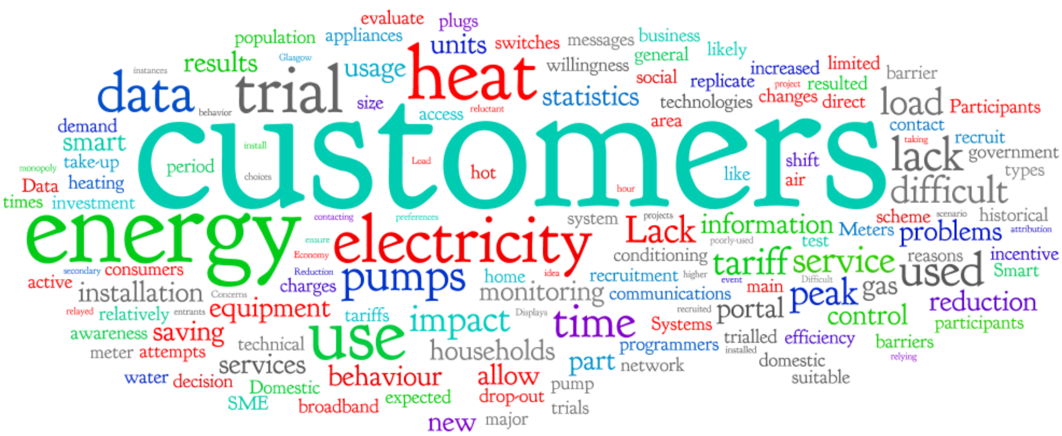



**Figure 5.3 'Word Cloud' of Barriers**[13]

The word cloud in Figure 5.3 demonstrates that no single barrier or concern dominates; rather there is a wide range of issues and challenges to overcome. This level of variety in the barriers is itself a useful conclusion, as it shows the difficulty in anticipating the way in which customers may react to any given intervention, and so how to counteract these potential barriers.

A number of the case studies did not focus on reporting barriers or difficulties experienced, particularly those relating to the customer. Without detailed involvement in these projects it is not possible to know whether there were no major barriers, or merely that any which did occur were not reported. It would be beneficial if case studies reported the difficulties they faced in order to allow these experiences to be learnt from other deployments. However, a number of key barriers have been identified as follows:

- **The replicability of results:** the case studies described within this Sub-Task are generally standalone and have not been repeated across different countries or types of customer. It is therefore not possible to determine how the results of any one trial would translate to wider adoption of Smart Grid interventions, for example in another country. In addition, many of the trials involve a small number of consumers who have chosen to take part. It is not clear how this level of engagement would change for trials including the whole population, due to differences in the attitudes of consumers (e.g. 'early adopters' vs. 'laggards').

[13] Created with www.wordle.net

- **The level of incentive available:** A number of trials have involved the provision of a financial incentive for taking part. In some cases, this incentive was not effective as it did not communicate a strong enough signal to customers. In trial environments, larger incentives have been offered to customers, which can be effective in the short term but would be difficult to translate to Business as Usual. Consideration should therefore be given to the value of the response to the party requiring it (e.g. the network operator) and what customers will expect to receive, in order to address any mismatch between the two.
- **Inflexibility (real or perceived) of SMEs:** A number of trials have sought to involve SMEs in providing demand response, but experienced difficulties in recruiting participants. This is often due to a perceived lack of available flexibility on the part of the customer, or concerns over any activity which may impact upon their core business. It may be possible to overcome perceived inflexibility but this can require significant resources to engage customers.
- **Selecting the most appropriate communication channels:** A large number of the case studies have used various methods to provide information to consumers (IHDs, smart phone apps, paper bills and internet portals). There is variability in customers' response to these communication channels. Some trials report little engagement between customers and web-based information, whilst others report that customers requested further information on the web portal and suggested other ways in which it could be used, suggesting a much higher level of engagement. The design of communication channels, and the most suitable medium for providing information, needs to be carefully considered based on the preference of the customers involved. This could require a degree of flexibility or customisation to allow the user to control the information they receive, rather than a 'one size fits all' approach.

# 6 Next Steps

This report has focussed on consumer interaction with Smart Grid related activities. In particular, it highlights customer attitudes and views towards a wide range of initiatives and the resultant impact on energy behaviour. This information will be combined with information gained from Sub-task 1 (which explored the external factors impacting customer behaviour) and Sub-task 3 (the impact of the way that customers assess risks and rewards on the decision making process).

Once Sub-tasks 1 to 3 are completed, all aspects of the energy behaviour model presented in Section 2.1 will have been investigated. The final step of the project is then to combine the information and knowledge to provide guidance to Smart Grid implementers on how to ensure Smart Grid propositions are attractive to the wider population, rather than only to innovators and early adopters. This is focus of the Sub-task 4 of Task 23.

# 7 Acknowledgements

The Operating Agent would like to gratefully acknowledge the following individuals for their support and contributions to the preparation of this report:

Chae,Yeoungjin, Korea Power Exchange, Korea

Duncan Yellen, EA Technology

Even Bjørnstad, Enova, Norway

Magnus Brolin, SP Technical Research Institute of Sweden, Sweden

Yvonne Boerakker, DNV Kema, Netherlands

# Appendices

## Appendix A Consumer Surveys

## Appendix B Case Study Template

## Appendix C Case Studies

## Appendix D IEA Demand Side Management Programme

# Appendix A Consumer Surveys

This Appendix provides a short summary of the various consumer surveys that have been reviewed as part of this project. Most surveys focus specifically on Smart Grid related measures, but a small number of other surveys are included that focus on related topics that are considered to provide interesting lessons for Task 23 such as sustainability, travel and climate change.

The following provides a list of the consumer surveys that were reviewed.

| Ref. | Country | Panel Size | Title |
|---|---|---|---|
| CS 1 | UK | | Retail Market Review: Domestic Proposals |
| CS 2 | UK | 100 | Consumer First Panel |
| CS 3 | Ireland(*) | 1,880 | 2009/10 research on residential and business attitudes and experience of the electricity market across the island or Ireland |
| CS 4 | Europe | | Consumer Attitudes to Electricity Disclosure in Europe |
| CS 5 | UK | | What makes People Recycle? An evaluation of Attitudes and Behaviour in London Western Riverside |
| CS 6 | UK | 1,000 | Public Attitudes towards climate change and the impact of transport, 2010 |
| CS 7 | USA | | Public Perception of energy consumption savings |
| CS 8 | UK | 56 | Motivators and barriers to successful public participation in community-based carbon reduction programmes |
| CS 9 | UK | | The Effectiveness of feedback on Energy Consumption – A review for DEFRA of the literature on metering, billing and displays |
| CS 10 | UK | 2,396 | Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters |
| CS 11 | UK | 2,159 | Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters (Wave 2) |
| CS 12 | UK | 120 | Smart Meters: research into public attitudes |
| CS 13 | UK | | Smart for All – Understanding consumer vulnerability during the experience of smart meter installation |
| CS 14 | UK | 2,704 | Role of Community Groups in Smart Metering-Related Energy Efficiency Activities |
| CS 15 | UK | 2,000 | Demand Side Management: A Discussion Paper |
| CS 16 | UK | | Demand Side Response in the non-domestic sector |
| CS 17 | Germany | 29 | Smart Homes as a Means to Sustainable Energy Consumption: A Study of Consumer Perceptions |
| CS 18 | UK | 1,000 | An Easier Life at Home? 'Selling' the Green Deal to UK households |
| CS 19 | UK | 5,914 | Customer Experiences Of Time of Use Tariffs |
| CS 20 | International | 9,108 | Understanding Consumer Preferences in Energy Efficiency Accenture end-use consumer observatory |
| CS 21 | International | 10,200 | Revealing the Values of the New Energy Consumer – Accenture end-consumer observatory on electricity management 2011 |
| CS 22 | Sweden | 3,000 | Ladda Sverige – Survey on Perception of Electricity and Climate in Sweden |
| CS 23 | UK | 1,000 | Demand Side Response research |

## CS 1. Ofgem Retail Market Review

| Title: | Retail Market Review: Domestic Proposals (Ref 166/11) |
|---|---|
| Date: | December 2011 |
| Organisation(s): | Ofgem |
| Country | UK (Great Britain) |

This review focussed on identifying changes to improve the level of engagement of domestic electricity consumers in the retail market in GB. The primary focus was on determining what could be done to make it easier for consumers to choose the tariff that is most appropriate for them.

Some of the findings of the review included:

- Consumers were disillusioned by the retail market and were frustrated at rises in electricity prices.
- Consumers that do try to switch to an alternative supplier, find it difficult to make a well informed choice. In some cases, this leads to consumers switching to a more expensive tariff.
- The current large number of energy tariffs and the complex structure of many, act as a barrier to effective consumer engagement in the market.

Consumers indicated that they would be more likely to switch suppliers if it was easier to make comparisons between tariffs. For example, a common standing charge and price comparison metric was preferred.

It is worth noting, that a number of price comparison web-sites exist in the UK that provide consumers with up-to date comparisons of energy tariffs offered by a wide range of energy providers. However, these sites typically require annual energy consumption estimates to be entered, for which annual price comparisons are provided. Small changes in annual energy consumptions can often lead to different energy suppliers being identified as the cheapest. Although tariff information must be provided by all energy retailers, accessing it is not always straightforward.

The conclusions of the Consultation called for the following changes:

- Suppliers should only offer one standard tariff per payment method
- Ofgem should set a standardised element for all standard tariffs
- Suppliers should compete on a single unit-rate for each standard tariff
- All non-standard tariffs should be for a fixed duration with no automatic contract roll-over
- The prices, terms and conditions for non-standard tariffs should be guaranteed for the duration of the contract

Further work is required to understand the interaction between these proposals and new, innovative time of use tariffs.

In November 2012, the Government announced plans to put these proposals into action. As a result, energy suppliers will be expected to move consumers to the tariff that is the cheapest for them.

## CS 2. Consumer First Panel

| Title: | Consumer First Panel |
|---|---|
| Organisation(s): | Ofgem |
| Country | UK (Great Britain) |

A panel of 100 domestic consumers has been recruited from across Great Britain to help the Energy Regulator, Ofgem, to better understand the views of consumers. The panel members are selected so as to be demographically representative of the GB population (as far as is possible for a panel of 100 members).

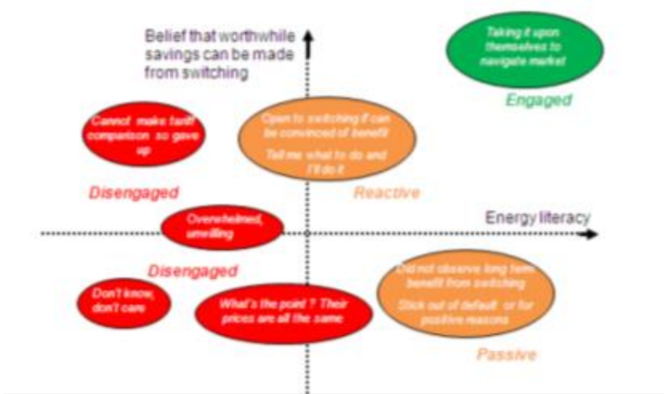
The panel has been running since 2008. A series of workshops are held each year to explore the views / perspectives of the panel members on a selected topic.

The second series of workshops (2009) focussed on understanding attitudes to home energy use and experiences of switching Suppliers. The workshop also examined views on what types of information they would like to see on their energy bills. The results showed that (in general) consumers thought their bills were very confusing. The types of information that they would like to see on their bills included

- an assessment of whether they are a low/medium/high user
- information showing the tangible meaning of 1kWh of electricity
- information on alternative tariffs

The third series of workshops (2010) focussed on gauging consumers' understanding of and interest in Distribution Network Operators (DNOs). Despite having been previously informed about DNOs, there was little spontaneous recall of DNOs. More worryingly, the findings reported little interest in finding out more about DNOs.

The fourth series of workshops (2011) was designed to understand the key pieces of information energy consumers need to help them review their energy options, and how consumers would prefer this information to be presented. The workshops showed that the degree of engagement by consumers was shaped by two key factors, energy literacy and the belief that worthwhile savings can be made, as summarised below:




This investigation into the views on barriers to engagement in the energy market highlighted many concerns over excessive profit-making in the energy retail sector. There was significant concern over high energy prices however consumers considered that there was little incentive to switch their energy provider. They perceived that prices were similarly high for all energy retailers, and thus there was little opportunity to make any savings.

## CS 3. Attitudes and experience of the electricity market across the island of Ireland

| Title: | 2009/2010 research on residential and business attitudes and experience of the electricity market across the island of Ireland |
|---|---|
| Date: | 2009/2010 |
| Published by | CER (Ireland) and Utility Regulator (Northern Ireland) |
| Country | Republic of Ireland and Northern Ireland (The island of Ireland) |

The Research Perspective Limited was commissioned to investigate the attitudes and experiences of residential, small business (SME) and Large Energy Users (LEU) to the electricity markets across the island of Ireland. The sample sizes were 780 residential customers in Republic of Ireland (RoI), 750 residential customers in Northern Ireland (NI), 400 SME from both markets and 150 LEU from RoI and 100 from NI.

The research identified that there was confusion, especially amongst residential customers, but also SME customers, about the different roles within the electricity industry. This confusion was a potential inhibitor preventing customers switching energy supplier. The factors that influenced the decisions of residential customers who had not recently swapped supplier are detailed in the table below:

| | Republic of Ireland | |
|---|---|---|
| | A factor | Not a factor |
| Like current service | 54% | 19% |
| No reason to | 46% | 28% |
| Concern about an alternative supplier's provision of a reliable electricity supply | 36% | 34% |
| Concern about an alternative supplier to be as responsive if there is a power outage | 35% | 35% |
| Do not believe that prices will remain as low as the alternative supplier claims | 35% | 32% |

The research discovered that customers who also had a gas supply were twice as likely as those who did not to switch electricity supplier. This was surmised to be because customers were aware of and trusted Bord Gais which neutralised some of the perceived barriers to switching.

Twenty six percent of the surveyed residential customers from RoI had switched electricity supplier. The most popular reason for switching was in order to save money. Most residential customers who had changed supplier found the process easy and saved the amount that they expected. Forty percent of RoI and 20% of NI SME customers surveyed had switched electricity supplier. A similarly high level of satisfaction was reported amongst these customers.

Residential customers were then asked about the likelihood that they would switch to a Smart Meter related tariff that would have the added functionality of an In-Home Display, on line bills with clearly displayed consumption information, printed bills with clearly displayed consumption functionality and a Time-of-Use tariff. The chart below shows the percentage of residential respondents who would be willing to switch Supplier to gain extra functionality and tariff structure.

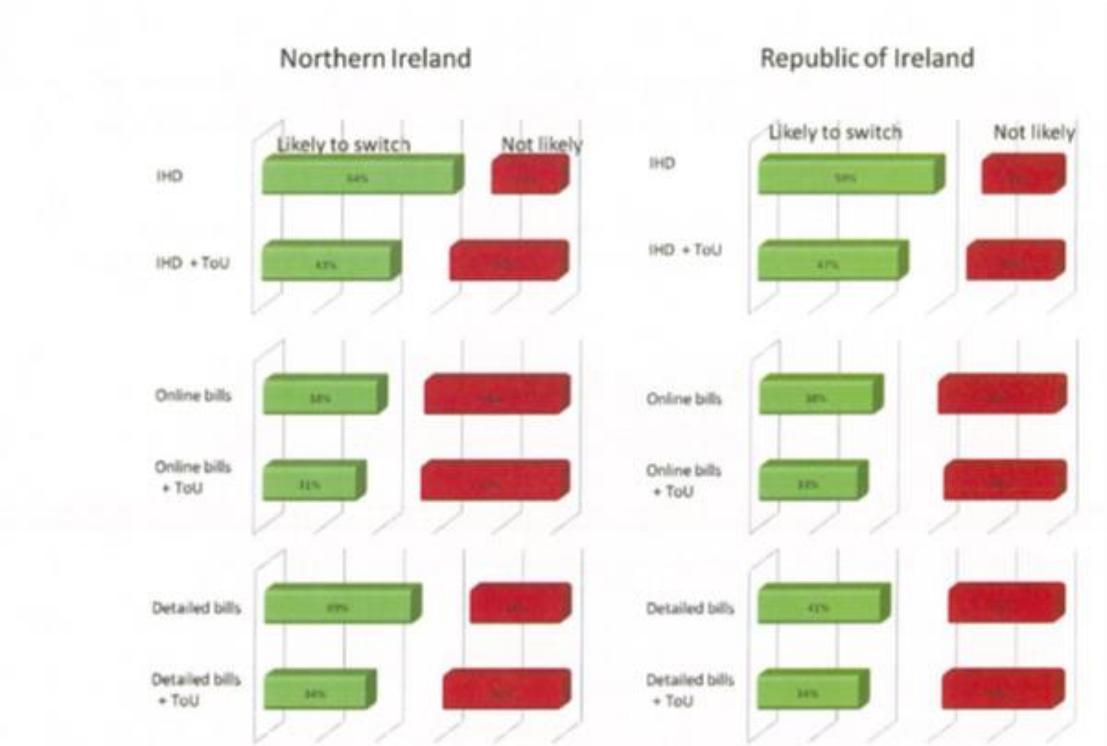



**Figure 49: Percentage of residential respondents who stated that they would switch to if each offer was available from an alternative electricity supplier**

The following reasons were given for not wanting to switch to the new deal.

| Reason for not switching to gain benefit | NI | RoI |
|---|---|---|
| I don't believe that I would be able to reduce my bill | 57% | 26% |
| It would be too inconvenient to change when I use electricity | 21% | 24% |
| I do not want to be told when I can use electricity or not | 14% | 21% |
| I have little control over how much electricity I use during peak hours | 12% | 17% |
| I am not interested in changing when I use electricity in order to reduce my bill | 11% | 17% |
| I don't know enough about when I use electricity to know how to change when I use it | 11% | 16% |
| Other | 28% | 6% |

## CS 4. Consumer Attitudes to Electricity Disclosure in Europe

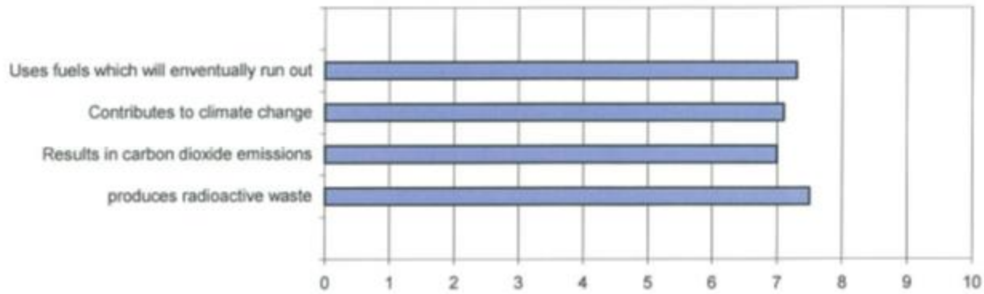
| | |
|---|---|
| Title: | Consumer Attitudes to Electricity Disclosure in Europe |
| Date: | 2003 |
| Published by | EU Altener program |
| Country | Europe |

This report makes up part of the "Consumer Choice and Carbon Consciousness for Electricity (4C Electricity) project performed as part of the EU Altener program. The program was investigating consumer interest in and requirements of carbon labelling for electricity. Focus groups were held with domestic and SME electricity customers in Austria, Germany, Hungary, Sweden and the United Kingdom. A further 1,000 SME and 2,000 domestic electricity customers in Austria, France, Germany, Greece, Hungary, Italy, Poland, Spain, Sweden and the UK were interviewed by telephone. Interviews were carried out with large electricity users in Austria, Germany, Hungary, Sweden and the UK.

The survey suggests that electricity consumers would like more information than just price when choosing an electricity supplier. Domestic and SME electricity consumers favoured a label showing the environmental impact and the fuel mix of their electricity. They also wanted to know the country of origin and proportion of any imported electricity. The majority surveyed also suggested that comparative information about their fuel mix would be useful however there was no consensus as to whether this should be by company profile, country average or European average.

Householders and SME's expressed a preference to purchase electricity generated from renewable sources rather than coal, gas or nuclear. Fifty percent of households and SME's suggested that they would be willing to pay up to 5% more for their electricity if it was associated with low impact on climate change or no nuclear waste however less than 30% of respondents were unwilling to pay any extra at all.

The two charts below show the level of concern amongst domestic electricity customers and SME about the consequences of electricity generation.




.Figure 6 Level of concern about the consequences of electricity generation – domestic consumers

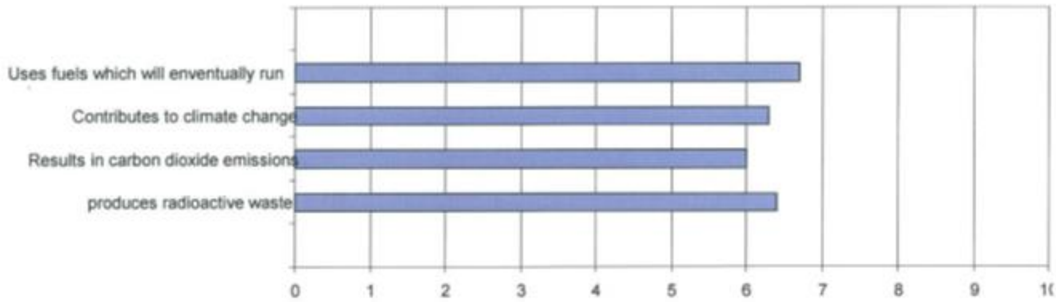



Figure 7 Level of concern about the consequences of electricity generation – SMEs

The most popular method of receiving information about the generation source of their electricity was with their electricity bill with more than half customers questioned expressing a preference to receive information this way. A third of customers suggested that they would like to receive the information in an annual report, and nearly 15% suggested that they would like to receive it through the internet. There was also support for a means to compare the electricity mix of different electricity suppliers when making a decision about changing electricity supplier.

## CS 5. What Makes People Recycle? An evaluation of Attitudes and Behaviour in London Western Riverside

| Title: | What Makes People Recycle? An evaluation of Attitudes and Behaviour in London Western Riverside |
|---|---|
| Date: | 2003 |
| Published by | The Open University, MORI Social Research Institute |
| Country | UK |

This paper investigates the determinants of residents' recycling behaviour in the London boroughs of Lambeth, Hammersmith and Fulham, Kensington and Chelsea and Wandsworth in 2001. The survey highlighted the importance of convenience and information/ education as behaviour motivators.

The importance of making recycling facilities convenient and reliable was highlighted as a barrier stopping residents recycling their rubbish. Residents with access to kerbside collection, or good nearby facilities were more likely to participate in recycling. The importance of this service being delivered properly and to a high standard was also emphasised.

The information that potential recyclers wanted in order to participate further was different for different types of people. This has implications for marketing campaigns which should be delivering different messages to different niche markets. Important messages that required communicating include:

- Householders want to be told why they are recycling – what are the environmental benefits?
- How individual actions make a difference,
- Householders want to know that the rubbish that they sort is going to be recycled,
- Householders want to know which items can be recycled and what they have to do with it for it to be recycled.

Those who recycled infrequently or not at all saw recycling as a hassle for them or that it was not cool. Those who recycled more frequently liked the feeling that they were doing the right thing.

Another theme mentioned was that householders did not think that individuals should be the only groups taking action. Businesses, government and supermarkets should share responsibility for the problem and help to tackle it.

The conclusions from this survey could easily be translated to the electricity industry. Householders will take actions, however the reasons why they need to do something needs to be properly explained and it needs to be made easy for them. They need to know that even their little contribution is important, and that business and government are also contributing towards tackling the problem.

## CS 6. Public attitudes towards climate change and the impact of transport

| | |
|---|---|
| Title: | Public Attitudes towards climate change and the impact of transport: 2010 |
| Date: | 2011 |
| Published by | Office for National Statistics |
| Country | UK |

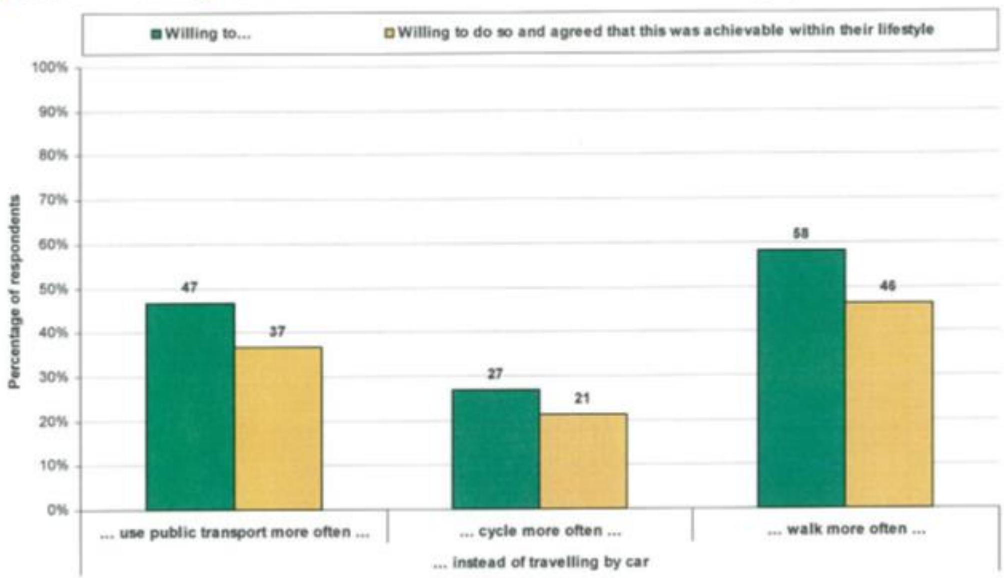
This report was based on random probability interviews with adults over the age of 16 in private households in Great Britain. Surveys of over one thousand respondents have been carried out every year in August from 2006 to 2010 with an extra survey in February 2008. The 2010 survey focused less on attitudes to climate change than previous surveys, concentrating more on respondent's attitude to changing their travel behaviour to limit the impact on climate change.

Between 2006 and 2010 the proportion of adults who were at least 'fairly concerned' about climate change has reduced from 81% to 70%. Graduates were significantly more likely to be at least fairly concerned about climate change than non-graduates. Eighty-seven percent of those who were at least fairly concerned about climate change were willing to modify their behaviour in some way to help limit climate change, compared to only 39% of those with little or no concern.

The proportion of respondents who thought that emissions from road transport contributed to climate change had reduced from 72% in 2006 to 59% in 2010.

Forty-six percent of those surveyed were willing to reduce the amount that they travelled by car. Forty-seven percent were willing to use public transport more often instead of making a car journey. Twenty-seven percent were willing to cycle instead of making a car journey, while 58% would walk in preference to making a car journey. The chart below shows a comparison between those surveyed who were willing to use another mode of transport, and whether they were willing and able to use another form of transport within their lifestyle.

Figure 2.5 Willingness to use other modes more often instead of travelling by car



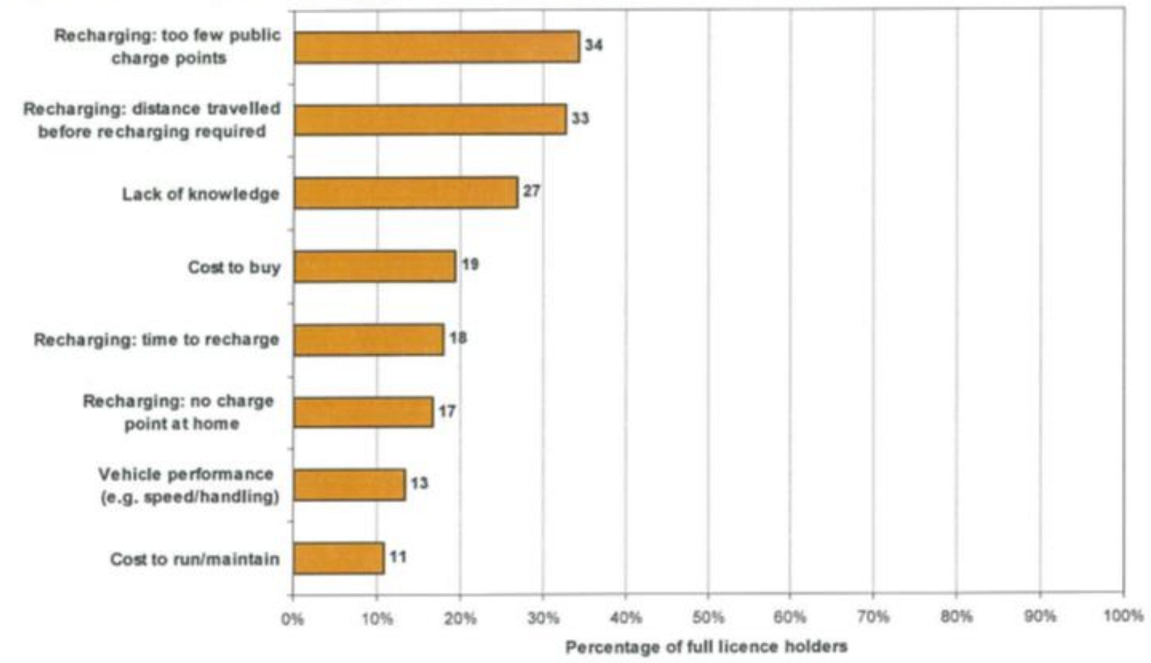

Source: Opinions Survey – 2010.
Base number: public transport = 995; cycling = 993; walking = 994.

There was strong opposition to fuel tax rises or other charges being increased to encourage people to travel by car less, but there was support for greater tax spending on public transport to encourage increased use, even amongst those who did not use it often or were unwilling to use it more.

When asked if they would be willing to drive more slowly on the motorway in order to reduce $CO_2$ emissions from their car, 59% were at least fairly willing. Female drivers were more willing to find this acceptable (65%) than male drivers (54%).

Drivers were then asked about their knowledge of electric vehicles. Forty-five percent reported to have at least a little knowledge (57% of men and 33% of women). The chart below shows the main perceived barriers to purchasing an electric vehicle. Issues surrounding recharging the vehicle are perceived to present the biggest obstacle.

**Figure 4.5 The main perceived barriers to purchasing electric car/vans**




Source: Opinions Survey – 2010.
This is based on full license holders who had heard of electric cars prior to being surveyed (98% of full licence holders).
Respondents could choose more than one response and were not prompted with a list of possible responses.
Other less common responses, not included in the chart included: "technology: doesn't work/not proven", "nothing", "size of vehicles/practicality", "appearance of vehicles/image", "don't know", "no environmental benefits", "safety".
Base number: 720.

The most popular encouragement that would persuade drivers to consider buying an electric vehicle was cost related: to run/maintain (27%), subsidies, tax reductions or grants (27%) cost to buy (23%).

## CS 7. Public perception of energy consumption savings[1]

| Title | Public perception of energy consumption savings |
|---|---|
| Authors: | Attari, DeKay, Davidson, Bruine de Bruin |
| Source: | PNAS Early Edition, www.pnas.org/cgi/doi/10.1073/pnas.1001509107 |
| Country | USA |

An online survey was conducted by a team of researchers from three US universities to explore consumer understanding of how much energy they use for certain activities, and the potential opportunities for making energy savings.

Some of the survey findings are summarised below.

Respondents were asked to describe the most effective thing that they could do to conserve energy. The responses were divided into the following two categories:

- Those involving curtailment actions (i.e. turning lights off)
- Those involving efficiency actions (i.e. using energy efficient light bulbs)

The results showed that 55% of respondents mentioned curtailment activities, compared to only 11% that mentioned energy efficiency improvements. The authors note that energy efficiency activities are considered to generally save more energy, highlighting the fact that users do not necessarily understand what actions they can take to have the biggest impact on energy consumption.

Participants were also asked to estimate how much energy was used by nine appliances, and the energy savings that could be achieved by undertaking six activities. Analysis of the correlation between these perceptions and actual energy use showed that users underestimated energy use and potential savings by a factor of 2.8 on average. More interestingly, the underestimates were small for low energy activities but large for high energy activities. It is important to note, that this study did not focus solely on energy consumption activities within the home, but included energy behaviours such as transporting goods by train vs truck.

The results also showed that those respondents with higher numeracy skills and those with stronger pro-environmental views had more accurate perceptions, in line with other research findings.

One of the main conclusions was that the consumers who took part in the study had a relatively poor knowledge of the comparative energy use and potential savings relating to certain behaviours. The participants were overly focussed on curtailment activities, rather than the more effective energy efficiency activities. It is suggested that this could be due to the additional effort and costs associated with researching and purchasing energy efficient appliances.

[1] Public perceptions of energy consumption and savings; Attari, DeKay, Davidson, Bruine de Bruin; PNAS Early Edition, 2010 accessible via

## CS 8. Survey of Non Participants in Ashton Hayes

| Title: | Motivators and barriers to successful public participation in community-based carbon reduction programmes |
|---|---|
| | PhD dissertation thesis, Institute of Energy and Sustainable Development Computing Sciences & Engineering, De Montfort University: Leicester |
| Date: | 2007 |
| Authors: | Gerard Joseph Edwards |
| Country | UK |

Ashton Hayes is a small village in the North West of England that is aiming to be England's first carbon neutral community. The village comprises some 350 households, and to date the community has achieved a 23% reduction in $CO_2$ emissions.

Despite a number of community events to engage households in the initiative, only 181 of the 350 households had participated in one or more of the activities. Thus, a survey was carried out to explore why the remaining households had not participated. A total of 56 households were surveyed, with 18 refusing to take part with no reason provided. The following provides an overview of some of the responses provided by the 56 households who did take part in the one-to-one interviews.

Households were asked about the number of environmentally friendly behaviours (EFBs) they regularly performed. All claimed to be performing at least one EFB, with the average at 3.82. The majority (82%) indicated they were interested in climate change.

Only one household was unaware of the Going Carbon Neutral Initiative ongoing at Ashton Hayes.

A total of 20 households were aware and were taking part in EFBs because of the initiative, even though they had not directly participated in any of the community events. Some indicated that their interest in EFBs predated the Going Carbon Neutral Initiative, and did not result from publicity surrounding the initiative. The survey showed that these households did have a high level of engagement with other participants, which led to motivation to take part in EFBs.

Householders were asked to comment on whether they thought that they knew what to do about climate change. Here, the majority 30 out of 56 agreed that they did know what to do.

Lack of information was the main reason cited for not taking part in more environmentally friendly behaviours. In particular, households asked for information that was practical, detailed and also cost/benefit information.

Other significant barriers to participation were lack of time and the presence of other more important things preventing them from taking action (53.6% of respondents). The analysis confirmed that those that indicated they had a lack of time or other things to do did undertake fewer EFBs than households who did not think time was an issue.

Cost was not identified as a significant barrier to participation.

## CS 9. The Effectiveness of Feedback on Energy Consumption

| Title: | The Effectiveness of feedback on Energy Consumption – A review for DEFRA of the literature on metering, billing and direct displays |
|---|---|
| Author: | Sarah Darby |
| Date: | 2006 |
| Published by | Environmental Change Institute, University of Oxford |
| Country | International, with focus on UK |

This report provides a summary of the learning available from trials of methods to assist domestic energy consumers to reduce their energy consumption. The summary looked at international trials, but focused especially on available UK learning. The article considered the effectiveness of direct and indirect feedback and evidence that different methods provide long term evidence of behaviour change resulting in prolonged energy savings. There is a brief survey of the progression of understanding of the effect of feedback on domestic energy consumption amongst psychologists and sociologists. The article concludes that:

*". . . clear feedback is a necessary element in learning how to control fuel use more effectively over a long period of time and that instantaneous direct feedback in combination with frequent, accurate billing (a form of indirect feedback) is needed as a basis for sustained demand reduction. Thus feedback is useful on its own, as a self-teaching tool."*

'Direct Feedback' would be immediate information from a meter or an associated meter display (e.g. an IHD).

'Indirect Feedback' is feedback that has been processed before being presented to the end user, usually via billing.

Work investigating methods of indirect feedback suggests that billing based on accurate, frequent meter readings can achieve energy savings of about 10%. This rose to about 12% when consumption figures were compared with those from the same period the previous year. Another study that asked householders to provide regular meter readings to their utility, and provided informative billing resulted in prolonged energy savings for the customers involved. Three years after the trial had finished, those that had been involved were consuming 8% less electricity than the general population. The importance of accurate quarterly billing, based on actual meter readings rather than estimates was highlighted as particularly useful. Other work suggests that comparing a households consumption data with their historical consumption is more effective that comparisons with an assigned group.

Trials that investigated the effectiveness of direct displays separate from the meter suggest that these can achieve savings of around 10%. There is evidence that high energy users may respond better to this form of intervention than lower energy consumers.

Other measures such as key meters, or keypad meters for those on pre-payment tariffs have been shown to help householders reduce their electricity consumption because the householder is more aware of how much energy they are consuming. Displaying more complex information about energy consumption either on TV's or PC's has also been proven to help reduce energy use.

## CS 10. Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters

| Title: | Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters |
|---|---|
| Date: | 2012 |
| Organisation(s): | DECC |
| Country | UK |

This survey comprised 2,396 face to face interviews. It was weighted to provide nationally and regionally representative results by age, working status, region, social grade, household tenure and ethnicity within region.

A key finding of the survey was that only 49% of electricity bill payers had heard of Smart Meters. 51% of those who had heard about Smart Meters only claimed to know a little bit about them, whilst 24% said that they knew nothing. Only 25% of those who had heard of them claimed to know "a fair amount". Men generally claimed to know more about Smart Meters than women.

Five per cent of respondents claimed to have had a Smart Meter fitted already, although the report authors believe that some of these respondents were confusing Smart Meters with In Home Displays (IHDs). One third of respondents were in favour of the installation of Smart Meters in every home in the country, while one fifth were opposed. Interest in having a Smart Meter installed was greatest amongst younger respondents (18 to 34 year olds), higher social grade, higher incomes, higher levels of qualifications, those most interested in climate change and those who are concerned about their energy bills and personal finances.

When asked if they could think of at least one benefit of having a Smart Meter installed, 61% of respondents could spontaneously think of an advantage, 22% could not think of anything, and 17% did not know. The benefits spontaneously mentioned included:

- Being able to budget a bit better (33%)
- Avoiding waste (26%)
- More accurate billing (19%)
- Avoiding having the meter read (9%)
- Doing their bit for the environment (8%)

When asked to spontaneously name one disadvantage of having a Smart Meter installed, 40% respondents could name a disadvantage, 41% said that there were no disadvantages, and 19% could not think of a disadvantage. The most frequently mentioned disadvantage mentioned was cost (either to themselves through higher energy bills, for the energy companies or for the taxpayer or government)(19%), that the data would be misused (10%), that the Smart Meter would be difficult to use (7%) or the inconvenience of having the meter installed (6%).

Forty-eight percent of respondents who claimed to have had a Smart Meter fitted were satisfied with the overall experience of using the Smart Meter.

Sixteen percent of bill payers claimed to have an In Home Display (IHD). Of those who had one, 56% claim to look at it, 22% never look at it and 22% have never installed it. Of those who look at their IHD, 51% checked the kilo-watt measurement, 46% looked at the money display and 8% checked the carbon saving measure. Four percent did not know what they were looking for on the display. Most customers who owned an IHD were positive about the effect on their household energy bills. Thirty-five percent regularly check the display when they are on their way in or out of the house, 55% have used the display to encourage other members of the household to reduce their energy use and 69% have used the display to discover which appliances use the most electricity.

## CS 11. Quantitative Research into Public Awareness, Attitudes, and Experiences of Smart Meters (Wave 2)

| | |
|---|---|
| Title: | Quantitative Research into Public Awareness, Attitudes and Experience of Smart Meters (Wave 2) |
| Date: | 2013 |
| Organisation(s): | DECC |
| Country | UK |

This survey was conducted during October 2012. 2,159 bill-paying adults were surveyed, weighted to be nationally and regionally representative.

The results from this survey suggest that there has been little change in either knowledge or attitude towards Smart Meters or IHD in the period between Wave 1 and Wave 2 questionnaires being conducted other than an increase in interest in information about Smart Meters and IHD.

A third questionnaire is due to be conducted in April 2013.

## CS 12. Smart Meters: research into public attitudes

| Title: | Smart Meters: research into public attitudes |
|---|---|
| Date: | 2012 |
| Authors: | Navigator for DECC |
| Country | UK |

One hundred and twenty respondents from England, Scotland and Wales were interviewed in a mixture of group discussions, home interviews and individual interviews. The sample was designed to incorporate a spread of respondents from different age/ life stage, socio-economic group, gender, private and social tenants and owner occupiers.

At the time that the survey was undertaken many of those questioned were being careful about how they spent their income because of the prevailing economic uncertainty. Energy Suppliers were viewed with cynicism. Respondents stated that it was no longer worth changing Energy Suppliers because the savings that could be made were marginal. Responses included:

> *"I'm not sure it's worth it any more. You change it and then you end up changing back, and you get all the talk about what they can do for home insurance, car insurance."*

And

> "*I've thought about changing again but it's so confusing, you get phone calls, 'we could save you £27 a year', but that's not worth bothering with."*

Respondents were therefore considering other options to reduce their energy bills such as turning off appliances and lights, turning the central heating down, only heating key rooms, improving home insulation, replacing old inefficient appliances and installing low voltage lighting.

> *"Insulation, definitely pleased, double cavity, lofts, this wall was single skin, I insulated it, used foil backboards . . .12V low voltage lighting, can dim it down and all the lights are low energy, and low wattage wherever they can be."*

Or

> *"We don't heat the hall or the landing, we have it on in the living room only, you go out of that room and it's freezing, but it's no big deal, we're all adults."*

This had led some respondents to consider their other consumption habits, or notice 'others' wasting energy.

When the householders who already had a IHD were questioned about them, most found them easy to install and had placed them in a central, easily visible location (although some older respondents displayed some confusion - some had put the display in their meter cupboard assuming it should be kept close to their meter or had felt the task of installing it was beyond them). Householders who owned IHD re-counted initial experiences such as:

> *"We had a lot of fun turning things on and off. Last night I think we got it down to 7."*

Some households reported making discoveries about how energy intensive certain appliances were while others had used it as a tool to educate other members of the family to become more energy aware. The IHD's capability to display consumption in £ and pence was also thought to be very useful. IHD's were an important educational device that children could relate to, either via colour changes for younger children, or financial messages for older children. They helped reduce the conflict when one member of a household was suggesting that another should act in a more energy efficient manner – it was the device telling the message, not the household member. None of the respondents reported having moved the IHD away from its prominent position, despite having had it for a little while. They felt that the IHDs had been instrumental in helping their household to learn better habits

> *"Habits in the house have changed, we don't leave computer screen on now, we turn them off instead of leaving them on screen saver, turn them off at night, laptops they turn them off at the plug, don't leave them on charge . . . and when kids took their clothes off at night, chuck them in washing machine, ½ load, but now when you see how much a washing machine can affect the level I wait till it's a full load, that makes a big difference."*

When asked for their opinions on Smart Meters, respondents showed a lack of clarity about their advantages but privacy and health issues were not major concerns. Concern was expressed about the cost of the roll out. At the time that this research was being conducted there was some uncertainty about whether households would be forced to have a Smart Meter fitted. Any compulsory approach was very unpopular.

## CS 13. Smart for All

| Title | Smart for All – Understanding consumer vulnerability during the experience of smart meters installation |
|---|---|
| Date: | November 2012 |
| Organisation(s): | RS Consulting, National Energy Action (NEA) and Consumer Focus on behalf of Department of Energy and Climate Change, |
| Country | UK (Great Britain) |

This survey was designed to specifically look at the experience of households that include vulnerable people who have had a Smart Meter installed. Thirty vulnerable households and six non-vulnerable households were interviewed. These interviews were either in-depth interviews in the householders home. The households meter swap was managed by one of two Electricity Supply companies, British Gas or E.ON – fifteen vulnerable householders, and three non-vulnerable householders from each.

A further eight focus groups were conducted; four groups with British Gas vulnerable customers, two with British Gas non-vulnerable customers, and two with E.ON vulnerable customers

The E.ON customers who were having Smart Meters installed had responded to a direct mailing offering them a Smart Meter. This mailing explained that Smart Meters were being rolled out across Great Britain and highlighted the advantages of the new meter. These customers had therefore 'opted-in' to the process. The majority of these vulnerable E.ON customers had also been handled via a dedicated call-centre, designed to ensure that their Smart Meter installation took account of their particular needs.

The British Gas customers by contrast were part of an 'end-of-life meter exchange'. They were informed either by a letter and/or call informing them that their meter required replacing and making an appointment. Vulnerable customers were handled via the same call handling team and process as non-vulnerable customers.

The householders who had opted to have their meters replaced were happy with the pre-installation communication and phone call that they received. They understood the benefits of the new meter and the call answered any queries they may have. Medical conditions were covered in at least two thirds of calls and most were told how long the visit would take. Those householders who were receiving an end of life exchange generally did not receive a letter prior to the phone call making the appointment to change their meter. A third did not recall hearing the term 'smart meter' during this phone call. They had less understanding of what a smart meter was prior to installation however this lack of information was not important to them. The support needs of these customers were not assessed.

Most customers were happy with the installation of the new meter. Most of the householders were also happy with the security arrangements, personality and tidiness of the installer, period without electricity and checks once energy was re-established. Generally the installations took under two hours except in cases when problems were encountered.
Most of the customers were given a demonstration of the In Home Display unit and many were happy with this demonstration immediately after the installation, for example:

> "*Yes, explained a little bit about them. How to check what electricity I'm using on a daily basis, cost per hour, emissions that we're sending off and the same with gas. Noticed the oven sent it red – I was chuffed that most of the time it stayed on green."*
> (Customer who opted in, aged 39, physical and mental health conditions, children under 12 in household, receiving benefits)

Some did not grasp how the unit worked. They either thought that the demonstration was too quick or more frequently blamed themselves for not understanding what they had been shown. Many of the customers also felt that they were being given too much information at once for them to take in and retain.

> "*If I'd tried there and then to understand what was involved, I would probably have forgotten some of it anyway. I felt that I needed to try it before asking any more questions."*
> (Customer who opted in, aged 80+, physical health conditions, receiving benefits)

> "*If they could talk me through maybe more how to use those. It's probably very, very simple. Just a follow-up call would have been nice I suppose. It's more a man's thing normally isn't it, you know to check meters and . . . But I do everything here, I'm on my own now."*
> (End of life meter exchange customer, aged 59, physical and mental health conditions, receiving benefits, low income)

Following the installation, many of the customers had questions, especially about how to operate the In Home Display, however very few contacted their supplier. Most householders were left a booklet explaining how to use the In Home Display but few had got around to reading it. Some thought that a DVD would be a better alternative to the booklet. Some were also aware that they had not been told the cost of electricity that the In Home Display would use, however they had not contacted their supplier to find out this information.

Additional problems were encountered by some householders. One pensioner who spoke English as his third language had thought that the Smart Meter was an energy efficiency measure rather than a means of behaviour change and did not really understand the demonstration of his In Home Display. A working mother who lived with her two young children and mother who suffers from dementia had not been told during the phone call making the arrangements for the new meter to be fitted that it would be useful for her to be around for the In Home Display demonstration. When she got home from work she saw the In Home Display but her mother had no recollection of any demonstration. The householder put the display away in a draw straight away. She commented that had she known that the installation was going to be complicated she would have arranged to be around, and after having participated in a focus group she was curious about the In Home Display and would go home and play with it.

A few householders had not used the In Home Display and stated that they did not intend to. These customers were typically the frailest elderly customers and some with literacy and mental health issues. The majority of customers had changed their behaviour to reduce the amount of electricity they used such as putting less water in the kettle when making a drink.

"*You look at it, and you think, you ask yourself 'How can I stop it? Maybe I don't need to use that so often . . . Which I've done with the washing machine . . . I'm not frightened of it, I'm just glad. I'm rather pleased that I have it now."*
(End of life meter exchange customer, aged 74, physical health condition)

There did not appear to be any evidence of older householders adjusting their behaviour to a detrimental extent – they generally believed that they were energy efficient anyway and that there was little they could do to change their behaviour.

"*It's one of them things, you've got to have your heating on. You know, you can't do without heating, not when you're old people, you've got to have your heating on."*
(End of life meter exchange customer, aged 73, physical health conditions, receiving benefits, low income)

Older customers tended to express the view that Smart Meters would be of more use to the younger generation who had a careless attitude towards energy consumption.

*"The impact I think would be greater for younger households. They might become more careful . . . Our generation was more careful and less wasteful."*
(End of life meter exchange customer, aged 76, physical health conditions, receiving benefits, low literacy, low income)

Customers who had opted to have a Smart Meter installed felt more positive towards their energy supplier following the installation. Customers whose meter was replaced as part of the end of life meter exchange program also felt more positive towards their supplier, although to a lesser extent than the E.ON group.

## CS 14. Role of Community Groups in Smart Metering-Related Energy Efficiency Activities, DECC

| Title | Role of Community Groups in Smart Metering-Related Energy Efficiency Activities |
|---|---|
| **Date:** | **March 2013** |
| **Organisation(s):** | **Energy Saving Trust for Department of Energy & Climate Change** |
| **Country** | **UK (Great Britain)** |

The survey was distributed to 2,704 community contacts of the Energy Saving Trust. One hundred and seventy eight completed the questionnaire. Additionally 54 in-depth telephone interviews were conducted, some of which were with respondents who had completed the questionnaire and had given permission to be contacted for additional discussion.

The community groups who completed the questionnaire were involved in a variety of energy efficiency and renewable energy projects such as installing energy efficiency measures in homes and community buildings. The groups have a variety of expertise and links within communities.

The feedback from the survey identifies a role for voluntary organisations in smoothing the path for the installation of Smart Meters, familiarising householders with the In-Home Display and then helping them to make energy savings based on the information that it provides.

> "*Community groups are a good way to communicate this [the smart meter roll out] because people don't trust the energy companies, as they just see their bills going up all the time."*

Another respondent suggested that:

> *"I think the rationale behind smart meter roll out needs to be better articulated as I think there might be a fear within the community that this is a technical exercise designed by energy companies to save them money and sell more products."*

This mistrust could mean that householders are wary of letting energy company representatives into their homes.

## CS 15. Demand Side Response: A Discussion Paper

| Title | **Demand Side Response, A Discussion Paper** (Ref 82/10) |
|---|---|
| Date: | July 2010 |
| Organisation(s): | Ofgem |
| Country | UK (Great Britain) |

A nationally representative sample of approximately 2,000 consumers was interviewed in December 2009 to explore how likely they would be to undertake certain energy saving measures.

The research showed that there was considerable interest in shifting energy consumption to off-peak periods. In particular, measures such as heating water and using appliances at different times of the day were supported by over half of those interviewed (56% and 51% respectively). The use of automatic control to switch off appliances when prices were high was less popular, but even this was rated 'likely' by more people than those rating it 'unlikely'.

A sample of the results is shown below

| **Total number of participants** | **1,961** |
|---|---|
| Heat water at different times of the day | |
| Very/fairly likely | 56% |
| Very/fairly unlikely | 25% |
| Use certain appliances after midnight | |
| Very/fairly likely | 51% |
| Very/fairly unlikely | 33% |
| Install technology to automatically switch off appliances when prices are high | |
| Very/fairly likely | 47% |
| Very/fairly unlikely | 31% |
| Carry out chores such as cook meals in cheaper periods (e.g. after 7pm) | |
| Very/fairly likely | 41% |
| Very/fairly unlikely | 40% |
| Use electric storage heaters | |
| Very/fairly likely | 35% |
| Very/fairly unlikely | 47% |

## CS 16. Demand side response in the non-domestic sector

| Title: | Demand side response in the non domestic sector |
|---|---|
| Date: | 2012 |
| Published by | Element Energy, De Montfort University |
| Country | UK |

A study was carried out to understand the potential for reducing peak electricity demands, and the associated barriers to further DSR uptake in the non-domestic sector in the UK. The study comprised the following two elements;

- A consultation with energy consumers and other stakeholders to gather information on the current level of engagement with DSR and the barriers to uptake.
- A data modelling exercise to estimate the potential for DSR by non-domestic buildings.

The results of the consultation with energy consumers are summarised here.

Hundreds of organisations were invited to take part, which led to telephone interviews (typically lasting 45 to 60 minutes) with 16 organisations from a range of sectors.

Consumers were asked to describe the barriers to the uptake of DSR, and the responses were categorised into one of five types, as indicated below.

| Type | Response | Number of times cited |
|---|---|---|
| Cultural / institutional | Lack of awareness<br>No view of the wider picture<br>Multi—tenanted buildings<br>Inertia | 18 |
| Negative perception issues | Fear of negative impact of service levels<br>Over-stated benefits of DSR | 16 |
| Economic | Lack of financial incentive<br>Lack of credit under CRC | 15 |
| Lack of technologies / DSR offers / Demonstration | Lack of DSR offers from Suppliers<br>Lack of demonstration of safe and cost effective demonstration | 9 |
| Complexity | Complex agreements<br>Balancing Mechanism arrangements | 9 |

The survey highlighted that energy is not the ‘core’ business for the non-domestic building sector, and as such, is not considered a key priority. Furthermore, energy spend is often a relatively low overhead, and therefore organisations find it difficult to justify spending time to engage with DSR. Organisations that have actively engaged in DSR initiatives suggested that considering the income from this relative to net profit provides a more compelling case for DSR rather than considering the income as a percentage of turnover or total overheads.

Complexity is also considered to be a barrier to DSR uptake in the UK, particularly in terms of the requirements put in place by the Transmission System Operator for the balancing services it procures. For example, the need to be able to predict load availability up to a month in advance can be problematic for many consumers.

Any $CO_2$ savings achieved through the implementation of DSR are delivered at the national level, rather than at an individual level (i.e. at the consumer’s premises). As such, DSR measures do not contribute to the $CO_2$ reduction targets that large public and private sector organisations are required to deliver under the CRC Energy Efficiency Scheme.

Lack of awareness of electricity consumption was also considered an important barrier – which could be considered to be surprising as customers with demands over 100kWh have had half-hourly metering for a number of years. In addition, in 2002 the Building Regulations introduced a requirement for sub-metering of significant end loads in buildings with a floor area greater than $500m^2$. For buildings with floor areas above $1,000m^2$, this should be via automated meter reading and data collection.

## CS 17. Smart Homes as a Means to Sustainable Energy Consumption

| | |
|---|---|
| Title: | Smart Homes as a Means to Sustainable Energy Consumption: A study of Consumer Perceptions |
| | Journal of Consumer Policy, Vol. 35 pp 23-41 |
| Date: | 2011 |
| Authors: | Alexandra-Gwyn Paetz, Elisabeth Dütschke, Work Fichtner |
| Country | Germany |

In this study, 29 participants were divided into small focus groups, and shown a demonstration Smart Home, with energy management and ICT solutions, which were demonstrated in the home and then discussed.

Although a very small number of participants were involved, the study provides an insight into consumer views towards variable tariffs, smart metering, smart appliances and home automation.

Participants were recruited in a number of ways, including direct mailings to University students, newspaper ads and distribution of flyers to the general public. As a result, the focus groups contained a high proportion of students, with 21 of the 29 participants younger than 30 years of age. A pre-questionnaire identified that the participants considered themselves to be environmentally aware and (generally) open to innovations.

Some of the findings are summarised below.

*Variable Tariffs*

The majority of participants would consider a variable electricity tariff (22 out of 29), with a Time of Use tariff being the most popular. For most, the main motivation was the opportunity to save money, with reducing environmental impact a secondary benefit. However, for a minority (three), the environmental benefits were the most important factor.

Trust (or a lack of) was cited by those motivated by environmental benefits, with reassurances sought that variable price levels set by the energy company were correct.

The participants indicated a preference for tariffs that did not change too often, i.e. were fixed in advance for a reasonable length of time (i.e. for a month or longer). This was because of the perceived difficulty of managing their demand pattern according to a tariff that frequently changed.

Analysis of data provided via a pre-questionnaire showed that savings of 80 euros per year would be needed to change behavioural patterns – anything less than this would not result in behavioural change.

*Smart metering*

All of the participants were excited by the ability of the Smart Meter to provide real time feedback on the energy consumption profile of the Smart Home. Most recognised how the information could be used to analyse the load in their own homes. For example, one participant made the following comment:

> *"I'd start turning on and off every appliance in order to see its impact on the load curve. Maybe it would be also interesting to borrow some home devices of my neighbour and see whose is more efficient. This nourishes my playing instinct"*

In line with other surveys, though, the participants expected that the frequency of looking at their real time display would diminish over time.  Concerns are raised over the smart meter included:

- Its usefulness being limited as only total load consumption information is available
- Data privacy was raised by two participants
- Limited potential for motivating energy savings (as the participant considered themselves to be a low user already)
- Concerns over whether the information would be effective, for example some people just may not respond to any information on energy use.

## CS 18. An easier life at home? 'Selling' the Green Deal to UK households

| | |
|---|---|
| Title: | An easier life at home? 'Selling' the Green Deal to UK households |
| Date: | 2013 |
| Published by | UK Energy Research Centre |
| Country | UK |

This report provides the interim findings of the VERD project. This project investigated the rationale behind the household's decision to embark on home renovation and the likelihood of a homeowner deciding to embark on a scheme motivated to improve a property's energy efficiency. The research was based on a sample of over 1000 homeowners in the UK.

The survey discovered that the biggest factor prompting a house owner to undertake renovations

*"is to improve domestic life, with householders facing competing priorities and those needing to extend or adapt space at home, being more likely to consider renovations."*

The other major trigger prompting a homeowner to embark on renovations is *"when something in the home needs fixing or replacing – such as a boiler or a window."* Homeowners are unlikely to embark on renovations for the sake of energy efficiency. They may however undertake energy efficiency renovation at the same time as they carry out other renovations. A strong 'value proposition' is important to motivate a house owner to undertake renovations, whilst hassle, disruption and having to deal with unreliable contractors are the disadvantages that the 'value proposition' must outweigh.

If a house owner decides to undertake energy efficiency renovations they are twice as likely to consider using the Green Deal as not.

## CS 19. Consumer Experiences of Time of Use Tariffs

| Title | Consumer Experiences Of Time of Use Tariffs |
|---|---|
| **Date:** | **October 2012** |
| **Organisation(s):** | **Ipsos MORI for Consumer Focus** |
| **Country** | **UK (Great Britain)** |

The survey was carried out via three waves of omnibus surveys in February and March 2012. 5,914 interviews were conducted using a nationally representative methodology, of which 4,761 were mains electricity customers who were at least jointly responsible for paying household bills. Of these, the 620 with Time of Use (ToU) tariffs were asked a sub-set of questions about their use of and attitude to their tariff. Fifteen were then re-interviewed about their experiences in more detail.

Results from the study indicate that 13% of domestic bill payers are on ToU tariffs, usually either Economy 7 (66%) or Economy 10(10%).

Economy 7 rewards customers for using electricity during seven night time hours with a lower electricity price however the cost of electricity at other times is higher than the standard tariff. Economy 10 likewise has a cheaper tariff for an overnight period, and also a limited number of hours during the day, but a higher peak time charge. These tariffs were traditionally linked with properties that were usually in an off-gas area, dependent on storage heaters that used off-peak electricity to charge in order to provide heat during the day time. Customers on these tariffs have a more complicated meter set up, and these meters sometimes need to be changed if the customer moves onto a standard tariff.

Sixty-six percent of ToU customers have gas central heating and 24% electric storage heaters. Half of ToU tariff users take advantage of the cheaper night-time tariff to run appliances other that water and space heating. However, 38% of tariff users did not have storage heating and did not use appliances at night. There is evidence that householders 'inherit' these ToU tariffs when they move into a property without any clear understanding of how it works.

> "*The big problem with the Off Peak rate is that unless you've got storage heaters I'm not convinced that it's actually worth anyone having it. And what really annoys me is that I only found out recently when I talked to EDF is that when you have two meters a day and night one they actually charge you more on the day rate than they would if you didn't have the night one. And I think that's a real swindle, I was gobsmacked when I found that out, so I think it's a bit of a con personally, my feeling about it."*

Twenty four percent of respondents did not think that the ToU tariff was appropriate for their household. This rose to 35% amongst those households who has gas central heating. Some households have adapted well to the tariffs and make considerable savings by using appliances at night often using timer switches to turn them on and off. Some consumers feel unable to take full advantage of potential savings that may be gained by doing this because they do not want to disturb neighbours or they have been given safety advice against running appliances when they are asleep or out of their home. There was also some evidence that householders do not understand the time-bands of their tariff. One respondent stated:

*"I know very little about it, to be honest, I wasn't even aware I had it. But I believe it starts at midnight, I don't know when it finishes but I assume around 6:00am. But I have very little use of it. I don't have any storage heaters, for example, so there is not anything on during the night . . ."*

Seventy percent of ToU tariff users are satisfied with the tariff. The level of satisfaction is only a little lower among those who think that they are on the wrong tariff. This suggests that those who are gaining nothing from being on the ToU tariff are unaware that it may be costing them extra or causing them problems. The report suggests that 38% of ToU tariff users have no reason to be on these tariffs and are therefore probably spending more on their electricity than they should be.

The survey suggests that ToU consumers also find it hard to compare tariffs offered by alternative energy suppliers. They also suffer from meter reading issues although this is hard to attribute directly to ToU tariffs however because of the extra confusion caused by the complexity of the metering arrangements suggest there may be a link.

## CS 20. Understanding Consumer Preferences in Energy Efficiency (2010)

| | |
|---|---|
| Title: | Understanding Consumer Preferences in Energy Efficiency, Accenture end-use consumer observatory |
| Date: | 2010 |
| Organisation(s): | Accenture |
| Type of study: | On-line survey |
| Country | International |

An on-line survey was carried out in 2010 to gain an understanding of consumer opinions and preferences towards electricity management programs. A total of 9,108 individuals from 17 countries took part in the survey, with typically 500 participants from each country taking part. No indication is provided of how participants were recruited, although the authors do comment that the sample was generally representative of the general population. The only exceptions were China and South Africa, where the sample was representative of the urban population, rather the population as a whole.

Respondents were asked questions covering six target areas, focussing mainly on and around the issue of electricity management programs. The summary findings do not explain specifically what is meant by this term, or whether or not the term was defined for the benefit of respondents. In this context, it has been assumed that an energy management program involves setting a target for reducing energy consumption, with specific rewards available for meeting the target. The target could include an overall reduction in energy consumption, or a reduction in energy during certain times of the day or the year.

Results are available based on the whole sample of respondents, in some cases regional variations are also presented. The responses to selected questions are presented here.

Question: "*Have you heard of programs that help you to optimise your electricity consumption" (i.e. electricity management programs)?*

Responses: 28% responded "I have heard about them and know what they are"

38% responded "I have heard about them but do not know what they are"

34% responded "I have never heard about them"

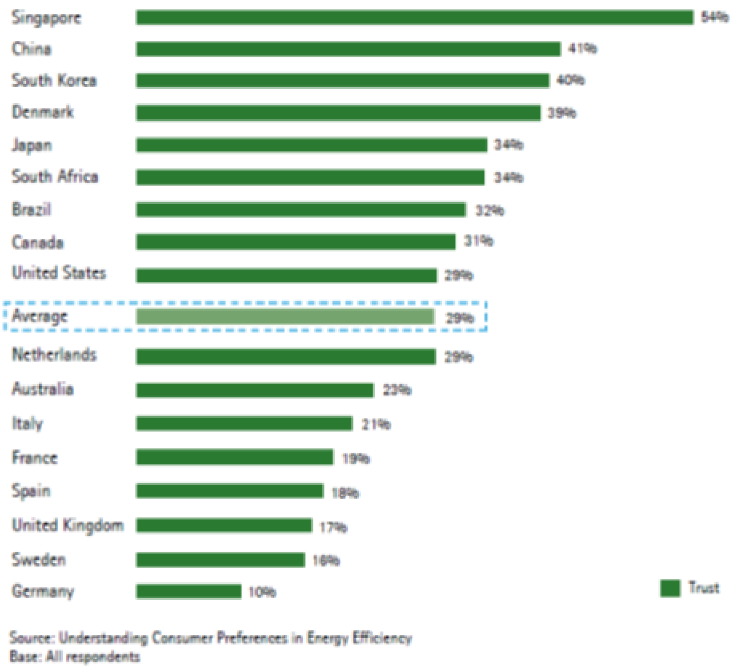
Of the 66% who had heard about these programs, only 9% admitted to having enrolled in a programme – indicating a very low level of enrolment. More than 58% were unaware whether their electricity provider offered such a program or not.

Question: "*Who would be your first choice to deal with/be in contact with regarding the following situations?"*

- *Get general information on energy management programs*
- *Get customised advice on the best electricity management programs for your situation*
- *Purchase or sign-up for an electricity management program*
- *Contact for support regarding issues you may have with an energy management program you have enrolled in*

For all four options listed above, the respondents indicated a preference for contacting their electricity provider. However, when asked who they most trust to inform them about actions to optimise their electricity consumption, electricity providers did not rate so well. In this case, they were trusted by only 29% of respondents. This indicates that whilst they may have a preference for receiving information from their electricity provider, there is not sufficient level of trust to ensure that consumers will necessarily act on the information provided.

The issue of trust was the area that demonstrated one of the (if not the) largest variation in the responses from region to region, as indicated below. For example, only 10% of respondents in Germany indicated trust in their electricity provider, compared to 54% in Singapore. Even in Singapore electricity providers are only trusted by around half of the consumers.



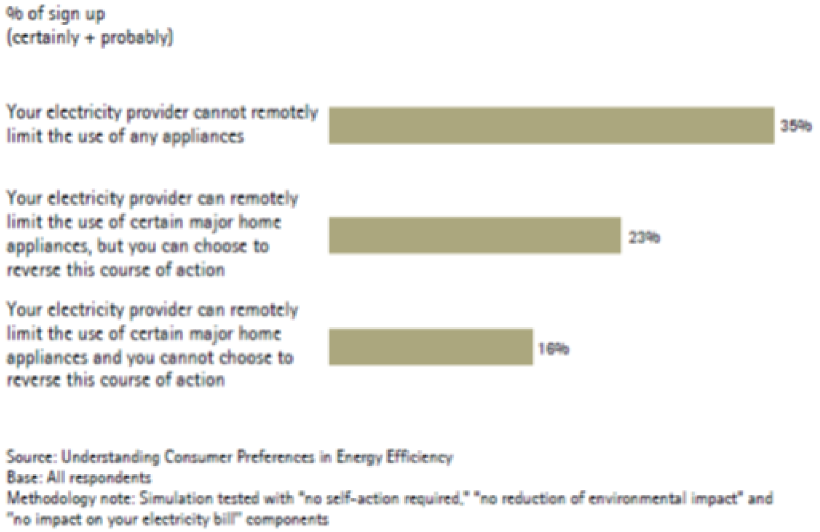

Consumers were asked what would discourage them to participate in energy management programmes, and here concern that the cost of electricity would be increased was cited as the most important factor. Other top concerns included:

- Electricity saved would be sold on at a profit
- Concerns over access to electricity consumption data
- Would require changes to entertainment choices or loss of comfort
- Would have no positive impact on the environment
- Would make electricity bills more complicated

Interestingly, the factor that would most encourage participation was also cost, with the response "It would decrease the amount of my electricity bill" selected by 88% of respondents. Thus, cost is seen as a risk and a benefit by the same sample of consumers.

Consumers were asked to weight the importance of four different factors on their decision to enrol on an energy management program. This was an area that showed significant variation amongst the regions. For example, the "impact on electricity bill' received the highest weighting in South Korea (at 51%), compared to only 27% in the Netherlands.

The survey also provides an interesting insight into the impact of controlling home appliances on the likelihood of participating in an electricity management program. As indicated below, the less control consumers have over their electricity usage then the less likely they are to sign up to a program.



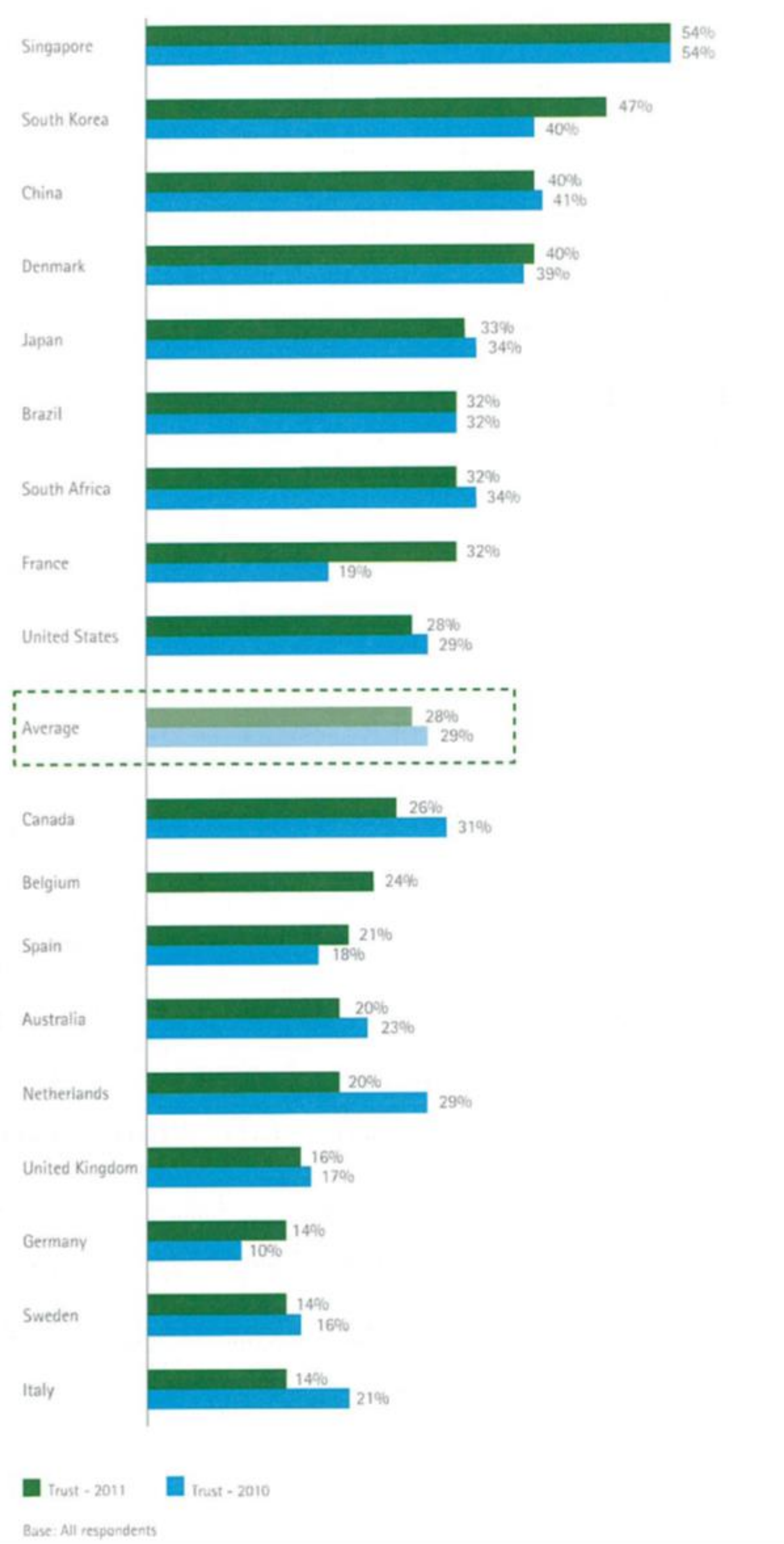

Consumers were divided into one of six segments (according to their willingness to take action and how they like to receive advice and their demographics). For all segments, social pressure was regarded as a key driver to motivate them to undertake certain sustainable activities (such as recycling or reducing electricity consumption).

## CS 21. Revealing the Values of the New Energy Consumer

| Title: | Revealing the Values of the New Energy Consumer – Accenture end-consumer observatory on electricity management 2011 |
|---|---|
| Date: | 2011 |
| Organisation(s): | Accenture |
| Country | International |

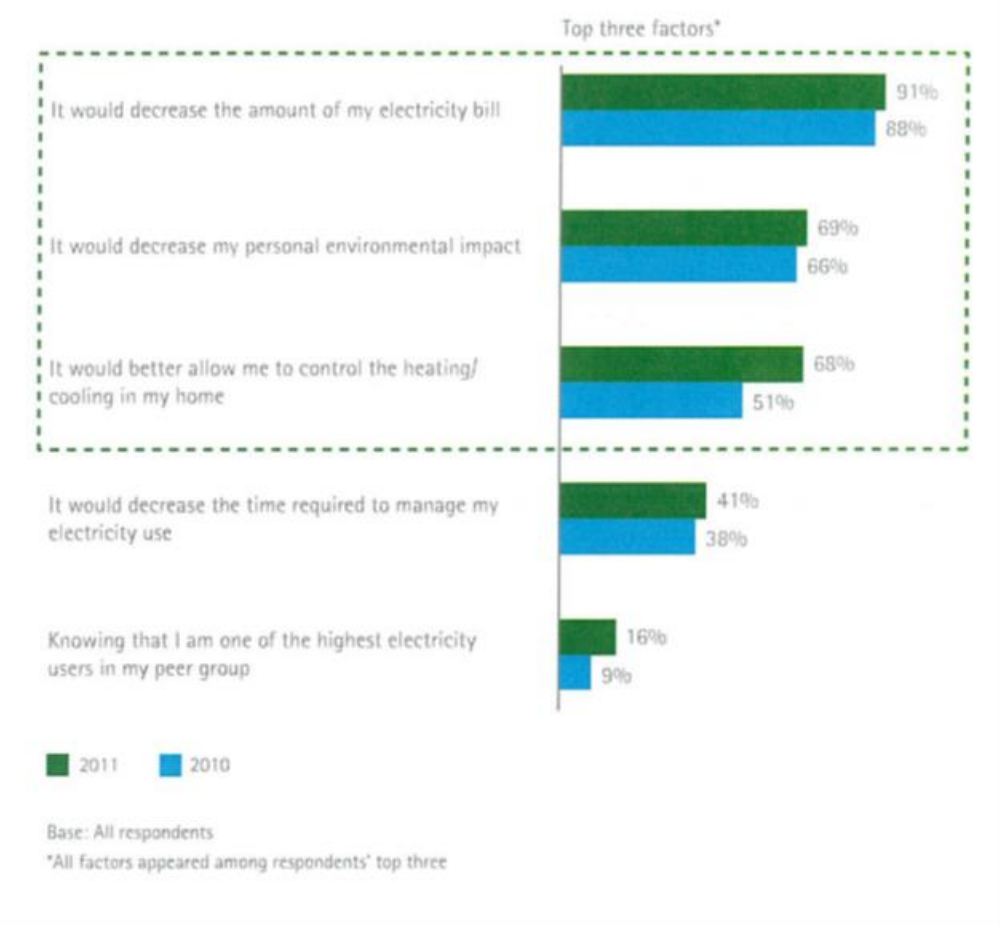
A further on-line survey of around 10,200 participants in 18 countries was carried out by Accenture in 2011. This time, consumers were asked questions about the delivery of electricity management services, the value that householders would attach to in-home technologies and whom they would prefer to buy such services off.

Following on from the survey that they conducted the year before, respondents were once more asked if they would trust energy efficiency information that they received from their utilities/electricity provider. The chart below shows a comparison of the results from the 2011 survey with the results from the 2010 survey, with results categorised by respondents nationality.

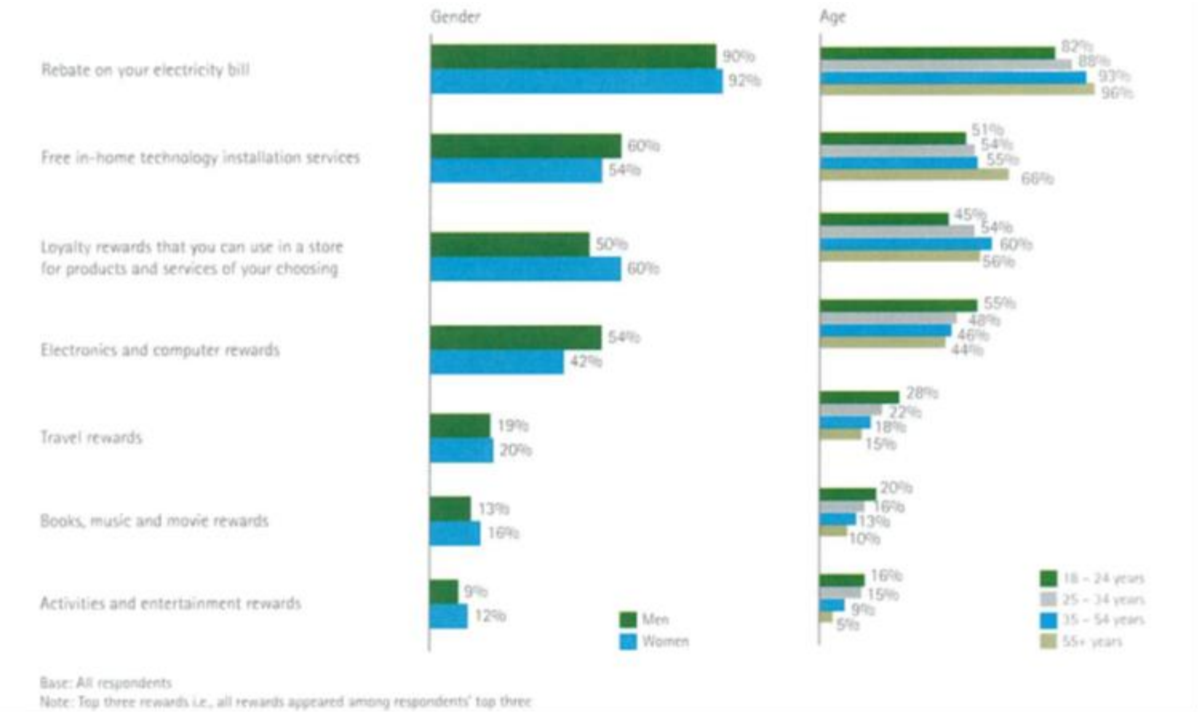

Singapore 54% 54%
South Korea 47% 40%
China 40% 41%
Denmark 40% 39%
Japan 33% 34%
Brazil 32% 32%
South Africa 32% 34%
France 32% 19%
United States 28% 29%
Average 28% 29%
Canada 26% 31%
Belgium 24%
Spain 21% 18%
Australia 20% 23%
Netherlands 20% 29%
United Kingdom 16% 17%
Germany 14% 10%
Sweden 14% 16%
Italy 14% 21%
Trust - 2011
Trust - 2010
Base: All respondents

Most countries only saw quite small fluctuations in trust towards their energy supplier however some countries saw a far more significant change. Energy suppliers were trusted less in Italy, the Netherlands and Canada in 2011 than 2010, but there had been an improvement in trust of energy supplier in France and South Korea.

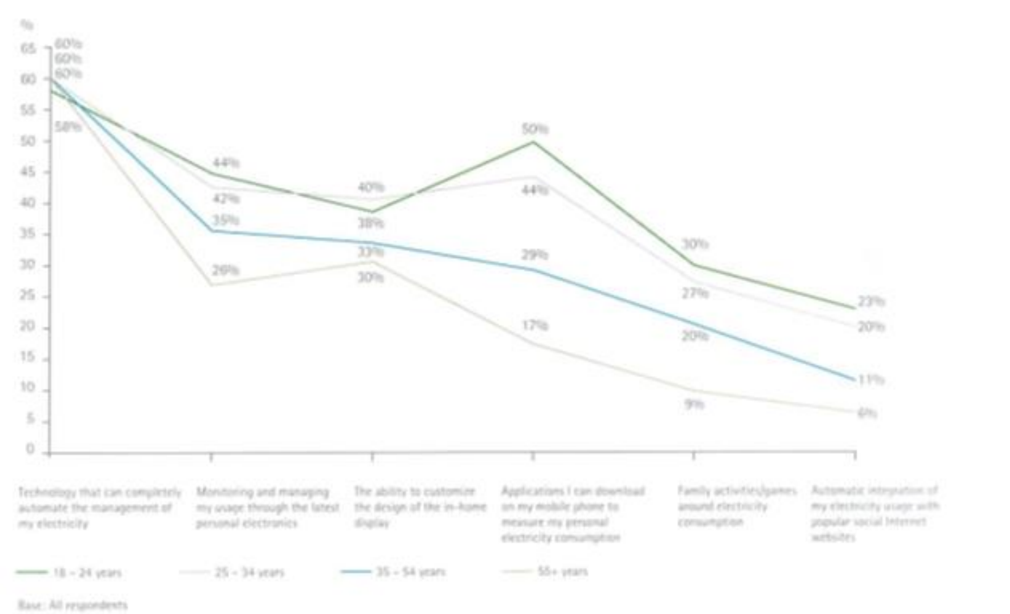
When asked what would interest them in enrolling in an energy management scheme, most householders wanted to reduce the size of their bill, however there was also interest in these schemes because of their ability to help householders decrease their environmental impacts or the increased control that they would gain over their house temperature.




Different demographic groups would prefer different types of rewards for enrolling in electricity management programs.  All groups wanted to see a rebate on their electricity bill. Women were also interested in loyalty rewards that could be spent on shopping, whereas men were more interested in free installation and rewards that could be redeemed against electronics and technologies. Different rewards were more attractive to different age groups. The older age bracket (55+) was most interested in free installation, whilst the youngest group (18-24) was most interested in electronic and technology rewards. This is demonstrated in the chart below.




And different demographic groups would prefer the energy management service to provide different functions and features. All age groups were interested gaining complete control over their household electricity consumption. The youngest age group (18-24) wanted to be able to measure their household electricity consumption via an application on their mobile phone.




It is therefore important that providers of energy management services understand that different demographics of the population are motivated by different concerns to become involves in energy management schemes, although most are looking to save financially as their primary motivating factor. Consumers are interested in different types of rewards for participating in these activities beyond financial gain, and are interested in receiving different functionality from the management system.

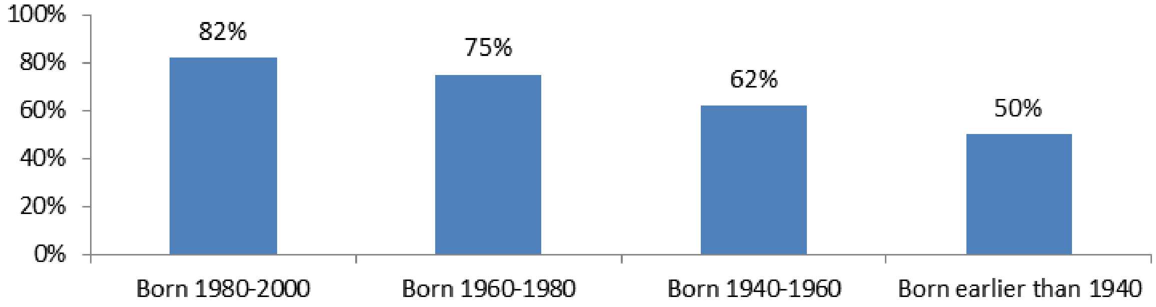
## CS 22. Ladda Sverige – Survey on perception of electricity and climate in Sweden

| Title: | Ladda Sverige – Studie om svenskarnas syn på el och klimat |
|---|---|
| Date: | 2012 |
| Organisation(s): | Swedenergy |
| Country | Sweden |

The project ”Ladda Sverige” is an initiative by the Swedish electricity production and distribution industry through their branch organization Swedenergy. Its purpose is to increase the knowledge of the consumers about electricity and the climate. One part of the project consists of a survey2 where 3000 consumers answered questions about their perception of electricity and climate effects of electricity usage.

The survey shows that the knowledge about the electricity production in Sweden and the effects on the climate could be increased. It also shows that 30 % of the respondents are willing to decrease their electricity consumption in order to decrease their impact on the climate, even though only 18 % think that the total consumption in the country will decrease the coming decade.

The study concludes that there is a willingness among the Swedish people to change their energy consumption. Especially this is the case among the younger part of the population, where 82 % of the respondents born 1980-1990 are willing to produce their own electricity in the future. It is also expected by all age groups that the number of electrical devices in households will increase during the next decade.




**The percentage of the respondents in different ages answering “yes” to the question: ”Would you in the future be willing to produce your own electricity, for example by having solar panels?”.**

It can be concluded from the study that even though the knowledge about electricity and the power system in some areas are low, the consumers seem willing to become more active in terms of decreasing their consumption and producing their own energy. This is especially the case if the benefit for the environment of such actions is made clear to the consumers.

[2] Ladda Sverige. Svenskarna: El - en lösning för klimatet. Swedenergy 2012. In Swedish. Available at http://www.svenskenergi.se/Global/Dokument/Ladda%20Sverige/Filer/Rapport2012_Ladda%20Sverige_El-en-l%c3%b6sning-p%c3%a5-klimatet.pdf

## CS 23. Demand response research

| Title: | **Demand Response Research** |
|---|---|
| Date: | 2013 |
| Organisation(s): | EA Technology / UK Task 23 National Team |
| Country | UK |

The UK national team for Task 23 commissioned a market research study to assess the attitudes of domestic consumers towards demand side response. The survey was designed to explore domestic consumer attitudes and current behaviours with with regard to energy usage and, in particular, their views and attitudes towards demand side response. An online survey was completed by 1004 respondents.

### *Energy efficiency*

The results of the survey indicate that most of the households considered themselves to be reasonably efficient in terms of energy usage. Saving money is the primary motivations for reducing household consumption. Environmental benefits are a secondary consideration. Interestingly, around half (49%) would accept some change in their lifestyle in order to save energy

### *Demand side response*

The respondents were provided with a general description of demand side response and asked whether or not they were aware of the concept. Around a quarter of the respondents had previously heard something of this idea (although less so amongst older age groups).

The general level of interest in DSR was relatively **high**, especially if there is an incentive/reward scheme; 82% of respondents indicated that they would be interested in the concept, with a third indicating they are 'very interested'. Saving money was a key driver of the interest in DSR (through cheaper rates and/or overall reduced consumption), although other specific incentives (such as a reward scheme) was also viewed favourably.

### *Flexibility to shift the energy consumption*

The respondents were asked to comment on whether they considered they had any flexibility to alter their pattern of energy consumption. Around a third (31%) indicated that they did have the flexibility to adjust the timing of their electricity. Those with the most flexibility to shift electricity use include:

- …older age groups (55+ yrs)
- …retired or unemployed/not seeking work
- …in smaller households (1 or 2 person)
- …often at home during weekdays
- …households with lower than average energy consumption

Amongst those who have flexibility to shift day-to-day electricity use, 60% could do this at relatively short notice, e.g. in response to a message or signal. Around three-quarters of those who have a washing machine, dishwasher or tumble dryer see the opportunity to change/delay the time of using these appliances. However, there was less scope to do this with other types of electrical equipment (i.e. electric showers, electric water or space heaters).

### *Barriers to DSR*

Amongst those not interested in DSR, the main barriers centre on convenience and independence. However, security (of information/data) and trust (in the electricity supplier's motives) were also important concerns, together with the possibility of needing to invest in special equipment; and whether the savings/rewards would justify participation.

There was some reluctance to (or lack of understanding of) the idea of automatic control; only around half of those who could change/delay the timing of the appliances they use would be willing to accept automatic control for this.

A significant proportion of respondents ( between quarter and a third) would be very much concerned by the potential fire risk and possible performance issues of running appliances at different/alternative times.

### *Incentives required*

Over half of respondents (56%) indicated that a lower electricity bill (i.e. reduction or discount) would be the best/most suitable incentive to participate. However, the offer of specific payments or free 'Smart' appliances was also acceptable. There was little support for vouchers, donations to charity or support for community programmes.

When asked 'unprompted' to comment on the level of reward expected, the responses were wide-ranging. The average (mean) level of reward expected was over £2,000 per annum, but this was skewed by several respondents suggesting unrealistically large sums (2 over £1 million!). When prompted with various suggested levels of reward, around half (49%) would see participation in a DSR scheme as worthwhile if yielding rewards of up to £50 p.a. Around a quarter (23%) would be likely to participate for reward of only up to £25 p.a.

### *Overall conclusions*

The overall conclusions of the market research suggest that the outlook for the introduction of a DSR scheme is positive. There is fairly widespread flexibility to shift the timing of electricity use on a day-to-day/short notice basis. Whilst money is undoubtedly the key driving factor, a significant proportion still sees value in participation in a DSR scheme for realistic levels of reward.

### *Follow up work*

The online survey is to be followed up with two focus groups to explore the attitudes in more depth. The focus groups are scheduled to take place in October 2013.

# Appendix B: Case Study Template

## Description:

A general description of the project. Include information on the duration of the trial. Are any results / outcomes available. If the project is on-going, when is it expected to be completed, when will results be available.

## Customers Involved:

Describe the customer types involved in the trial, and the numbers of customers involved.

## Technologies Deployed:

Description of technologies deployed

## Customer Offerings:

Description of customer offerings – i.e. the commercial arrangements – including tariffs, penalties etc.

## Customer Engagement Approach:

How were customers recruited? Did they voluntarily opt in, did they opt out?

Was there a special focus on trying to aim to create 'enthusiasm for the smart meters/smart grids by the households/SMEs. If so, what was the approach taken.

## Smart Metering:

Describe the metering arrangements in place, and what the smart meter was used for – i.e. to collect data for billing, to feedback information to customer, information on energy prices, to directly control loads.

## Tariff:

What type of tariff did the initiative include?

For example, Time of Use pricing, Critical Peak Pricing etc

Did customer's voluntarily opt-in, or was it mandatory?

If it was a trial / pilot – how long did it run for? What happened to the customers at the end – did they continue with the same tariff.

If it was a voluntary opt-in arrangement, how many customers dropped out during the trial. What were the reasons for customers leaving the scheme?

What were consumer experiences?

What aspects did consumers like? Did any aspects raise concerns or complaints?

## Remote / Automatic Control of Appliances:

Did the trial involve any remote or automatic control of appliances / end-use loads?

What approach was taken to ensuring consumer acceptance or acceptability of the controls?

Was it a voluntary ‘opt-in’?

Was there the option for manual override under certain circumstances/

What were consumer experiences?

What aspects did consumers like? Did any aspects raise concerns or complaints?

## Information and Data Sharing:

What information (energy data) was shared, and who was the data shared with. Were any third party organisations involved?

Were any specific difficulties encountered?

Were any specific consumer concerns encountered?

Were consumers actively aware of how their data was being used, and by whom? How was this explained to consumers?

How was the energy consumption information used? Examples might include:

- to provide direct feedback to the consumer
- to provide more accurate billing for the consumer
- to assist the Network Operator manage the network better
- to assist the Energy Retailer to detect fraud, provide better customer service etc.

## Advice / Customer Engagement:

What method(s) were used to inform customers about the trial, and about what actions they could take to modify their energy consumption (both the pattern of consumption and amount of consumption). Was engagement provided upfront only, or was it on-going?

What advice was provided?

Who provided the information? To what extent was information personalised to the needs of each individual, or was it general advice?

Was advice provided ‘face-to-face’ or via general leaflets or information campaigns.

Where there particular concerns or issues that needed to be addressed either at the outset or once the trial/project was underway?

## Results:

Summary of energy savings, peak load savings.

## Key Lessons Learnt (to date):

- Key lessons
- What where the key learning points – what went well, what when badly
- What was the customer experience – what aspects were viewed positively, what aspects were viewed negatively.

## Major Barriers Encountered (to date):

- Key barriers

## References:

Links to sources of information / reports / presentations etc

## INT 1. ECOWATT Trail in Brittany – Using Energy Responsibly

### Description:

EcoWatt is a scheme set up by EDF Energy. Brittany only generates 8% of the electricity that it uses, the rest being transmitted from power plants some distance away elsewhere in France. Approximately 28% of homes in Brittany are heated by electricity. During winter peak periods there is an increased risk of power cuts. Based on a voluntary approach this scheme aims to raise awareness of issues surrounding balancing the power system, and encourage consumers to alter their energy use during periods of peak demand.

Initially 9,400 customers signed up to the scheme however evidence suggests that reaction to the nine alerts issues over the winter 2008/9 was more widespread than just these participants. The following year 18,500 customers had registered via the internet. Eleven alerts were issued. By March 2012, 50,000 households had enrolled in the scheme with an estimated reduction in consumption during events of between 2 and 3%.

### Customers involved:

Domestic, businesses and community organizations are involved in this scheme.

### Technologies deployed:

The internet, SMS messaging, mobile phone apps, widget, RSS feeds and email are deployed to inform participants who have signed up to the scheme about alerts.

### Customer offerings:

No rewards are offered however the threat is that without action blackouts are possible. Inhabitants of Brittany do not want a new nuclear power station built on the peninsula.

### Customer engagement approach:

Knowledge of the scheme has spread via channels such as the internet, word of mouth, social media and news reports.

### Smart metering:

Smart Meters have not been installed as part of this initiative.

### Tariff:

No tariff was used for this program

### Remote / Automatic Control of Appliances:

No remote or automatic appliance control was used for this program

### Information and Data:

No information or data sharing was used in this trial

## Advice / Customer Engagement:

Information about the scheme is available via the internet. A dedicated web-site provides the facility for participants to sign up to be sent notifications of any alerts. This web site provides energy saving advice.

## Results:

Demand reduced by between 1 – 1.5%, the equivalent of a city of 60,000 inhabitants, increasing to between 2 - 3% during winter 2011/12.

## Key lessons learnt (to date):

- Brittany has a strong sense of community which has helped motivate participation;
- The program explained the reasons why Brittany was particularly at risk of black outs and asked for assistance via this scheme to overcome the issue;
- There was also strong opposition in Brittany to building a nuclear power station to overcome these problems.

## Major barriers encountered (to date):

- Different attitude towards electricity and the electricity industry in other countries would make this scheme difficult to replicate.

## References:

Further information on this project can be found at:

http://www.ecowatt-bretagne.fr/

http://clients.rte-france.com/lang/an/clients_producteurs/services/actualites.jsp?id=9345&mode=detail

http://iphonebattery.iphoneersatzteile.co/positive-balance-of-the-device-ecowatt-in-brittany

http://www.lagazettedescommunes.com/105716/bretagne-ecowatt-a-ecrete-jusqua-3-de-la-demande-electrique-lors-des-pics-indique-rte/

## INT 2. SDG&E Reduce Your Use Day

### Description:

The “Reduce Your Use” scheme was introduced to motivate householders in the San Diego area to reduce their electricity consumption at times of peak consumption (between 11am and 6pm). These periods are typically on the hottest days of the summer when the Air Conditioning load is high. The scheme has been necessitated by the closure of a nuclear power station. Householders sign up to the scheme, which has no penalties attached. For every kilowatt hour saved a credit is assigned to the household’s next bill. Alerts are issued the day preceding the event. Historical electricity consumption data is used to calculate if any saving has been achieved.

### Customers involved:

Households and businesses can sign up to this scheme

### Technologies deployed:

Internet, Smart Meters, emails and SMS messaging

### Customer offerings:

There are no penalties involved with this scheme. Customers who successfully use less electricity during the Reduce Your Use periods receive a credit against their next bill.

### Customer engagement approach:

No information is available on this.

### Smart metering:

Smart Meters have already been installed in this area. Historical data from them is used to calculate an amount that householders must consume less than in order to earn rewards. This information is available to householders via their internet account.

### Tariff:

There are no tariffs associated with this scheme however householders can save $.75 or $1.25 per kWh saved (the higher sum is for those who have enabling technology).

### Remote / Automatic Control of Appliances:

Customers who already have home automation received a larger rebate per kWh reduction in energy use however having technology is not a requirement for involvement.

### Information and Data:

Participants are able to access information about the amount of energy they have saved via their online account.

## Advice / Customer Engagement:

Advice on effective ways to save energy is available on the schemes web site.

## Results:

In one locality 78% of SDE&G customers earned money back against their next bill resulting in a total rebate in the area of $205,000.

On average householders saved $2.50 per event and $20 over the year.

## Key lessons learnt (to date):

## Major barriers encountered (to date):

## References:

Further information on this project can be found at:

http://www.sdge.com/save-money/reduce-your-use/reduce-your-use-rewards

http://www.prnewswire.com/news-releases/sdge-launches-reduce-your-use-day-rewards-157505085.html

http://carlsbad.patch.com/articles/carlsbad-residents-sdge-bills-reduce-your-use

http://www.sdge.com/newsroom/press-releases/2013-04-10/sdge-receives-smart-grid-award-praised-using-technology-promote

## INT 3. PG&E SmartRate

### Description:

PG&E operate three time-based tariffs (two open to new enrolment as of May 2012), as follows:

- SmartRate™: an overlay on other available tariffs which has a high price during the peak period on event days, referred to as SmartDays, and slightly lower prices at all other times during the summer. Prices vary by time of day only on SmartDays. Enrolment was halted for a period during the well-publicised legal case involving PG&E's roll-out of Smart Meters, but was allowed to continue from November 2011.
- Rate E7: a two period, static ToU rate with a peak period from 12 PM to 6PM. This rate is now closed to new enrolment; and
- Rate E6: a three period ToU rate, typically joined by customers with solar PV installations. The rates are as follows:
    - Summer Weekdays: Peak period 1 to 7PM, partial peak 10AM to 1PM and 7 to 9PM. Off-peak prices at all other times.
    - Summer Weekends: Partial peak 5 to 8PM. Off-peak prices at all other times.
    - Winter Weekdays: Partial peak 5 to 8PM. Off-peak prices at all other times.
    - Winter Weekends: Off-peak prices at all times.

These are part of the array of tariffs offered by PG&E and are not part of a trial. E7 was first offered in 1986 and was targeted at customers with air conditioning. Enrolment continued until 1996, when a new meter type was required (at a cost of $200) to join the tariff.

SmartRate can be used in conjunction with SmartAC- a program in which customers receive a payment from PG&E in return for allowing PG&E to remotely turn down their air conditioner at times of high system load (either through direct control of the air conditioning unit, or via the thermostat). Further details are available via Case Study INT11.

Results from the scheme appear to be published yearly, and the 2011 results are described within this template.

### Customers involved:

SmartRate had 23,000 customers enrolled in 2011; approximately 4,800 of these were also enrolled in the SmartAC program. Around 50% of SmartRate customers are 'low income' customers (CARE (California Alternate Rates for Energy- a program through which low-income homes receive lower rates than non-CARE customers)), compared to 25% of the general PG&E population. Customers enrolled on the SmartRate program are more likely to be located in hotter regions than the general population. Customers choose to opt-in to the SmartRate tariff and are given bill protection for the first year.

73,700 and 14,100 customers are enrolled on E7 and E6 respectively. Evaluation has been carried out for E7 customers without their own generation only. E7 customers differ from the general population: they generally have higher consumption, a smaller share of customers is on low incomes (CARE) and a higher share is in 'all-electric' households. Customers choose to opt-in to the E7 tariff. It is therefore not possible to say that the price responsiveness of the E7 customers could be extrapolated to the general population. The attrition (drop-out) rate for E7 customers is 3.8% per year.

89% of E6 customers are net metered (i.e. have their own generation) compared to 1% of the general PG&E population. 4% are CARE customers (compared to 28% of the general population). Customers on both E6 and E7 are much less likely to have Smart Meters installed than those on the flat rate tariff

## Technologies deployed:

Some customers within the SmartRate program have air-conditioning, and some of these consumers also participate in the SmartAC program. The load impact of SmartDays has been analysed against the probability that the household has air conditioning (for those customers who are not also enrolled on the SmartAC program). The average impact for customers with a greater than 75% probability of owning an air conditioning unit is 0.28kW, compared to 0.07kW for those with only a 0 to 25% probability. Although the response from customers who are unlikely to own air conditioning is low, it does demonstrate that a response can be provided in the absence of this technology.

## Customer offerings:

See 'Tariff' for details of tariffs offered to customers.

## Customer engagement approach:

Customers opt-in to the program, but marketing for the program has previously focused on specific geographic regions. They are offered bill protection for the first year.

The published information does not indicate to what extent the program was used to try and create any enthusiasm around Smart Meters/ the 'Smart Grid'.

## Smart metering:

Customers who are part of the SmartRate program must have a Smart Meter installed. Although not specified within the PG&E website it is assumed that the Smart Meter is used to enable hourly billing and therefore accurate payment during Smart Days.

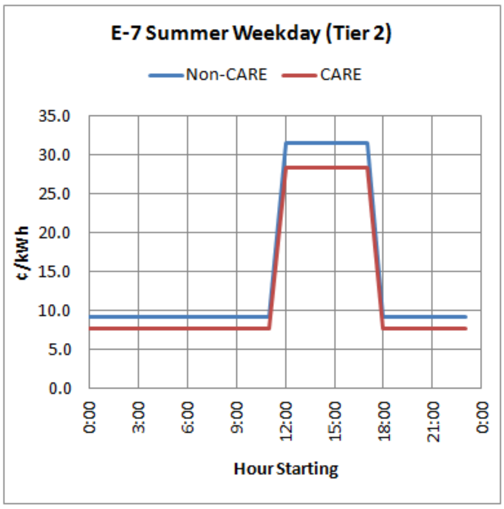
## Tariff:

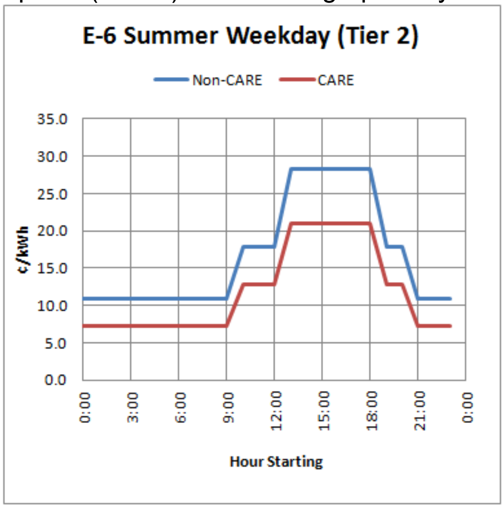
SmartRate™

- A critical peak pricing tariff which is an overlay to the customers otherwise applicable tariff (OAT). The SmartRate consists of an incremental charge that applies during peak periods on SmartDays (a maximum of 15 days per year) and a per kilowatt hour credit that applies for all hours from June to September. The additional peak period charge on SmartDays is $0.60/kWh (around 8 times the Tier 1 E1 rate on normal days). The credit is around $0.03/kWh, with an additional credit of $0.01/kWh to Tier 3 and high usage residential customers.
- Customers are notified a day ahead of a SmartDay based on the weather forecast by a method of their choosing (email, phone etc). Customers can chose to receive no notification. Roughly 15% of customers either chose not to be notified or provided information which was initially incorrect or became outdated. The impact of these notifications is described in 'Advice/ Customer Engagement' (below).
- Customers are only exposed to ToU pricing on SmartDays (apart from a very small (25 in 2011) number of customers who OAT is ToU).
- Customers are given 'bill protection' for the first year. This was designed to "address the risk aversion that pilot programs and market research have shown to be a significant barrier to enrolling customers onto dynamic rates".
- The retention rate for customers on the SmartRate program is relatively high (2.3% drop-out due to de-enrollment in 2011). Non-CARE customers de-enroll at a much higher rate than CARE customers.

E7 and E6

Tariff information is summarised in the ‘Description’ (above) and shown graphically below.




- Customers choose to opt-in to the tariffs (although E7 is now closed to new applicants)

## Remote / Automatic Control of Appliances:

Remote/ automatic control of appliances only applies when the SmartRate program is combined with the SmartAC program, which is described under Case Study 16.

## Information and Data Sharing:

Not applicable for this initiative.

## Advice / Customer Engagement:

Customers receive notifications of each SmartDay by up to four means (email addresses, phone numbers). Some customers elect not to be notified of SmartDays, or provided invalid information. Analysis of the impact of SmartDays has shown that customers who receive no notification have an average impact of 0.02kW (compared to an average of 0.25kW). Perhaps more surprisingly, the impact increases with increasingly number of notifications (0.13kW for one notification, 0.49kW for four notifications). This shows the value of customer advice in conjunction with tariff information. It may be that customers who are most keen to receive notifications (and therefore provide multiple phone numbers and email addresses) are those who are more likely to actively engage in the program anyway.

## Results:

SmartRate Program

- Average load reduction per event per household in 2011 was 0.24kW (similar to 2010 results) and the aggregate load reduction per event was 5.6MW. The results were highly variable across 'Local Capacity Areas' (a transmission constrained load pocket designated by the California Independent System Operator (CAISO)). These differences can be attributed to differences in climate/ geography between the areas.
- The average load reduction for CARE customers in 2011 was 39% as large as for non-CARE customers. This is despite a tendency for non-CARE customers to be located in cooler areas, and for CARE customers to be more likely to have air conditioning which has been shown to be a good enabling technology to take part in the SmartRate program.
- Event notification is highly correlated with load reductions, even among customers notified more than once.
- Air conditioning ownership is a strong driver of demand response.
- Customers that are enrolled in both SmartRate and SmartAC provide significantly greater demand response than those who are SmartRate alone.
- The vast majority of customers who sign up for SmartRate stay on the program.
- Between June and September 2011, 79% of SmartRate customers saved money compared with their otherwise applicable tariff.
- 'High Responders' (i.e. those providing the greatest response) are typically non-CARE customers, located in hot areas with air conditioning and high monthly usage.
- The size of the impact does not appear to change substantially depending on the number of summers a customer has participated in the program for.

E7 Static Time of Use Tariff

- During the peak price period in July from 12PM to 6PM customers use an average of 14.3% less electricity compared to the reference load.
- Customers are observed to decrease load during the peak period in the hottest month, with load increasing again (to levels similar to the reference group) immediately following the peak period (6 to 10 PM).
- During the summer (when there is the greatest difference in prices for E7 customers) the average load reduction was 0.27kW, these demand reductions coincide almost exactly with the peak pricing period (12 to 6PM). During winter, customers provided smaller, statistically insignificant demand reductions when prices are lower. On average E7 customers demand was 0.08kW lower than that of the control group during winter peak period hours. The average weekday load reduction across the whole year was 0.11kW (9.1%).
- Over the course of the year, 96% of customers on E7 had a lower average bill than they would have done with the same consumption profile on the E1 tariff (standard flat rate tariff), with an average saving of 11.6%.

## Key lessons learnt (to date):

- Critical Peak Pricing and static ToU tariffs with residential customers can provide load reduction during peak periods.
- Enabling technology (particularly large single loads such as air conditioning) contributes substantially to the size of response provided.
- Customers are willing to sign up to such a scheme and drop-out rates are relatively low.
- However, not all customers on the program provided a response, some sign up but do not opt to receive notifications of events and therefore provided little demand response.
- Specific information regarding customer experiences is not provided but the low drop-out rate would suggest that customers are generally happy.

## Major barriers encountered (to date):

- Barriers specifically related to this scheme are not described within the reference document. However, they have provided bill protection for customers on the SmartRate program to overcome the perceived barrier of customers' concern regarding the risk of paying more under the program.

## References:

2011 Load Impact Evaluation of PG&E's Company's Residential Time Based Pricing Programs. Available from:

http://fscgroup.com/reports/2011-pge-residential-time-varying-pricing-programs-evaluation.pdf Accessed 24/10/2012

## INT 4. Florida Power and Light Residential Load Control Pilot Project

### Description:

This pilot was established to evaluate the technical and economic benefits of a two-way communicating programmable thermostat technology to enhance Florida Power and Light's (FPL) existing switch-based direct load control program, On Call. The technology provided FPL with enhanced capability to monitor and control heating and cooling during system-critical periods. Participants had remote internet access to thermostats for programming to save energy and to monitor the temperature of their homes, and to override FPL curtailments

### Customers involved:

The pilot involved 400 residential customers. All the customers involved in the trial were from Broward County in south Florida. They lived in detached properties, inhabited by one family and had central air conditioning and heating appliances.

### Technologies deployed:

The pilot deployed programmable thermostats that could also be controlled by FLP. Householders could control their heating technology and monitor the temperature of their home remotely via the internet. The internet function could also be used to override any FLP curtailments

### Customer offerings:

There were no commercial offering involved in this trial.

### Customer engagement approach:

Two methods of recruiting participants in the trial were used in order to compare the appeal of this new product with the existing 'On Call' technology.

A group of 1000 existing On Call participants were given the opportunity to switch to the new technology in lieu of the credits that they would receive for taking part in the existing scheme. 2.2% of these customers switched.

The remainder of the trial participants were recruited from a direct mail shot to householders who would have been eligible to join the On Call scheme. They were offered either the new technology, or the existing On Call credit scheme. There was a 16% greater increase in response rate to the mail shot when the new technology was offered. 59% of respondents chose the On Call scheme and 41% chose the new thermostat scheme. On-going support was available from a free-phone line, the number of which was on the thermostat and the program web site.

Statistical analysis suggests that the new technology was statistically more appealing than the existing On Call scheme.

### Smart metering:

Smart meters were not installed as part of this trial. Air conditioner energy consumption data was gathered and transmitted by the thermostat.

### Tariff:

This trial did not require any trial intervention

## Remote / Automatic Control of Appliances:

FPL was able monitor and control heating and cooling during system critical period. Householders retained an override function, giving them the ability to override any curtailment.

One participant who left the trial blamed curtailments for their decision.

The override rate by event type is shown in the table below.

| Event type | Number of events in average | Average cumulative override rate |
|---|---|---|
| All events: 8 summer and 1 winter | 9 | 0.96% |
| Typical summer peak days, 50% cycle | 4 | 1.07% |
| Peak hour overrides for typical summer peak days, 50% cycle | 4 | 0.18% |
| Winter, 50% cycle | 1 | 2.28% |

## Information and Data Sharing:

This trial did not involve sharing data.

## Advice / Customer Engagement:

Participants were encouraged to program their thermostats. They were provided with information on three occasions telling them how this could be done.

1) by brochure at the time that the thermostat was installed;
2) by email following installation
3) by email in Spring 2008.

Fifty six percent of trial participants programmed their thermostats.

## Results:

- Customer satisfaction with the new thermostat is shown in the table below:

| | June 2008 (before events) | June 200 (after 9 events) | Test of statistical difference (t-test, 90% confidence) |
|---|---|---|---|
| Overall satisfaction with thermostat program, “Very satisfied” | 71%<br>59 responses | 68%<br>60 responses | No difference |
| Would “definitely” recommend program to a friend | 79%<br>63 responses | 73%<br>62 responses | No difference |

- Impact reduction customer overrides averaged less than 1%;
- Thermostat summer peak hour reductions, net of overrides, averages 0.93kW per participant at the meter;
- Thermostat winter peak hour reduction, net of overrides, averaged 0.91kW per participant at the meter;
- 4.75% of participants dropped out of the trial;

## Key lessons learnt (to date):

- Thermostat-based load control requires much more customer support than the 'On Call' program;
- The thermostat  technology was more attractive to potential customers than the 'On Call' system

## Major barriers encountered (to date):

- The new technology failed the post-trial statistical cost effectiveness test.
- Programmers uses 12% more annual cooling energy than none programmers;

## References:

More information about the trial can be found at:

http://aceee.org/files/proceedings/2010/data/papers/1953.pdf

## INT 5. Electricity Customer Behaviour Trial

### Description:

This Customer Behaviour Trial (CBT) is part of the Irish National Smart Meter Plan which is a commitment in the Irish Government's Energy Policy Framework. The objective of the CBT was to discover the potential for Smart Meter technology in conjunction with Time-of-Use tariffs to change consumer behaviour in terms of a reduction of peak load and overall electricity use.

### Customers involved:

5,375 domestic customers initially recruited via a phased 'opt-in' model, representative of the national profile. 723 SME were enrolled onto the trial. Participation was limited to:

- Customers of Electricity Ireland (this was the only electricity supplier in Ireland at the start of the trial, however supply competition was opened up during the trial. Any participant switching from Electricity Ireland during the trial was deemed to have dropped out of the trial;
- Consumers had to have been at their current address for over a year. This restriction was put in place remove those most likely to move during the Trial period, and therefore reduce attrition;
- Consumers who had opted out of sales and marketing contact from Electricity Ireland;
- Consumers who used Night Save rate electricity and had therefore already modified their electricity consumption;
- Consumers classified as in payment arrears or liable to being disconnected.

### Technologies deployed:

Smart Meters were installed in all participant households. From the 1st July to 31st December 2009 data was collected on a half hourly period and used for benchmarking. The test period lasted from 1st January to 31sy December 2010. Some participants also tested an electricity monitor. The purpose of the technology aspect of this trial was to:

- To learn about providing supporting systems, testing and deployment od smart meters;
- To assess the performance of different Smart Meter systems and communication technologies, and especially their performance in the context of the Irish environment;
- To identify risks and issues that should be considered in the contest of a full Smart Meter roll out.

The number and combinations of customer installations were as follows:

- Metering system with GPRS communications – 5,800 single phase and 500 three phase meter;
- Metering system with PLC communication – 1,100 single phase meters for customers in Limerick and Ennis (mix of urban and village locations);
- Metering system with 2.4GHz Wireless mesh – 1,591 meters in Cork City and 690 in rural County Cork.

### Customer offerings:

The CBT also wanted to discover if there was a "Tipping Point" when the price of electricity would significantly alter usage.

A control group was billed against their normal electricity supplier tariff and saw no changes to their bills. They received none of the DSM stimuli and were requested to continue using their electricity as normal.

The Time of Use tariffs were designed:

- To be neutral in comparison with a standard Electric Ireland tariff ensuring that the 'average' participant who did not alter their consumption pattern would not be penalised;
- The base Time of Use tariff reflects the costs of transmitting, distributing, generating and supplying as per standard tariffs;
- The time of use system bands were based on system demand peaks;
- Tariffs would be based on cost inputs used in the 2009/10 regulated tariffs.

All participants testing time-of-use tariffs were guaranteed that they were guaranteed that they would not pay more for their electricity than if they had been on a normal Electricity Ireland tariff. All participants received a balancing credit at the end of each benchmarking period. Those who had incurred costs above this average were recompensed on a case by case basis.

A small Prepayment User trial was also undertaken to test whether a Smart Meter could be used as a Prepayment Meter. This trial has sixty participants, mainly staff members from Electricity Ireland.

## Customer engagement approach:

5,375 participants were recruited following a voluntary 'opt-in' model using a tear off slip. The average response rate was 30%. In order for the participants to be representative of the national population, a phased recruitment process was implemented. Once recruitment was completed the consumers who had volunteered was compared to those who had not responded in order to check and confirm for national representivity.

## Smart metering:

The smart meter was used to collect half hourly data for billing. Three communication systems were trialled: power-line carrier, wireless LAN and point to point wireless. The following observations were made.

- Currently PLC could deliver monthly readings however there was issues with reliable daily data collection and on-demand tasks. Outside ideal network conditions the reliability deteriorated.
- The GPRS system worked well with good availability however scaling the system to large numbers may be an issue. This would be useful as a short term solution for a small number of meters however there may be issues with it in the long term;
- The 2.4GHz mesh system worked in urban areas however performance was disappointing in rural areas. This was largely because of European Regulatory limitations on the signal power at this licence exempt frequency.

Management of access to install indoor meters was a key deployment issue, but it benefited from time spent developing a plug and play meter design. Technical difficulties were encountered in 3% installations. Time and resources to deal with these issues must be factored into any future roll out.

## Tariff:

Once recruited, participants were allocated to a test group, or the control group. Allocation was based on achieving an even profile in each experimental cell across demographic, behavioural and attitudinal perspectives. Data from the benchmarking period and the pre-trial survey was used to achieve this.

### Table 1: Domestic Time of Use Tariff

| | | **Night**<br>23.00-08.00 | **Day**<br>08.00-17.00<br>19.00-23.00<br>Weekdays<br>17.00-19.00<br>Weekends and bank holidays | **Peak**<br>17.00 -19.00<br>(Monday to Friday). Excluding Bank Holidays |
|---|---|---|---|---|
| Tariff A | Euro Cents per kWh | 12.00 | 14.00 | 20.00 |
| Tariff B | Euro Cents per kWh | 11.00 | 13.50 | 26.00 |
| Tariff C | Euro Cents per kWh | 10.00 | 13.00 | 32.00 |
| Tariff D | Euro Cents per kWh | 9.00 | 12.50 | 38.00 |

### Table 2: Domestic Time of Use Tariff (Weekend tariff)

| | | **Night**<br>23.00-08.00<br>And all weekends | **Day**<br>08.00-17.00<br>19.00 -23.00<br>Excluding Bank Holidays | **Peak**<br>17.00-19.00<br>(Monday to Friday)<br>Excluding Bank Holidays |
|---|---|---|---|---|
| Monday to Friday | Euro Cents per kWh | 10.00 | 14.00 | 38.00 |
| Saturday & Sunday | Euro Cents per kWh | 10.00 | 10.00 | 10.00 |

### Table 3: SME Time of Use Tariff

| | | **Night**<br>23.00-08.00 | **Day**<br>08.00-17.00<br>19.00 -23.00 | **Peak**<br>17.00-19.00<br>(Monday to Friday)<br>Excluding Bank Holidays |
|---|---|---|---|---|
| Electric Ireland | | | | |
| Tariff A | Euro Cents per kWh | 14.00 | 15.00 | 22.00 |
| Tariff B | Euro Cents per kWh | 7.50 | 16.00 | 22.50 |
| | | | | |
| Bord Gáis Energy | Euro Cents per kWh | Tariff applied varied by individual participant | | |

### Table 4: Residential Matrix allocation as of 13 November 2009

| Tariff | Bi-monthly bill and energy usage statement | Monthly bill, and energy usage statement | Bi-monthly bill, energy usage statement and electricity Monitor | Bi-monthly bill, energy use statement plus Overall Load Reduction | Total |
|---|---|---|---|---|---|
| Tariff A | 342 | 342 | 342 | 342 | 1,368 |
| Tariff B | 127 | 129 | 127 | 128 | 511 |
| Tariff C | 342 | 342 | 343 | 343 | 1,370 |
| Tariff D | 127 | 129 | 126 | 127 | 509 |
| Weekend | | | | | 100 |
| Control Group | | | | | 1,170 |
| | **938** | **942** | **938** | **940** | **5,028** |

Participants also received a fridge magnet and sticker. The fridge magnet displayed the time bands and costs, customized for each tariff group.

## Remote / Automatic Control of Appliances:

The trial did not include any elements of remote or automated control of householders appliances.

## Information and Data Sharing:

There was no information sharing element to this trial.

## Advice / Customer Engagement:

A decision was made that cooking and oven use would be excluded from any communication about energy reduction or peak shifting in order to avoid any sensitivity about prescribing when people should cook meals.

Both the Test and Control groups were exposed to national energy efficiency campaigns that were being run by various organisations at the time.

All the Test groups received a Fridge magnet, tailored to their time-of-use tariff, showing the different time bands

## Results (Domestic):

- Time of Use tariffs and DSM stimuli are found to reduce overall electricity usage by 2.5% and peak usage by 8.8%;
- The combination of bi-monthly bills, energy usage statement and electricity monitor is found to be the most effective combination of stimuli, reducing peak usage by 11.3%;
- Overall energy reduction is linked to the level of usage – high consumers tended to deliver the greatest reduction in usage;
- Analysis suggests the shifting of load from peak to post-peak and in general to night usage from peak;
- No single tariff group in combination with DSM stimuli was more effective than others;
- The peak and overall load reductions detected for all the stimuli proved to be statistically significant apart from the overall load reduction for the bi-monthly billing and detailed energy statement stimulus, although the peak load reduction achieved for this stimulus was statistically significant;
- The data from the trial proved no evidence of a Tipping point – peak usage was estimated to be highly inelastic relative to price.

## Results (SME):

- Time of Use tariffs and DSM reduced overall usage by 0.3% and peak usage by 2.2%. Neither result was statistically significant;
- There was no tariff, DSM stimulus or tariff and DSM stimulus group that reduced overall electricity use or peak usage by a statistically significant amount;

## Key lessons learnt (to date) (domestic):

- Participant adapted their usage to the tariffs. 82% participants made some changes to the way that they use electricity with 74% stating that their household made major changes;
- The fridge magnet and stickers were found to be useful by participants, achieving 80% recall and 75% found the fridge magnet useful;
- The electricity monitor was deemed an effective support to achieving peak and overall electricity reduction;
- The trial succeeded in making participants more aware of their energy usage;

## Key lessons learnt (to date) (SME):

- Tariffs were regarded as effective supporting overall energy usage and reduced peak usage. 71% stated that peak cost forced them to attempt to reduce the usage at this time;
- Participants had a higher level of regular monitoring of their electricity usage with an increased likelihood of trying to identify ways to reduce usage;
- The electricity monitor was found to be an effective tool to reducing overall and peak electricity use;
- Among those participants who achieved an overall load reduction, the reduction was 8.51% on average, and amongst those who achieved a peak load reduction, the peak reduction was 10.25% on average.

## Major barriers encountered (to date) (domestic):

- Linking behaviour change to bill reduction proved a barrier to peak load reduction. This may be difficult to address because of exaggerated saving expectations;
- The Overall Load Reduction incentive was not well remembered;
- Participants were reluctant to shift usage to night time because of safety concerns and convenience;
- The Trial did not provoke any secondary benefits such as increased awareness of general energy efficiency or investment in energy efficiency products for the home;

## Major barriers encountered (to date) (SME):

- The main barrier to reduction was the perception that it was not possible to move usage to other times
- The web-site information was poorly-used;

## References

Further information on this project can be found at:

http://www.cer.ie/en/information-centre-reports-and-publications.aspx?article=5dd4bce4-ebd8-475e-b78d-da24e4ff7339

# INT 6. PG&E SmartAC Program

## Description:

PG&E operate the SmartAC program with residential and small/ medium customers. The program involves the installation of programmable communicating thermostats (PCTs) and/ or switches in customers' homes with central air conditioning (CAC) units. When a SmartAC event is called, the control devices limit the duty cycles of CAC units or adjust thermostat temperature settings, reducing demand.

SmartAC events can be called in emergency situations between May 1st and October 31st for six hours or less, to a total of 100 hours per year. The results discussed below are for summer 2011. During this period the system was only used for test purposes. The program has run from 2008 onwards.

## Customers involved:

In 2011 the program involved 146,000 residential and 6,200 small/ medium business customers. This equated to 161,484 controlled devices in residential properties and 11,533 devices in business premises.

## Technologies deployed:

The results for 2011 focus on the control of air conditioning units either directly through switches, or via a thermostat. The program website suggests that customers with heat pumps would also be eligible to join the program.

The program uses two switches working directly with air conditioning units, LCR5000 and LCR5200 via the use of two different algorithms:

- 50% simple cycling: the device has its duty cycle limited to run no more than 50% of the time.
- 50% TrueCycle 2: limited to run no more than 50% of a baseline value, and so is limited to ensure the unit uses only 50% of the load they would have done otherwise.

It also uses UtilityProPCTs under simple and TrueCycle cycling and ExpressStat PCTs with simple cycling only, or by adjusting the temperature set point. For residential customers this temperature adjustment is 2 degrees in the first hour, and 1 degree in each of the following two event hours. For business customers the temperature adjustment is 1 degree in each of the first three event hours. The majority of technology was controlled under the TrueCycle2 algorithm.

In residential properties, 84% of controlled devices were switches for air-conditioning, and 16% were programmable thermostats. In business properties, 90% of controlled devices were thermostats and only 10% were switches for air-conditioning units.

## Customer offerings:

The installation of equipment to participate in the SmartAC program is provided free of charge and customers are provided with free technical support. Customers are able to opt-out of participating in an event either via the internet or telephone.
A financial reward is not offered for participating in SmartAC only (i.e. when not used with the SmartRate program described under Case Study 6).
The benefits of participating in the program are summarised for prospective program members via the PG&E website as follows:

- Free technical support of customers' air conditioning systems during their participation in the scheme. Technicians will repair any problems relating to the SmartAC device.

- The benefit for the community is highlighted, “You reduce the likelihood of power outages and help the environment- all without sacrificing comfort or control”
- The benefits for the environment are also summarised, “By generating less electricity from fossil fuel plants during peak periods, fewer greenhouse gases are produced and that means cleaner air for all of us”.

## Customer engagement approach:

Details of the recruitment methodology are not given within the literature reviewed. Information regarding the program is provided on the PG&E website. It is not known whether direct marketing of the scheme to customers (e.g. via mailshots) has taken place.

## Smart metering:

The eligibility criteria for joining the scheme does not include a requirement to have a Smart Meter installed. As the technology does not rely on communications via the Smart Meter and does not require billing information it would appear that the scheme could operate effectively without Smart Meters.

Smart Meter data has been used for residential customers to allow analysis of data from the 2011 program. For business properties this approach was not possible and so data from the CAC data logger was utilised.

## Tariff:

Some customers on the SmartAC program also take part in the SmartRate program. An analysis has been undertaken of the benefits of ‘dual enrolment’. The results are summarised in ‘Results’ below.

## Remote / Automatic Control of Appliances:

- The program involves the automatic control of air conditioning units and thermostats.
- Customers are able to opt-out of participating in any particular event and are provided with free technical support.
- Residential standard cycling strategy in 2011 was 50% TrueCycle2 for switches or UtilityProPCTs and 50% simple cycling for customers with ExpressStat PCTs. This led to an increased size of response relative to a more simple switching strategy in 2010.
- Small/ Medium business standard cycling strategy in 2011 was 33% for TrueCycle 2 switches and PCTs. These control strategies were improved between 2010 and 2011 and this resulted in an increase in load reduction of 70% and 120% for residential and business customers respectively.

## Information and Data Sharing:

Not applicable.

## Advice / Customer Engagement:

Not applicable.

## Results:

- Residential Customers have an estimated impact of 0.50kW per event (compared to a reference load of 2.30kW)- a load reduction of 22%.

- Controlling residential air conditioning units directly (via CAC switches) provided nearly twice the impact of controlling thermostats, with average residential impacts per device of 0.32kW and 0.54kW for thermostats and CAC switches respectively.
- Residential customers with higher reference consumption of electricity were shown to provide a greater impact than those with lower reference consumption. The average per customer per event impact for customers in the top 10% of consumption is 0.85kW, compared to 0.19kW for customers in the bottom 10% of consumption.
- For residential customers who are enrolled in both SmartAC and SmartRate the control devices are activated for both event types. Analysis of the impacts for dually enrolled customers and those on SmartRate or SmartAC only is shown below:
    - Average Impact for SmartAC only customers: 0.58kW
    - Average Impact for SmartRate only customers: 0.33kW
    - Average Impact for Dually-Enrolled customers: 0.68kW
- 1,000 residential customers who took part in a two hour test event did not experience statistically significant more discomfort than a control group of customers who did not take part in an event. This result was replicated for small/ medium business customers.
- The mean impact for a residential customer for five and two hours events were 0.65kW and 0.61kW respectively. This demonstrates that the size of response is not adversely affected if a longer event is necessary. The 'snapback' demand following the end of an event is also roughly the same (0.28kW for five hours, 0.26kW for two hours).
- Small/ Medium Business customers have an estimated impact of 0.29kW per event (compared to a reference load of 1.71kW) - a load reduction of 17%. The size of impact was not influenced by the type of technology (controlled air-conditioning or thermostat).

## Key lessons learnt (to date):

- Analysis of the data shows that residential multi-device properties appear to provide no more load impact per premise than single-device properties. Installing multiple devices per premises increases costs (due to additional equipment and installation time) without any further benefit. Conversely, business multi-device properties appear to provide roughly the same amount of impact per device as single device properties and are therefore most cost efficient as they only require one visit by a technician to install equipment and provide maintenance. It is suggested that the difference between residential and business customers is due to the higher likelihood that business customers operate multiple air conditioning units at one time.
- Customer satisfaction with SmartAC program is generally high- customers who were asked to rate "how satisfied they were with the program overall" on a scale of 1 to 10 (1 being "Very Dissatisfied" and 10 being "Very Satisfied"). The mean scores among residential and business customers were 8.0 and 7.7 respectively.
- The following recommendations were made as a result of the 2011 review of the program:
    - Concentrating recruitment of customers to those with particularly high summer energy usage (estimated to increase per customer load reduction by 50%)
    - Further improvements in device communications.

## Major barriers encountered (to date):

Some technical communications issued were experienced in contacting the switches to ensure a response for each test event. This has been improved via the use of a new algorithm which attempts to contact the device every half hour, rather than once only.

No barriers in relation to customer experiences/ engagement are identified within the literature reviewed.

## References:

PG&E Website for SmartAC Program: http://www.pge.com/myhome/saveenergymoney/energysavingprograms/smartac/ Accessed 25/10/2012

2011 Load Impact Evaluation for Pacific Gas and Electric Company's SmartAC Program. The FSC Group. June 2012. Available from: http://www.pge.com/myhome/saveenergymoney/energysavingprograms/smartac/ Accessed 25/10/0212

## INT 7. ETSA Direct Load Control

### Description:

ETSA (now SA Power Network, Distribution Network Operator in South Australia) have implemented a number of phases of trials of Direct Load Control. The main driver of this trial is to reduce peak electricity demand, particularly that from air conditioning units. The trials have taken place in three main phases (Phase 1 completed March 2006, Phase 2 during Summer 06/07 and 07/08 and a third phase in Summer 09/10), with different numbers of customers/ geographies involved at each stage. The aim of the project was to investigate both the technology and customer acceptance.

The results of each stage of the trials are described below. It is not clear whether any trials are currently ongoing, although the SA Power Networks website currently states: "We are now committed to implementing our invaluable trial learning's".

### Customers involved:

The customers involved in each stage of the trials are shown below:

- Phase I (completed in March 2006): Sample size of 20 residential customers. The customers were selected from a pool of 50 in the Adelaide metropolitan area that represented a cross section of the community in terms of house type, age of house, occupants' lifestyle, size and type of air conditioner etc.
- Phase II (completed in Summer 06/07 and 07/08): Marketing to approximately 12,000 residential and commercial premises. This resulted in 4,000 contacts from which 2,392 air conditioning units were suitable for the trial in approximately 1,570 residential and commercial locations. The total number of units used in the trial was therefore 2,392. This phase was split into two sub-phases:
    - Phase II(a): Focusing on 'Type 1' air conditioners from a total pool of 1,108 units.
    - Phase II(b): Focusing on 'Type 2 and 3' air conditioners from a total pool of 1,158 units.
- Phase III (completed Summer 09/10): 1,100 potential participants. The mix between residential and commercial premises is not stated in the literature.

### Technologies deployed:

Automatic switching of air conditioning (either split or ducted refrigerated systems). The literature describes the use of a Demand Response Enabling Device (DRED or Peakbreaker) connected to the air conditioning unit in order to facilitate direct load control, via the use of an FM radio signal. Newer air conditioning units required an additional interface card.

### Customer offerings:

Phase I: Customers identified based on ensuring that the sample was representative of the metropolitan area of Adelaide. The available literature does not indicate whether customers were offered any particular incentive (financial or otherwise) to participate in the trial.

Phase II: This phase was preceded by a marketing and community engagement program, "Beat the Peak" focused in an area with a significant penetration of air conditioners which are supplied by two substations which are likely to be constrained within a small number of years. Customers were offered a AUS$100 incentive to take part.

Phase III: This trial was specifically marketed to customers in a different location to Phase II. The incentive offered to customers to take part is not stated within the literature reviewed.

## Customer engagement approach:

Customers were targeted according to geography in Phase II and III of the trial. The engagement approach used for Phase I is not clear. Customers in Phase II and III voluntarily opted-in to the trial. In the case of Phase II a specific marketing campaign was used to attract customers. This resulted in 47 and 16 features in local and national media respectively, with only one including negative commentary. No media disputed the demand side message, or raised issues with the use of the demand side to resolve the problem as against use of the supply side. For Phase II a direct marketing campaign in the local area was also employed via the use of direct mailshots, bus shelter advertising, large posters in shops and on the back of the local community bus and articles placed in local council newsletters. Customers were provided with a self-addressed envelope to indicate their interest via the direct mail shot, could call one of three designated call centre operators, contact a dedicated email address or contact ETSA via a registration form on their website. All customers who expressed an interest received a personal letter from ETSA thanking them for registering and were followed up with a phone call. Some of the key lessons learnt from this customer engagement are summarised in 'Results' (below).

The customer engagement approach used in Phase III (direct marketing, media campaign etc) is not clear from the literature reviewed.

## Smart metering:

Each phase used interval meter data to determine the size of response (stored in either 15 or 30 minute intervals depending on the size of connection). Data was received using both remote connections and on site reading. It is not clear if the 'interval meter' referred to in the documentation was a 'Smart Meter' or whether it was fitted specifically for the purposes of the trial.

## Tariff:

Not applicable.

## Remote / Automatic Control of Appliances:

The trial investigated the use of direct load control of a variety of types of air conditioning units, in various phases. An additional switching/ interface device was installed to facilitate this direct load control. The complexity of the installation of the direct load control equipment varied according to the type of air conditioning unit, this also effected the time taken by the installer to install the equipment. One design of air conditioner required a more intrusive installation which would take longer. Approximately 6% of customers dropped out when this was explained to them.

A variety of lengths of interruptions were trialed, from as little as 8 minutes in each 30 minute period to a maximum of 25 minutes in a 60 minute period.

The literature reviewed does not state whether customers were provided with a manual override function to opt-out of any particular interruption.

## Information and Data Sharing:

Not applicable.

## Advice / Customer Engagement:

Not applicable.

## Results:

- The use of direct load control showed a measurable decrease in demand when activated. The average reduction for the Glenelg and Mawson Lakes areas were 0.45kW and 1.34kW respectively (compared to average air conditioning ratings of 3.08kW and 5.07kW), as part of the Phase III trial. This difference is thought to be due to the geography of the regions involved.
- There was also high variability in the size of response within each geographical region.
- The Phase I trial showed a demand reduction of 17%.
- Phase I also demonstrated that it was possible to interrupt air conditioning loads without customers experiencing a reduction in comfort levels.
- The second phase of the trial (following the 'Beat the Peak' marketing campaign) observed a change in community attitude including a new openness to thinking about how to manage peak demand. This change in attitude extended beyond trial participants. This also demonstrated that it is possible for customers to change their view that the supply side should be entirely responsible for the balance of supply and demand. The avoidance of jargon and divorcing the discussion from pricing was believed to be important in describing to customers the difference between paying for electricity supply and paying for electricity transmission/ distribution.
- The early outputs from the trial indicated that it is feasible to sustain interruptions of 15 minutes in a 30 minute period without leading to any customer complaints regarding comfort levels.
- There was a higher drop-out rates of customers when the installation required access to the home rather than a 'garden installation'.
- When a more intrusive installation was required, customers were much more trusting when the installation was to be carried out by a representative from the manufacturer of their air conditioning system rather than a third party.

## Key lessons learnt (to date):

- The marketing used prior to Phase II "demonstrated that the community values direct and simple communications that avoids technical, market and political emphasis and is prepared to respond with a strong ethos of contribution and involvement in "doing their bit" as long as they understand where the value lies in their contribution. The every little bit helps message is one the community feels comfortable with."
- Where customers have volunteered to take part in a trial, and require a visit by an installation technician in order to set-up the equipment involved it should be noted that "homeowners need to be given a significant level of control over the installation time. Installers cannot expect volunteers to act like customers and to be available in a schedule that suits the installer rather than the volunteer".

## Major barriers encountered (to date):

- Customers were more likely to drop-out when an installer required access to the inside of their home (as opposed to a 'garden installation').
- Customers were also more likely to drop-out if they perceived a risk for damage to either their equipment (their air conditioning unit) or the fabric of their building.

## References:

Demand Management Program Interim Report No. 1. June 2007. ETSA. Available from: http://www.sapowernetworks.com.au/centric/industry/our_network/demand_management.jsp Accessed 29/10/2012.

Demand Management Program Interim Report No. 3. June 2010. ETSA. Available from: http://www.etsautilities.com.au/public/download.jsp?id=11891. Accessed 29/10/2012

http://www.sapowernetworks.com.au/centric/industry/our_network/demand_management.jsp Accessed 29/10/2012

## IT 1. Impact of a mandatory ToU rate among residential customers in Italy

### Description:

RSE is currently monitoring a selected panel of customers in Italy in order to analyse the effects of the introduction of a mandatory Time of Use electricity rate in Italy starting from July 2010.

The panel is composed of 28,000 household customers, randomly selected among the whole Italian population, and it contains their monthly consumptions during both peak and off-peak hours.

Data acquisition has started in July 2009, i.e. from one year prior to the introduction of the ToU tariff, and it will likely continue beyond 2013.

### Customers involved:

About 28,000 residential customers, all subject to the universal supply regime in Italy.

### Technologies deployed:

The only technology deployed in the project is the smart meter used to measure customers' electricity consumptions

### Customer offerings:

All the customers are subject to the universal supply regime in Italy and therefore have to comply with the rules established by the Italian Authority for Electricity and Gas (AEEG); however, they are allowed to switch to the "free market" and therefore choose another DSO without any penalties whenever they want

### Customer engagement approach:

Customers were randomly selected among all the customers subject to the universal supply regime in Italy: the four major Italian DSO's were asked to extract 1 out of every 1,000 their customers, after ordering them alphabetically.

### Smart metering:

Smart meters were exclusively used to collect customers' monthly consumptions during both peak and off-peak hours.

### Tariff

The customers have been subject to the following tariffs:

- July 1st 2009 ÷ June 30th 1st 2010: **flat tariff**
- July 1st 2010 ÷ December 31st 2012: **transitional ToU tariff**
- January 1st 2012 ÷ now: **final ToU tariff**

The switch from flat to ToU tariff was mandatory for all customers subject to the universal supply regime. No complaints were filed during the monitored period by any of the customers involved.

### Remote / Automatic Control of Appliances

There were not any remote or automatic control of appliances/end-use loads inside customers' homes.

## Information and Data Sharing

All the results were shown during both national and international conferences, always in an aggregate form, in order to protect customers' privacy. Consumers organization were informed but they were not directly involved in the process of data acquisition and analysis.
The main difficult encountered was elaborate an automated procedure to elaborate the huge amount of data which were transmitted monthly to RSE.
Customers were unaware that their consumption were being recorded and transmitted to RSE by their DSO, in order to prevent Hawthorne effect.
The results have been used by the Italian Authority for Electricity and Gas (AEEG) to test the effectiveness of the entry into force of a mandatory ToU tariff and elaborate new strategies to improve its weak points.

## Advice / Customer Engagement

Customers were unaware of their participation in the test case and the information they received before the entry into force of a mandatory ToU tariff was the same of all the residential customers in Italy; such information included both advertising campaigns and a systematic splitting of their consumption between peak and off-peak hours in their bills prior to the entry into force of the tariff itself.

## Results:

The change in the behaviour of the Italian users has not been negligible because about 60% of the customers in the panel have moved their consumptions according to the price signal provided by the ToU tariff; the positive effect of such behaviour has been balanced by the remaining 40% of the customers who have modified their consumption habits in the opposite way that the ToU was supposed to induce.

Therefore, there has been a limited shift of consumptions from peak to off-peak hours in the period July 2010 – June 2012 after the introduction of the mandatory ToU tariff: it has resulted to be around 1%, with on overall savings of about 6.45 M€ achieved by all the residential customers in Italy.

## Key lessons learnt (to date):

The main reasons which have prevented a larger shift to occur among the customers are:

- consumption allocation during off-peak hours was high even before the introduction of the ToU tariff, thus reducing the amount of consumption which would be shiftable in principle;
- the price signal conveyed to the customers was very low, due to the tiny price difference between peak and off-peak hours.

There are some aspects of the ToU tariff which may be improved, such as the allocation of the hours of the day to the peak and off-peak sets, or the introduction of the "Critical peak pricing" in parallel with the ToU tariff.

## Major barriers encountered (to date):

The main barrier is the not uniform customers participation; customers have, in fact, reacted in very different ways, from those who have complied with the dictates of the ToU tariff, to those who have ignored it. It is difficult to explain all the reasons behind that, especially the ones not directly connected with the introduction of the ToU tariff.

## References:

S. Maggiore, M. Gallanti, W. Grattieri, M. Benini, *"Impact of the enforcement of a Time-of-Use tariff to Residential customers in Italy"*, CIRED 22nd International Conference on Electricity Distribution, June 2013;

S. Maggiore, *"Impatto su comportamenti e consumi delle famiglie di un sistema di prezzi biorari dell'energia elettrica"*, RSE protocol 12000915, march 2012, available on http://www.rse-web.it;

## KR1. Jeju Island

### Description:

Jeju test-bed was selected based on her renewable potentials, island characteristics and public relations to general tourists. The primary focus of this project was to connect different electronic devices that never connected before and to develop feasible business model and commercial solutions for national market.

Republic of Korea is a partly unbundled electricity market. While generation side has been competitive since 2001, the demand side has been in the hand of monopsony retailer, KEPCO (Korea Electric Power Corporation). This project involves most of the renowned business names in Korea such as Samsung, KT (Korea Telecom), SKT, LG (LG Chem), POSCO, and KEPCO.

Among 5 domains, Smart Place (smart consumer) aims to simulate competitive retail electricity market and to provide new bundled services with new pricing schemes. In addition, aggregated demand resources take part in the wholesale market in order to give pricing signals from demand side, which does not exist in Korea yet.

### Customers involved:

About 2,300 homes and a few businesses are taking part in the trial, they are located in a rural community.

### Technologies deployed:

Smart meters, IHD (In-Home Display), PV panels, smart appliances are the focus of residential consumer technologies.

### Customer offerings:

The each consortium develops various dynamic tariff types and services while the incumbent utility tried to test real-time pricing scheme based on her current tariff.

A technical solution enabling customers with solar photovoltaic (PV) panels to use the power they generate within the home is also included in the trial.

### Customer engagement approach:

At the initial stage, customer engagement was not considered to have significant importance. During the course of test-bed implementation, customer empowerment and proper education have been recognised as critical to the successful deployment of consumer technologies such as smart meter, IHD and smart appliances. Since the test-bed is located at rural area where power of community elders is strong, each consortium was deliberately very careful to interview and select potential test participants. Local elders and key opinion leaders in the community were consulted in advance.

While participation in the trial is voluntary, customers are offered indirect financial incentives to participate. Smart appliances, PV panels, and IHDs were provided without any cost burden to customers. Some customers agreed to participate before the incentive was mentioned while some others strongly complained when they did not receive free smart devices.

Preliminary survey results have shown that the majority of participants (86.2%) have interests in electricity consumption reduction. After participating in the trial, 42.6% of the consumer answered that their electricity consumption behaviour has changed while the other 57.5% said their behaviour hasn't changed. Since the trial in consumer side is basically a simulation, which means that there had been no financial obligation for consumers, more detailed researches are needed before reaching a conclusion.

### Smart metering:

Smart Meters are being rolled out to about 2,300 customers. The Smart Meters include the following functionality:

- Automated meter reading controlled by HEMS, with data captured in 5-minutes and 15-minutes intervals
- In home display, providing information on consumption and cost of electricity with various time intervals from hourly to daily
- Demand response test using smart meter function

Data analysis of Smart Meter data is already completed as part of this project (analysis of data from approximately 2,300 residential customers). However, the official outcome is yet to be opened after the government's final test-bed review in July 2013.

### Tariff (Intervention type T)

Pricing schemes are still being developed – no further details available

### Remote / Automatic Control of Appliances (Intervention type)

N/A

### Information and Data Sharing (Intervention type F)

Real time energy metering and energy consumption data – no further details available.

### Advice / Customer Engagement (Intervention type)

N/A

### Results:

It is too early to be able to assess the results of the trials in terms of the amount of peak energy reduction or energy savings achieved.

### Key lessons learnt (to date):

- It is important to include diversified customer groups in terms of age, location, number of family member, household income
- It is very important to share customer's historical consumption data among test participating firms
- Customer engagement procedures are needed to be developed and introduced as a formal requirement before more wider implementation of smart meters
- Customers should bear part of financial burden if the customers were willingly to choose their tariffs. Simulation of electricity tariff choice was ineffective

### Major barriers encountered (to date):

- Lack of  real money incentive
- Lack of customer diversity. Most of the customers in the test-bed are homogeneous
- Law and regulation that do not allow bundled services including electricity, gas and IT services.
- Systems may not allow all tariff types to be trialled
- Conflict of interests between new entrants and transmission/distribution/retail monopoly. Neutrality of network access was not fully tested

### References:

Further information on this project can be found at:

http://www.smartgrid.or.kr

## NL1. ADDRESS

### Description:

ADDRESS is a large-scale Integrated Project co-founded by the European Commission under the 7th Framework Programme, in the Energy area for the "Development of Interactive Distribution Energy Networks".

The project started on June 1st 2008 and will last 5 years (2008 - 2013).

It is carried out by a Consortium of 25 partners from 11 European countries, carefully selected to meet the needs of the project in terms of skills, competencies and understanding of the problem and possible solutions, each of them bringing specific knowledge of at least one aspect of the supply chain. Enel Distribuzione is the Coordinator.

The total budget is 16 M€ , with 9 M€ financing by the European Commission.

Within the ADDRESS project tests will be performed to validate the solutions developed in the project. The validation will be partly done by means of simulations and laboratory tests, and partly in three field tests, which are a combination of actual field-testing and developed prototypes.

The ADDRESS Consortium has selected the test sites in three European countries with different network topologies and acceptance conditions which, taken together, provide a validation of the entire concept. Additionally, in Spain and France different climate conditions (warm in Spain, cold in France) will ensure different equipment and usage patterns.

ADDRESS stands for **Active Distribution network with full integration of Demand and distributed energy RESourceS** and its target is to enable the **Active Demand** in the context of the smart grids of the future, or in other words, the active participation of small and commercial consumers in power system markets and provision of services to the different power system participants.

To deal with active demand a new approach will be adopted by ADDRESS: it may be called the **"Demand Approach"** in contrast to the **"Generation Approach"** that is generally used to deal with generation and in particular Distributed Generation (DG).

Contrary to DG and large industrial customers, domestic customers are not motivated by purely economic considerations. Moreover, they are not able (e.g. due to the lack of appropriate equipment) or not prone to characterize precisely in advance the services and flexibilities that they can provide. Domestic consumers are not likely to "offer" services. Therefore, the services they can provide will be "requested" through the developed price and/or volume signal mechanisms and will be provided on a voluntary and contractual basis.

**The French Site:**

This test will validate the whole ADDRESS chain: from AD buyers to controllable appliances at the consumers' premises. The test will be performed in the **Houat and Hoedic** small islands, in the Brittany Region, under the responsibility of EDF.

**Figure 1: Location of French Trial**

The main test objective of the French field test is to demonstrate that the ADDRESS solution works from start to the end by means of:

1. Validation of market design (market simulator) and the ability of players to formulate AD needs and offers to the market or to the aggregator in case of bilateral relationships

- formulation of AD needs and bids by players based on actual requests from electricity system functions/players or based on requests resulting from simulations of possible problems and player's needs;
- portfolio management by Aggregator;
- AD offer formulation by Aggregator;
- (simulated) interaction of different entities with aggregation platform and (simulated) market interaction.

2. Validation of technical validation of AD requests by DSO simulator

**3. Validation of home system and interoperability/communication**

**4. Verification of AD product provision to AD buyer and of consumers' response**

**5. Validation of consumer behavior**

6. Test of combination of AD with Renewable Energy Sources (RES): requests taking RES production into account for load/generation balance and grid issues.

**The Italian Site:**

This field test will be carried out in Carpinone, in the Molise Region, and focuses on the Distribution System Operator (DSO) control system. The test will be performed under the responsibility of ENEL Distribuzione.

**Figure 2: Location of Italian Trial**

The objectives of the Italian field test are to test the prototypes and algorithms developed for the DSO to enable and exploit Active Demand (AD). Since the Italian field test is focused on the validation of the DSO's control system prototypes and algorithms, the participation of consumers to the AD market will not be taken into account.

The test objectives are:

1. Is it possible to allow AD activations in normal conditions while assuring network security? In order to answer this question a number of underlying issues must be solved, such as:

- Will the Load Areas be distributed into a wide enough variety to be appealing for market parties?
- Can the DSO consistently provide enough flexibility on the grid to allow for demand reshaping?
- Is the DSO (and the Transmission System Operator) able to validate AD bids in time and calculate usable curtailment factors for the Aggregators?

2. Can DSOs utilise AD options to solve short-term network security issues?

3. Is the DSO able to purchase AD products for its own benefits without disturbing the market place?

As this trial does not directly involve customers within the scope of Task 23, it is not taken further in the analysis.

**The Spanish Site:**

The Spanish field test in Castellon, in Valencian Community, will focus on the low voltage network with the participation of 300 consumers.

**Figure 3: Location of Spanish Trial**

Consumption and consumers' behaviour will be taken into account in order to manage loads through the Energy Box (EB), according to the AD signals sent by the Aggregator. The test will be performed under the responsibility of IBERDROLA.

The test objectives are:

**1. Validate social acceptance and customers' commitment**. Different questionnaires will be completed out during the field test period (pre/during/post trials).

2. Full validation of aggregator functionality and 'core business model' through the validation of the Aggregator Toolbox functionality.

3. Technically validate proposed solutions and prototypes for the Home System:

- **Validation of home system communication;**
- **Validation of EB interaction with equipment;**
- **Validation of equipment operation;**
- **Validation of the EB user interface;**
- Validation of EB algorithms;
- Validation of communication between EB and metering equipment;
- Validation of communication between EB and Aggregator;
- Collection and processing of metering information.

## Customers involved:

- French site: 50 to 100 customers
- Italian site: Participation of consumers to the AD market is not taken into account (focusing on validation of DSO control system and algorithms)
- Spanish site: 300 consumers

## Technologies deployed:

**French field test:**

The equipment installed at each consumer's premises consists of:

- one PC with the Energy Box software (EBox PC);
- up to 7 smart wall units to control the electric radiators and the water heater;
- up to 3 temperature sensors;
- 5 smart plugs to control some types of classical electric appliances; and
- Smart washing machines developed in the project and able to communicate directly with the EBox are installed at some 10 consumers.

**Spanish field test:**

The Spanish field test is carried out in the Mediterranean city of Castellon de la Plana; it is focused on the validation of the relationship between the Aggregator and the Energy Boxes (EBox_es), as well as the interaction between the EBox_es and the equipment downstream inside the consumers' dwellings. Three hundred (300) consumers are participating in the test with the following equipment:

- one EBox;
- five smart plugs;
- one smart washing machine (25 participants);
- one air conditioning management system (30 participants); and
- one dedicated measuring device, plus the official smart meter. – see picture below.

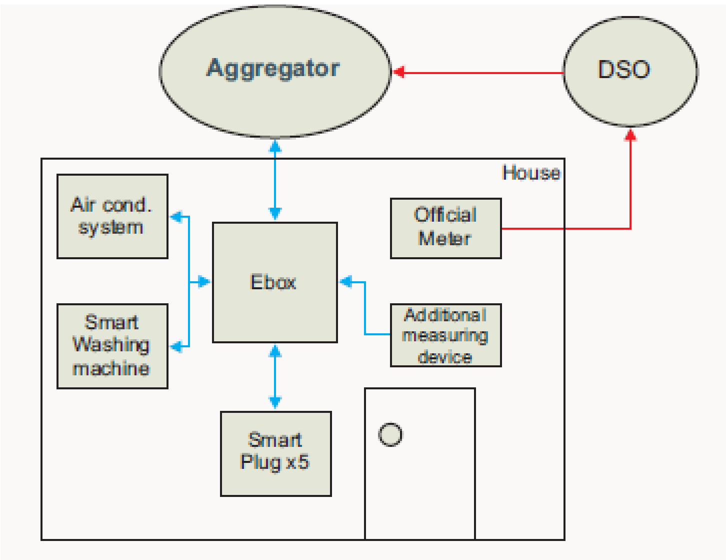



**Figure 4: Conceptual Architecture for the Spanish field test**

## Customer offerings:

No detailed information has been found on customer offerings.

## Customer engagement approach:

No information is available on the recruitment process used for the trial in France.

**Spanish field test:**

The process to recruit the consumers was divided into phases. The first one was carried out by phone calling potential consumers in order to request their availability and desirability for participating in the field test. During the conversation with consumers, the requirements, rights and obligations were presented and the incentives to participate were explained.
The second phase of the recruitment is the gathering of all the contracts signed by the consumers. Iberdrola has subcontracted a local company in the area where field test is being developed to carry out this activity. This subcontracted company visited all the recruited consumers in order to:

- Sign the ADDRESS contract.
- Analyze the different appliances inside the house in order to configure the EBoxaccording to these possible loads.

During this process some consumers rejected to participate in the project due to different reasons:

- Time between phone recruitment and signature of the contract (mostly); for instance, some consumers did not remember when they had accepted to participate in the project.
- Consumers did not like the explanation of the objectives of the project.
- Consumers did not agree with the rights and obligations defined in the contract.

## Smart metering:

The EnergyBox is in the project developed.  The role of the smart meter seems to differ between the pilots:

- Spanish field test: the meter appears to only be used for billing (see picture within 'Technologies Deployed' section).
- French field test: There appears to be no special role for the meter in the context of this project, based on the figure below.

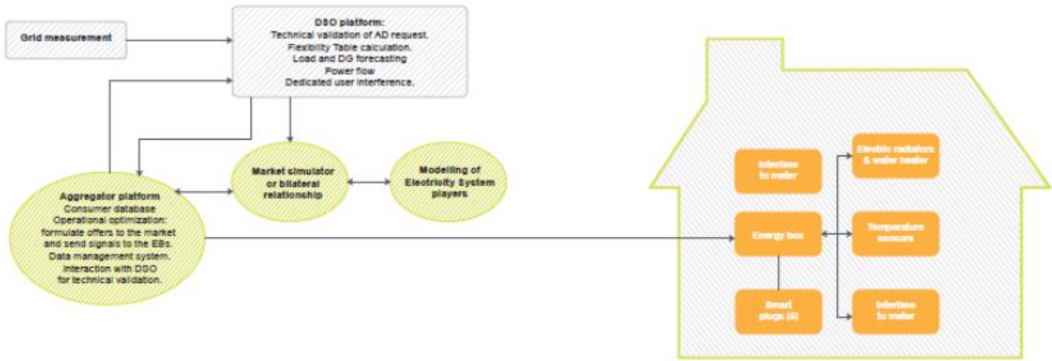



**Figure 5: French Trial**

## Tariff (Intervention type T)

Not applicable for this trial.

## Remote / Automatic Control of Appliances (Intervention type C)

Both the French and Spanish trials involved the use of an Energy Box (EBox) to control appliances and make measurements. A Home Area Network will be tested with the equipment installed in the different houses:

- Energy Box gateway between consumers and Aggregator toolbox which manages the loads downstream (i.e. in the house)
- Measurement devices measures the global consumption in the house
- Smart plugs and smart loads recieve the orders from the EBox and schedule or interrupt their cycling work according to them.
- The Energy Box manages the thermal, shiftable and interruptable loads taking into account the user's preferences and the signals received from the Aggregator.

## Information and Data Sharing

Spain:

The consumers will participate during the entire test with the equipment[1] installed in their houses. All the information regarding the use and measurements are sent to the Aggregator server everyday, where the measuring data is collected, in order to assess and analyze the consumers' response to the Active Demand events. With this information and the information gathered through different questionnaires/ interviews done during the test (at the beginning, in the middle and at the end), the consumers are classified into different clusters and are identified with a prototype load curve.

## Advice / Customer Engagement

In the case of Active Demand, previous experience shows that people are reluctant to take part in field tests due to concerns over its impact on comfort and lifestyles, as well as unease over data protection and safety. Control is another issue, with experience suggesting that the option to override comfort settings at any time gave participants more confidence in participating, even though they seldom used that option during the testing period.

[1] The equipments installed in all the dwellings are: EBox (ZIV): five smart plugs (Philips and ZIV) where different appliances will be connected (water heater, washing machine,dishwasher, dryer ...);additional measuring device that will be used to communicate with the EBox, and official smart meter, which was already installed. Additionally, the following equipment will be also installed in some of the houses (full HAN consumers): smart washing machines (25) from Electrolux; air conditioning management system (30) from Intesis.

For this test, Iberdrola has recruited 300 consumers in order to deploy the equipment that will be tested during the field test (6 months). The recruited consumers have signed a contract and will receive a fixed incentive for their compromise in participating in the field test. Additionally, consumers will receive a variable incentive based on the quality of their participation in the experience, according to the signals received from Aggregator and how they let EBox to manage their appliances with these signals.

## Results:

Results in relation to peak reduction or overall improvements in energy efficiency are not yet available. However, a number of conclusions have been published showing customers experience of using the technology (E-Box) and their motivations for taking part, as follows:

- Before the trial, consumer expectations of living with the technology were positive (In France and Spain 85% and 62% respectively thought living with the EBox would be either “fairly easy” or “easy”).
- Many consumers also expected programming the EBox to be straightforward- 64% in France thought it would “easy” or “fairly easy” in France, compared with 42% of those in Spain. 43% of Spanish trial participants did not know what to expect in relation the EBox.
- For some participants their experiences during the trial did not live up to the positive expectations; these consumers found using the EBox difficult and for many, the technology was invisible.
- Motivations for adopting AD go beyond financial incentives. Results suggest wider system benefits are important to people:
    - Participants in France are motivated because ADDRESS was a new technology (29%), and others are driven by more collective concerns about the environment (29%) and improving energy security in the islands (21%), whilst only 21% are interested in saving money (Figure 6).
    - The majority of participants in Spain (68%) are interested in saving money, 11% expressed interest in ADDRESS as a new technology and 8% in protecting the environment and energy security (3%), whilst other reasons (7%) were a combination of the above factors, mainly interest in the technology and environmental concerns featured strongly (Figure 6).
- These motivations are mirrored by participants’ rationales for saving energy. In France, 68% wish to save energy equally for money and environmental concerns, compared to 47% in Spain. Similarly, 8% in France wished to save money more than protecting the environment compared to 35% in Spain. Furthermore, there was considerable interest in other aspects of AD, such as feedback on household energy consumption, evident through conversations with participants in France.

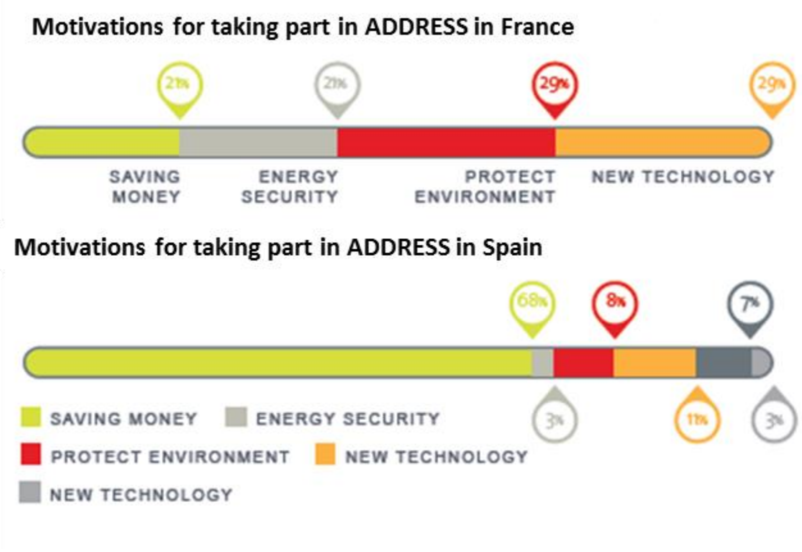



**Figure 6: Motivations for taking part in ADDRESS**

## Key lessons learnt (to date):

- For positive consumer engagement with AD, the usability of the technology, contracts and contextual issues are all important.
- User interfaces must be easy to understand, allowing users to input settings and to access the different functionalities that the EBox can provide.
- Accessing information about electricity consumption was very important to consumers in this respect.
- Consumers need support with the installation of AD technology to minimise technical problems and to facilitate setting the parameters of the load control.
- The ability to over-ride the system when needed is central to acceptance.
- Contracts need to be understandable, transparent and clearly set out the potential financial benefits and implications of different actions;
- Consumer privacy and data must be protected.
- Financial savings are important to consumers, although other factors such as environmental protection are important in their decision to adopt AD technology. The full range of benefits must be clearly communicated to consumers to ensure as wide a take-up as possible.

## Major barriers encountered (to date):

See also lessons learnt

## References:

http://www.addressfp7.org/

## NL 2. Power Matching City 2

### Description:

A project to demonstrate the energy system of the future with smart energy services, as well as the validation of costs and benefits of this system in practice in order to enable the energy transition.

PowerMatching City aims to predict what the energy system of the future will look like. The system allows consumers to “freely and automatically exchange electricity, while keeping u the comfort level.” Grid operators can use the concept for peak load reduction for capacity management, while utilities can use it as virtual power plant. Phase 2 (Power Matching City 2) focuses specifically on how smart grids can be integrated in the wholesale processes of an energy company. Power Matching City 2 will also examine capacity management.

Project will run until September 2014

### Customers involved:

Power Matching City 2 is a follow up on Power Matching City 1.

In Phase 1 22 households were involved, that were mainly part of a neighbourhood association, with already interest in ‘Green projects’. Households were spread over Hoogkerk and surroundings.

In Phase 2 18 households were added to the 22 from Phase 1. These 18 households are all living in the same street in Groningen, about half of all households in the street are involved in PowerMatching City 2. This is relevant, as it might give different dynamics.

The 18 ‘new’ households are connected in a Home Owners Association (and live in relatively expensive dwellings 400-500k Euro).

### Technologies deployed:

Includes:

- Heat pumps (already installed in the dwelling, but slightly adapted)
- Micro-CHP (installed specifically for the project, to replace condensing boilers)
- Washing machines
- Thermal heat storage (300 litre tanks)
- EVs (included in the project, but driving at a location >100km from the pilot site)
- PV

### Customer offerings:

Households pay €1000 start fee (to cover costs for e.g. smart appliances). During the project the €1000 is paid back to the participants.

New energy services have been developed in the context of the project, together with the participants of the project (co- creation).

1. Save smart (buy electricity as cheap as possible, sell it for the highest possible price at the APX or the balancing market).
2. Together comfortably sustainable. Try to be as sustainable as possible with the community as a whole. About half of the participants have PV. There is then a prioritization of options:
    - 1) try to use electricity generated by own PV.
    - 2) use power generated by neighbors
    - 3) use power from grid.

Portals: Participants get a tablet with energy display, to get insight in own consumption and production, share of renewable, forecasts, costs, forecasts of costs, etc.

Automated control:

- MicroCHP/ heat pump: fully automated.
- Washing machine, diswasher: you set time when it should be finished, the rest is automated (but can always be overruled).
- For other appliances (e.g. vacuum cleaner): price and sustainability indicated at any moment and time so that the resident can decide when to use it.

Monitoring: starts 1 September. Currently monitoring for baseline. One year price profiles will be shared with residents. Interviews and workshops during the year. And measurement of how much energy is consumed to validate cost-benefit models.

Some more detail: 2030 profiles (much RE, much gas) are used for APX and balancing market. Average price is about 30-37 cent/kWh, but prices vary between 0 – 50 cent/kWh. The changes in prices will determine costs for end user (incl. commodity costs, capacity costs and taxes).

## Customer engagement approach:

Home owners association was very enthusiastic, and started to recruit participants.

Street was constructed in 1990. Before joining Power Matching City 2, there were initiatives to collectively buy PV, to collectively buy heat pumps. Participation in a smart grid was a logical next step.

Sustainability and independence are main drivers.

## Smart metering:

Smart meters are used (15 min. values), for information gathering for billing. Currently no 'actual billing', based on the price profiles of 2030 – see previous questions. Furthermore, billing system in the Netherlands is currently based on a fixed monthly pre-payment, not on actual use of the period. But a 'dummy' bill will be produced based on time of use prices (real time pricing).

## Tariff

Tariff: please see the above. Virtual prices and tariffs were used, based on APX and balancing market (15 min. base).

## Remote / Automatic Control of Appliances

See also previous questions.

Mix of ToU, forecasting and real time.

## Information and Data Sharing

No third parties involved in the project.

Partners included: a DNO (Enexis) + retailer (Essent), ICT (ICT Automatisering) TNO (Knowledge Institute developing the PowerMatcher technology) and Gasunie (gas infrastructure company).

Further partners: Technical University of Eindhove (Faculty of Electrical Engineering). Technical University of Delft (Faculty of Industrial Design) and Hanze University of Applied Sciences (for socio-economic analysis)

## Advice / Customer Engagement

Co-creation and decisions on services; took place together with project participants. Saving tips were shared during the meetings.

Helpdesks in place (just for technical problems).

## Results:

The aim of project is to understand if the services that have been developed will have impact or not, what works and what doesn't. Technically everything is feasible. But what will be impact on costs, on level of RE used locally. Information will be used to validate cost benefit models for the various stakeholders.

## Key lessons learnt (to date):

Lessons: everything can always better. But: innovative projects require some flexibility. The challenge is to get started and not keep brainstorming on even more fantastic ideas.

Lessons from Phase 1 implemented in Phase 2. Suppliers of appliances are involved, which wasn't the case in Phase 1. This makes it easier to upscale to other locations.

Lighter computers being used, ICT in the cloud, just a small box near the meter (this is cheaper, makes it easier to upscale).

One of the main lessons from Phase 1 was "that it is only through the efforts of all parties along the entire energy chain that it becomes possible to fully exploit the opportunities in smart grids".

Households have perceived a high(er) level of comfort and indicate that they do not experience any inconvenience from participating in PowerMatching City's smart grid, since the energy trading on the local market is fully automated. The acceptance level amongst consumers is high.

The frequency of visits to the energy portal by consumers participating in the project indicates that it provides relevant information of interest to the customer.

A "bi-directional, interactive relationship between households and technology" is required so that households can understand the consequence of their energy actions. A learning loop is required that answers their questions about the operation of the system and helps them to achieve their energy goals.

## Major barriers encountered (to date):

- Customers are not able to use the "energy portal" to evaluate the payback period for investment decisions (e.g. new appliances or changes in heating technologies). Historical energy consumption data from before the installation of the smart meter is not available via the portal and it does not provide any support enabling the end user to evaluate investments themselves. This represents a challenge for the development of future energy portals.
- Households have indicated that they would like more advice on what to do/ how to use the portal.
- Appliances and equipment which is not part of the PowerMatching project do not provide device level consumption data to the portal and so the impact of consumers' use of these appliances is not clear.

## References:


http://www.tno.nl/downloads/factsheet_powermatching_en.pdf Accessed 22/07/2013

http://www.powermatchingcity.nl/site/pagina.php?id=46 Accessed 23/07/2013

## NL3. Rendement voor Iedereen

### Description:

Testing eight different services across two pilot sites (Utrecht and Amersfoort).

### Customers involved:

In Amersfoort 100 households are involved, all from one neighbourhood. It is a bottom up project, where service offerings have been co-created with the residents. Almost all households have PV panels on their roof.

In Utrecht also 100 households are targeted, but are recruited by a small local commercial company, also offering internet access in the same neighbourhood.

### Technologies deployed:

Net-to-grid system (comparable with Plugwise systems). Centrally controlled, with plugs at appliance level. Appliances controlled: tumble dryer, refrigerators, dish washers, washing machine. PV.

### Customer offerings:

In Amersfoort and Utrecht each 4 services have been defined.

In Amersfoort focus is on how to 'actively involve' end users. How to communicate services to end users. No system for actual billing (like in Power Matching City), less focus on market mechanisms (like in Power Matching City). Testing of messages/concepts end users are sensitive to. Questionnaires are used to analyse behavioral component.

Still unclear whether price incentives will be used.

Recruitment of participants: 'area ambassadors' used to recruit participants. The ambassadors were working together in a working group and have contributed on the set up of the pilots: requirements of the appliances, content of contracts for the households. Ambassadors recruited 100 participants.

Model (of using ambassadors) works well. But there need to be someone that coordinates/ organizes/ invites ambassadors, this requires a certain investment.

### Customer engagement approach:

See text above: both pilot sites are based on an opt in set up.

### Smart metering:

Smart meters have been installed in the context of the project. See also '8 services' for better understanding of what has been offered.

### Tariff

No information available yet, as services are defined, but not yet developed in full detail. Flexible pricing/price incentives may be used (depending on the services being tested – see list of 8 services that have been defined - , but it will not be used for actual billing.

### Remote / Automatic Control of Appliances

Bottom up – co-creation process – based on opt in: the best way to avoid complaints.
There might be complaints, but I am not aware of any.

8 services/concepts are being tested (1-4 in Amersfoort, 5-8 in Utrecht):

1. Insight in consumption (no control of load). This leads to savings (at least in the short term). Ambassadors have saved about 10%. (not clear yet if these savings will be achieved also by other households, nor clear whether they will remain over time. Ambassadors helped to translate information to the context of the households (easier accessible information).
2. Insight in consumption combined with saving recommendations. (Try to consume at times that PV generates power) guiding households in how they can achieve this.
3. Insight + price incentives
4. Insight + automated control. (can always be overruled by household).
5. Storage – vehicle to grid
6. EV- rental car service (green wheel concept).
7. Neighbourhood optimization (use each other's energy, try to reduce as much as possible).
8. PV BOX - test a technology to predict PV generation.

Energy savings not an aim, but load shifting is.

## Information and Data Sharing

What information (energy data) was shared, and who was the data shared with. Were any third party organisations involved

No information available yet, as services are defined, but not yet developed in full detail.

## Advice / Customer Engagement

**No results yet (pilot is still running).**

## Results:

Ambassadors have saved around 10% of their energy consumption via the use of an 'insight into consumption' (without control of load), although it is not clear if these savings will persist over time or be replicated by other trial participants.

## Key lessons learnt (to date):

**No results yet (pilot is still running).**

## Major barriers encountered (to date):

**No results yet (pilot is still running).**

## References:

http://www.smartgridtv.nl/article/home/64/smart-grid-rendement-voor-iedereen-in-utrecht-en-amersfoort/ (only available in Dutch)

Interview with Petra de Boer, DNV KEMA.

## NO 1. Malvik Norway

### Description:

This case description reports on a pilot project testing Demand Response (DR) among households in Norway. The main elements of the project were:

- smart metering

- remote load control functionality

- time variable grid tariff (Time of Use)

- hourly spot energy price.

40 household customers in the municipality of Malvik in Mid-Norway participated in the pilot study, which lasted for one year (~2007). Results from the study are publicly available.

Most information for this case study report is from Sæle and Grande (2011).

### Customers involved:

40 "typical" Norwegian household customers were part of this pilot. A key characteristic of the customers is the presence of an electric water heater (storage tank) for tap water or even an electric boiler for a hydronic space heating system. These units demand much power, from 2-3 kW up to 12-15 kW, while also having substantial heat storage capacity.

### Technologies deployed:

A major objective with the pilot was to induce shifting of power loads for the mentioned water heaters away from peak hours. Smart meters with hourly readings and Remote Load Control capabilities were used to achieve this. The necessary hardware was paid for and installed by the network owner.

### Customer offerings:

The contractual arrangement between the supplier/grid owner and the electricity customer included the following:

1) An hourly spot price as the basis of the energy contract

2) A grid tariff with three elements:

    - a fixed part (annual amount)

    - variable part, per kWh

    - a peak hour payment (per kWh, only during defined peak hours)

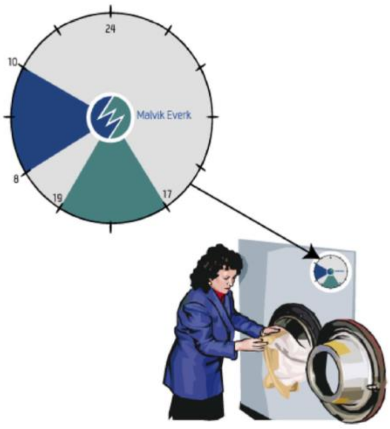
3) Option to have loads remotely controlled (by network owner)

4) A graphical "sticker" – reminder of peak hours, to stick on appliances

5) Two information meetings during the pilot

6) Web site with network costs and other relevant information.

The figure below shows the sticker used as a reminder of peak hours.




Source: Sæle and Grande (2011)

### Customer engagement approach:

Customers were recruited via an article in a local newspaper and via letters sent by email. Participation was voluntary.

Two meetings were offered to inform and motivate customers for load shifting. The "sticker" was reminding people that both the energy price and the network tariff were higher in peak hours (08 to10 and 17 to 19).

Customers were encouraged not to use the most power-demanding appliances in the peak hours, this to avoid the peak hour grid payment and the higher energy price in these hours.

### Smart metering:

An automatic meter with weekly readings had already been installed for all customers in this network. The 40 participants in the pilot had their meters adjusted to accommodate hourly reading, thus enabling network and energy contracts based on one hour time resolution. Consumption data was fed back to the network operator.

In addition, the meters were modified to enable load control (on-off) for electric heaters.

### Tariff:

The pilot introduced the Time of Use Tariff. This tariff was designed by adding a specific peak element to the existing standard network tariff. This element can be described as a "penalty" – fixed rate per kWh – for consumption in the predefined "peak hours". Peak hours were between 08 and 10 in the morning and between 17 and 19 in the evening, on weekdays. There were no peak hours in weekends.

The elements of the tariff were the following: fixed element: 187.5 Euros/year, variable part: 0.875 Eurocents per kWh, and peak hour payment: 7.88 Eurocents per kWh (in peak hours).

In addition a spot price based energy contract was recommended, although it was allowed for the customer to continue with any previous energy contract. High spot price would usually coincide with the peak hours, and would be an added incentive to shift loads.

### Remote Control of Appliances

Achieving load control in the peak hours was a major objective of this project. The primary end use technology addressed was water heaters. These installations require high power loads, and typically engage in a predictable time pattern as a result of water use habits of the households. Water heaters thus are important contributors to the morning and evening peak loads in the Norwegian power system. On the other hand, these installations represent substantial energy storage capacity, and the time of loading this storage does not substantially affect the comfort of use. It is therefore possible to move large power loads without reducing the comfort of the household. The water heaters were remotely controlled by the distribution system operator.

In addition, the pilot addressed other high power household appliances, such as dishwashers and washing machines. These appliances were controlled by the household, inspired by the general information around the pilot, and by the information stickers put on the appliances.

## Advice / Customer Engagement

In addition to remote control, customers were advised to avoid using electricity in the peak load periods, with an emphasis on appliances with a high energy demand.

The main intervention to achieve this, in addition to general information provided by the DSO, was the information sticker to be placed on the relevant appliances as a reminder to avoid peak hour use (see figure above).

## Results:

The average registered demand response in this pilot was the following, measured as a reduction in load in the peak hours:

- 1 kWh per hour for customers with standard water heaters
- 2.5 kWh per hour for customers with electric boilers for space heating.

The effect is illustrated in the figure below.


Fig. 8. Load profile for a household customer with hot water space heating system and RLC [13].

It has been estimated that an aggregation of this DR to all Norwegian households, would sum up to a 4.2 % reduction in the registered national peak load demand.

## Key lessons learnt (to date):

Significant load shifting is possible, given:

- motivated customers (here: small pilot group)

- suitable economic incentives (tariff and spot price)

- good information and "behavioural trigger"

Customers were mainly motivated by economic savings, but also electricity savings mattered.

Remote load control by the DSO was accepted, as long as it did not reduce general comfort.

Some customers adjusted other energy behaviours to better suit the new tariff. Some also said that their interest in and awareness of own energy consumption had increased during the pilot.

## Major barriers encountered (to date):

No specific major barriers were identified during the pilot.

Participants were generally motivated, and it is uncertain whether same positive results can be achieved in a full scale project.

## References:

Hanne Sæle and Ove S. Grande (2011): Demand Response From Household Customers: Experiences From a Pilot Study in Norway. IEEE Transactions on Smart Grid, vol. 2, no. 1.

## NO 2. eWave in-home display

### Description:

eWave is the display technology tested in a pilot project carried out in cooperation with a national research project titled "Environmental benefits from full-scale implementation of smart metering". We refer here also to the pilot project itself as "eWave". Its aim was to investigate ways of increasing customer awareness of own electricity consumption and thereby induce changes in behaviour in order to reduce this consumption. The in-home display "eWave" was a central element of this pilot project.

The pilot project was carried out in the period 2010-2012, and is thus completed as such. To date only preliminary results are available, however final report is expected in 2013.

### Customers involved:

Household customers in the municipalities of Follo (Eastern Norway) and Askøy (Western Norway) were selected for participation in this pilot project. The total of 91 households were distributed with 44 and 47 participants in the two respective regions. Follo Energi and Askøy Energi are the two power suppliers involved in the pilot.

The participating household are characterised as general and "average" Norwegian households. Since Norwegian households typically use electric energy for energy demanding end uses like space and tap water heating, their annual electricity consumption is quite high – at least compared to continental European households. Mean annual electricity consumption in Norwegian households is 16000 kWh. The participants in the pilot study are no exception to this, however the homes participating in this pilot were on average somewhat newer than the average Norwegian home. Direct electricity and wood stove were the main heating technologies.

### Technologies deployed:

The key technology in this pilot was a new Norwegian in-home display for electricity consumption, eWave (see illustration).

The unit has a range of display options, including graphs and "speedometer". Both current power and accumulated energy consumption, in addition to monetary (cost) variables, are available.

Although the eWave resembles a "smart grid-type" display, a smart meter is not required. A pulse reader connected to the main electricity meter registers the electric power, and communicates with the display. Further, the display is connected with the service provider over the internet via the household Wi-Fi network. This allows for price and other relevant information to be communicated between the service provider (power retailer) and the display.

This pilot aimed at increasing the households' general awareness of their electricity consumption, thus no specific end use loads were targeted in an explicit way. Still, it follows as a natural result that this increased awareness materialises in behaviour changes targeting the main end uses. The project survey showed that participants in the pilot tended to report behavioural changes such as:

- turning off appliances when not in use

- turning off lights when no one present

- reducing indoor temperature when no one is at home

- reducing indoor temperature during the night.

The implied effect of the eWave technology thus is related to the following end uses: heating, appliances and lighting.

### Customer offerings:

The in-home displays were offered for free to the customers of the electricity suppliers Follo Energi and Askøy Energi. The displays and necessary hardware were installed by the project.

The main offering to the customers was the information given by and functionality embedded in the display and its motivation to save energy.

### Customer engagement approach:

Participants were recruited on a voluntary basis by an advertisement in a local newspaper and on a relevant web page.


Facsimile: Advertisement to recruit participants in the eWave pilot project.

Text says: "Free aid to a lower electricity bill". "This unique offer is given to only 50 of our customers".

Other than this modest recruitment effort, no activities to promote the technology or create further enthusiasm were made. Once installed in the home, the idea was that the information displayed on the unit alone should motivate behavioural changes.

### Smart metering:

The display unit used in the pilot was not part of a smart metering concept. It was only used to record and process real time consumption data, and "pair" this information with current (tariff dependent) price data from the energy supplier to render the relevant information on the screen.

Metering for billing purposes was made the traditional way (manual reporting).

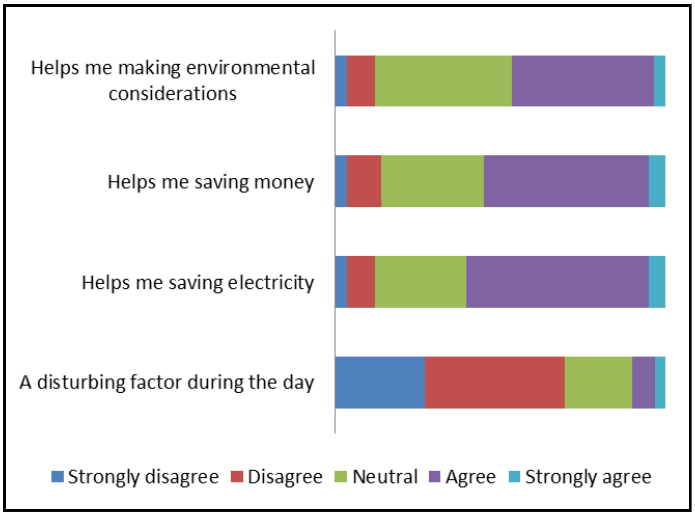
### Information and Data Sharing

The main purpose of the pilot was to test the effect of the feed-back display on awareness of own energy consumption, energy savings from behavioural changes, and the general acceptance and perceived usefulness of such a unit. eWave emulates the customer feed-back capabilities of a smart meter based information system, without the actual smart meter. Central smart-meter functionalities related to data storage and transfer, remote control etc., were therefore not part of the pilot. Further, load control, more accurate billing and other benefits associated with smart metering were not addressed.

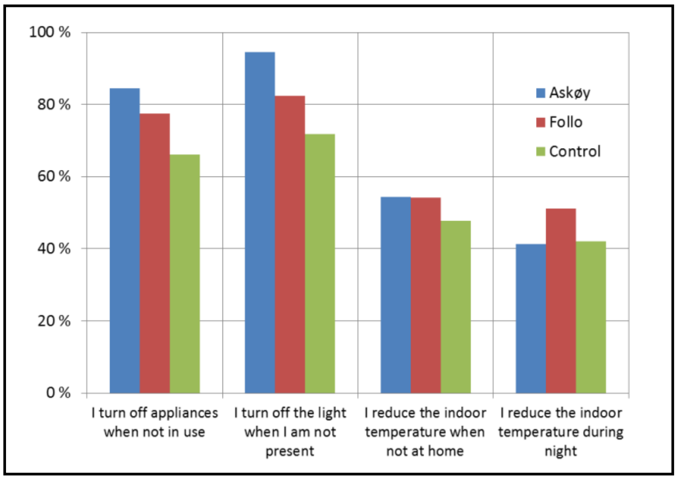
A few customers discontinued their participation. This was mostly due to technical faults of the display units.

No major concerns concerning data security, privacy, etc. were set forth. This may be due to the fact that consumption data were not used for other purposes than the disply, and also that no third party actors were involved.

Consumer experiences were generally positive. A survey taken up during the pilot indicates that very few customers consider the display a "nuisance". On the contrary, positive statements are given regarding saving of both energy and money, and environmental protection.




Further, households participating in the pilot report greater engagement in energy saving behaviours than a control group, with the exception of turning down indoor temperature during nighttime.




Preliminary analyses indicate energy savings in the order of 6 – 8 %. This has to be analyzed further and will be documented the final report of the pilot.

## Results:

This pilot shows that ONLY the feed-back of relevant price and consumption data on (well designed) display unit in itself may induce behavioural changes that result in energy savings. In this case the savings were in the range of 6 to 8 percent.

When interpreting these results, one must keep the recruitment process of the pilot in mind. A voluntary and limited participation, requiring an active response for signing up, could indicate that the participants are more interested in energy saving issues than the average household. Part of the reported effects could be attributed to this possible bias.

## Key lessons learnt (to date):

Customers reported behavioural changes such as:

- Turning off appliances when not in use
- Turing off lights when no one present
- Reducing indoor temperature when no one is at home, or during the night

Customers were able to make energy savings of 6 to 8%, even without engagement after the installation of the meter.

## Major barriers encountered (to date):

- No major barriers encountered, although it is not clear whether the results (energy saving and willingness to engage) would be replicated in the general population.

A few customers discontinued their participation mainly due to technical faults of the display units.

## SE 1. Consumer reactions to peak prices.

### Description:

This is a project testing the price sensitivity of households having electric heating systems, but also has other heating options available. The trail was performed during two winters: 2003/2004 and 2004/2005 The project included customer surveys and in-depth interview with participating customers. The results from the project are summarized in the report [1].

### Customers involved:

The customers involved consisted of single family houses. The category "Households – General" in the customer segmentation table would be the most appropriate classification of the participating households in this project.

During the winter 2003/2004, 45 households connected to the grid of Skånska Energi participated in the project. During 2004/2005 53 households connected to the grid of Skånska Energi participated, and an additional 40 households connected to Vallentuna Energi was also involved.

### Technologies deployed:

No technologies was deployed in this project. The involved households all had electric heating, but the majority of them also had other heating options, typically by burning fuels like oil or wood. Typically the houses were equipped with water borne heating systems, which can be heated with either electricity or using oil or wood. However, the number of households having the different alternatives as possible heating options have not been specified.

### Customer offerings:

The customer was in this trial offered a supply contract using an alternative tariff structure, where the supplier could charge an extra high price during a certain hours per year. No other offered were made.

### Customer engagement approach:

The customers were recruited by mail. The first year, 200 randomly picked households were sent an offer to participate in a trial with a new and special price list. Together with the offer, a list of advice was appended, describing how to decrease electricity consumption during the extra expensive hours. This was followed by a telemarketing approach in a second round to consumers who had got the offer. Finally, 45 households accepted the new offer.

The second year, a similar approach was used to engage more households. The first 45 households from the first year participated also the second winter, together with another 8 at Skånska Energi (hence a total of 53 households) and an additional 40 households at Vallentuna Energi.

### Smart metering:

In order to perform hourly billing, hourly meter reading was applied in the project. The smart meters was only used for collecting data, no feedback information to the consumers was performed using the meters. The feedback to the consumers was performed through the energy bill only.

### Tariff

The customers were offered a price scheme based on hourly pricing. The supplier had the right to apply an extra high price 40 hours/year. The remaining part of the year, the customers get a rebate on their usual electricity price. The rebate was 7.6 öre[1]/kWh (including tax and VAT), and the extra high price was in the interval 3-10 SEK/kWh.

The price scheme was designed so it would be cost neutral in relation to the normal prices if the consumers didn't take any actions. If the consumer reacted on the price signal, the consumers could reduce their electricity bill. The offering from Skånska Energi implied a 1400 SEK/year cost reduction if the consumer reduced their consumption with 75% during the hours with an extra high price. During the experiment at Vallentuna Energi during winter 2004/2005, the cost reduction was decreased to 1000 SEK/year in order to see the interest also at a lower cost decrease.

## Remote / Automatic Control of Appliances

Not applicable in this project.

## Information and Data Sharing

The consumers got information about situations with extra high prices by text messages to their mobile phones the day before the actual hour. Thereby they had time to react to the peak prices. The information to consumers consisted by their ordinary bill (no extra information was provided).

## Advice / Customer Engagement

The households received advice on how to temporarily reduce their electricity consumption when they were given the offer to join the trial. This was performed by supplying the consumers with a short document in the same mail. Hence, the information was provided by the power company. The document concerned general advice (e.g. avoid using dish washer) and advice depending on the heating system that the consumers were equipped with (e.g switch to firing bio fuels for heating).

## Results:

During 2003/2004, the extra high price was used for 39 hours during 15 different occasions. During 2004/2005, the high prices was used for 37 hours during 14 occasions for Skånska Energi, and 39 hours during 15 different occasions for Vallentuna Energi.

The trail showed a average decrease in electric power consumption by 50% the hours when the consumers were subjected to extra high prices. In fact, the actual decrease can have been even greater since some households switched to oil or biofuels the night before they were subjected to the high prices.

At the end of the trail, a survey was performed including all participants, and in-depth interviews was performed with 20 households. The overall results from the survey and interviews show that the majority of the households participated actively in the peak reductions and that the overall impression of the trial was positive.

[1] 1 öre = 0.01 SEK.

## Key lessons learnt (to date):

Key lessons:

- Even though no technical equipment was installed at the consumers, it is still possible to achieve significant peak reductions.
- The results are robust in the sense that there seems to be no difference between the years or between the consumers of the two power companies being in different parts of the country.

The consumer experiences, which was mainly analyzed through the interviews, can be summarized by the following:

- The trial was considered as a positive experience.
- There were different motives to why the consumers joined, such as: It was economically beneficial; it was both economically beneficial and interesting; it is considered as good for the environment; it was considered as a challenge to reduce the consumption.
- There were not really any major troubles to reduce the peaks.
- No disadvantages with decreasing the consumption was experienced.
- The rebate and the economical incentives are important, but the level are not that important, it rather the “symbolic value” that is of importance.
- The majority didn’t have any knowledge about how much money they saved, but it was still considered as a positive experience.
- There were households that were prepared to install some kind of control system for reducing consumption levels on their own expense.
- The general experience was that there would not cause any major problems to introduce this on a larger scale.

## Major barriers encountered (to date):

No key barriers were pointed out in this project.

## References:


[1] S. Lindskoug. *Demonstrationsprojekt: Effektstyrning på användarsidan vid effektbristsituationer*. Elforsk rapport 05:31, October 2005. In Swedish. Available at http://www.elforsk.se

## SE 2. Consumer reactions to peak prices – continuation project

### Description:

This project is a continuation of the project "Consumer reactions to peak prices" (SE2) [1]. The main reason is an increasing number of heat pumps, which leads to an uncertainty and concern considering the power demand in occation of very low outdoor temperatures. By prolonging the project, and increase the number of participants in the project, a greater knowledge is expected to be achieved by heat pumps, and in particular the possibility to indirect control these consumers with peak pricing.

The trial was performed during the winter 2005/2006. The results from the project are summarized in the report [2].

### Customers involved:

The customers involved consisted of single family houses. The category "Households – General" in the customer segmentation table would be the most appropriate classification of the participating households in this project.

Customers to Skånska Energi that have participated earlier years to the project were offered a prolonged contract for an extra year. The number of participants was increased by 50 customers that have installed a heat pump. In total 75 households participated in the project. An additional 75 customers to Skånska Energi that will not be alerted of peak prices, are used as a reference group.

### Technologies deployed:

No extra technologies were deployed in this project.

### Customer offerings:

The customer was in this trial offered a supply contract using an alternative tariff structure, where the supplier could charge an extra high price during a certain hours per year. No other offers were made.

### Customer engagement approach:

The customers involved in the preceding project were sent a regular mail with the new offer in a similar way as the previous project. The report [2] does not does not describe how the new customers were engaged in the project, but it is reasonable to assume that the same procedure by using mail was applied. Hence, the customers voluntarily made the choice to join the trial.

### Smart metering:

In order to perform hourly billing, hourly meter reading was applied in the project. The smart meters was only used for collecting data, no feedback information to the consumers was performed using the meters. The feedback to the consumers was performed through the energy bill only.

### Tariff

As for the preceding project, the customers were offered a price scheme based on hourly critical peak pricing with a rebate for all the remaining hours. However, in this project the rebate is modified to reflect a proportional rebate to the number of hours of peak prices. If peak price was applied for 40 hours/year, the rebate was 7.6 öre[2]/kWh. If peak price was applied for 20 hours/year, the rebate was decreased to 3.8 öre/kWh. If more than 40 hours of peak pricing was applied, the rebate was proportionally increased.

Also in this project, the price scheme was designed so it would be cost neutral in relation to the normal prices if the consumers didn't take any actions. If the consumer reacted on the price signal, the consumers could reduce their electricity bill.

## Remote / Automatic Control of Appliances

Not applicable in this project.

## Information and Data Sharing

The consumers got information about situations with extra high prices by text messages to their mobile phones or by e-mail the day before the actual hour. Thereby they had time to react to the peak prices. The information to consumers consisted by their ordinary bill (no extra information was provided).

## Advice / Customer Engagement

The households received advice on how to temporarily reduce their electricity consumption when they were given the offer to join the trial. This was performed by supplying the consumers with a short document in the same mail. Hence, the information was provided by the power company. The document concerned general advice (e.g. avoid using dish washer) and advice depending on the heating system that the consumers were equipped with (e.g switch to firing bio fuels for heating).

## Results:

During the winter 2006/2006, very low outdoor temperatures occurred. Within one period night temperatures was as low as -15 to -18 degrees Celsius three nights in a row. The extra high price was applied for 33 hours during 11 different occasions. 8 of these occasions concerned the time period 7-10 am, and the remaining three occurred between 8-10 am, 4-7 pm and 6-7 pm.

The results show that load reduction in percent was lower than in the former winter periods of the preceding project. The reason for that is probably the high numbers of heat pumps than earlier. The need for electricity for heating purposes has thus been lower. In contrary the reduction in kW has been higher due to lower average outdoor temperatures, which means need for increased heating.

[2] 1 öre = 0.01 SEK.

## Key lessons learnt (to date):

Key lessons:

- Even though no technical equipment was installed at the consumers, it is still possible to achieve significant peak reductions.
- Even when very low outdoor temperatures, customers are willing, capable and persistent to substantially reduce the load when peak prices are alerted. This has not been proven during earlier years, due to milder winter periods. The business model has thus proved to be valid even at temperatures when load shortage is more likely to occur.
- The results of the analysis considering the load characteristics of the heat pumps which extract heat from the outdoor air, shows a surprisingly linear function of outdoor temperature. This means that the concerns of an electricity supply network power shortage in case of low temperatures caused by an increasing number of heatpumps, in not as serious as expected. This has been shown at temperatures down to -18.
- Due to the thermal heat storage in the house, the need for heating is even out during the day. During the test period the outdoor temperatures varied substantially between day and night, which strengthen the impact of the thermal heat storage on the test results.
- The analysis also showed that the economic advantage of heat pump is not as extensive as expected. This can be explained by the fact that the heat pump does not serve the total need of heating. It is likely that many homes in addition to heat pump have direct heating in bathrooms, hallways and kitchen. In addition many households have not of practical or economic reason, converted to heatpump heating in other building such as garage, storage buildings etc.

## Major barriers encountered (to date):

No key barriers were pointed out in this project.

## References:


[1] S. Lindskoug. *Demonstrationsprojekt: Effektstyrning på användarsidan vid effektbristsituationer*. Elforsk rapport 05:31, October 2005. In Swedish. Available at http://www.elforsk.se

[2] S. Lindskoug. *Demonstrationsprojekt: Effektstyrning på användarsidan vid effektbristsituationer - fortsättningsprojekt*. Elforsk rapport 06:83, May 2006. In Swedish. Available at http://www.elforsk.se

## SE 3. Sala-Heby

### Description:

The distribution system operator Sala Heby Elnät AB, a local distribution system operator located in the eastern part of Central Sweden, installed smart meters and introduced in April 2006 a new tariff structure to investigate the possibility to decrease the system load using a demand charge in the residential sector. The new tariff was introduced in April 2006 and analyses of the impact on the demand for time period April 2006 - December 2008 are available. The study was performed by statistical analyses and by in-depth interview with a sample of the households. The results from the project are summarized in the paper [1].

The period of analysis comprised the twelve-month period preceding the introduction of the demand-based tariff, i.e. April 2005–March 2006, and the two twelve-month periods following the implementation, i.e. April 2006–March 2007 and April 2007–March 2008. In accordance with the above delineation, the period of analysis was further divided into the summer seasons 05, 06 and 07, the winter seasons 2005–2006, 2006–2007 and 2007–2008 as well as peak and off-peak periods.

### Customers involved:

The customers involved in the project would fall into categories the “Households – Non fuel poverty” and “No on-site generation”. In total 500 households were exposed to the new tariff in the project, whereof 232 households were included in the study presented in [1].

### Technologies deployed:

No technologies was deployed in this project.

### Customer offerings:

The consumers were exposed to a new grid tariff design by the DSO. There were no possibilities to change tariff, and hence, no offers were made to the consumers in that sense.

### Customer engagement approach:

All the 500 households covered by the pilot project were contacted by phone and requested to answer a set of questions on date of moving in, number of family members, square meter living space, space and water heating system and any recent changes in that regard, use of the statistics service and whether they would consider participating in an interview study. 362 of the 500 households answered the survey questions. Among those, 232 respondents were favorably disposed to being interviewed. These households were grouped into categories according to space heating system, and further divided according to the number of household members. Outgoing from this, ten families with an aggregate of 19 family members living in single-family and row houses were picked for in-depth about electricity consumers’ perception of and experience with the time-of-use tariff.

Concerning the statistical analyses, the distribution system operator provided the tariff rates and hourly meter readings of the individual households. However, due to incomplete time series, the number of households included in the analyses had to be reduced to 50.

### Smart metering:

In order to perform hourly billing, hourly meter reading was applied in the project. The smart meters was only used for collecting data, no feedback information to the consumers was performed using the meters. The feedback to the consumers was performed through the energy bill only.

## Tariff

In the project and demand-based time-of-use grid tariff was applied. The demand-based tariff is made up of a fixed access charge (EUR) depending on fuse size (A) and a variable distribution charge (EUR/kW) that is calculated on the average of the five highest meter readings (kW) in peak hours. In off-peak hours electricity distribution is free of charge. Hours in weekdays between 7a.m. and 7p.m. have by the distribution system operator been defined as peak hours, while remaining hours are referred to as off-peak hours. The rate of the demand-based tariff also varies between the summer and the winter seasons, which range from April to October and November to March.

The households did not have the choice to opt in for the tariff or not; they were all subjected to the grid tariff. The tariff was introduced in April 2006 and is still in use.

## Remote / Automatic Control of Appliances

Not applicable in this project.

## Information and Data Sharing

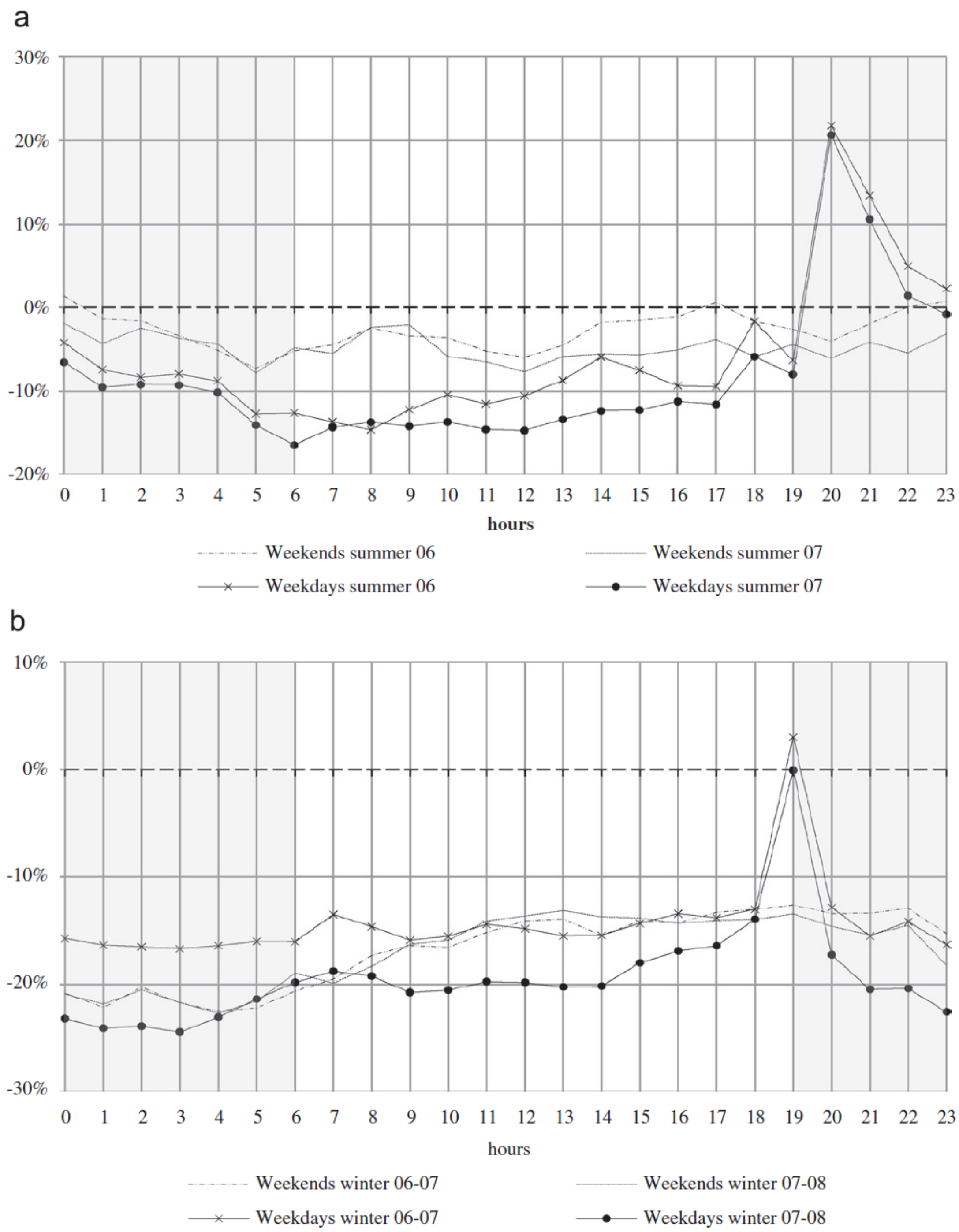
For billing purposes the distribution network owner collects hourly demand data, on which the bill is based. This information is only used for this purpose and no third party has access to this data. The feedback information to consumers consists of the information in their electricity bill, but also by statistics presented through a personalized web page supplied by the DSO.

## Advice / Customer Engagement

The households were informed about the tariff through a booklet on the demand-based tariff that was distributed together with the electricity bill in connection with the implementation of the new tariff. Hence, the information was provided by the power company. The document described the different components of the tariff.

## Results:

The changes in the demand curve is illustrated in the figure below from [1]




The figure shows the following: (a) Relative changes in the shape of demand curves representing weekends and weekdays in the summer seasons of 2006 and 2007 in relation to the summer season of 2005. The light gray areas represent off-peak hours, whereas the white area represents peak hours. (b) Relative changes in the shape of demand curves representing weekends and weekdays in the winter seasons of 2006–2007 and 2007–2008 in relation to the winter season of 2005–2006. The light gray areas represent off-peak hours, whereas the white area represents peak hours. Source: [1].

As can be seen in the figure, an overall decrease in electricity usage can be identified. Further, the shift in the demand has resulted in a new peak in demand between 8 and 9 pm during summer, and 7 and 8 during winter. Seeing that these peaks occur in off-peak periods, they are however of no negative consequence to the distribution system operator in question.

## Key lessons learnt (to date):

Households are generally sympathetic to being charged according to a demand-based tariff, seeing as how the distribution system operator's motive for introducing it relates to environmental issues.

Assessing the hourly meter values are not always easy, and the databases containing the data are not always adapted for presenting feedback back to the consumers.

Feedback through web pages on the consumption levels is considered by many consumers as too longwinded and time consuming for them to get around and use it regularly.

## Major barriers encountered (to date):

No key barriers were pointed out in the reporting of this project.

## References:


[1] Bartusch, C., Wallin, F., Odlare, M., Vassileva, I., Wester, L., 2011. Intoducing a demand-based electricity distribution tariff in the residential sector: Demand reponse and customer perception. Energy Policy, 39, 5008-5025.

# SE 4. Information through digital channels and its potential to change electricity consumption patterns

## Description:

The main objective of this project was to investigate the potential of changing electricity use patterns in various types of housing thanks to improved information. Three case studies were conducted in collaboration with three grid companies:

1. Skånska Energi AB (in Södra Sandby outside Lund) with an Internet-based statistics service "My Electricity Use" [1];
2. Öresundskraft AB (in Helsingborg) with its service "Your Pages" [2]; and
3. E.ON Sweden AB (in Malmoe), with Internet-service "Energy Dialog - Private" [3].

A synthesis of these three trials is presented in [4].

All the studies used statistical data to analyze how the annual energy consumption changed between years, and if there were any impact of the used of the web based services provided by the DSOs where the households could follow their electricity consumption. Also, questionnaires were sent out to the participating households containing questions about the household, their energy behavior and the use of the statistical service.

The statistical data varied some between the three studies. In 1, data for the years 1999 – 2008 were used. In 2, the corresponding time frame was 1998 – 2008, and in 3 June 2008 – May 2009.

## Customers involved:

In all three case studies, the participating consumers were selected by the researchers and the DSO in cooperation. The projects themselves included many more consumers, which all had access to the web service, but could use it as they pleased.

In study 1, 300 households were selected to be included in the study. The selected households consisted of single family houses, and constituted a mix of electric heating, heat pumps, and other heating alternatives. They had all fuse size 20 A.

In 2, 446 households were selected. These were grouped into 3 categories according to the following:

- 200 single family houses having an electricity consumption more than 10,000 kWh/year and a fuse size of 20 A or more. These households all have a heating system based on electricity (direct heating or heat pump).
- 207 flats having no electricity based heating.
- 10 consumers that did not have access to the web based service provided by the DSO. These would act as a reference group in the analyses.

In 3, 500 households were selected by EOn using selection criteria provided by the research group performing the analyses. The households were grouped into the following three groups:

- 200 single family houses having an electricity consumption more than 10,000 kWh/year and a fuse size of 20 A or more, that participated in the "Energy Dialog - Private" trial.
- 200 flats (without electric heating) participating in the "Energy Dialog - Private" trial.
- 100 mixed households not participating in the "Energy Dialog - Private" trial. These worked as a reference group in the analyses.

Referring to the customer segmentation, all households that participated in the trial would fit into the category, “Non Low Income/ Non Fuel Poverty Household”  and “Without on-site generation”.

## Technologies deployed:

No technologies was deployed in this project. However, the three trials all included web sites presenting statistics as feedback to the consumers.

## Customer offerings:

The three projects all had web services where the customers could get information about their electricity consumption. No other offers were made.

## Customer engagement approach:

The approach for consumer engagement was similar in the three trials. The consumers were offered to use the web page provided by the DSO in order to get a better understanding and control of their energy consumption. Hence, the consumers voluntarily joined the project. The offers were distributed by regular mail.

The analyses of the trials, including sending out the questionnaires, was performed by Lund University. The sender was thereby the university and not the DSO.

## Smart metering:

Smart meters were not a part of these trials. The statistical service provided by the DSO was not based on hourly metered values, and the analysis was based on annual energy consumption levels.

## Tariff

No specific tariffs were applied in these projects.

## Remote / Automatic Control of Appliances

Not applicable in this project.

## Information and Data Sharing

No data was shared with any third party in the projects. The consumption data was used to give feedback to the consumers on the their consumption levels

## Advice / Customer Engagement

The consumers were engaged in the trial by the involved DSOs. The statistical analyses were performed by Lund University and the questionnaires were sent out by the university.

The information to the consumers mainly consisted of how the web service worked and what kind of information they could get from the web service. Not much information about how to reduce their energy consumption was given. This information was provided by the DSOs.

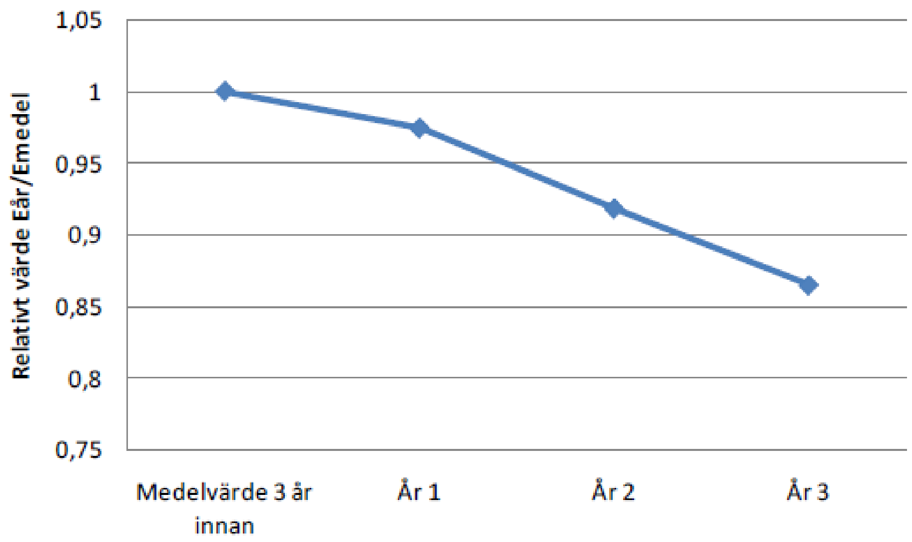
## Results:

### Trial 1

The main hypothesis of this study assumed that the statistics service, as a way to inform households, may lead to lower electricity consumption, thanks to better understanding of energy use patterns and costs. This hypothesis was not confirmed; the analysis showed that electricity use totally for all the users of the service as a group actually constantly increased while it decreased for the non-users group. However, the majority of the users of the service have reduced their energy consumption, but since the ones who have increased their consumption have increased a lot, the total mean shows an increase in consumption.

### Trial 2

The analysis of trail 2 showed that electricity use totally for all the users and non-users living in flats constantly increased while it decreased for the both groups for households living in single family houses. The decrease for single family houses was almost 15% the third year of the trial, as illustrated in the figure below. The figure shows relative change in consumption for single family houses, where the value 1 is equal to the mean of the 3 years before the start of the trial. As can be seen, the consumption decreases the three years included in the statistical analyses.




("Medelvärde 3 år innan" = "Mean value 3 years before". "År 1" = "Year 1")

### Trial 3

The analysis of the consumption levels in trial 3 showed that electricity use totally for all the users and non-users of the web service was on almost the same level as before (-0.04 % for the users and +0.02 % for non-users). In the users group, the share of the households who had increased their consumption levels was 47%, and the share who had decreased the consumption was 44% (the remaining 7% had less than 100 kWh/year in change). The non-users group show a similar behavior.

## Key lessons learnt (to date):

The results of the three trials can be summarized in the following conclusions, as stated in [4]:

- It is impossible to state whether the usage of the statistics service leads to reduced or increased electricity use in the households.
- The explanation why the households using the statistics service often have had growing electricity usage could be that the rising power consumption caused a need to have better control over electricity needs and energy bills, and households started to use the statistics services for this reason.
- It is unable to prove that users of statistics services have had significantly better energy use and conservation behaviour than non-users.
- Households that have received the highest grades in the energy use profile belonged often to the user groups "elderly (65 +)" and “home owners”.
- Energy advice, as part of the statistics service, was required by several customers. There should be more information together with statistics service for users as a tool for achieving better energy efficiency.
- Lack of time, problems with the service and lack of contact with the company were the main reasons to not use of the statistics service.
- It requires a lot of interest and commitment among households if the target is to lower electricity consumption. The statistics service can give residents a good basis for decisions on energy conservation and energy efficiency and provide good information to improve knowledge, attitudes and behaviour.

## Major barriers encountered (to date):

No key barriers have been pointed out.

## References:


[1] J. Pyrko, E. Ersson. *El-info via digitala kanaler: Potential att förändra elanvändning i bostäder Fallstudie 1 ”Min elförbrukning” hos Skånska Energi AB*. Elforsk rapport 09:91. November 2009. In Swedish with English abstract.

[2] J. Pyrko, E. Ersson. *El-info via digitala kanaler. Potential att förändra elanvändning i bostäder. Fallstudie 2: "Dina sidor" hos Öresundskraft*. Elforsk rapport 09:92. November 2009. In Swedish with English abstract.

[3] J. Pyrko. *El-info via digitala kanaler. Potential att förändra elanvändning i bostäder. Fallstudie 3: ”EnergiDialog-Privat” hos E.ON Sverige AB*. Elforsk rapport 09:93. November 2009. In Swedish with English abstract.

[4] J. Pyrko. *El-info via digitala kanaler: Potential att förändra elanvändning i bostäder Syntes.* Elforsk rapport 09:90. November 2009. In Swedish with English abstract.

## UK 1. Energy Demand Reduction Trial (E.ON)

### Description:

The Energy Demand Research Project (EDRP) was a major project in Great Britain to test consumers' responses to different forms of information about their energy use. Four energy suppliers each conducted trials of the impacts of various interventions (individually or in combination) between 2007 and 2010. The interventions used were primarily directed at reducing domestic energy consumption, with a minority focused on shifting energy use from periods of peak demand. Measures were generally applied at household level but one supplier also tested action at community level.

The trials were undertaken by four energy supply companies: EDF, E.ON, Scottish Power and SSE.

There were over 60,000 households involved in the whole trial, of which 18,000 were given smart meters.

This case study provides a summary of the trial conducted by E.ON.

### Customers involved:

The E.ON trial involved a total of 28,450 households, which were divided into one of the following three groups:

- Control group – 13,596 households
- The non-smart meter group - 6,799 households
- The smart meter group - 8,055 households

This trial was novel by virtue of the fact that the customers were not aware they were participating in a trial. E.ON used its customer base in the midlands to recruit for its trial. Rather, customers were selected by the Supplier from its existing customer base. Only customers on standard, Age Concern or green tariffs were eligible for selection. Customers with no consumption history (i.e. new builds or with fewer than 2 actual meter reads in the preceding 12 months) were not included. Customers with pre-payment meters were also excluded.

### Interventions deployed:

Each trial group received a range of interventions, as indicated below. Not all customers received all the interventions. For example, some customers only received the energy efficiency tips, whilst others also received the RTD display.

**Non-Smart Meter Group**

- Additional bill data: graphs on quarterly bills showing historic energy consumption information.
- Energy efficiency advice: monthly tips sent by post.
- Real time display: clip-on RTD showing current electricity use, cost, $CO_2$ emissions and historic data.
- Customer engagement: monthly request for customer to read meters and provide the reading to E.ON, so that E.ON could provide accurate bills (referred to as the "Hawthorne" group)[9].

**Smart Meter Group**

- Smart meter.
- Accurate billing and no meter reading visits.
- Monthly bills.

- Additional bill data: graphs on monthly bills showing historic energy consumption information.
- Energy efficiency advice: monthly tips sent by post.
- Real time display: mains RTD showing current electricity and gas use, cost, $CO_2$ emissions and historic data, plus a “traffic light” indicator of current consumption.

In each of these Groups, customers were categorised into one of the following:

- Fuel poor (FP)
- Not Fuel poor (NFP)
- High Baseline Use (HU) – with a consumption of more than 7,000kWh/year of electricity
- E7 – with an off-peak tariff

## Customer offerings:

Customers did not opt-in to the trial, rather they were provided with the interventions identified above as if it was ‘business as usual’. The only exception to this involved the Smart Meter households, who had to consent to having a Smart Meter installed. Again, this was very much presented as a ‘business as usual’ task, and the main issue was with gaining access to the property for the meter installation.

## Customer engagement approach:

As mentioned previously, households in the non-smart meter trial groups were sent interventions as if this was business as usual. They were not invited to become part of a trial, nor were they aware that they were participating in a trial.

All E.ON control households were selected without the knowledge of the households and received no trial interventions.

## Smart metering:

All the smart trial groups required the households to accept the Smart Meter. Letters were sent to households describing the benefits of the particular combination of interventions they were being offered. The letter did not tell customers that they would be part of a trial. Towards the end of the recruitment process, E.ON also used the reason of meter recertification as a means of persuading customers to agree to smart meter installation.

## Tariff:

Customers continued with their existing tariff arrangement, which was a standard flat rate tariff or for the E7 customers, an off-peak tariff with 7 hours of cheap electricity during the night.

## Remote / Automatic Control of Appliances:

No remote or automatic control devices were evaluated as part of the trial.

## Information and Data Sharing:

Customers were not aware they were taking part in a trial, and data sharing was ‘business as usual’, i.e. between the customer and the Supplier. As such, no special provision had to be made regarding data sharing. The data was subsequently analysed by an independent company (AECOM). It is not known what provision, if any, was required to enable customer data to be shared in this way.

## Advice / Customer Engagement:

The non-smart meter trial participants were sent monthly tips by post. Smart meter trial participants were also given additional bill data such as graphs on their monthly bills showing historic energy consumption information.

The monthly energy efficiency tips were deployed in both non-smart and smart trials. However, the intervention was accidentally withdrawn for 12 months. Thus, the smart meter group only received the full set of inventions measures a year later than intended.

## Results:

The data from the trial was analysed by both the Energy Supplier and an independent Consultant (AECOM), and the results are published. Some key findings from these analyses were:

- None of the interventions trialed with the non-smart meter group had a significant impact on electricity consumption;
- Significant reduction in energy consumption were achieved by High Energy users;
- Significant reductions in energy consumption persisted until year 1 / quarter 3. In the fuel poor category, savings increased over time;

Qualitative data was also collated through consumer surveys. The data collated from these surveys have also been extensively analysed to explore the responses and whether or or the responses are linked to the group with which the respondent belonged.

Some of the findings of this analysis include:

### *Energy Efficiency Advice:*

- Respondents were asked whether they recalled receiving advice on reducing energy consumption. The analysis showed there was a significant difference between responses from the trail groups (i.e. with or without a smart meter). Overall, 57% recalled receiving the advice. However, 48% recalled the information if they had been provided with an RTD compared to 65% of those who had not.
- Regarding the usefulness of the advice, 8% of respondents found it “Not at all useful”, 20.7% found it “Not very useful”, 50.9% found it “Quite useful” and 19.6% found it “Very useful”.

Interpretation on the overall findings suggest that

- Advice on heating, lighting and appliances is the easiest place to start
- More work is needed on delivering advice relating to cooking. This could be due to the fact that cooking involves decisions that “*distract from, override or are unrelated to energy use”.*

### *Real Time Displays:*

Households given a RTD included:

- Those given the a clip on RTD for the electricity consumption only, but no advice was given
- The RTD as above, but this time, advice was provided.
- A mains (i.e. not battery) RTD displaying both gas and electricity data.

Intriguingly, less than half of the respondents (40.7%, 42.0% and 48% respectively) were aware they had a RTD display.

Among those who knew they had one, around half (51-54%) looked at it every day. However, the proportion that looked at is less often increased with the complexity of the intervention.

Approximately 80% of the respondents though the display was either “Very useful” or “Quite useful”.

The RTDs trialed also differed, with different features and displays on the battery-operated units compared to thee mains-fed unit. This made it impossible to determine which features were liked overall. The following describes the responses relating to each type of RTD:

- For those with the mains-fed RTD, the most useful feature was the ‘traffic light’ system, with current electricity using in kW the least useful. There was no different in the overall ratings given to numeric or graphic displays of information.
- For those with the battery operated RTD, the respondents rated cost and temperature information the most useful. The least useful was greenhouse gas emissions and usage alarm features.

### *Action Taken:*

Respondents were also asked whether they had taken (and/or were still taking) a range of actions that could reduce energy consumption. The results suggest that a high number of respondents claimed to have taken action. With the claims being similar for across the groups, as summarised in the following Table. This makes it difficult to explain why the High Energy Users exhibited such large reductions in energy consumption if the claimed level of action taken was similar. The authors claim that this might suggest doubts over whether the energy reductions seen by the High Energy Users are in fact genuine, and not a ‘regression to the mean’.

| | Had taken action | | Still taking action | |
|---|---|---|---|---|
| | FP and NFP | HU | FP and NFP | High Energy User |
| Turned the thermostat down | 70.2% | 73.0% | 67.9% | 70.0% |
| Reduced the amount of time your heating is on | 70.8% | 70.2% | 68.5% | 68.6% |
| Have showers instead of baths | 71.2% | 75.6% | | |
| Fitted a hot water cylinder jacket | 34.5% | 34.2% | 69.6% | 73.4% |
| Filled kettle less | 75.3% | 75% | 73.3% | 72.2% |
| Put pans on lids when cooking | 73.4 | 75.2% | 71.7% | 73.0% |
| Used lights less | 79.7% | 78.0% | 77.5% | 76.0% |

## Key lessons learnt (to date):

One of the key lessons learnt is that care must be taken in the original decision of a trial to ensure than statistically meaningful conclusions can be drawn. Even with a trial of this size, it was difficult to ascertain the level of energy reductions delivered and whether these were statistically significant or not.

Other key learning points reported from the overall trial were

- The overall smart metering system needs to deliver reliable communication. Problems were identified with Home Area Network (HAN) and Wide Area Network (WAN) communications. Greater communication reliability is required for any system that is rolled-out to all customers. Even a small percentage of problems could result in a large number of homes being affected.
- Smart meter data will have inconsistencies and, therefore, data validation processes need to be agreed to check the data, and edit it as necessary, for correct operation. This is particularly the case where data cleaning needs to happen across several different market participants. Furthermore, rules will have to be devised for gap-filling for the half-hourly data if used for billing purposes.
- Marketing and advertising campaigns at a national level, local/community level, and from trusted organisations are required to generate a broad level of awareness across all customer groups
- Messages should be built into awareness campaigns to mitigate against negative publicity from customers attributing (for example) boiler faults to the meter change and rollout programme

## Major barriers encountered (to date):

It was reported that a significant cause of aborted installations was caused by problems caused by the customers themselves. Examples include where the meters were made inaccessible by fixed items such as kitchen cupboards or alterations to walls at the property. This was generally caused by customers' lack of awareness of the need to ensure access to their meters. Other problems include lack of space for the smart meter installation.

## References:

Energy Demand Research Project Final Analysis

## UK 2. Charm Research Project (Home Energy Study, bActive and iGreen)

### Description:

Charm is a research project that investigated whether the day to day behaviour of individuals could be changed by feeding back information on their own behaviour and that of others. The study revolved around the use of social norms and practice theory.

Social norms approach attempts to influence behaviours by providing information about what most people do, or think should be done.

The study employed practice theory to understand how participants responded to the digital feedback they were provided, by focusing on practices such as 'doing the laundry' rather than on individuals or societies.

The study consisted of three parallel trials, as follows

- Home energy study
- iGreen
- bActive

In each study, participants were divided into three groups:

- feedback group, that received feedback on their own behaviour
- a social norms group, that received feedback on their own behaviour and that of others
- control group, that received no feedback

The aim was to explore the extent to which information on social norms could be used to encourage behaviour change.

### Customers involved:

The Home energy study trial involved a total of 400 households professionally recruited via door-to-door contact. However, only 316 of these successfully completed the trial.

The iGreen study used a Facebook 'app' to collect information on certain sustainable practices. The 'app' was publicised at three Universities and on a number of social networking sites. A total of 2,800 people downloaded the iGreen app, but only 52 completed all seven rounds of the associated quiz about their behaviour.

The bActive trial used a smart phone based 'app' to record how much walking participants undertook over a 6 weeks period. As participants were required to carry the phone in their trouser pocket, participation was restricted to male participants. Participants were recruited from the Bristol area, using a free Smart Phone as an incentive for participation. One hundred and fifty one participants took part in the trial, completing pre- and post-trial surveys, and 27 participants completed individual interviews or focus group sessions.

## Technologies deployed:

### Home Energy Study

The Home Energy Study employed an existing 'Real Time Display' connected to the existing electricity meter via a current transformer around the incoming supply. The Display was modified so that the data could be transmitted via mobile phone signal to a central server. Participants in the feedback groups were sent weekly e-mails showing a graph of their own electricity consumption pattern in two-hourly blocks, together with energy saving tips. Those in the social norms group also received feedback on the average and 'best performing' consumption of other participants in the trial.

### iGreen

The iGreen trial involved a series of seven questionnaires looking at sustainable behaviours running as an 'app' on Facebook. Thus, no specific technologies were trialled. All were asked a set of questions on seven separate occasions over at least a 6 week period, and the responses were analysed to determine whether or not there was any change in the responses during the course of the study. Those in the individual feedback group were provided with information on how they responded last time they took the questionnaire, whilst those in the social norms group were also provided information on how others responded. Those in the control group received no feedback at all. For example, a typical question was 'Last week, how often did you leave the tap on whilst doing the washing up?'.

### bActive

For this trial, an 'app' was developed for a Smart Phone, to enable the amount of walking undertaken by participants to be collated via the accelerometer within the phone itself. As with the iGreen study, those in the individual feedback group were provided with information on how much they had walked, whilst those in the social norms group were also provided information on how far others in the trial had walked. Those in the control group received no feedback at all.

## Customer offerings:

Participants in the Home Energy Study were offered a £80 incentive to take part in the trial, half paid up front and half on completion.

Participants in iGreen study were incentivised to complete questionnaires through prize draws and access to sustainability themed games that could only be accessed after the questionnaire was completed.

Participants in the bActive trial were incentivised to take part in the trial through the offer of the free phone.

## Customer engagement approach:

### Home Energy Study

Once in the trial, the consumer engagement focussed around the weekly e-mails sent to the participants during the 18 week study. The e-mails comprised an example graph of their own consumption pattern on a single day, which also included information on the consumption of others for those in the social norms group. The number of times that these graphs were viewed (on average) by the households is shown below:

- individual feedback group: 13.4 times
- social norms group: 19.8 times

This suggests that those provided with information on how much electricity was consumed by others were more engaged. However, when asked whether they had tried to save energy and whether they thought they had saved energy, the responses from the two groups were the similar, as indicated below.

| | **Claimed that tried to reduce electricity** | **Claimed that did reduce electricity** |
|---|---|---|
| **Control** | 37% | 19% |
| **Individual** | 88% | 53% |
| **Social norms** | 86% | 57% |

## Smart metering:

**Home Energy Study**
No smart metering involved – customers retained their existing dumb meters

**iGreen**

No metering involved

**bActive**

No metering involved

## Tariff (Intervention type T)

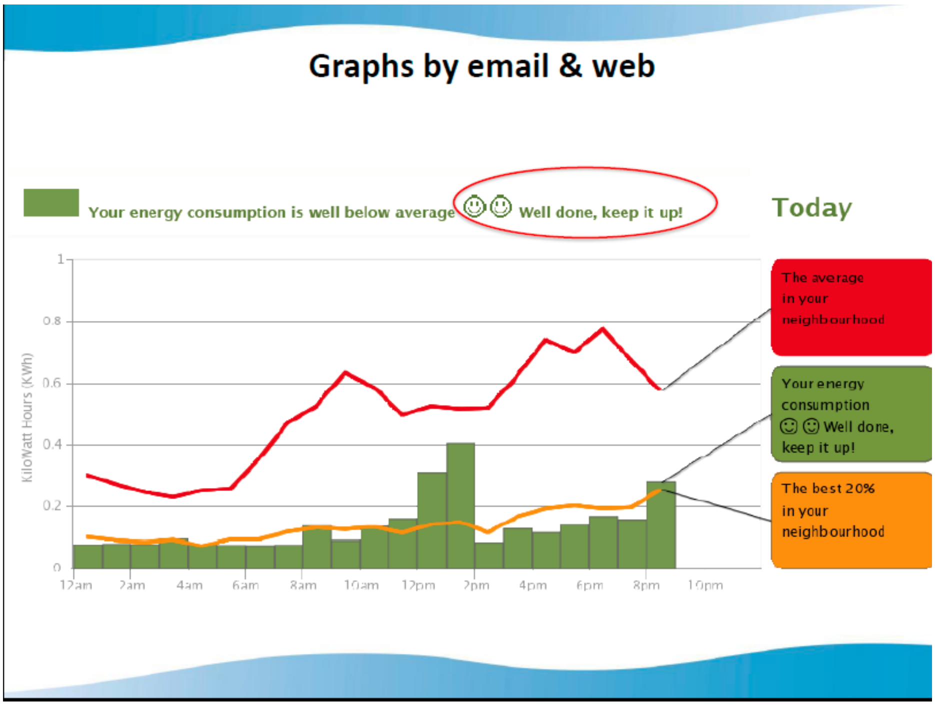
None for any of the trials

## Remote / Automatic Control of Appliances (Intervention type C)

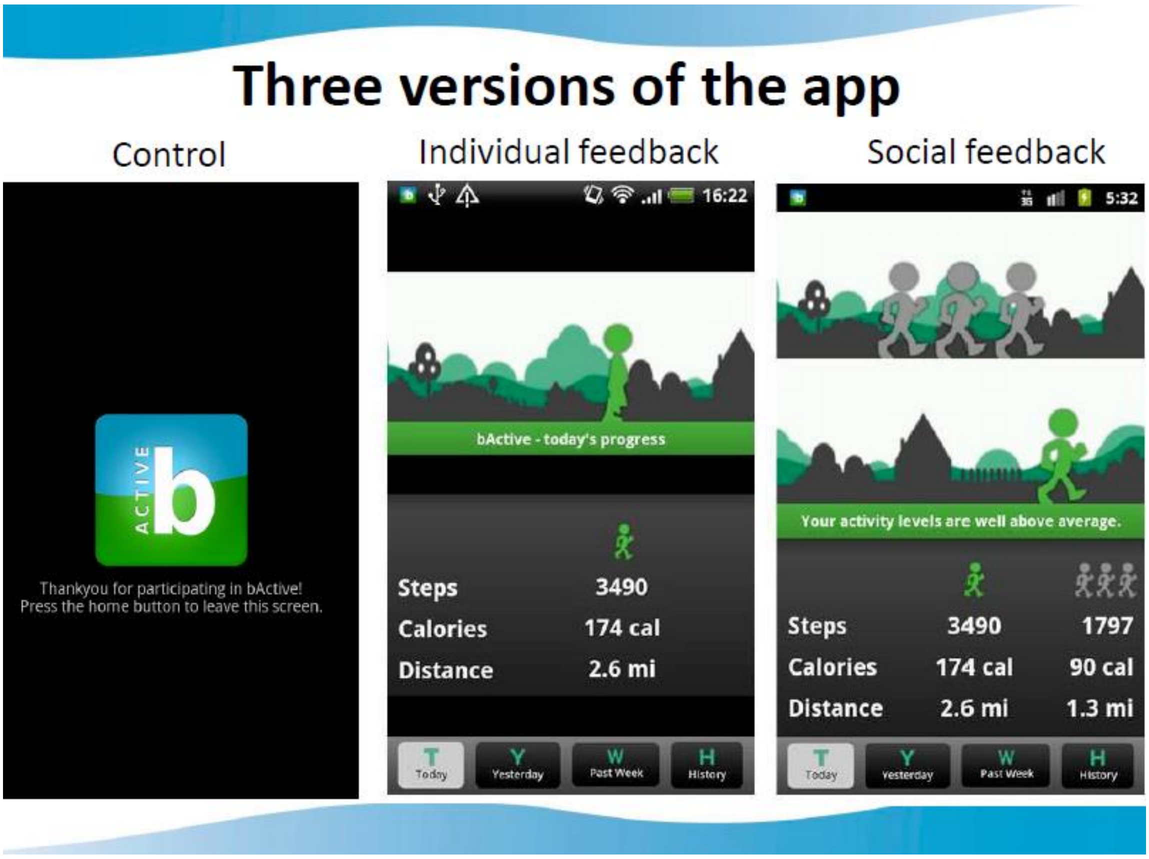
None for any of the trials

## Information and Data Sharing (Intervention type F)

Examples of the information provided to participants is provided below.




***Feedback with social norm data for Home Energy Study trial***




***Feedback for bActive trial***

## Advice / Customer Engagement (Intervention type A)

Customers in the Home Energy Study (excluding those in the control group) received energy saving tips via a weekly e-mail. For example, one of the e-mails warned about 'vampire energy usage' to encourage householders to turn off appliances rather than leave them idle or in 'standby'. Householders were also able to access more detailed information on any of the information raised in the e-mails via a link to a web-site.

Customers in the bActive and iGreen trial were not given any advice or tips, other than the feedback provided to those not in the control groups. However, the games available on the iGreen trial were focussed on sustainable activities such as recycling, which could have helped to raise awareness of green issues.

## Results:

In the Home Energy Study, the quantitative analysis showed that the social norms condition did not, on average, change energy consumption more than those who received individual feedback. However, the participants did download the emailed graphs significantly more often. This would tend to suggest that the social norms feedback was more engaging.

In-depth interviews were conducted with 24 participants. The results of this qualitative analysis showed that participants were focused on the issue of wastage, and particularly the avoidance of wastage rather than any monetary savings made. This was identified as a desire to be frugal (i.e. careful use of money or resources) rather than thrifty (i.e. preserving resources for further consumption). However, this desire was offset by a number of other factors including personal preferences, upbringing, identity, social expections, household relationships and material constraints.

The results also indicated that the level of feedback needs to be disaggregated such that particular behaviours that are wasteful can be identified. This could include feedback in small time intervals so that individuals can match the pattern of consumption to particular practices in the home. Similarly, feedback on how often other people use the washing machine may also be useful.

In the bActive trial showed some interesting results in terms of the impact of social feedback on motivation. Some individuals were very competitive, and liked winning and beating the average. However, others avoided looking at the graphs because of the comparisons. Some participants noted that they walked more on days when they thought they could beat other participants in the trial, but walked less on other days. As with the Home Energy Study, the results of the quantitative analysis showed that despite creating competition, there was no evidence that those provided with social feedback walked more as a result.

Participants in the iGreen study all claimed to have changed their behaviours. This could be due to the questions 'reactivating' existing beliefs (norms) and reminding participants to act on existing intentions. Although the participants found the onerous quiz questions to be onerous, resulting in high drop-out rates, the quizzes and games were enjoyable.

In all the studies, participants were able to interpret the graphical traces, and were quickly able to understand the implication of the peaks and troughs and compare themselves against the social norm. Individuals were also able to interpret the graphs and link the display to their own practices.

## Key lessons learnt (to date):

Quantitative analysis of the three studies did demonstrate that social feedback resulted in a significant change in behaviour. However, the qualitative analysis did show evidence of increase awareness of existing behavior. It also highlighted that whilst there is often a strong desire to do the ‘right thing’ (be that save energy, walk more or be more ‘green’) there are a number of other factors that impact on behavior change. For example, the desire not to be ‘smelly’ limited behavior changes linked to personal hygiene (washing clothes or showering). Similarly, the responses of other people in the household can frustrate efforts to reduce energy consumption.

The bActive study showed that social feedback produced a strong competitive strong in some, whilst it was strongly disliked by others.

## Major barriers encountered (to date):

Each study was a relatively small sample size, that may have limited the impact on determining the impact of social feedback.

## References:

This case study is prepared based on presentation made at the Charm Conference, 27 February 2013, British Academy, London. More information can be found at http://www.projectcharm.info/

## UK 3. Thinking Energy

### Description:

Programme overview:

A smart home can be described as the intelligent integration of household devices into a network that brings benefits and new functionalities to the customer and value to E.ON. For instance, a customer might see advantages in terms of reduced cost, improved convenience, greater control, higher levels of comfort or a smaller carbon footprint.

Attempts have been made in the past to bring the Smart Home to market, but they have failed to reach mass market penetration. It is E.ON's belief that increased internet connectivity, more user-friendly devices, improvements in open standards and pressure on energy bills mean that the market for smarter homes has moved from a niche to a more desirable one.

However, the 'winning' concepts for smart home systems are still unclear. Therefore, E.ON is working collaboratively with platform providers and business partners to achieve the best outcome.

To achieve this, Thinking Energy is a three-year research, demonstration and development programme looking at the Technical Readiness, Customer Acceptance and Value Opportunities of Smart Home technologies in domestic settings.

As part of this, various concepts have been defined from functions of daily domestic life such as Power, Heat, Light, Mobility and Hot Water.

Thinking Energy is used as E.ON's "factory" where design, development and testing of these concepts will take place. These aim to integrate technologies in a customer-friendly way which may reduce cost, improve convenience, allow greater control, raise levels of comfort or reduce their carbon footprint.

The technology:

Thinking Energy is not primarily about a technology, since customer behaviour is the key to successful Smart Home products and services. However, this is facilitated by the technology which E.ON is testing, developing and launching.

75 households in Milton Keynes (45 miles north-west of London) have been selected as trial participants to give real-life feedback from real people in real homes. This ensures that the products and services which E.ON launch across Europe have been proved in realistic environments.

The technology provides householders with a system which monitors and controls energy consumption, appliances, lighting, heating and hot water. The customers have access to an online portal, mobile phone app and in-home display.

The trial:

The trail is a three-year programme which models itself as a 'genuine journey of investigation' as neither the E.ON team not the participants know where it will lead. Some initial questions were clear (such as "how much energy can be saved by intelligent monitoring and control?") – other routes of enquiry will come up as research is carried out.

### Customers involved:

The customers involved in this trial all volunteered to take part. One of the selection criteria was that householders involved must own their own home, to make permissions for any changes or alteration simpler. Some householders had on-site generation prior to becoming involved in the trial.

### Technologies deployed:

Smart Home Platform

Each component of the system communicates with the platform by wireless communications, to ensure that it is plug and play, with no need for re-wiring, plumbing or drilling. Each component can be monitored and controlled remotely by an online portal, smartphone app or in home display. The control system allows the householder to monitor the energy use of the household or individual appliance and compare energy use over a time period, or with the energy use of other households of a similar composition (based on number of occupants and size of house at the moment but potentially becoming more sophisticated). Messages and energy saving tips can also be sent through to the system by the energy company. If the household generated electricity the technology can calculate the net saving provided by this generation compared to if the householder was buying all the electricity that they used from their Electricity Supplier.

Total Household Energy Consumption

Total household energy consumption data is collected by the system in preference from a Smart Meter, however if a Smart Meter has not been installed consumption data can be collected from a 'dumb' meter by other means. The system can also monitor any electricity generation by the household from photovoltaic panels for example.

Appliance control

Household appliances can be monitored and controlled via plug-adaptors that go between the appliance plug and the wall socket. Multi-socket strips for multiple appliances are also available. Appliances and lighting can also be grouped so that the entire group can be turned on or off together with ease. Thus appliances that are frequently left on standby because the socket that they plug into cannot be reached could be turned on or off via the system. Data visualisation from the individual appliance can be viewed, and compared to other monitored appliances.

Central Heating and Domestic Hot Water

The system allows the temperature to be controlled by a central thermostat via individual temperature sensors in each room. The system also controls when the central heating and hot water turns on. Schedules can be inputted for different days of the week. This schedule can be altered remotely to either advance or delay when the heating and hot water system is due to turn on, or turn the heating or hot water system on or off.

## Customer offerings:

The technology is being offered to the householder as a means of providing additional Comfort, Convenience and Control. Customers do not need to switch energy tariffs or even be supplied by E.ON.

## Customer engagement approach:

E.ON posted leaflets to 6,000 households in the Milton Keynes area. Three hundred households responded to the mailshot. Two hundred were selected for face to face interviews. One hundred and twenty had their houses surveyed for suitability. From this group, sevety five households were selected to participate in the trial.

## Smart metering:

A Smart Meter is desirable when installing the system, but not essential.

## Tariff:

No tariffs were offered as part of this trial.

## Remote / Automatic Control of Appliances:

Initially, the participants received whole home energy use monitoring and visualisation, with no control. They were then given appliance level monitoring and control. Some have now received whole home gas central heating control through the system, and full visualisation of PV generation.

The participant are divided into four groups, who are each set to receive different technologies; smart white goods, connected LED lighting, connected electric vehicles and home battery systems and more advanced heating and hot water systems.

The trial continues to examine how much householders are willing to cede control of their energy consumption in favour of increased comfort or reduced bills.

## Information and Data Sharing:

The householders' energy data was not shared with any other organisations apart from for the purposes of research by academic institutions.

## Advice / Customer Engagement:

On-going advice will be offered to households via their energy control system suggesting ways that they could reduce their energy use.

## Results:

Householders are very positive about the system. They use the system to educate themselves about energy use in the home, and have become far more energy aware as a result. They like the extra control that it gives them over appliances, and their energy consumption. The system also provided them with greater heating comfort, with many suggesting that the system gave them greater control of their central heating system than they had previously been able to achieve. Householders used their ability to remote control appliances in unexpected ways, such as to turn on the kettle as they were about to get home from walking the dog!

Eighty per cent of householders thought that they had reduced their energy usage as a result of the technology, although this did not result in reduced bills necessarily because of increases in the cost of energy over the trial period. Some households made dramatic cost savings as a result of being able to run appliances more efficiently, discovering that they were faulty or not operating in a way that they had expected.

## Key lessons learnt (to date):

- Customers became significantly more knowledgeable about their energy use, allowing them to make informed decisions about their usage, including trade-offs
- Customers valued the extra control of their energy usage that this system provided them with;
- Many commented that they were able to achieve a higher level of control and comfort from their heating system with the new technology;
- The technology is valued for its ability to add to a households' lifestyle rather than its energy saving abilities per se. It is best accepted as a "lifestyle product".

## References:

Further information can be found at:

http://pressreleases.eon-uk.com/blogs/eonukpressreleases/archive/2013/08/19/1963.aspx

http://pressreleases.eon-uk.com/blogs/eonukpressreleases/archive/2013/01/14/1913.aspx

## UK 4. Customer Led Network Revolution

### Description:

While network management and demand response technologies exist and are well documented, this project focuses on deploying these for the first time at the distribution level.

GB is a fully unbundled electricity market. This project involves GB's largest regional wires-only distributor (Northern Power Grid) and the largest national unaffiliated energy retailer (British Gas).

The aim is to test a range of customer-side innovations (innovative tariffs and load control incentives in association with different low carbon technologies) alone and in combination with network-side technology (including voltage control, real time thermal rating and storage).

This template has been written based on information published by the project up to the end of April 2013. Further detailed results will be released into the public domain as the project progresses.

### Customers involved:

Over 14,000 homes and businesses are taking part in the trial in various 'test cells' (i.e. trials of different technologies, or different levels of monitoring). This includes the following cells of relevance to Task 23. The numbers given below is based on the number of customers recruited by the end of November 2012:

- Basic monitoring of domestic customer load profile: 8,909
- Enhanced monitoring of domestic customer load profile: 172
- Basic monitoring of SME customer load profile: 1,800
- Enhanced monitoring of SME customer load profile: 88
- Domestic heat pumps: 305 on flat rate tariff, 77 on a ToU tariff, 1 on restricted hours (with some customers to be transferred from the ToU trial), 17 with direct DNO control.
- Domestic micro-chp generation: 13 on flat rate tariff,
- Domestic PV generation: 150 (monitoring only)
- Domestic PV with automatic in-premises balancing: 99
- Domestic PV with manual balancing via an In-Home Display: 150
- Domestic electric vehicles: 4
- Profiling for generation under 'smart tariffs': 230
- Domestic Time of Use (ToU) tariff: 683
- SME ToU tariff: 51
- Domestic electric hot water: 13 customers with enhanced monitoring (no behaviour change attempted)
- Domestic electric hot water and storage heating: 57 customers with enhanced monitoring (no behaviour change attempted)
- SME restricted hours: 2 (see notes on customer acceptance and the suitability of the offering). It was not possible to recruit any customers for a direct load control trial.

The customer segments (as defined in this project) are therefore 'general/ non-specified' customers and those with on-site generation.

### Technologies deployed:

At the start of the project it was intended to involve customers with a range of low carbon technologies including electric vehicles, photo-voltaic panels, heat pumps, micro-chp generation and 'smart appliances' (externally controllable washing machines).

The uptake of electric vehicles has not been as high as expected and the trials involving this technology have been delayed until further customers can be recruited via other support mechanisms. There have been delays in relation to the availability of suitable externally controllable washing machines.

## Customer offerings:

The trial aims to test three tariff types across domestic and small business (SME) customer groups. The three tariff types are as follows.

- Time of Use - a static time of use tariff leaving customers with total discretion over how they respond.
- Restricted Hours - a static time of use tariff with an additional automated load switching facility which runs key loads outside of peak periods as a default, but allows customers to override this default if they wish.
- Direct Control – a proposition which allows certain loads to be occasionally interrupted through external dynamic signals and which does not allow customers to override the interruptions.

A technical solution enabling customers with solar photovoltaic (PV) panels to use the power they generate within the home is also included in the trial. Two systems are under investigation- one automatic system, and the other relying on manual intervention by the consumer (who is informed via an In-Home Display). CLNR should provide insight as to which solution gives most value to the consumer.

## Customer engagement approach:

Successful engagement with customers is recognised as critical to the deployment of technologies required for the successful transition to a low carbon economy. Specific tasks include: prioritisation of profile of customers for participation and development of propositions to be offered to customers.

Participation in the trial is voluntary, but customers are offered a £100 incentive to participate (£50 up after enrolment, and £50 once the trial is complete), some customers agreed to participate before the incentive was mentioned.

Preliminary results have reported that the majority of customers have signed up to trials as they feel they can make savings on their bills, and only a few appear to be motivated by reducing their carbon emissions.

The take-up rates experienced to date include 11% for PV propositions and 8% for ToU tariffs. The domestic ToU elements of the trial are now oversubscribed. This runs contrary to the current perception in the UK that consumers require fewer options and reduced complexity in the tariffs system.

It was intended to recruit SME customers to restricted hours and direct control trials. This has encountered difficulties in recruiting customers. 270 customers were initially attracted to the proposition but subsequently withdrew, often citing difficulties in adapt their business at the times required.

## Smart metering:

Smart Meters are being rolled out to a large number of customers as part of the CLNR trial. British Gas is also providing historical data for 11,000 existing smart meter customers. The Smart Meters include the following functionality:

- Automated meter reading, with data captured in half-hourly intervals
- In home display, providing information on consumption and cost of electricity and gas
- Direct load control capability

Data analysis of Smart Meter data is currently underway as part of this project (analysis of data from approximately 5,000 residential customers). Less than 2% of customers have opted out of having their data included in this analysis.

Within recruitment for the ToU trial two groups were targeted ‘Smart Exiting’ (those already with Smart Meters) and ‘Smart Eligible’ (those without Smart Meters who could have them installed to take part in the trial). Recruitment rates were 11% higher in the 'Smart Eligible' group, suggesting that the installation of a Smart Meter may have been seen as an advantage by the customer.

## Tariff:

The Time of Use tariff used consisted of a three –rate system, as follows:

| Time Period | Description | Rate |
|---|---|---|
| 07:00-16:00 | Day | 4% below standard rate |
| 16:00-20:00 | Peak | 99% above standard rate |
| 20:00-07:00 | Night | 31% below standard rate |
| Notes<br>The night rate applies all weekend (Saturday and Sunday).<br>A standing charge is applied in addition to the per-unit costs | | |

The tariff was designed to be "cost neutral" for the purposes of the trial, such that customers who exhibit no behaviour change on average will not suffer any financial penalty. The incentive available relates to cost savings through load switching (i.e. a reward of a lower bill than normal, not the risk of a higher one). The tariff was only available to customers taking part in the CLNR trial.

Customers opted-in, with a take-up rate of 8% from those approached. The test cell relating to ToU tariffs was oversubscribed.

The tariff was effective from 1st May 2012 and will run for the length of the trial. It is not yet clear if customers will be able to stay on the tariff at the end of the trial.

## Remote / Automatic Control of Appliances:

Customers in Test Cell 20(auto) had PV generation and automated in-home balancing via the diversion of excess PV generation to heat water via an immersion-heated hot water tank. The customers in this test cell did not also have an IHD.

## Information and Data:

N/A

## Advice / Customer Engagement:

Some customers in the PV in-home balancing trial were provided with an In Home Display (IHD) which showed the real-time excess generation. The customer could then use this information to decide whether they could make use of this energy 'in-home' rather than exporting to the grid. The display provided is shown below. The green region indicates excess generation (net export) and the red region indicates import of power from the grid.


Figure 24: In-Home Display for Manual PV Balancing – Screen Display

## Results:

### Time of Use Tariffs:

It is too early to be able to fully assess the results of the trials in terms of the amount of peak energy reduction or energy savings achieved. Work is ongoing to determine both these results, and conclusions in relation to customer acceptance and behaviour. An interim report has been published showing the early results from the time of use and PV in-premises balancing trials. Detailed surveys are being held with a cross-section of the customers involved in the trials.

Some preliminary results are available in relation to the response of customers to the ToU tariff in the summer. This is shown below, where TC1a (Test Cell 1a) and TC9a (Test Cell 9a) refers to customers on a standard tariff (no intervention) and a ToU tariff respectively.

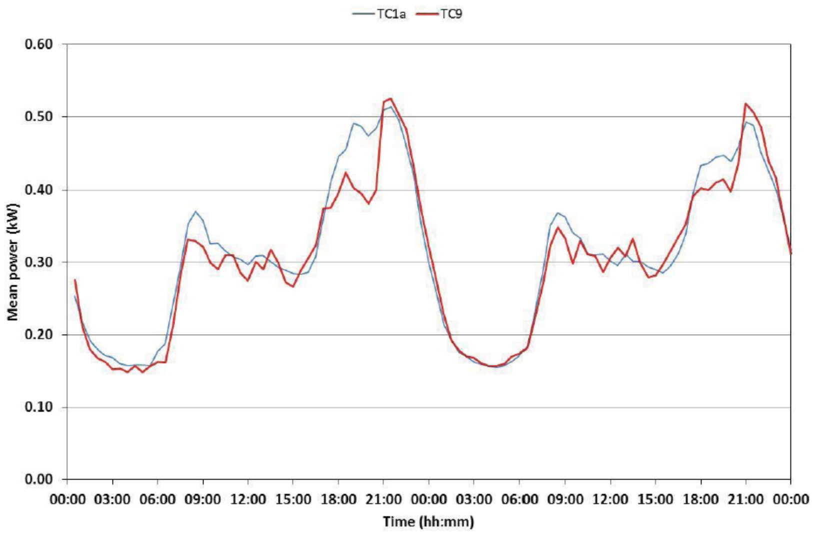



Figure 21: Comparison of TC1a and TC9a customers: summer mean (September 6$^{th}$ / 7$^{th}$ 2012)

ToU customers appear on average to have a lower demand between 18:00 and 20:00 hours compared to test cell 1a customers for the same day, implying that the tariff has indeed induced a shift on these two days during the summer. It is also useful to consider the difference in consumption for the trial participants before and after they adopted a ToU tariff, this is shown below.

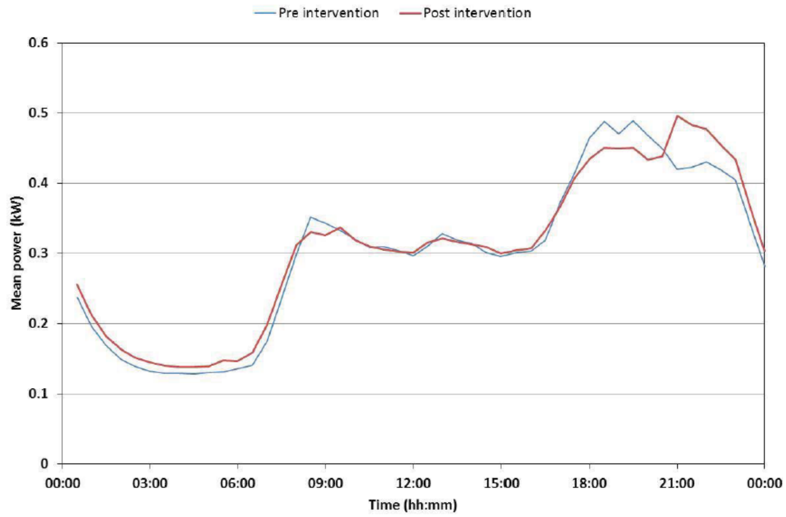



Figure 23: Mean weekday load comparisons of the pre and post intervention periods for test cell 9

**Customer Recruitment and Acceptance**

Interim results are available in relation to customer recruitment, as follows:

- Take-up rate for Time of Use tariff trials was 8%
- Take-up trials involving customers with PV generation was 11%

Almost all the potential customers for involvement in the heat pump trials were in the social housing sector. This identified 950 customer prospects. Of these, approximately 500 were not taken forward, 100 of those were tenant refusals. The main reasons that were given were:

- They were happy with their existing system
- They were not sure about the technology
- They did not want either the upheaval of changing heating system or larger radiators.

The reasons behind high customer take-up rates for the ToU tariff trials have been investigated, leading to the following conclusions:

- Saving money on bills was a factor. The majority of customers believe they can save money as a result of being on a ToU tariff, particularly if they rarely use electricity at the peak times.
- Customers with solar PV generation appear to be highly engaged in their energy usage/ generation

**In-Home Balancing of PV Generation**
*Manual Balancing via an IHD*
The preliminary analysis of customers with advice only (i.e. not automatic control) is given in the table below. Graphs of the resulting profiles are given in April 2013 report (see References section).

| Consumption (kWh) | January 2013 | | September 2012 | |
|---|---|---|---|---|
| | Test Cell 5 (PV only) | Test Cell 20man (PV with IHD) | Test Cell 5 (PV only) | Test Cell 20man (PV with IHD) |
| Peak Period | 3.4 | 3.8 | 2.3 | 2.6 |
| Daily Total | 10.8 | 12.7 | 7.5 | 9.7 |
| % of mean daily consumption | 26.7 | 26.1 | 23.9 | 22.4 |

- Peak power and relative peak consumption is similar between the two groups
- Mean total consumption is greater for the manual intervention customer group (Test Cell 20) which appears to be a consequence of increased daily consumption.
- A social investigation will hopefully illuminate whether this is due to underlying socio-economic factors such as occupancy during the day, or whether the PV/IHD combination is encouraging a change in behaviour.

*Automatic Balancing using Immersion Heated Hot Water Tanks*

For customers with automatic balancing in the summer there is a clear increase in demand between 8:00 and 16:00 (total demand, including that served by the PV generation) and a much lower evening peak. The demand is dispersed throughout the day. The results from the two test cells are shown in the table below.

| Consumption (kWh) | January 2013 | | September 2012 | |
|---|---|---|---|---|
| | Test Cell 5 (PV only) | Test Cell 20auto (PV with automatic balancing) | Test Cell 5 (PV only) | Test Cell 20auto (PV with automatic balancing) |
| Peak Period | 3.4 | 4.0 | 2.3 | 3.0 |
| Daily Total | 10.8 | 17.6 | 7.5 | 16.3 |
| % of mean daily consumption | 26.7 | 22.6 | 23.9 | 18.7 |

- Test cell 20 customers have a much greater daily electricity consumption than those in test cell 5. This can be attributed to the use of electricity for hot water heating.
- Although they have a higher overall energy consumption the relative peak load of test cell 20 customers is lower than that of test cell5.
- A shift in peak load is witnessed for the days analysed during the summer period where customers appear to shift their energy consumption.

## Key lessons learnt (to date):

The load profiles for all customers (TC1- no intervention, TC5- PV but no intervention, TC20manual- PV with an IHD and TC20auto- PV with automatic balancing) on two summer days are shown below.

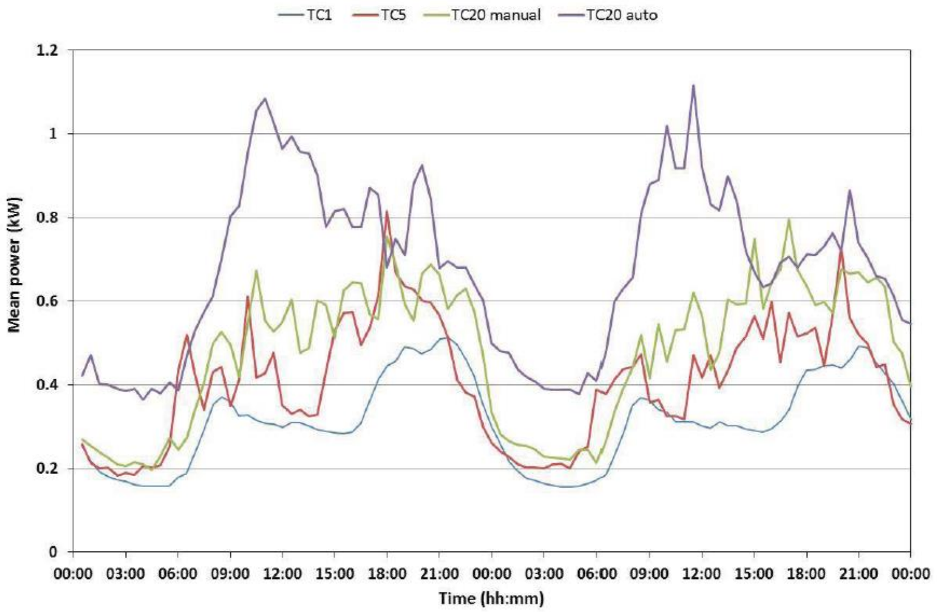



Figure 42: Comparison of all solar customer test cells summer mean with TC1a summer mean (sep 6/7)

- The preliminary results indicate that ToU tariffs reduce the early evening peak, at least in the summer. However, there is a significant payback as demand increases at the end of the peak rate period. From a network perspective, there may therefore be limited value in such tariffs.
- It is important to trial tariffs that are likely to be viable, rather than aiming to set tariffs that deliver the maximum amount of DSR
- Useful learning can be gained from offering tariffs, even if take up is low

- The supplier of a 'smart' (externally controllable) washing machine for the project has stressed the importance of the customer experience. As part of this they also note that any remote control by a third party should not be made available to the detriment of the appliance's intended functionality, so the customer has an override option. The DNO therefore needs to accept that they will not receive 100% of the available resource when a request is made as some customers will chose to override the interruption.
- Early indications show that SME customers who are considering adopting a ToU tariff appear to be unwilling to change behaviour to any great extent to access cheaper rates, particularly if doing so would have an impact on business operation.
- SME customers would not accept either the restricted hours tariff, or direct control if it would have any impact on their core business activities.
- The reasons expressed by business customers for taking part include:
    - Enthusiasm for environmental projects
    - Wanting to save money
    - Having an interest in the results of the monitoring trial if possible
    - Agreeing to take part as long as it's not intrusive to the business

## Major barriers encountered (to date):

- Not all tariffs that will be useful in the future are possible to trial now:
- Domestic Hot Water heating was not suitable for providing peak time DSR, as the majority of these customers are on an Economy 7 tariff and so do not heat their hot water at peak times.
- Not many customers with low-carbon technologies such as heat pumps and EVs. For heat pumps this has been affected by delays in the implementation of the Renewable Heat Incentive scheme (a government subsidy).
- Systems may not allow all tariff types to be trialled
- Lack of white goods suitable for direct control
- Difficult to recruit SME customers for direct load control/ restricted hours, because the impact on a customer's operations is considered to be too great.
- ZigBee smart plugs have been used for monitoring, and could be used for interventions. However, where plugs are not hard-wired there have been instances of customers accidentally turning them off/ removing them. Hard-wired smart switches would overcome this problem.
- A broadband internet connection was intended to be used to facilitate monitoring and demand management within the trial. The average take-up of broadband in the UK was approximately 67% in August 2011. However, within the social housing sector the take-up is substantially lower at 45% and so flexibility is required regarding the communications method to be used.
- The reasons cited by business customers for not taking part include:
    - Previous problems with installation of Smart Meters in their business
    - Don't like the idea of equipment being installed
    - Concerns about the size or impact of the monitoring and control equipment
    - They don't want overlap between the trial and existing energy saving/ environmental projects
    - They do not have the power to make the decision to take part- for example they may have a landlord or contract for their electricity through a broker.

## References:

Further information on this project can be found at:

http://www.networkrevolution.co.uk

The information included in this template is based upon the results reported in the 3rd and 4th progress reports, available from:

http://www.networkrevolution.co.uk/industryzone/projectlibrary

The 4th Progress report (including work up to the end of November 2012) referenced the production of a “customer recruitment appraisal and lessons learnt report” for residential and SME customers.

## UK 5. Low Carbon London

### Description:

This is a Tier 2 Low Carbon Network Fund (LCN Fund) project being undertaken by UK Power Networks (a UK DNO) in Inner and Outer London, with a total project cost of £36 million.

The project was approved in the first round of LCN Fund projects (December 2010) and is planned to conclude in June 2014. The project involves both commercial (contracts for demand response, energy efficiency consultation, network support from distributed generation and Time of Use (ToU) tariffs supported by Smart Meters) and technical (an active network management system, smart meters, an operational data store, electric vehicle charging and micro-generation) solutions.

The trials as part of this project are ongoing and only minimal results have been released to date. Progress with trials is summarised below, based on the latest progress report submitted to Ofgem (the UK regulator responsible for LCN Fund trials).

### Customers involved:

There are a wide range of trials involved in the overall Low Carbon London project, including:

- Demand Response with Industrial and Commercial (I&C) customers, via the use of aggregators (at least 60 customers stated in the bid document);
- Residential customers: Plans to access data from 14,000 smart meters in residential properties, bid also suggests the project is to "include at least 5,000 residential customers (with their consent) through efficiency measures, ToU tariffs and responsive demand contracts".
- SME customers

### Technologies deployed:

There is an intention to carry out trials in relation to heat pumps, small scale embedded generation, photovoltaic installations and electric vehicles.

### Customer offerings:

The Low Carbon London trial includes the following domestic and SME customer offerings:

- Smart metering of approximately 6,500 domestic and SME customers.
  - 5,600 of these participants have been invited to complete detailed energy behaviour surveys, As of December 2012 2,140 surveys had been returned,
  - Over 1,000 of the customers with Smart Meters agreed to participate in a dynamic wind-twinning time of use tariff,

- Various Electric Vehicle propositions including:
  - A time of use tariff for domestic customers,
  - Monitoring of charging posts (at commercial premises, public charging posts owned by Transport for London and private residential charging facilities)

- Monitoring of domestic and Industrial and Commercial size heat pumps,

- Monitoring of residential and Industrial and Commercial size Small Scale Embedded Generation (usually PV),

### Customer engagement approach:

The June 2012 project update states the following in relation to engagement/ recruitment of customers:

“Significant effort has been expended in trial participant recruitment- far in excess of that envisaged in the original bid or the early stages of the project. This investment has been made in recognition of and to address some of the challenges presented by the prevailing economic downturn and the reluctance of potential participants to commit to participation in the various projects trials. The efforts have included engaging a specialist market research company to undertake a detailed investigation and analysis of the I&C market with regard to its appetite for demand response and automated network management of distributed generation facilities.”

## Smart metering:

Under the project, over six and a half thousand Smart Meters had been installed by the end of 2012. These are L&G 5236 smart meters. All Smart Meters are accompanied by In Home Displays. The demographic profile of the smart meter trial participants has been carefully managed to be representative of London.

## Tariff (Intervention type T)

Residential and SME customers were recruited onto a Dynamic Time of Use tariff. The tariff will have three bands, high, medium and low. The bands are twinned to wind generation. Participants will be informed of any change to the band of their electricity the preceding day, either by text message or a device attached to their Smart Meter. The Low and Medium bands will be cheaper than the supplier’s (EDF Energy) Standard (Variable) rate. To be able to participate, a householder must already be an EDF Energy customer and have had a Smart Meter fitted and part of the Low Carbon London trial.

The price bands are (including VAT) per kWh unit:

Low – 3.99p

Medium – 11.76p

High – 67.20p

Consumers will be reimbursed if their electricity costs them more on this tariff than it would have done on their previous tariff. They will be paid £100 for signing up to the tariff and £50 for completing the trial and the final survey. They are allowed to leave the trial at any point, but would forfeit the final bonus payment.

The trial is targeting 1,521 participants

The tariff will be trailed between January and December 2013.

A separate time of use trial is being carried out with new and existing Electric Vehicle owners. This time of use trial is designed to encourage EV owners to charge their vehicles at night or at the weekend. Electric Vehicle owners are being recruited onto a tariff based on EDF Energy’s “Eco 20:20” tariff. The charge for off peak periods is 20% cheaper than the standard charge.

## Remote / Automatic Control of Appliances (Intervention type C)

N/A

## Information and Data Sharing (Intervention type F)

N/A

## Advice / Customer Engagement (Intervention type A)

Residential and SME trail participants have been recruited from within EDF Energy’s customer base on the whole; however some British Gas customers with Smart Meters were also recruited. The means of recruiting these customers into the trial is not clear.

At this point, no information has been released about any advice issued to trial participants with reference to changing their consumption patterns or becoming more energy efficient.

## Results:

Results are not yet published, but the bid specifies a number of reports which may be of relevance to Task 23 (or other work in this area), as follows:

- L1-1 Accessibility and validity of smart meter data;
- L4-1 Impact of Energy Efficiency Programmes;
- L6-1 Consumer attitudes to flexible energy rates;
- L6-2 Consumer/ SME responsiveness to ToU rates;
- L6-3 Public participation in supply demand matching (Workshop); and
- L6-4 Smart appliances for residential response.

The projected publication dates of these reports are not clear.

## Key lessons learnt (to date):

- Incentives were required to attract participants onto the trial.

## Major barriers encountered (to date):

- Recruitment for the trials domestic heat pump element has been difficult. A government support mechanism that was expected to be implemented was not, which has resulted in fewer heat pump installations than expected. Additionally, London is not a promising area to install heat pumps because of geological considerations and limited ground space caused by population density. Therefore a decision has been made to cease active recruitment for this area of the trial. Approximately five domestic heat pumps and fifteen industrial and commercial heat pumps have been recruited. No active trials are planned with these participants, rather to monitor their effect on the distribution network.

- Conflicting and contradictory messages to electricity consumers effected recruitment rates. The media backdrop and messages from the energy regulator and Government calling for a simplification of energy tariffs made attempts to recruit participants onto a time of use tariff more difficult.

## References:

Low Carbon Networks Fund: Low Carbon London full submission proforma (submitted by EDF Energy Networks). 28/11/2010. Available from: http://www.ofgem.gov.uk/Networks/ElecDist/LCN Fund/stlcnp/year1/low-carbon-london/Documents1/EDFET2001%20Addendum%20and%20Pro%20Forma.pdf Accessed 14/11/2012

Low Carbon London- Project Progress Report, June 2012. Available from: http://www.ofgem.gov.uk/Networks/ElecDist/LCN Fund/stlcnp/year1/low-carbon-london/Documents1/Low%20Carbon%20London%20June%202012%2015%20June%202012.pdf Accessed 14/11/2012

Low Carbon London – Project Progress Report, December 2012. Available from:

http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=164&refer=Networks/ElecDist/lcnf/stlcnp/year1/low-carbon-london

Accessed 30/04/2013

## UK 6. New Thames Valley Vision

### Description:

The New Thames Valley Vision project is located in the area around Bracknell, to the West of London. The area a mix of industrial, commercial and domestic energy users. At the start of the trial the energy use in the geographical area was traditional in character, with little penetration of renewable generation or new electricity loads (e.g. heat pumps or electric vehicles).

Through improved consumer end use monitoring and sub-station monitoring this project assist via the more efficient management of the distribution network.

Automatic Demand Response (ADR) will be deployed with large business customers. Once this has been successfully deployed, the role out of these principles to smaller SME businesses will be investigated in order to understand the extent that similar principles could be applied to this sector.

### Customers involved:

- Domestic – 1000 homes will have Smart Meters installed;
- SME – 100 will have Smart Meters installed and the potential of ADR will be investigated with around 30 small businesses;
- Large Commercial – demonstrate the deployment of ADR.

### Technologies deployed:

- Smart Metering;
- ADR solution.

### Customer offerings:

There were no customer offerings as part of this trial.

### Customer engagement approach:

- A shop was opened in the shopping district of Bracknell called "Your Energy Matters" to form a test bed for building relationships between customers and DNO;
- Commercial customers were engaged via a Consumer Consortia Event held in conjunction with Thames Valley Chamber Of Commerce;
- An internet site has been rolled out.

### Smart metering:

Smart Metering will be used to gain accurate data about the electricity network. One thousand domestic homes and one hundred SME will have Smart Meters installed.

### Tariff:

There was no tariff intervention as part of this trial

## Remote / Automatic Control of Appliances:

ADR technology will be installed in large commercial premises. The project will then investigate the potential for installing this technology in SME sites.

## Information and Data Sharing:

There is no data sharing as part of this trial.

## Advice / Customer Engagement:

An important aspect of this trial is about improving methods of engagement with large industrial and commercial customers.

## Results:

There are no results from this trial to date.

## Key lessons learnt (to date):

- Trial selling points that have assisted the recruitment of commercial customers include: service/benefits the company could gain, energy audit to identify potential energy savings, reduction in energy bill, local aspect of the trial, opportunity for Bracknell businesses only, link with the local council, positioning the project as a 'business in the community' initiative, asking for permission to check eligibility - thus positioning the project as selective and exclusive rather than in need of participants,
- A brief 'pre-audit' of a company's site was useful to enable companies to get a better understanding of the scheme and allow them to base decisions on figures relating to their own premises;
- A new commercial customer engagement framework has helped the processing of companies interested in participating in ADR.

## Major barriers encountered (to date):

- Businesses did not respond well to: LCN fund (businesses were averse to taking Government money), focus on searching for sites to put trial kit in for a project, environmental benefits;

## References:

Further information on this project can be found at:

http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/stlcnp/year2/new-thames-valley-vision/Pages/index.aspx

http://www.thamesvalleyvision.co.uk/

http://www.ena-eng.org/smarter-networks/Index.aspx

## UK 7. Sola Bristol

### Description:

The Bristol (So La Bristol) project will investigate long term methods of managing network issues caused by customers with installed PV. In order to do this the project will combine installing energy storage and a DC network in customer's premises and the use of variable tariffs. This DC system will be shared by the customer and the DNO. The project will include 40 premises which it is anticipate will include 30 homes, 10 schools and a section of an office.

### Customers involved:

It is anticipated that the trial will include 30 homes from Bristol City Council social housing stock, 10 schools and a section of an office.

### Technologies deployed:

The trial will investigate the following technologies:

In domestic homes:

- Up to 4.8kWh battery storage;
- 2kWe PV panels connected to a DC network;
- Lighting converted to operate on the DC network;
- Computing converted to operate from the DC network;
- Central heating pump and controller converted to operate from the DC network;
- Smart appliances controlled via the LC Connections manager;
- Variable tariffs.

In Schools:

- 19.2kWh battery storage;
- PV panels connected to the DC network 3.6kWe;
- Up to 40kWe connected to the AC network;
- Lighting converted to operate from the DC network;
- Computing converted to operate from the DC network;
- Three phase balancing.

Office:

- 19.2kWh battery storage;
- PV panels converted to the DC network 10kWe;
- Lighting converted to DC network;
- Computing converted to DC network;
- Three phase balancing;
- Supplemented by a feasibility study on a large office of IT centre.

### Customer offerings:

Domestic participants will be offered a shadow tariff (not affecting their current supply arrangements). This variable tariff will be designed to reward customers for taking advantage of the installed battery storage and PV generation. The tariff has been designed to be as simple as possible for the customer to understand, as well as being socially acceptable. A Dynamic fixed tariff was therefore designed that will offer a scaling factor based on the customer's existing flat tariff based on supply and DNO savings. This scaling takes into consideration DNO savings achieved through deferring network reinforcements, and the reduction in importing electricity during the period of peak electricity cost. Using these tariffs and the installed technology, customers can reduce their electricity bills by:

- Using energy from their PV panels, especially when they are generating at or near peak;
- Storing excess generation in their batteries, ideally for use during the peak period (normally 5-7pm);
- Reducing use of electricity at the peak period, for example by turning off appliances etc. when not in use.

## Customer engagement approach:

Domestic customers are to be recruited from the Bristol City Council social housing stock.

## Smart metering:

A LV Connection Manager home energy management system device will be used to monitor the network voltage profile, battery storage and demand response. The device can also:

- Forecast the homes next day electricity demand;
- Estimate micro generation output for different periods of the day, charging the battery during periods of excess generation;
- Move any smart appliances to periods of micro generation output;
- Calculate if the battery needs additional charging using off peak or low carbon intensive electricity.

## Tariff:

Detailed information about the tariff offered to householders is not available however it was designed to be simple to understand and socially acceptable. The tariff offered is a Dynamic fixed tariff. It will offer a scaling factor that considers the householders existing flat rate tariff. The scaling factor will consider the reduction in imported electricity during high peak periods, and the DNO saving from solving network constraints.

## Remote / Automatic Control of Appliances:

The battery at each property will charge and discharge intelligently. The LV connection manager will optimise charging and discharging of the battery for each property according to their individual consumption pattern. Eight different charge and discharge schedules – one for weekdays and weekends for each of the four seasons – will be programmed into the LV connection manager. Spare capacity in each battery will be reserved for DNO contributions. The customer will not be aware of any changes to the optimisation of their battery.

The householders lighting, heating pump and computing equipment will be wired off a DC network to take direct advantage of electricity generated by the properties solar panels either directly, or from the battery storage device. Smart appliances will be managed by the LV connection manager to perform as cost effectively as possible.

## Information and Data:

Information available to date indicates that there was no information/data sharing as part of this trial.

## Advice / Customer Engagement:

To date there is no information available about the advice offered to householders.

## Results:

This project is still at an early stage.

## Key lessons learnt (to date):

This project is still at an early stage.

## Major barriers encountered (to date):

This project is still at an early stage.

## References:

Further information on this project can be found at:

http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/stlcnp/year2/bristol/Pages/index.aspx

and

http://www.westernpowerinnovation.co.uk/So-La-Bristol.aspx

## UK 8. Domestic Demand Side Management

### Description:

This trial was a small scale investigation into the benefits of a new generation of storage heaters and water storage tanks. It sought to investigate if they could provide a higher comfort levels for householders whilst satisfying the heat requirements more efficiently. The trial also explored whether the new technology provided the local Distribution Network Operator with an extra measure to overcome some of the issues created by supplying electricity to a small island without an electricity connection to the UK mainland.

### Customers involved:

The trial involved six properties in Lerwick, Shetland owned by Hjaltland Housing Association. The properties included three one-bedroom flats, two two-bedroom bungalows, and a three-bedroom semi-detached house. The properties were selected by the housing association based on:

- Their relationship with the tenants;
- Their knowledge of the tenants willingness to participate in a trial that may cause some disruption;
- The tenants' willingness to provide feedback when the trail concluded.

The households were offered a £100 ex-gratia payment as an incentive to participate in the trial.

### Technologies deployed:

12.1 and 14.9kWh storage heaters and 14.0 and 17.1kWh hot water cylinders were installed according to the requirements of the participating property. The hot water cylinders and storage heaters were from Glen Dimplex's new Quantum range. The storage heaters were direct replacements for existing storage heaters in the properties. Their main features of the new storage heating system include:

- Highly insulated to prevent heat loss during non-heating periods;
- Energy efficient output, controlled by a timer and temperature control;
- Variable power output;
- User interface for programming comfort levels and heating periods;
- External control compatible with DNO interface to provide:
    - Communication to utility to provide frequency response and demand side management,
    - Mains frequency monitoring,
    - Variable frequency response,
    - Variable input power,
    - Core temperature sensing and setting,
    - Room ambient temperature setting and sensing.

The main features of the new hot water cylinders are;

- Three immersion heating element design to provide variable input power,
- Water temperature sensor built into immersion element to provide thermostat and over temperature safety cut out,
- Additional 3kW boost element;
- Foam insulation to minimise standing heat loss;
- Inlet diffuser to prevent hot and cold water mixing,
- Minimal stratification
- External control compatible with DNO interface to provide:

- Communication to utility to provide frequency response and demand side management,
- Mains frequency monitoring,
- Variable frequency response,
- Variable input power,
- Water temperature control – thermostat senses water temperature.

## Customer offerings:

The trial did not include any change in the participant's electricity tariffs.

## Customer engagement approach:

The customers were recruited on the basis of the likelihood of their receptivity to be involved in this trial by the housing association who managed the properties.

## Smart metering:

This trial did not involve Smart Metering.

## Tariff:

The participants in this trial were not asked to change their electricity tariff.

## Remote / Automatic Control of Appliances:

The trial involved remote control of the heating and hot water systems. It was discovered that the way that the logic programmed into the storage heaters and hot water tanks was constructed meant that any heating demand for the comfort of the householder would override the requirement of the DNO to control the devices. The devices also ignored load instructions to charge if the maximum charge temperature had been reached.

The devices have the potential to deliver frequency control response when requested by the DNO. This capability was tested during the trail and was partially successful.

## Information and Data Sharing:

This trial did not involve data or information being shared with a third party.

## Advice / Customer Engagement:

It is unclear what advice the trial participants were given about how to operate their new heating and hot water systems, and the format of this information. Some information was given, and participants had the opportunity to ask the installers if they had any queries about how the system should be operated. It is unclear if any suggestions were made about the optimum way that the technology could be run in order to be cost effective and of greatest benefit to the electricity network.

The use of the technology during the trial suggests that some households understood their heating and hot water system and were using it in an effective manner; some did not and were using the system to provide heat on demand rather than pre-charging the system.

The survey completed by participant's after the trial was concluded suggests that some households did not fully understand the advice and information that they had been given when the technology was installed.

## Results:

- The trial demonstrated that the new storage heaters and hot water cylinders are more controllable than the existing system that was removed from households;
- The new equipment was well received by householders;
- Evidence suggests that the new equipment was no more expensive to run than the system removed;
- Some of the householders did not fully understand how to use the new technology

## Key lessons learnt (to date):

- Design aspects relating to hierarchy of control logic need examining to maximise DNO DSM capability;
- While some households used the new storage heaters in the way they were designed, programming them to come on in accordance with their movements, others used them more like panel heaters, using the boost function as they required heat;
- More temperature sensors needed in hot water tanks;
- A standards paper will be drawn up for Shetland which will include minimum functionality and characteristics that equipment being installed on the island for Demand Side Management purposes should comply with.

## Major barriers encountered (to date):

- Data retrieval from the heating systems was problematic and resulted in data on the behaviour of the storage heaters/ hot water cylinders not being sent to the central data repository, and therefore lost;
- Engineers on site must be able to interrogate the system locally rather than relying on being relayed information from Glasgow

## References:

Further information on this project can be found at:

http://www.ena-eng.org/smarter-networks/Project.aspx?ProjectID=387

## UK 9. Sustainable Blacon

### Description:

One hundred and fifty participants were recruited from Blacon, a suburban area outside Chester. They were split into three groups, 'Active', 'Passive' and 'Control'. The 'Active' group were issued with an AlertMe™ system which allowed participants to monitor their electricity consumption using an online display. The system also allowed participants to control appliances remotely. The 'Passive' group were issued with Wattson™ meters which recorded electricity use at regular intervals and provided a real-time display of electricity consumption. The 'Control' group were not issued with any technological interventions. Participants in all three groups were requested to submit electricity and gas meter readings every month, and invited to educational meetings, consisting of eight sessions spaced throughout the year, some of which focused on energy use, but also on themes of interest to the participants such as water, waste and local food. Gas and electricity consumption data was requested from participants for the previous twelve months.

### Customers involved:

One hundred and fifty customers were recruited from Blacon. Blacon is a mix of private homes and a substantial number of council-built properties. The formerly council owned properties are now run by a local housing association in partnership with the local council.

### Technologies deployed:

Two technologies were employed as part of this trial, AlertMe™ and Wattson™. The Wattson™ device provided real time electricity consumption data as well as a record of electricity use over regular intervals. The AlertMe™ system is internet based, requiring the householder to log into the system for to access electricity consumption data. This system could also switch appliances on and off remotely.

### Customer offerings:

No commercial offerings were available.

### Customer engagement approach:

Participants were volunteers who responded to publicity circulated via Sustainable Blacon Ltd, existing community groups and leaflet drops. Rewards were offered for continued participation – a house energy efficiency make over worth between £300 and £2000 dependent on the householder's level of engagement in the programme.

### Smart metering:

Smart meters were not installed however an important aspect of the trial was investigating the benefit of In Home Display systems as an energy efficiency measure.

### Tariff:

No tariff packages were involved in this trial

## Remote / Automatic Control of Appliances:

No automatic control of appliances was included in this trial although the AlertMe™ system had the functionality to allow householders to remotely control their appliances,

## Information and Data Sharing:

No information sharing was involved in this trial.

## Advice / Customer Engagement:

Education sessions were held for trial participants. Some of the sessions focused on energy efficiency. A visit to a local energy efficient test house was organized. Other sessions were on subjects such as efficient water use, reducing waste and local food.

## Results:

Based on those households that provided historical gas consumption information, the 'Control' group achieved the largest mean reduction in gas consumption. The 'Passive' group achieved the smallest mean reduction in gas consumption. The 'Control' and 'Active' groups contained a majority of houses that achieved a reduction in carbon emissions. The 'passive' group was equally divided between households that reduced and increase gas usage.

Of those households that provided historical electricity consumption data, 23 of the 43 reduced their consumption but consumption at the other 20 houses increased. While six of the eleven houses for which historical data was available in the 'Control' group reduced their electricity consumption, four of those that increased their consumption only did so by a small amount but one recorded a large increase. Amongst the 'Passive' group nine of the sixteen households for which historical data was available achieved a reduction. The increase of the other seven houses, some of which were large, outweighed any decrease. The number of houses that achieved a decrease in electricity consumption in the 'Active' group was equal to the number that increased their consumption but those who increased their consumption outweighed those who decreased their consumption.

Householders found the educational sessions useful and results suggest that the programme helped participants to reduce their energy consumption.

Feedback from the group issued Wattson™ devices was that 76% had found the device at least fairly easy to use. Households issued with an AlertMe™ system found it more difficult to use – only 41% found it at least fairly easy to use. 82% of households issued a Wattson™ device thought that it had helped them save electricity compared to 37% who were issued an AlertMe™ system.

## Key lessons learnt (to date):

- The visual display unit (Wattson™) was useful prompt providing awareness of energy use;
- Householders reported that the Wattson™ helped them develop a better understanding of their households energy consumption, allowing them to discover which appliances caused a spike in their electricity consumption;
- Householders who received an AlertMe™ system failed it utilise it to its full potential particularly it's control functions that allowed the remote control of appliances;
- The education programme was credited by participants for helping to instil good behaviour practises such as turning of lights or appliances when not in use.

## Major barriers encountered (to date):

- Gathering historical data consumption data. Data was only collected for 46 households for gas and 43 households for electricity.

## References:

Further information on this project can be found at:

*Evaluation of Energy Management Systems Trial for Blacon Smart Energy Community LCCC Programme – Final Report,* Professor Roy Alexander and Tamara Hunt, October 2012

# Appendix D: Overview of the International Energy Agency and the Implementing Agreement on Demand Side Management Technologies and Programmes

The International Energy Agency (IEA) is an autonomous agency established in 1974. The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The aims of the IEA are to:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

To attain these goals, increased co-operation between industries, businesses and government energy technology research is indispensable. The public and private sectors must work together, share burdens and resources, while at the same time multiplying results and outcomes.

The multilateral technology initiatives (Implementing Agreements) supported by the IEA are a flexible and effective framework for IEA member and non-member countries, businesses, industries, international organisations and non-government organisations to research breakthrough technologies, to fill existing research gaps,, to build pilot plants, to carry out deployment or demonstration programmes – in short to encourage technology-related activities that support energy security, economic growth and environmental protection.
More than 6,000 specialists carry out a vast body of research through these various initiatives. To date, more than 1,000 projects have been completed. There are currently 41 Implementing Agreements (IA) working in the areas of:

- Cross-Cutting Activities (information exchange, modelling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (international experiments)
- Renewable Energies and Hydrogen (technologies and deployment)

The IAs are at the core of a network of senior experts consisting of the Committee on Energy Research and Technology (CERT), four working parties and three expert groups. A key role of the CERT is to provide leadership by guiding the IAs to shape work programmes that address current energy issues productively, by regularly reviewing their accomplishments, and suggesting reinforced efforts where needed. For further information on the IEA, the CERT and the IAs, please consult www.iea.org/techinitiatives.

The Implementing Agreement on Demand Side Management Technologies and Programmes belongs to the End-Use category above.

## IEA Demand Side Management Programme

The Demand-Side Management (DSM) Programme is one of more than 40 co-operative energy technology programmes within the framework of the International Energy Agency (IEA).The Demand-Side Management (DSM) Programme, which was initiated in 1993, deals with a variety of strategies to reduce energy demand. The following member countries and sponsors have been working to identify and promote opportunities for DSM:

| | |
|---|---|
| Austria | New Zealand |
| Belgium | Norway |
| Finland | Spain |
| France | Sweden |
| India | Switzerland |
| Italy | United Kingdom |
| Republic of Korea | United States |
| Netherlands | ECI (sponsor) |
| | RAP (sponsor) |

**Programme Vision during the period**: Demand side activities should be active elements and the first choice in all energy policy decisions designed to create more reliable and more sustainable energy systems

**Programme Mission:** Deliver to its stakeholders, materials that are readily applicable for them in crafting and implementing policies and measures. The Programme should also deliver technology and applications that either facilitate operations of energy systems or facilitate necessary market transformations

The Programme's work is organized into two clusters:

- The load shape cluster, and
- The load level cluster.

The 'load shape" cluster will include Tasks that seek to impact the shape of the load curve over very short (minutes-hours-day) to longer (days-week-season) time periods. Work within this cluster primarily increases the reliability of systems. The "load level" will include Tasks that seek to shift the load curve to lower demand levels or shift between loads from one energy system to another. Work within this cluster primarily targets the reduction of emissions.

A total of 23 projects or "Tasks" have been initiated since the beginning of the DSM Programme. The overall program is monitored by an Executive Committee consisting of representatives from each contracting party to the Implementing Agreement. The leadership and management of the individual Tasks are the responsibility of Operating Agents. These Tasks and their respective Operating Agents are:

- Task 1 International Database on Demand-Side Management & Evaluation Guidebook on the Impact of DSM and EE for Kyoto's GHG Targets – Completed
  Harry Vreuls, NOVEM, the Netherlands

- Task 2 Communications Technologies for Demand-Side Management – Completed
  Richard Formby, EA Technology, United Kingdom

- Task 3 Cooperative Procurement of Innovative Technologies for Demand-Side Management – Completed
  Dr. Hans Westling, Promandat AB, Sweden

- Task 4 Development of Improved Methods for Integrating Demand-Side Management into Resource Planning – Completed
  Grayson Heffner, EPRI, United States

- Task 5 Techniques for Implementation of Demand-Side Management Technology in the Marketplace – Completed
  Juan Comas, FECSA, Spain

- Task 6 DSM and Energy Efficiency in Changing Electricity Business Environments – Completed
  David Crossley, Energy Futures, Australia Pty. Ltd., Australia

- Task 7 International Collaboration on Market Transformation – Completed
  Verney Ryan, BRE, United Kingdom
  Task 8 Demand-Side Bidding in a Competitive Electricity Market – Completed
  Linda Hull, EA Technology Ltd, United Kingdom

- Task 9 The Role of Municipalities in a Liberalised System – Completed
  Martin Cahn, Energie Cites, France

- Task 10 Performance Contracting – Completed

  Dr. Hans Westling, Promandat AB, Sweden

- Task 11 Time of Use Pricing and Energy Use for Demand Management Delivery- Completed
  Richard Formby, EA Technology Ltd, United Kingdom

- Task 12 Energy Standards
  To be determined

- Task 13 Demand Response Resources - Completed
  Ross Malme, RETX, United States

- Task 14 White Certificates – Completed
  Antonio Capozza, CESI, Italy

- Task 15 Network-Driven DSM - Completed
  David Crossley, Energy Futures Australia Pty. Ltd, Australia

- Task 16 Competitive Energy Services
  Jan W. Bleyl, Graz Energy Agency, Austria / Seppo Silvonen/Pertti Koski, Motiva, Finland

- Task 17 Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages
  Seppo Kärkkäinen, Elektraflex Oy, Finland

- Task 18 Demand Side Management and Climate Change - Completed
  David Crossley, Energy Futures Australia Pty. Ltd, Australia

- Task 19 Micro Demand Response and Energy Saving - Completed
  Linda Hull, EA Technology Ltd, United Kingdom

- Task 20 Branding of Energy Efficiency
  Balawant Joshi, ABPS Infrastructure Private Limited, India

- Task 21 Standardisation of Energy Savings Calculations
  Harry Vreuls, SenterNovem, Netherlands

- Task 22 Energy Efficiency Portfolio Standards - Completed
  Balawant Joshi, ABPS Infrastructure Private Limited, India

- Task 23 The Role of Customers in Delivering Effective Smart Grids
  Linda Hull. EA Technology Ltd, United Kingdom

- Task 24 Closing the loop - Behaviour change in DSM, from theory to policies and practice
  Sea Rotmann, SEA, New Zealand and Ruth Mourik DuneWorks, Netherlands

For additional Information contact the DSM Executive Secretary, Anne Bengtson, Liljeholmstorget 18,11761 Stockholm, Sweden. Phone: +46 70 7818501. E-mail: anne.bengtson@telia.com

Also, visit the IEA DSM website: http://www.ieadsm.org