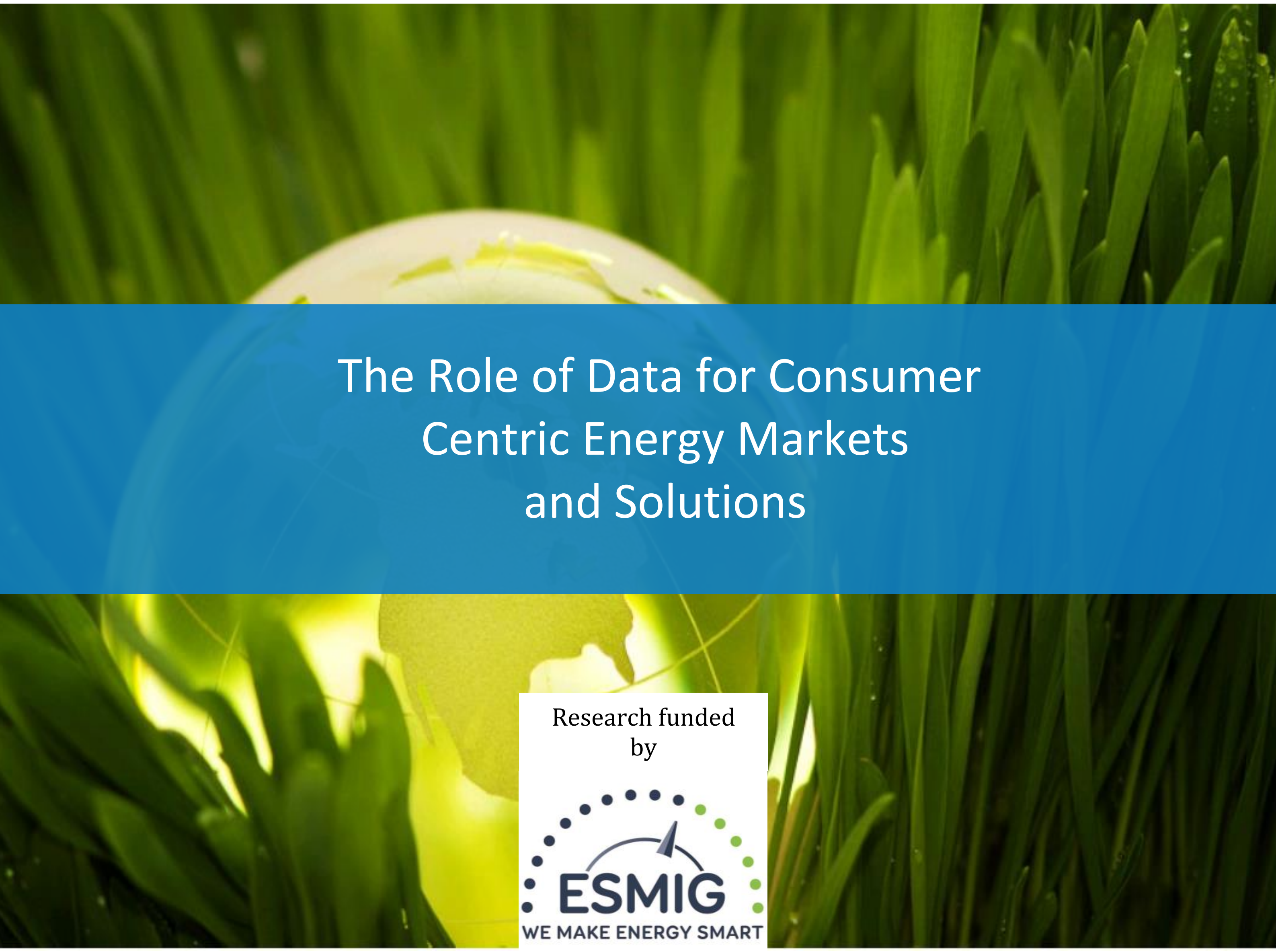
The Role of Data for Consumer Centric Energy Markets and Solutions



Research funded by

ESMIG
WE MAKE ENERGY SMART

Main Authors
Christophe Dromacque
Rafaila Grigoriou

Additional Contributors
Thomas Mikkelsen
Hanna Launonen
Ioannis Oikonomou

Delivered 11/12/2018

Contents

Figures

Tables

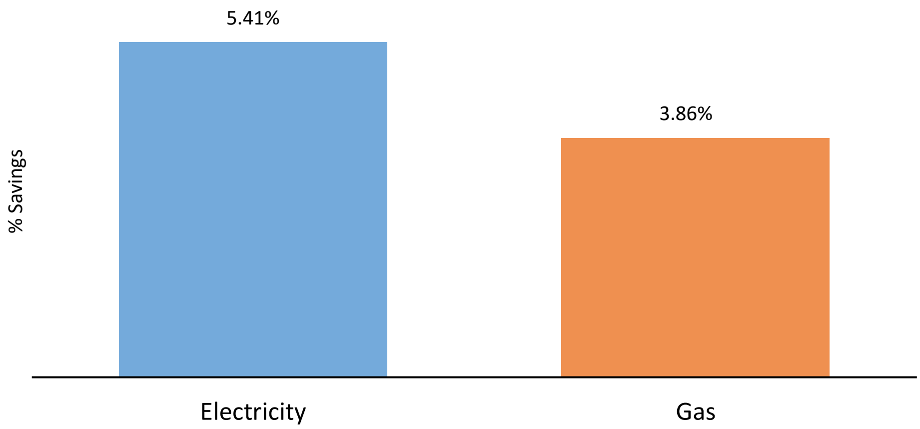
Executive Summary

Several trends are converging to make consumer centric energy markets a reality. On the policy side the European Commission, in its communication Delivering a new deal for energy consumers, highlights the key and central role of consumers in the global transition to a low-carbon society. The first of ten priority steps proposed is "*Providing consumers with frequent access, including in near real-time, to partially standardised, meaningful, accurate and understandable information on consumption and related costs as well as the types of energy sources*". Regarding infrastructure, already a majority of the EU member states (17) have taken a positive decision for a full roll-out of smart meters which will make available granular and reliable information about individual energy use. In addition, the increasing penetration of connected objects in homes and the decreasing costs of measuring and analysing ever-larger amounts of data will make real-time data ubiquitous. These driving forces have led to the development of new service-based business models in the energy industry independent from having to sell more kWh to grow. Examples can be found in Europe which potentially benefit customers, network operators and the society as a whole while improving margins for energy suppliers.

This report studies the impact of the provision of electricity and gas consumption feedback to households and sheds light on the added-value of near-real-time data in terms of customer engagement and benefits.

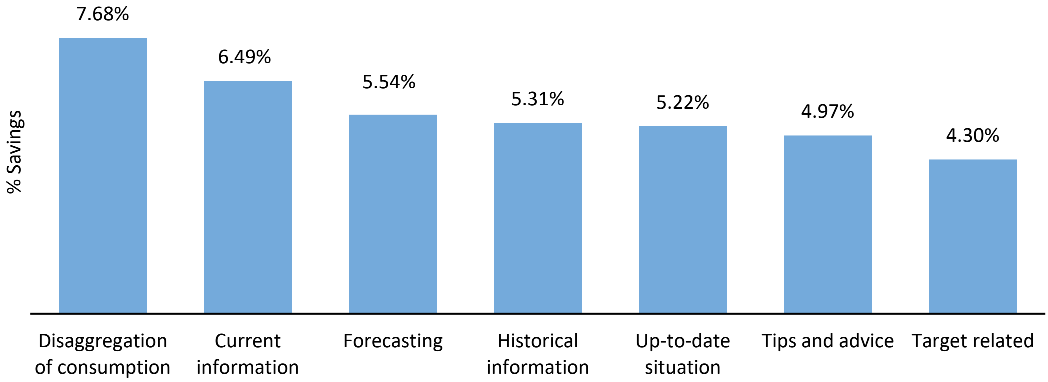
Consumption reduction in electricity and gas pilots

154 feedback trials have led to an average reduction of 5.4% in electricity consumption and 3.9% in gas consumption.



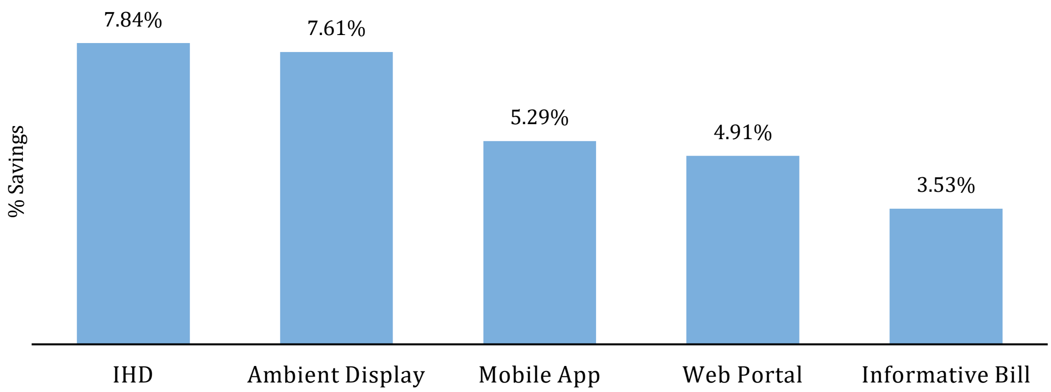
- **Feedback types**

Disaggregation feedback breaks down energy consumption per appliance or household activity. This type of feedback leads, according to our database, to the highest savings perhaps as it allows consumers to link their everyday activities with energy consumption and thus better focus their efforts. It is followed by current information feedback (KW or kWh consumption, up-to-date bill, etc.) which, being often based on real-time data, allows consumers to explore and discover the links between their actions and energy consumption thereby supporting the creation of new energy habits. (Section 2.3.)



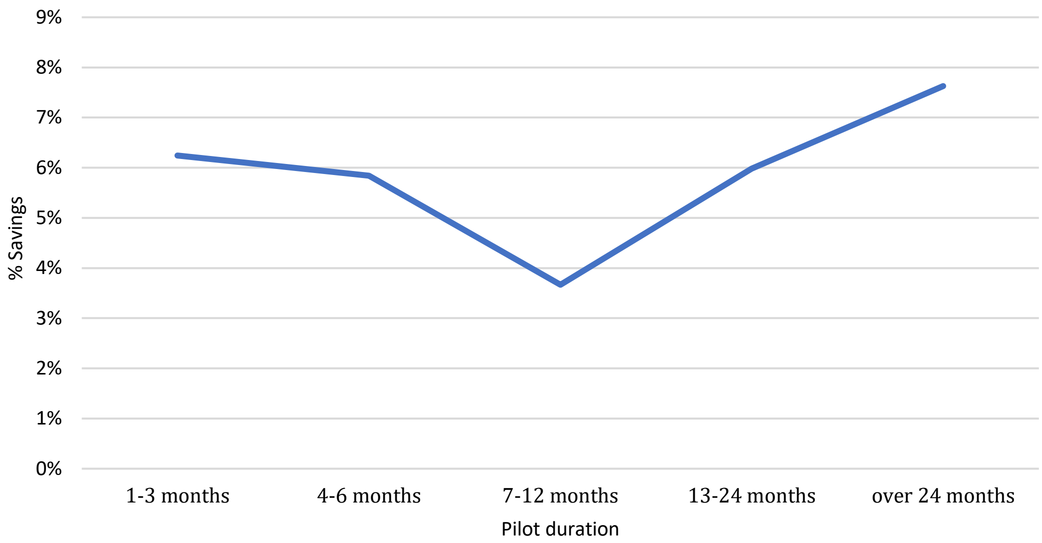
- **Feedback channels**

Providing feedback via IHDs leads, according to our database, to the highest savings. This may be attributable to three main advantages of IHDs over other feedback channels: IHDs can act as a constant reminder of energy consumption, reach the entire family - unlike bills, mobile apps and web portals - and can provide additional information via different dynamic menus - unlike ambient displays. (Section 2.4.)



- **Sustainability of impacts**

One of the most common questions when it comes to feedback interventions is whether the impact fades away as people's interest diminishes and they revert to their old habits or if behaviour change is sustained. Results extracted from our database confirm the former hypothesis: feedback are most effective in the short term, when task learning is most likely to occur, and over the long term as behavioural regulation becomes more automatic and newer more ambitious goals are set as previous ones are met. (Section 2.5.)



- **Satisfaction**

86% of pilot participants are satisfied with the feedback programme and 85% would have liked the programme to continue. In real market conditions, energy suppliers who offer feedback solutions should see some "soft" benefits in the form of, for instance, lower churn rates, marketing outreach costs and cost-to-serve. Suppliers should also benefit from increased acquisition rates and improved image. There is also some evidence of a "halo effect"; in that customers exposed to feedback programmes are more likely to get involved in other offerings. Suppliers may thus be able to capitalize on customers' newly built sense of empowerment and trust by cross-selling additional products and services. All of these benefits combined should lead to increased customer lifetime value. (Section 2.6.)

Maximising the impact of feedback

- **Additionality of feedback**

Our findings show that the impact of feedback increases with the number of feedback types and channels provided (Sections 2.3. and 2.4.) People (even people living under the same roof) are different and behaviour change is often triggered by different incentives and mechanisms. Energy conservation through feedback can thus only be maximised if the solution tends to different segments of consumers with different interest, norms and rationalities.

- **Customer segmentation**

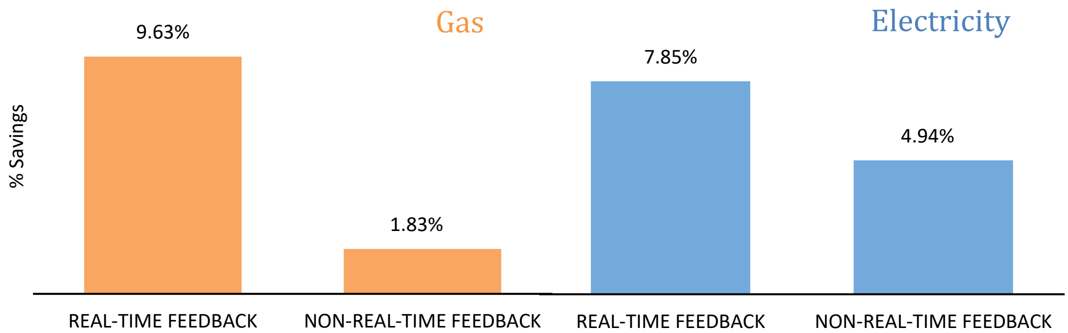
After a few months (3-4 according to our data), the importance of segmentation and targeted messages become crucial. Consumers should feel that the information they are given is relevant and that the advice is useful. Recent ICT developments allow creating seemingly tailored information on a mass-scale. (Section 2.5.)

- **Feedback cycles**

Feedback solutions should, rather than offering one static programme, bring participants through a cycle. For instance, starting with simple messages and suggest tasks of low degree of involvement and low perceived complexity and then progress towards more sophisticated or constraining behaviours. (Section 2.5.)

- **Real-time feedback**

Social sciences (c.f. Sections 2.1 and 2.5) suggest that people like to explore, they like to discover, in general more than they like to study or be taught. If feedback is to obtain the interest and involvement of consumers, then they must be able to learn at their own pace, in their own way, to their own desired extent. People should feel that they are enlightened by their own findings. This often happens in feedback programmes through being able to link actions to energy consumption which should logically, as our findings demonstrate, favour real-time feedback as an effective way to engage consumers. (Section 3.1.)

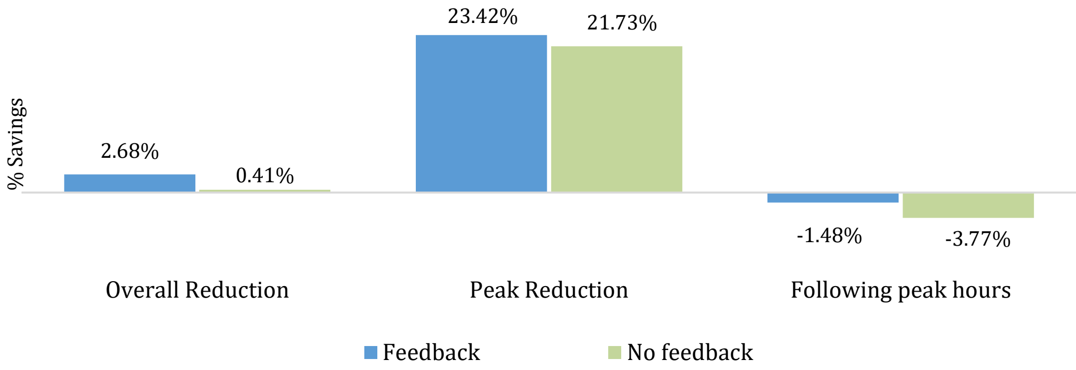


- **Inclusiveness**

Natural gas represents 37% of household's final energy consumption in Europe compared to 25% for electricity and in many countries a higher share of household energy expenditure as well. Our results show that providing real-time feedback on both gas and electricity leads to significantly higher savings: 9.2% for dual-fuel pilots versus 7.7% for electricity only pilots. (Section 3.1.3.)

Home automation and feedback

As could be anticipated, automation has proven a much more effective way to shift consumption in time than manual response (23% vs. 9%). An important finding however is that home automation should be coupled with feedback to maximise impacts on both peak and overall energy consumption. While some would argue that there is no point trying to engage and educate customers who have automated appliances, pilot results show that when efficiency improvements come solely from the technological side, people largely remain passive actors, leading to low levels of awareness, continued inefficient habits and sometimes a rebound effect (seeing its energy expenditures decrease, the customer might become more careless about his consumption). Pilots making use of the often near-real-time data generated by the home automation system to also provide feedback are more effective at reducing both peak (23% vs 22%) and overall consumption (2.7% vs. 0.4%).

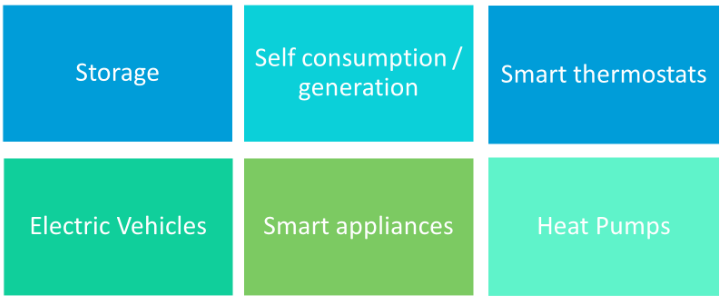


In real-life however, both in pilot and commercial contexts, home automation has often been introduced following an inverted evolution whereby technology has been at the fore-front, with consumption feedback being introduced as a next-step or a reaction to negative publicity. Another limitation to the impact of home automation technology has been the fact that, thus far, pilots have tended to focus on shifting demand in time by controlling one specific appliance (e.g. electric heater during French winters, air conditioner during Australian summers). In other words, automation pilots often do not consider the home in its entirety and all the major appliances in it nor the potential for overall energy savings the home automation system enables. It is therefore likely that more inclusive home automation pilots could have a greater aggregated impact both on participants' energy consumption and budget. (Section 3.2.)

Innovative Customer centric Data-driven Models and Services

Chapter 4 showcases a selection of innovative products and services commercially available in Europe. Innovative business models in the electricity industry revolve around two main themes sometimes offered in combination: a) providing households with the ability to automatically increase and decrease energy demand and be rewarded for providing grid flexibility and prepare the grid for an increasing electrification of transport and heating (e.g. electric cars, heat pumps) and b) enabling and maximising independence from traditional suppliers by optimising local generation (typically solar PV), battery storage and home control. In the case of gas, new services often focus on remote control and scheduling of water boilers and heating.

Many of these new services are in stark contrast to the traditional volume-based business models in the industry. The margins on the energy is sometimes zero, and the margins and profits are made from added-value services in relation to optimization, comfort and CO_2 reductions. It is also important to note that real-time measurements are a pre-requisite for these business models to function.



1 Introduction and Objectives

Energy use in identical homes with similar appliances occupied by people with similar demographics can vary by two to three times [1], indicating that, in addition to the building itself, the behaviour of occupants within the building impacts overall energy use. Actions focused on addressing sub-optimal consumer behaviour can thus have a very significant impact.

One difficulty with such actions lies with the fact that everyday energy-consuming behaviours (such as thermostat settings or switching on lights to read our favourite book) are largely habitual [2] and often reliant on automatic processes which may be particularly resistant to change [3]. As a result, "*most people have only a vague idea of how much energy they are using for different purposes and what sort of difference they could make by changing day-to-day behaviour or investing in efficiency measures*" [4]. Numerous studies have led to the widely accepted conclusion that households are still scarcely knowledgeable on what energy efficiency entails, how much energy they consume, how much they pay for it, why and how they should save energy.

Another difficulty is that increases in knowledge and concern from mass communication campaigns may not translate into observable change of behaviour, unless the general information is combined with other more tailored and targeted techniques [5].

Until recently however, the potential to provide households with individualised up-to-date information has been limited by the lack of appropriate technology [6].

European authorities are well aware of these different barriers. In its communication Delivering a new deal for energy consumers [7], the European Commission (EC) highlights the key and central role of consumers in the global transition to a low-carbon society. It proposes a three-pillar strategy: 1) helping consumers save money and energy through better information; 2) giving consumers a wider choice of action when choosing their participation in energy markets and 3) maintaining the highest level of consumer protection. The first of ten priority steps proposed is "*Providing consumers with frequent access, including in near real-time, to partially standardised, meaningful, accurate and understandable information on consumption and related costs as well as the types of energy sources*". On the enabling infrastructure side, already a majority of the EU member states (17) have taken a positive decision for a full (80% or more of energy consumers) roll-out of smart meters which will make available granular and reliable information about individual energy use.

The positive impact of the provision of consumption feedback to households is well documented. For instance, VaasaETT (2011) averaged the results of 74 feedback trials worldwide [8]. The US Electric Power Research Institute [9] analysed approximately 50 feedback studies. Ehrhardt-Martinez, Donnelly, & Laitner (2010) examined 57 studies around the world [10]. These meta-reviews report reductions in the range 0-20% using different types of feedback mechanisms and depending on specific contexts and geographies.

They also highlight several knowledge gaps which we aim to fill with the present study:

- The meta-reviews provide clues on the benefits of near-real-time feedback compared to other less granular update mechanisms. However, the added-value of near-real-time feedback in terms of engagement and energy savings was not the focus of the research and thus not explicitly reported;

- Although gas represents 37% of household's final energy consumption in Europe (compared to 25% for electricity [11]) we are not aware of any meta-study of the impact of smart-meter enabled feedback programmes on gas consumption;
- There is a lack of research on the added-value of near real-time data to achieve other customer benefits such as providing a wider choice of services from traditional energy players or new entrants and participate in energy markets through for instance Demand Side Flexibility (DSF).

2 The Potential of Feedback for Energy Conservation

2.1 A Social Science Framework

Understanding the experiential learning cycle of consumers is not a purely academic exercise. Insight into how consumers learn and why feedback works maximises the impact of pilot studies and will eventually improve policy making. The traditional role of feedback is to make energy and its consumption visible, thus expanding on residential consumers' awareness as a prerequisite to reducing the quantity of energy consumed in the household. Energy consumption feedback is an essential element in effective learning and behaviour change, as well as in raising social awareness, changing consumers' attitudes, and leading them to engage critically with their habits and practices.

David Kolb's theory of experiential learning has been used in schools and in adult education for many years. The hypothesis states that people learn through concrete experiences, analysing their own experiences, trying new experiments that further the idea of what they just learnt and noticing the results of those. The process is therefore cyclical – the more upward turns people go through with experimenting and analysis, the more they learn.

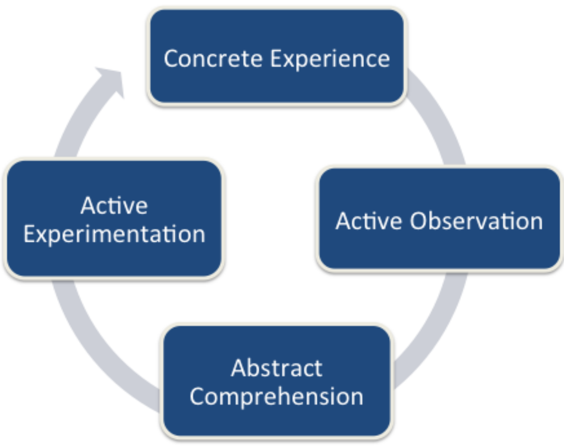


Figure 1. Kolb's experiential learning cycle.

An example of the experiential learning cycle in action has been analysed by researchers developing displays at YelloStrom (DE), Onzo (UK) and the RISE Institute (SE) as they observed and interviewed people who are given displays. The consumer has the initial experience of turning on the display and noting that it is recording real-time electricity consumption. This is the first concrete experience and step 1 in the cycle. She/He actively observes what the display does (step 2), comprehends that she/he is seeing real time energy consumption (step 3) and decides to perform another active experiment (step 4) carrying it around the house to note what happens when she/he turns on the lights or the micro-wave. This is turn leads to new realisations i.e. micro-waves use a lot more electricity than lights - and a new cycle has started. This next cycle is teaching not only about the display but also about how much different appliances use.

"*We thought we were undertaking an infrastructure project, but it turned out to be a customer project*"

Chris Johns, President of PG&E about the SmartRate Pricing Program pilot.

Different social science frameworks are (consciously or unconsciously) put to use when designing feedback interventions: theories of rational behavioural change; theories of habitual behaviour; and social practice theory [1]. These tend to combine in different ways for different segments of the population.

Theories of rational behaviour change such as the theory of planned behaviour [12] focus on the inner, mental world of the consumer i.e. attitudes, beliefs, values, ability to make changes. This important dimension provides a lever for feedback to engage with consumers' values and attitudes such as environmental concern, desire to save money, desire to engage in a community project, and enjoyment of game-type actions.

However, a limitation is that people are also bound by their individual habits. For example, the habit of leaving the lights on in unoccupied rooms may trump in inner value of saving electricity.

Theories of habitual behaviour [13] [14] have closely investigated this type of barriers. Ingrained habits are extremely useful features of human life because they enable people to do many regular, often quite complex daily tasks skilfully and safely, without having to think things through or consciously coordinate limbs, mental work and household equipment. However, habits can block inner desires for energy saving, partly because people often perform their habits without realising, but also because habits require conscious, oft-repeated effort to change. Feedback can therefore lead householders to learn to recognise when they are acting out of habits that block their felt desires to save energy and/or their desire to act more rationally in relation to energy consumption. Advanced feedback algorithms for instance can spot out-of-the-ordinary behaviour compared to a norm and provide information on how to change them.

Social practice theories [15] [16] [17] take this yet a step further. Social practice theorists argue that individuals' efforts to change their energy saving behaviour are limited by the fact that each individual is embedded in a social setting which has its own routines, expectations, and material content. This tends to lock into place things like cooking times, temperature settings, the amount of hot water consumed for personal hygiene. It also tends to make energy consumption invisible, since people are thinking of fitting in with others around them and their daily obligations, rather than the energy

---

[1] This section was written in collaboration with Dr Raymond Galvin from the E.ON Energy Research Center, Institute for Future Consumer Energy Needs and Behavior, School of Business and Economics, RWTH Aachen University in Germany.

consumed in doing so. Feedback can provide information to help households identify the routine practices that lock their energy consumption in place. In that respect direct engagement with households in the form of constant reminders of their energy consumption to develop specific ways of embedding feedback within the practices householders regularly engage in can be useful.

Table 1. Feedback mechanisms and social science frameworks.

Theory	**Feature of the framework**	**Type of response**	**Feedback related process leading to energy efficiency**
Rational behaviour change	Values	Information, admonition	Information: short messages connecting consumption levels to environmental effects, energy supply issues and costs of energy.
	Attitudes, beliefs	Information	Information: short messages about how energy savings can be achieved; messages about time of use and energy supply.
	Perception of ability to make changes	Information and engagement	Positive feedback when energy consumption is reduced; positive messages framing householders as capable, effective agents of change.
	Social influences on values	Action	Formation of local social networks for sharing ideas and learning; positive approaches being absorbed by individuals through social contact.
Habitual behaviour	Not being aware of one´s routine actions in relation to energy	Information	Messages about habits, their invisibility, their stubborn effects on energy consumption – contrasted with how easy energy savings is when new habits are formed that achieve saving without conscious effort.
	Requires conscious, repeated effort to change	Support, information, engagement	Learning from households what habits are typical, widely found, and cause unnecessary consumption; Information on steps for changing habits. Examples of specific habits that have changed.
Social practices	Invisibility of energy consumption	Information	Messages that connect energy consumption to specific everyday routine practices such as: preparing meals; body care & cleanliness; washing clothes and dishes; home entertainment; working from home.
	New habits frustrated by poor fit with existing routines	Engagement, support	Discuss practices openly and plan for change. Information and support on how to connect new practices with new habits.
	Support of social group when new practices established	Support, engagement	Encouraging households to discuss the notion of social practices, as well as individual habits, in inter-household networks for support and sharing of information, successes and challenges.

2.2 Sample and Data

VaasaETT keeps an up-to-date database aggregating the findings of feedback, dynamic pricing and home automation pilots and commercial roll-outs around the world. Pilots are gathered from multiple sources: project databases such as the Intelligent Energy Europe's [18] or ADEME's [19], scientific publication databases such as PsycINFO, JSTOR, Web of Science, PubMed, Google Scholar, etc., proceeds of conferences, public reports published by energy utilities, vendors, research institutes and industry groups and finally the reference sections of selected articles for additional potential studies. The database consists of, at the time of writing, 130 electricity and gas pilots including 709 samples and involving about 5.5 million residential customers. The VaasaETT database is the largest of its kind. It is able to provide statistically robust quantified answers to questions related to the potential of different solutions to manage consumption in different context and thus regularly constitutes the building block of simulation and modelling exercises for the EC, the Norwegian Water and Energy regulator NVE, ESMIG, and others.

Inclusion rules:

To avoid accounting for out-of-date technology and characteristics likely to artificially inflate energy savings, pilots are included in this study regardless of their success or failure if and only if they meet all of the following criteria:

- The pilot ended within the past 10 years (ended after 2007);
- The pilot comprised at least 100 participants;
- The pilot lasted at least 3 months;
- The impact assessment methodology was mathematically valid and transparent.

Impacts are assessed from four perspectives:

- Energy conservation: The extent to which the experiment led to a reduction in overall energy consumption (%);
- Peak clipping: The extent to which the experiment led to a reduction in energy consumption during peak periods (%);
- Following peak hours: The extent to which the experiment led to a reduction in energy consumption directly following peak hours (%);
- Proportion of participant satisfied with the experiment (%).

Notes:

1. Pilot organisers rarely report the impacts of the experiments on all four perspectives. They usually report on what is of interest given the ultimate purpose of their experiment. For instance, dynamic pricing pilot organisers usually report on peak clipping whereas organisers of feedback pilots typically report on energy conservation. This explains the different sample sizes indicated under each graph.

2. Pilots organisers also usually form sub-groups within their pool of participants and try different solutions with different groups. A typical case would be to measure the response of participants when given an IHD and when given detailed informative bills. We call "samples" these sub-groups within a pilot.

3. Impacts within each pilot are not calculated by VaasaETT, they are calculated and reported by the pilot organiser. Rather, VaasaETT averages individual impacts in order to understand what the key determinants of successful pilots are. The average impacts are calculated by averaging the individual impacts with each sample equally weighted. The average impact on a group of samples is therefore given by:

$$s_{p,t} = \frac{1}{I} \sum_{i=1}^{I} s_{i,t}$$

With:

I = Number of samples
$s_{i,t}$ = Savings on sample i at time t

4. Given the smaller number of gas pilots, we were not able to go into as much depth as for electricity pilots, only general results are thus presented.

5. The list of pilots used in this study with publicly available results is shown in Annex 1.

The table below presents the sample taken under consideration for this study.

Table 2. Sample sizes of electricity and gas pilots analysed.

SAMPLE SIZES				
	Feedback		**Dynamic pricing**	
	#samples	#participants	#samples	#participants
Electricity	150	3,043,780	397	**611,351**
Gas	31	1,827,426		
TOTAL	**181**	**4,871,206**	**397**	**611,351**

2.3 Feedback Programme Types

This section investigates the impact of presenting participants with different types of energy consumption feedback.

2.3.1 Definitions

There are many forms of feedback content types only limited by imagination. For our analysis, we grouped them into the following categories:

- **Current information:** Typically shows the current price of electricity, power consumption, bill and CO_2 emissions.

- **Situational feedback:** Typically presents up-to-date information on consumption, bill, savings and CO_2 emissions levels since last bill received, last day, last week, last month, etc.

Below is an example of both types of feedback on Chameleon's In-Home Display (IHD):

Figure 2. Current information and situational feedback on IHD by Chameleon (UK).

- **Historical information:** Shows changes in the level of energy consumption over time. Watt-IS' interface helps consumers know if they reduced or increased their consumption over time or over the same period the previous year.

Figure 3. Consumption trend by Watt-IS (Portugal).

Energy Online by Mercury Energy (New Zealand) offers the ability to follow day-by-day consumption levels.

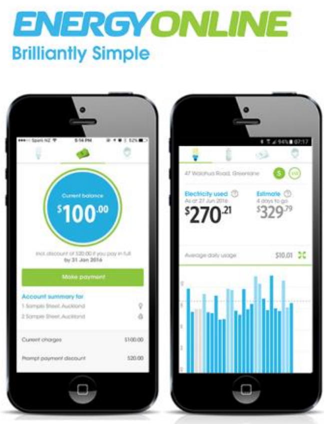


Figure 4. Day-by-day consumption by Mercury Energy (New Zealand).

- **Target related:** Consist in comparing the household's consumption level with peers, norms or according to pre-defined goals. Below are two illustrations by Engie (Italy) and PG&E (USA) comparing the household's electricity and gas consumption with similar and efficient households.

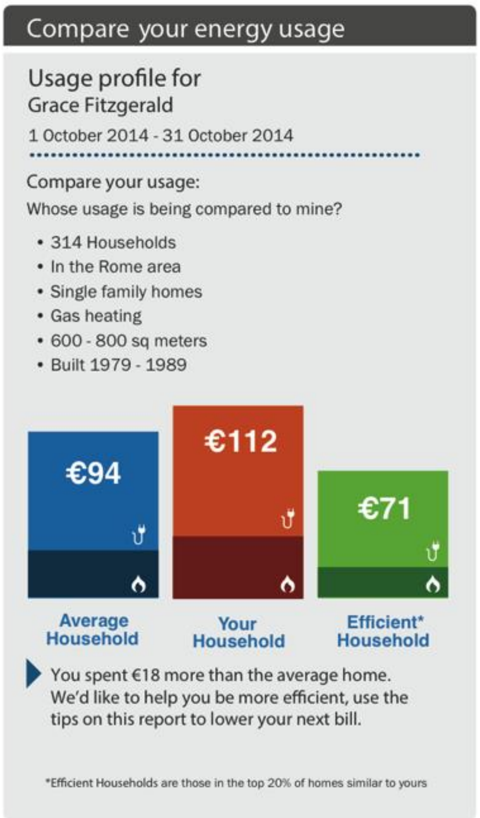


Figure 5. Normative feedback by Engie, Italy (left) and PG&E´s Smart Thermostat Trial, USA (right).

- **Tips and advice:** Numerical feedback messages are sometimes combined with advice on how to reduce energy use, power demand or how to benefit from dynamic tariffs. These can be very powerful when personalised and when valuing the impact of performing certain actions. For instance, Watt-IS and PG&E provide personalised tips to households and indicate the financial impacts of following these recommendations.

Your standby is around 30% higher than that of an average household and has increased in the past months. Use an extension cord with ON/OFF button to shut down stand-by equipment and save up to 20 €/year

Use your washing machine between 11pm and 6am and you can save up to 30 €/year

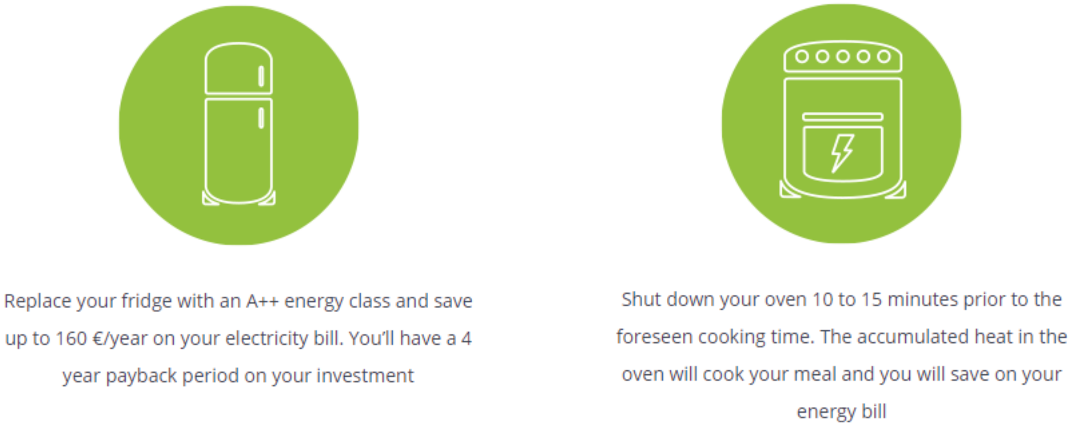


Figure 6. Personalised tips and advice by Watt-IS (Portugal).

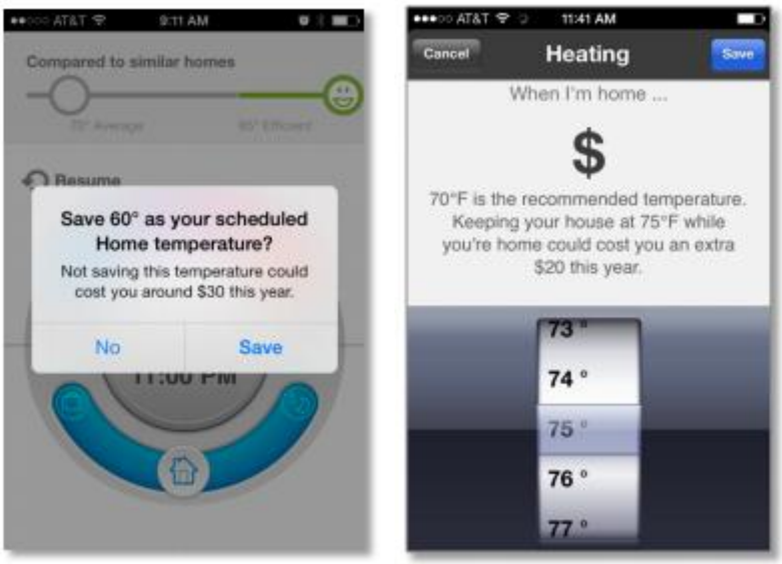


Figure 7. Loss aversion and setpoint coaching in PG&E's Residential Smart Gas Thermostat Trial (USA).

- **Consumption disaggregation**: Energy consumption is typically broken down according to appliance or household activity and shown in kWh or cost. For example, Watt-IS breaks down the consumption of electricity per appliance and provides a cost estimate of running them.

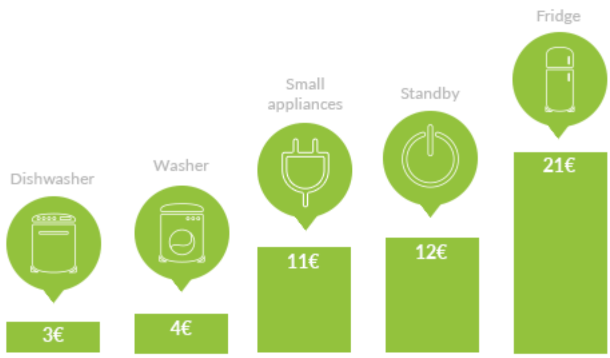


Figure 8. Breakdown of electricity consumption – Watt-IS (Portugal).

- **Forecasting** of bill and consumption. Duke Energy helps its customers anticipate their energy costs for the coming months.

Figure 9. Predictive consumption and costs by Duke Energy (USA).

2.3.2 Impacts

The figure below shows the impact of different types of feedback on overall electricity consumption. Sample sizes are presented in Table 3. Presenting participants with consumption disaggregation has the highest impact perhaps as it allows them to link their everyday activities with energy consumption and thus better focus their efforts. It is followed by current information feedback (KW or kWh consumption, up-to-date bill, etc.) which, being often based on real-time data, allows consumers to explore and discover the links between their actions and energy consumption thereby supporting the creation of new energy habits. (c.f. Section 2.1.)

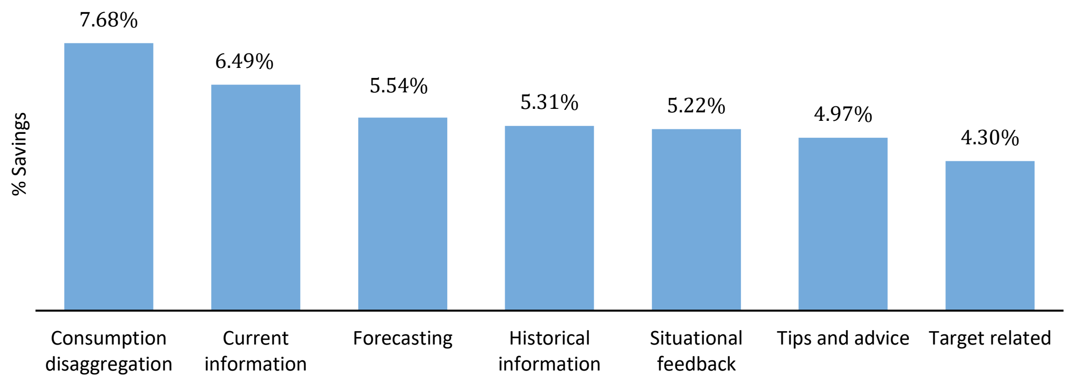


Figure 10. Impact of feedback types on electricity consumption.

Table 3. Impact of feedback types on electricity consumption. Sample sizes.

	# SAMPLES	# PARTICIPANTS
CONSUMPTION DISAGGREGATION	12	23,636
CURRENT INFORMATION	87	445,518
FORECASTING	18	1,060,650
HISTORICAL INFORMATION	67	1,311,902
SITUATIONAL FEEDBACK	132	2,751,268
TIPS AND ADVICE	53	1,471,562
TARGET RELATED	57	1,637,561

As explained in Section 2.1, people are different (including people living under the same roof) and behaviour change will be triggered by different mechanisms. Energy conservation in a household can thus only be maximised if the feedback solution tends to different segments of consumers with different interest, norms and rationalities. It is therefore safe to say that there is no "*silver bullet*" and that a feedback solution showing only consumption disaggregation will not lead to optimal results. This is supported by the graph below which shows that, up to 6, impact increases with the number of feedback types shown to participants. This is no longer true above 7 types of feedback perhaps as the number and variety of messages become confusing.

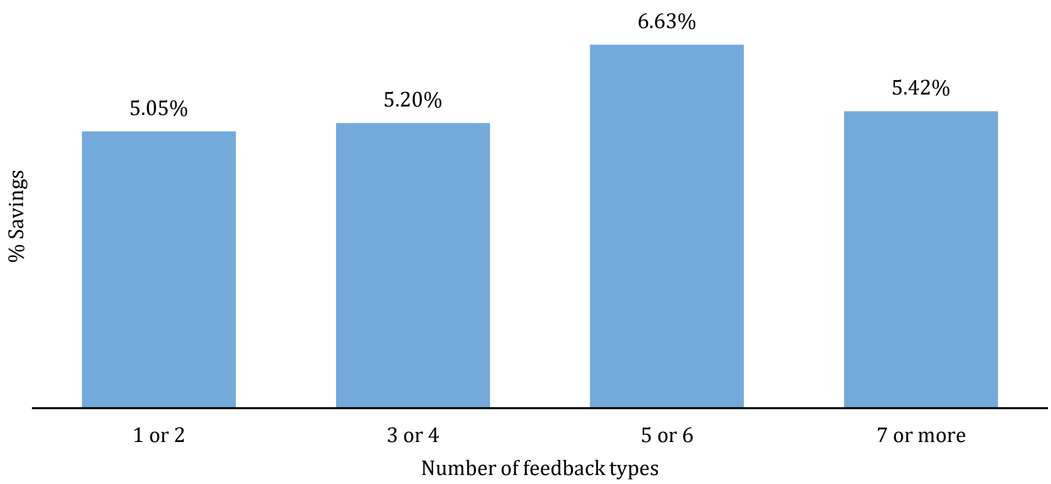


Figure 11. Impact of the number of different feedback types on electricity consumption.

Table 4. Impact of the number of different feedback types on electricity consumption. Sample sizes.

	# SAMPLES	# PARTICIPANTS
1 OR 2	20	64,402
3 OR 4	62	38,881
5 OR 6	29	778,339
7 OR MORE	16	1,035,701

2.4 Feedback Channels

This section investigates the impact of providing participants with feedback via different channels.

2.4.1 Definitions

IHDs are dynamic displays which typically provide participants with close to real-time and historical information on their electricity usage and costs. The home screen is always visible to the customer thus acting as a constant reminder of energy consumption. Additional information can be visualized through navigating to other screens. For example, Green Energy Options' IHD shows real time information both on electricity and gas consumption.

Figure 12. Electricity and gas consumption displayed on IHD – GEO (UK).

Ambient displays differ from IHDs in that they do not provide specific consumption information but rather visually signal messages about general consumption level or a change in electricity prices. Modern ambient displays are often visually attractive, maximising their chance of being placed somewhere visible by all, and intuitive which adds to their customer acceptance potential. Examples include the Aware Clock designed by the RISE Institute in Sweden and the Ambient Energy Orb used in several pilots in the USA (e.g. PG&E, ComEd, Southern California Edison, BG&E).

Figure 13. Ambient Devices' Energy Orb. BGE's Smart Energy Pricing Pilot (USA).

Figure 14. 'Aware Clock' – RISE Institute (SE).

Web Portals and mobile applications are often chosen as a means of providing consumption feedback to consumers due to their relatively low development costs and to the fact that they do not require additional devices to be given or sold to consumers. The ENEL Info + pilot mobile app and web portal provided participants with current consumption information, the current price time band, and historical consumption information.

Figure 15. Smart Info Mobile App, Enel Info+ Pilot (Italy).

Mobile applications can also offer consumers a convenient way to remotely control home appliances. Below is an app offered by Norwegian retailer Lyse which allows remote control of lighting and thermostat, scheduling and lets customers set up pre-defined consumption profiles (e.g. away or at home).

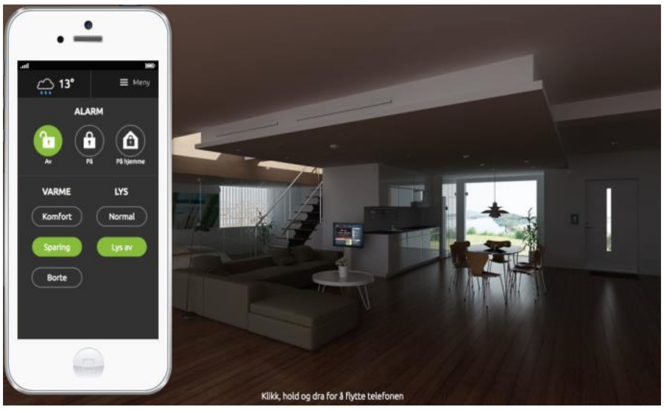


Figure 16. Mobile app by Lyse (Norway).

Informative bills and consumption reports. Most residential consumers in Europe still receive estimated bills adjusted for the time of year and the household's historical average consumption with the reconciliation taking place once a year. Smart bills on the other hand invoice for the actual consumption and provide additional information seeking to initiate more sustainable and efficient behaviours. Informative bills can be sent as frequently as once per month. Below is an example of smart bills sent by OPower (now part of Oracle) as part of the SMUD home energy reports trials (USA).

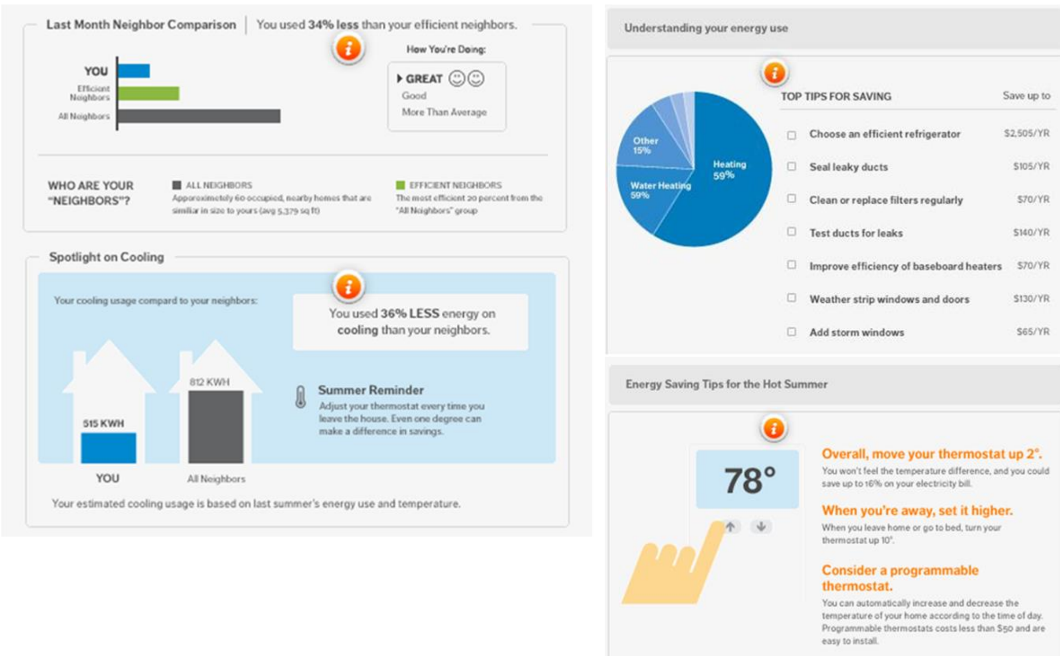


Figure 17. Normative comparison and actionable insights in SMUD's home energy reports (USA).

Smart thermostats are especially popular in gas pilots as they facilitate home control and scheduling of heating. Some models also include maintenance alerts and diagnostics. Below are pictures of some of the most tested smart thermostat in gas pilots.

Figure 18. Selection of smart thermostats.

2.4.2 Impacts

The figure below shows the impact on overall electricity consumption of providing participants with feedback using different channels. Sample sizes are presented in Table 5. Providing feedback using IHDs leads to the highest savings. This may be attributable to three main advantages of IHDs over other feedback channels - provided attention to design and customer experience prevent the display from being placed in a drawer -: IHDs can act as a constant reminder of energy consumption, reach the entire family - unlike bills, mobile apps and web portals - and can provide additional information via different dynamic menus - unlike ambient displays.

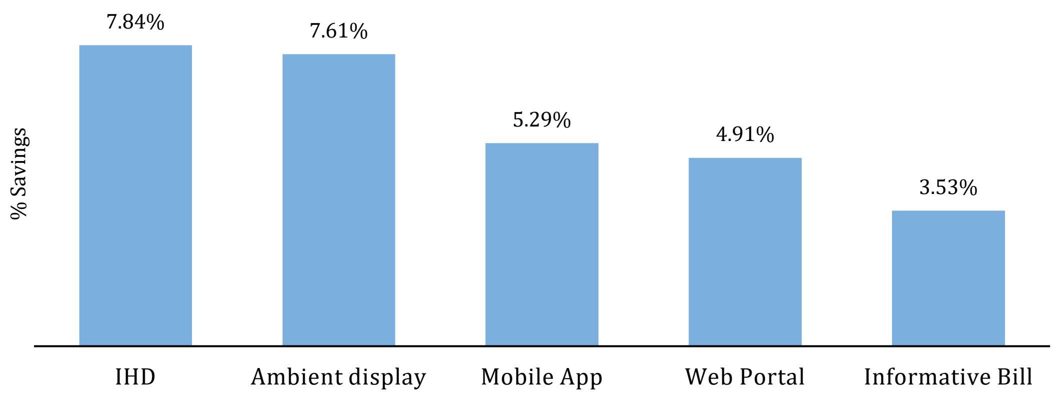


Figure 19. Impact of feedback channels on electricity consumption.

Table 5. Impact of feedback channels on electricity consumption. Sample sizes.

	# SAMPLES	# PARTICIPANTS
IHD	58	330,383
AMBIENT DISPLAY	7	161,975
MOBILE APP	5	12,044
WEBPORTAL	26	275,650
INFORMATIVE BILL	36	1,010,061

The graph below shows that the impact increases with the number of feedback channels used - in line with findings in section 2.3.2. The best feedback solutions therefore convey information using different channels thereby ensuring maximum acceptance and outreach. None of the analysed pilots has provided feedback through more than 4 channels.

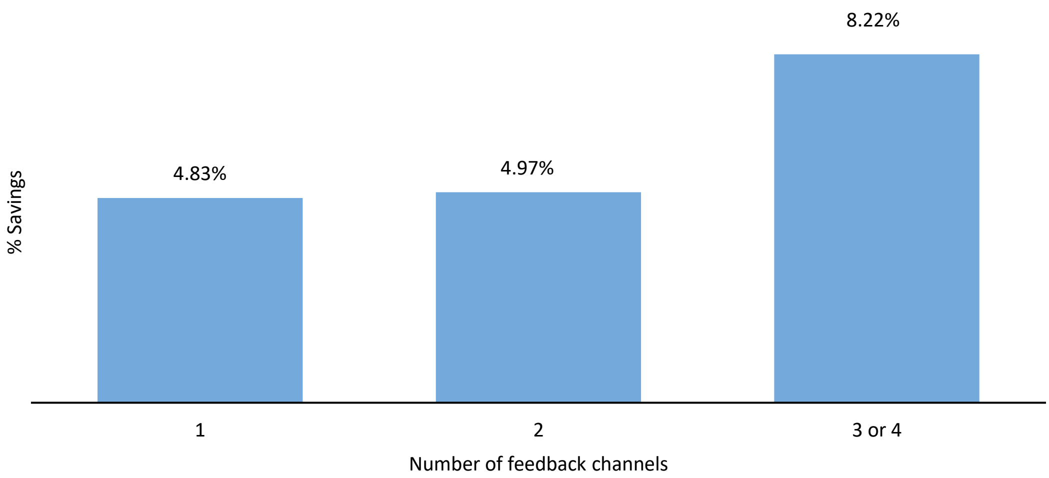


Figure 20. Impact of the number of feedback channels on electricity consumption.

Table 6. Impact of the number of feedback channels on electricity consumption. Sample sizes.

	# SAMPLES	# PARTICIPANTS
1	54	1,344,813
2	57	1,734,303
3 OR 4	20	159,830

2.5 Sustainability of Impacts

One of the most common questions regarding energy consumption feedback is whether the impact fades away as people's interest diminishes and they revert to their old habits or if behaviour change is sustained. The long-term impact of energy consumption feedback is not well understood and subject to debates both in the industry and in academia often due to the fact that most studies are carried out over short time frames (some just over a few months). Scientific literature does not really help as it provides quite inconsistent views. While some authors argue that feedback is more effective when provided over a long period of time (e.g. Darby 2006 [4]; Fischer 2008 [20]) others conclude the opposite (e.g. Ehrhardt-Martinez et al. 2010 [10]). Results extracted from our database confirm the former hypothesis: feedback becomes more effective over time, but the impact does not follow a linear upward trend.

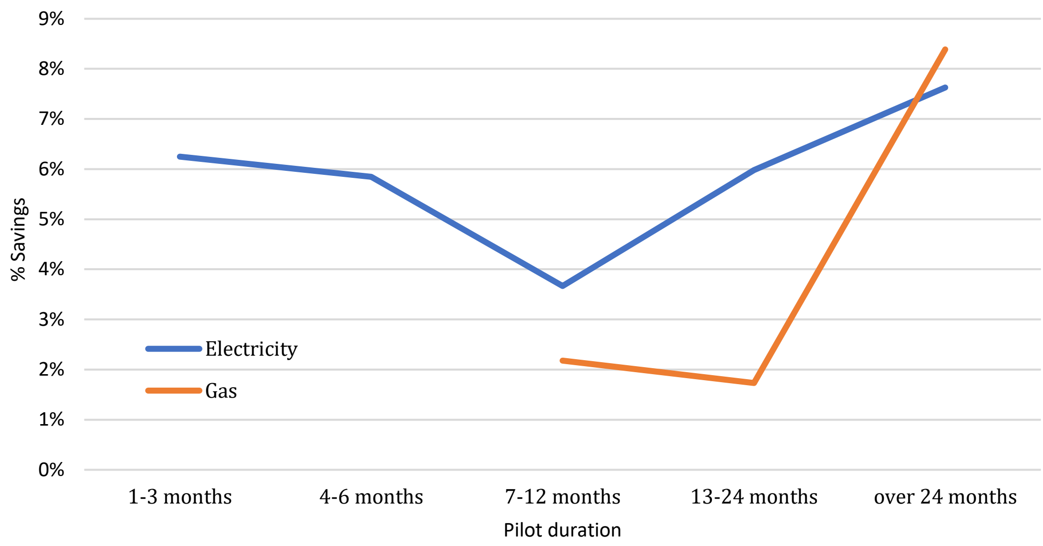


Figure 21. Impact of feedback over time.

Table 7. Impact of feedback over time. Sample sizes.

	ELECTRICITY		GAS	
	# SAMPLES	**# PARTICIPANTS**	**# SAMPLES**	**# PARTICIPANTS**
1-3 MONTHS	7	1,352		
4-6 MONTHS	15	10,229	-	-
7-12 MONTHS	46	2,124,241	6	533,005
13-24 MONTHS	49	880,881	9	350,366
OVER 24 MONTHS	17	53,547	7	576,054

Looking at electricity (the blue line)[2], the graph shows that pilots lasting between 7 and 12 months have a lower impact than shorter programmes (1-6 months). However, the trend reverses when pilots last more than 1 year. The highest results are in fact achieved for pilots lasting more than 2 years. The same pattern can be observed for gas (the orange line).

[2] For this specific point we have analysed pilots lasting 3 months or less.

The findings suggest that when consumers are engaged with task learning at the start of a programme (Step 1 in Kolb's experiential learning cycle – Section 2.1), feedback that enables them to directly identify links between activities and consumption and to learn how to reduce it through tasks of short duration, low involvement and low complexity (i.e. switching lights off in unoccupied rooms) are more successful. This corresponds to electricity pilots lasting less than 4 months.

Once learning has taken place and the novelty effect of taking part in a programme and receiving the technology has faded, the type of feedback used for this learning process has served its purpose and consumers begin to disengage with it while new energy efficient habits have not had time to form and household equipment has not been upgraded. These lead to a decreasing impact over time in feedback pilots lasting less than 9 months.

When feedback is provided for longer time periods, new sustainable habits (i.e. automatic) are able to form, the incentive to replace old appliances with more energy efficient models better understood, and consumers have come to realise the impacts of their actions on bills. Together this leads to a rebound in effect size.

Feedback is thus hypothesised to be most effective in the short term, when task learning is most likely to occur, and over the long term as efficient behaviour becomes more automatic and new goals are set as previous ones are met.

These findings have important implications for the design of feedback solutions which are not often tested in large pilots and therefore cannot be quantified in this study:

- Firstly, feedback should, rather than offering one static programme for the entire duration of the pilot, attempt to bring participants through a virtuous cycle. For instance, starting with simple messages and suggest tasks of low degree of involvement and low perceived complexity. The idea being to help consumers quickly achieve easy and visible reductions and then progress towards more sophisticated and constraining actions as they have internalised previously promoted messages;

- After a few months (3-4 according to our data), feedback programmes need to direct attention towards higher level motivations and personalised processes to help consumers look for new saving opportunities. In practical terms this means that, past the initial phase of the programme, the importance of segmentation and targeted messages become crucial. Consumers should feel that the information they are given is relevant and that the advice is useful. Segmentation is a means of classifying consumers into groups of people who display similar characteristics across multiple variables. By tailoring messaging to each of these groups, it becomes possible to create seemingly tailored information on a mass-scale. EU-funded project NatConsumers [21] recommends defining segments of consumers based on load-profile, socio-demographics and attitudinal information[3]. Pilots so far have often focused only on load-profile data from smart meters and basic

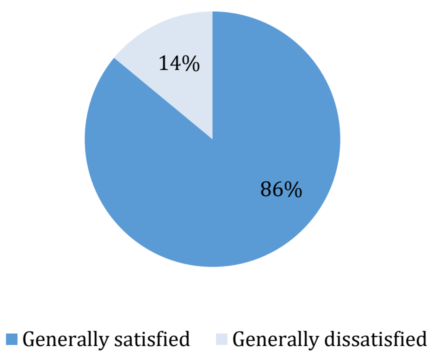
[3] The fact that some customers are responsive to arguments around saving money, others are motivated by environmental aspects, whilst still others may be attracted to being able to try exciting, new, technologies.

socio-demographics (e.g. post-code, heating system), more or less ignoring behavioural factors.

2.6 Participant Satisfaction

In real market conditions, energy suppliers who offer feedback solutions to help their customers reduce energy expenditure should see some "*soft*" benefits. They should for instance face lower churn rates, marketing outreach costs and cost-to-serve (for instance as fewer customers place bill-related calls into the call center). Suppliers should also benefit from increased acquisition rates and improved image. There is also some evidence of a "halo effect"; in that customers exposed to feedback programmes are more likely to get involved in other offerings and programmes. (cf. SMUD's home energy report pilots.) Suppliers may thus be able to capitalize on customers' newly built sense of empowerment and trust by cross-selling additional products and services. All of these benefits combined should lead to increased customer lifetime value.

A thorough impact assessment of feedback pilots should thus investigate not only what participants achieved in terms of energy savings, but also attempt at understanding their experience with the product. This is unfortunately not commonly performed and even less so in a comparable manner. Our large pool of pilots however allows us to combine enough cases to meaningfully report on satisfaction-related metrics. The graph below shows that 86% of participants are generally satisfied with the feedback programme and 85% would have liked the programme to continue.



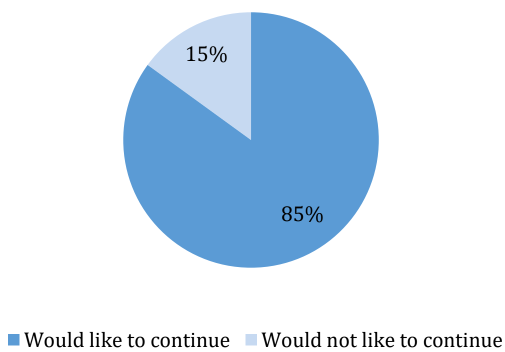


Figure 22. Customer satisfaction with feedback pilots.

Table 8. Customer satisfaction with feedback pilots. Sample sizes.

	# SAMPLES	# PARTICIPANTS
OVERALL PARTICIPANT SATISFACTION WITH PROGRAMME	17	412,478
PROPORTION OF PEOPLE THAT WOULD LIKE TO CONTINUE IN THE PROGRAMME	15	363,952

3 The Added-Value of Real-Time Data

3.1 The Impact of Real-Time Feedback

Social sciences (c.f. Sections 2.1 and 2.5) suggest that people like to explore, they like to discover, in general more than they like to study or be taught. If feedback is to gain the interest and involvement of consumers, then they must be able to learn at their own pace, in their own way, to their own desired extent. People should feel that they are enlightened by their own findings. This often happens in feedback programmes through being able to link actions to energy consumption which should logically favour real-time feedback as an effective way to engage consumers. The impact of feedback frequency is presented in the current section. The results confirm our assumptions.

3.1.1 Impact of real-time feedback on electricity consumption

Figure 23 shows consumption reductions in real-time[4] versus non-real-time feedback electricity pilots. Sample sizes are presented in Table 9. Real-time feedback is associated with higher electricity savings.

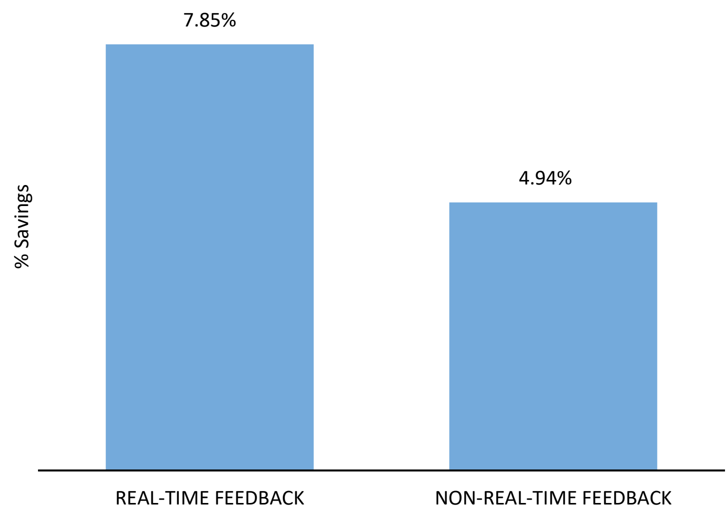


Figure 23. Impact of real-time feedback in electricity pilots.

Table 9. Impact of real-time feedback in electricity pilots. Sample sizes.

	# SAMPLES	# PARTICIPANTS
REAL-TIME FEEDBACK	59	212,839
NON-REAL-TIME FEEDBACK	37	1,245,988

[4] Defined as feedback with a frequency range of between 0 and 5 minutes.

The impact of feedback frequency was further investigated. The graph below shows that the impact of feedback decreases as they become less frequent. Real-time feedback lead to by far the highest savings – over 2% higher than "non-real-time up to daily" and 3% higher than "less than daily" feedback.

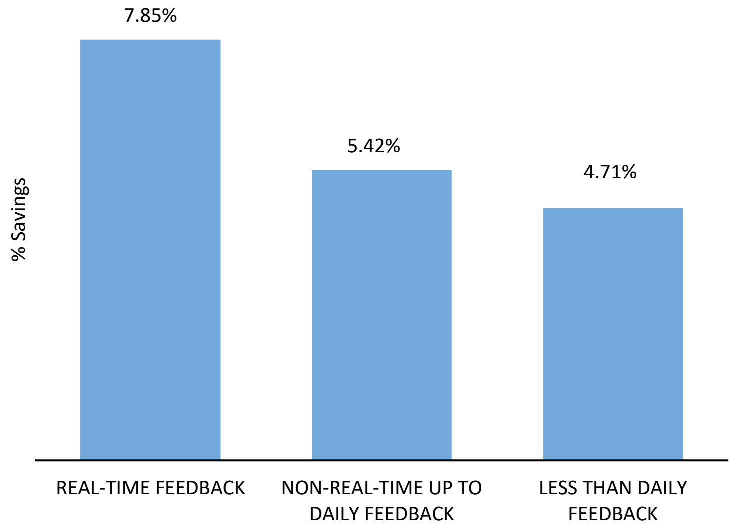


Figure 24. Impact of different feedback frequencies in electricity pilots.

Table 10. Impact of different feedback frequencies in electricity pilots. Sample sizes.

	# SAMPLES	# PARTICIPANTS
REAL-TIME FEEDBACK	59	212,839
NON-REAL-TIME UP TO DAILY FEEDBACK	12	1,019,732
LESS THAN DAILY FEEDBACK	25	226,256

3.1.2 Impact of real-time feedback on gas consumption

The analysis of the added-value of real-time feedback in gas pilots leads to the same conclusions. Real-time feedback leads to significantly higher savings. In fact, the difference is much more pronounced for gas than for electricity; real-time feedback in gas pilots leads to savings 5 times higher than non-real-time feedback (although based on a much smaller sample).

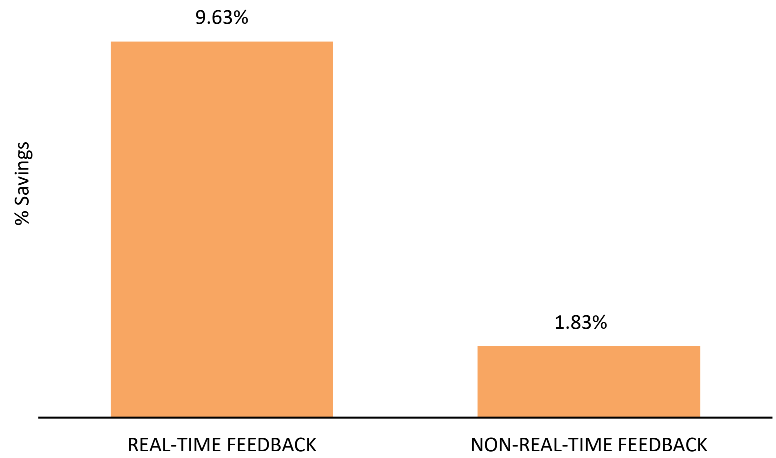


Figure 25. Impact of real-time feedback in gas pilots.

Table 11. Impact of real-time feedback in gas pilots. Sample sizes.

	# SAMPLES	# PARTICIPANTS
REAL-TIME FEEDBACK	7	6,456
NON-REAL-TIME FEEDBACK	9	702,161

3.1.3 Impact of real-time feedback in dual-fuel pilots

This section investigates whether real-time feedback on both electricity and gas (dual fuel) yields higher results than feedback on just one type of energy. Figure 26 shows energy savings in pilots that provided feedback on both electricity and gas versus pilots that provided feedback only on electricity (our database does not contain any gas pilots that did not involve electricity as well). Since providing feedback on both types of energies relate to a higher share of household expenditure, it is quite logical that real-time feedback on both energies lead to significantly higher consumption savings: 9.24% versus 7.71% for electricity only pilots.

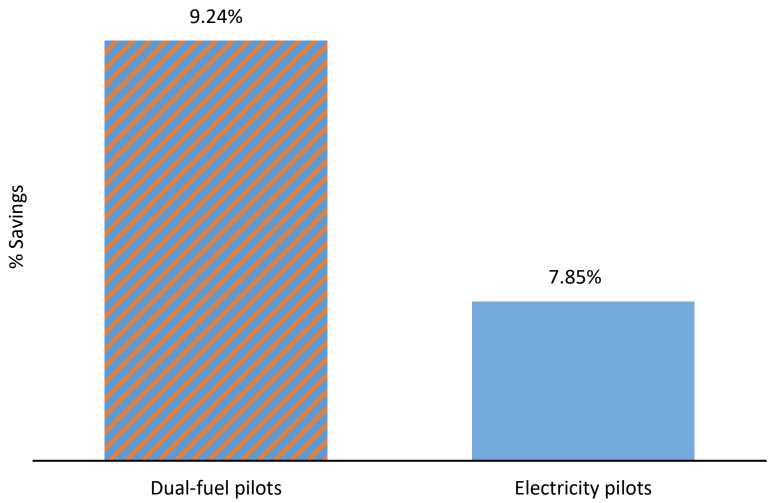


Figure 26. Impact of real-time feedback in dual-fuel pilots vs. electricity pilots.

Table 12. Impact of real-time feedback in dual-fuel pilots vs. electricity pilots. Sample sizes.

	# SAMPLES	# PARTICIPANTS
DUAL-FUEL PILOTS	9	8,308
ELECTRICITY PILOTS	59	212,839

3.2 The Additional Impact of Home Automation

This section investigates the impacts of automating the usage of some of the largest most common appliances in European homes. Through appliance automation, consumption can instantly drop whenever prices are high or networks congested or increase when for instance rooftop solar PVs are generating power benefiting consumers, network operators and the broader community.

3.2.1 Automation, consumption feedback and consumer education

The graph below shows the impact of home automation technology - separating automation pilots with and without feedback - on three key aspects of demand flexibility: overall consumption, peak consumption and consumption immediately following peak hours.

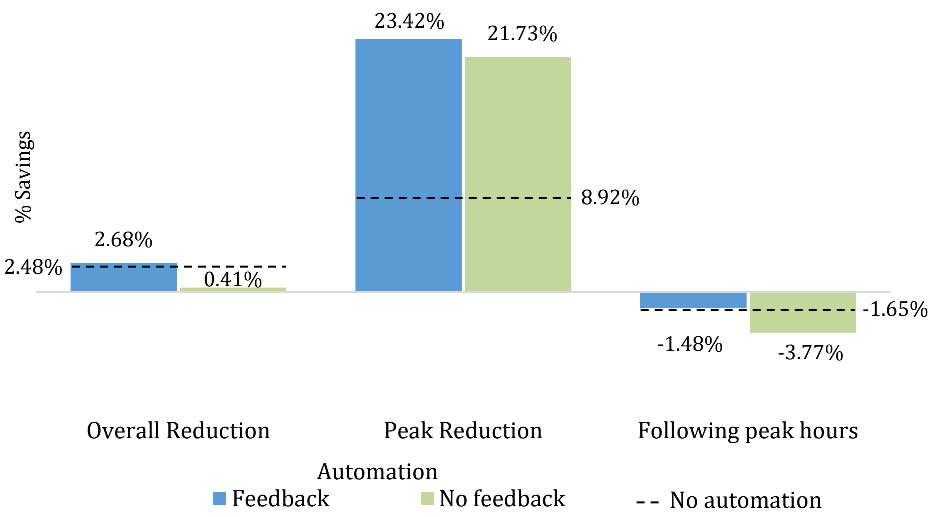


Figure 27. Impact of feedback in automation pilots.

Table 13. Impact of feedback in automation pilots. Sample sizes.

	AUTOMATION + FEEDBACK		AUTOMATION NO FEEDBACK		NO FEEDBACK	
	# Samples	# Participants	# Samples	# Participants	# Samples	# Participants
OVERALL REDUCTION	30	25,495	3	228	206	530,080
PEAK REDUCTION	49	22,906	17	7,278	324	577,046
FOLLOWING PEAK HOURS	11	4,901	6	1,670	160	266,419

Home automation proves very effective at shifting consumption away from peak hours. Pilots with automation managed to reduce peak consumption by 23% compared to 9% for pilots without automation (manual response to dynamic pricing and/or consumption feedback). There are several reasons for it. Even though consumers should always be allowed to overrun the program, automation enables fast reactions as well as controllable levels of reduction and has the advantage of being available during unplanned system emergencies. In addition, critical situations do not always occur when residential consumers are able to take action (when they are away for instance). Another important consideration for grid operators is that without automation they risk seeing millions of appliances come back on line at the same time. Automation can help mitigate this risk by switching appliances back on in cycles.

Figure 27 points to another crucial finding: pilots combining home automation with consumption feedback and consumer education; in other words, pilots making use of the often near-real-time data generated by the home automation system to also provide feedback are more effective at reducing both peak (23% vs 22%) and overall consumption (2.7% vs. 0.4%).

In summary, while automation drives peak consumption reductions, it is essential to introduce other mechanisms to develop sustainable energy saving habits. Indeed, while some would argue that there is no point trying to engage and educate customers who have automated appliances, pilot results show that when efficiency improvements come solely from the technological side, people remain largely passive actors, leading to low levels of awareness, continued inefficient habits and sometimes a rebound effect (seeing its energy expenditures decrease, he might become more careless about his consumption). A positive business case and an appealing payback time are other fundamental reasons why feedback should be part of any home automation package. Joule Assets and VaasaETT looked at the business case for residential DSF in 4 EU countries (France, UK, Italy and Germany) and found that between 77% and 87% of end-consumers' financial benefits come from overall consumption reductions (the rest from peak clipping) [22] This can be easily understood if one considers the fact that for instance critical peaks occur only about 30 hours a year whilst benefits from lowering overall electricity consumption occur continuously. Offerings with both automation and feedback have been found the best way to secure financial returns for both grid operators and consumers.

In real-life however, both in pilot and commercial contexts, home automation has often been introduced following an inverted evolution whereby technology has been at the fore-front, with consumption feedback being introduced as a next-step or a reaction to negative publicity. Another limitation to the impact of home automation technology has been the fact that, thus far, pilots have tended to focus on shifting demand in time often mostly ignoring the potential for overall energy savings the home automation system enables.

3.2.2 Automating the usage of specific home appliances

In this section, we investigate the impact of automating some of the main electricity consuming appliances in European homes [23] on overall consumption, peak consumption and consumption immediately following peak hours. Most automation pilots tend to focus on one specific appliance depending on the context of the local grid (e.g. electric heating in winter in France, air conditioning in summer in Australia) and do not consider the home in its entirety and all the major appliances in it. It is therefore likely that more inclusive pilots would achieve greater aggregated impacts in terms of both energy and financial savings for the participant.

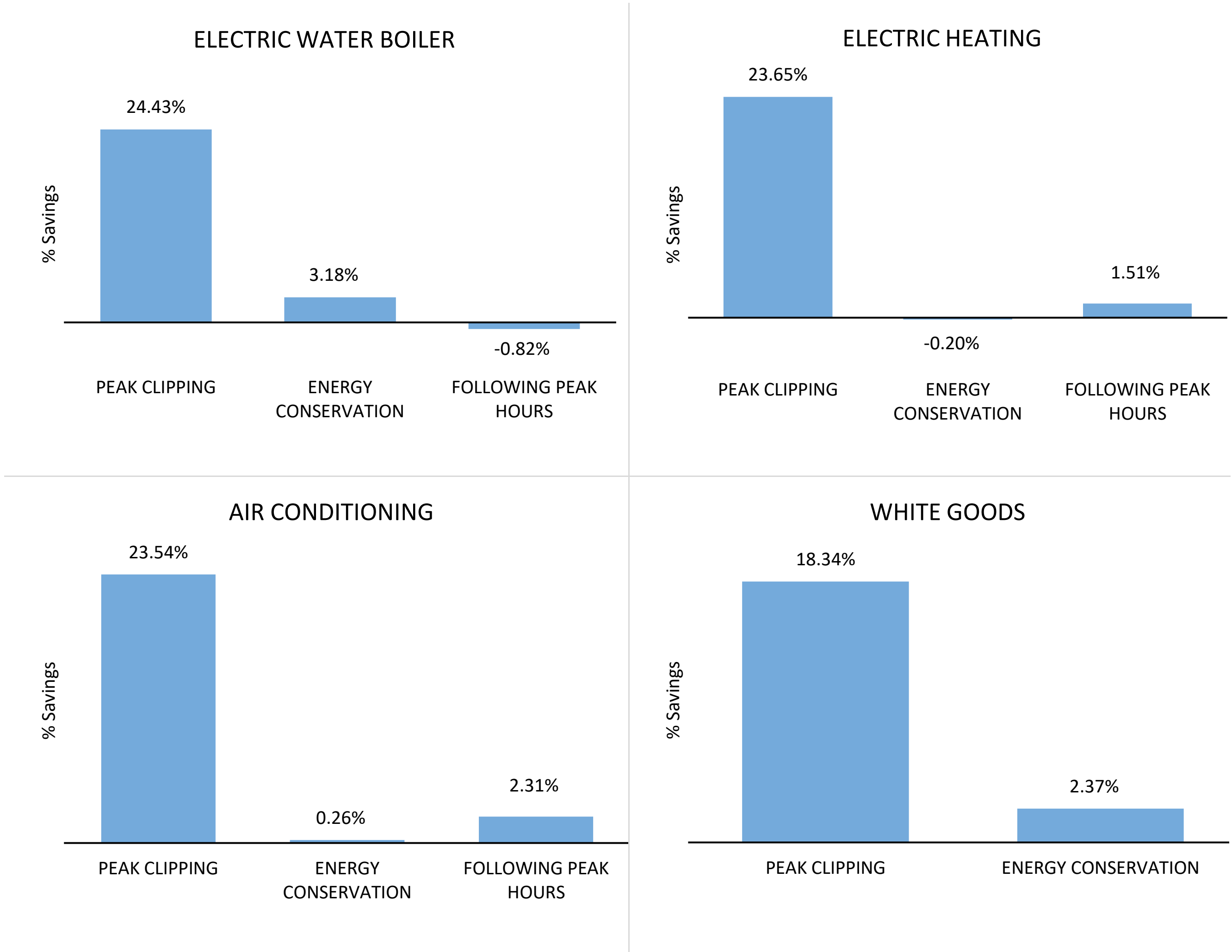


Figure 28. Impact of appliance automation on electricity consumption.

Table 14. Impact of appliance automation on electricity consumption. Sample sizes.

PEAK CLIPPING	# SAMPLES	# PARTICIPANTS
ELECTRIC WATER BOILER	22	10,191
ELECTRIC HEATING	9	1,233
AIR CONDITIONING	46	11,311
WHITE GOODS	6	2,703
ENERGY CONSERVATION	**# SAMPLES**	**# PARTICIPANTS**
ELECTRIC WATER BOILER	9	4,060
ELECTRIC HEATING	9	1,233
AIR CONDITIONING	46	11,311
WHITE GOODS	6	2,703
FOLLOWING PEAK HOURS	**# SAMPLES**	**# PARTICIPANTS**
ELECTRIC WATER BOILER	5	2,528
ELECTRIC HEATING	3	398
AIR CONDITIONING	6	1,049

Electric water boilers are among the most electricity consuming appliances in European homes. They are also intuitively very suitable for flexibility as water can be heated during off-peak hours or when self-generation is available and remain warm as the boiler is switched off thus making the loss of comfort almost imperceptible to consumers. This is not a new technology but one that has seldom been used. An exception is France where the load of 10 million water heaters (representing 3 GW) is currently automatically shifted away from peak hours to night time (off-peak hours). Pilots show that water boiler overall electricity consumption can be reduced by 3.2% and peak consumption by 24% while surrounding peak consumption increased by only about 0.8%.

The figure above also shows the impact of automated **heating/cooling** on electricity consumption. Pilot results are rather similar for both electric heating and air conditioning: overall electricity consumption barely changed (+0.2% and -0.3% respectively), peak consumption was reduced by 24% and surrounding peak consumption were reduced by 1.5% and 2.3% respectively. A parallel with gas may be interesting at this point. Automation in gas pilots focuses on overall consumption by offering customers the ability to schedule or remotely control the temperature settings in the home. Results from 8 pilots totalling 8,416 participants have shown an average gas consumption reduction of 4% which indicate that thus far automation has been more efficient at reducing overall gas consumption than overall electricity consumption. The reason may be that automation in electricity pilots often focus on peak shifting.

A number of smaller appliances that can be grouped in the category of **white goods** (i.e. refrigerator, freezer, tumble dryer, washing machine, dish washer) represent a significant and increasing proportion of electricity consumption in European homes. Our results show the impact of automated white goods on electricity consumption; overall electricity consumption decreased by 2.4% and peak consumption by 18%.

From an environmental perspective, real-time measurement of consumption and generation is a pre-requisite to optimise the usage of the fossil free production, as it is the only way to know, when it is actually available. Thus, although automation will not necessarily save energy it is capable of reducing CO_2 emissions as the use of clean generation can be optimised.

3.2.3 Automation and dynamic tariffs

Dynamic pricing involves substantially increased retail electricity prices during times of either heightened consumption (for example on abnormally cold winter days) or when the stability of the system is threatened and black-outs may occur. The dynamic tariffs are thus making up for the fact that consumers' decisions do not account for the cost of producing and transporting electricity in the different time periods. It is important to note that whether the dynamic part of the tariff is linked to the regulated network tariff or the competitive retail price - or both - does not influence the consumer's (or the technology's) response. As far as the consumer (or the technology) is concerned, he/she/it is receiving a signal to shift consumption to cheaper hours.

Four types of dynamic pricing schemes are investigated[5]:

Critical Peak Pricing (CPP) involves substantially increased retail electricity prices typically triggered by heightened consumption or when the stability of the system is threatened. The number and the length of critical peak periods which the utility is allowed to call are agreed upon in advance, when they are to occur is not. Residential customers are usually notified a day in advance if the next day will be a critical day, but if automation technology is provided, these rates can also be activated on the same day.

Critical Peak Rebate (CPR) are inverse forms of CPP tariffs. Participants are paid in accordance to the amounts that they reduce consumption below their predicted levels during critical peak hours. Participants to CPR pilots usually receive a payment after each critical peak period or a deduction on their next bill. This direct payment or discount is believed to present the advantage of making the reward of participants' efforts more concrete than the concept of savings which might be less easily perceived. As for CPP, the number and the length of critical peak periods which the utility is allowed to call is agreed upon in advance although when they are to occur is not.

Time-of-Use (TOU) tariffs induce people into using electricity at times when consumption is lower. Prices are therefore set higher during the higher consumption periods of the day, and lower during the rest of the day and on weekends. They can have two (peak and off-peak prices) or three (peak, partial peak and off-peak prices) levels of prices per day which are always the same. This lack of flexibility makes them rather unfit going forward with an ever higher penetration of intermittent generation unless they are coupled with CPP or CPR prices.

With the introduction of smart meters, more advanced tariff schemes have been tested. One such tariff is **Real-Time Pricing (RTP)**. Price development on the wholesale market are passed on to consumers – normally by the hour. In order to further encourage reductions during high price periods and limit the risk of high bills, participants are warned when wholesale prices reach a certain threshold decided upon in advance. Unfortunately, only few RTP pilots have been conducted, hence the results below should be taken with caution.

---

[5] For more information on the impact of participant education in dynamic pricing pilots and on the impact of peak / off-peak price ratio, please refer to Empower Demand 1 [8] - Pages 39-42 and Section 4.9.

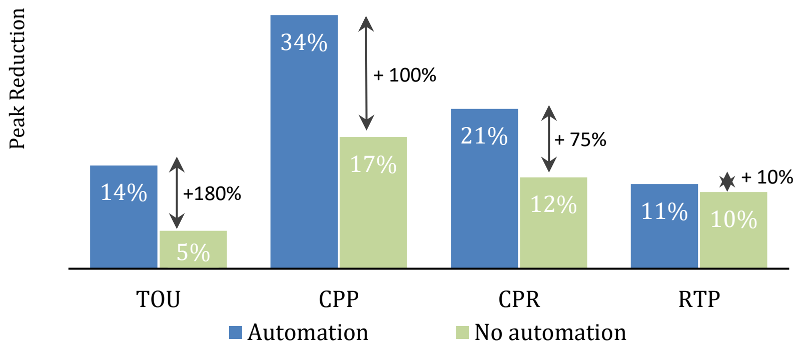


Figure 29. Impact of automation in dynamic pricing pilots.

Table 15. Impact of automation in dynamic pricing pilots. Sample sizes.

	AUTOMATION		NO AUTOMATION	
	# Samples	# Participants	# Samples	# Participants
TOU	28	20,124	210	509,508
CPP	33	13,201	86	59,272
CPR	8	699	21	3,217
RTP	4	281	7	5,049

Pilot results show that home automation enhances the impact of dynamic tariffs by 75-172% (ignoring RTP). Though all the tested tariffs schemes have pros and cons, dynamic pricing coupled with home automation have proven one of the most effective ways to secure demand flexibility in the residential sector. It is also important to keep in mind that though TOU and RTP peak consumption reductions are the lowest, they occur daily, whilst CPP and CPR produce the highest reductions but only for critical peak periods, typically about 30 hours a year. Pilot results indicate that rewards for peak clipping (CPR) are much less effective than penalties (CPP). It is important to keep in mind however that CPR might constitute a more acceptable form of dynamic pricing, thus achieving greater market penetration and aggregated impact. To the contrary, CPP alone may be perceived negatively by consumers and thus hinder the introduction of other products and services related to home automation which require satisfaction and trust towards energy suppliers.

4 Innovative Data-Driven Models and Services

This chapter presents a selection of innovative offers commercially available in Europe. We believe they illustrate the latest trends in smart-home and DSF-related products and services and, beyond that, provides insight into the future of competition in the energy industry.

4.1 GEO – Cosy Nordics (Finland and Norway)

Following the successful launch and adoption of Cosy Smart thermostat into the UK market to UK households, GEO took on the challenge to make Nordic homes Cosy too with pilots in Finland and Norway. The challenges of multiple zones, multiple heat sources, low winter temperatures, Nordpool spot pricing tariffs and a lack of existing home controls presented a few technical experiments.

The Cosy system includes local in-home control and remote control via a smart phone app, it requires professional installation by a qualified electrician along with internet access. Algorithms predict when to apply heating using the most cost-effective method available, by linking Cosy to a variable tariff from the utility and importing Nordpool spot pricing into the mix. Working with local utility and installation partners, the pilots came at a time when the Norwegian regulator (NVE) was planning to introduce ToU tariffs and increases to distribution costs, so there was a welcome addition to Cosy of an IHD to alert occupants of their usage and tariff period, whilst the app would alert those not at home if they desired so action can be taken. Impact calculations were carried out using average consumption per hour per degree temperature difference between set-point and external temperature. The consumption with Cosy and without Cosy was measured and significant savings were seen in all homes of around 20-30%.


Figure 30. Cosy Nordics Smart Thermostat and mobile app.

Homepage: https://www.geotogether.com/consumer/product-category/meet-cosy-our-smart-thermostat/

4.2 Enyway – Peer-to-Peer Electricity (Germany)

Enyway presents themselves as the energy retailer of the future. Or rather, they present themselves not as a retailer, but as a marketplace for exchanging energy. Enyway thus represents a new concept enabled by smart meter data with high accuracy and granularity.

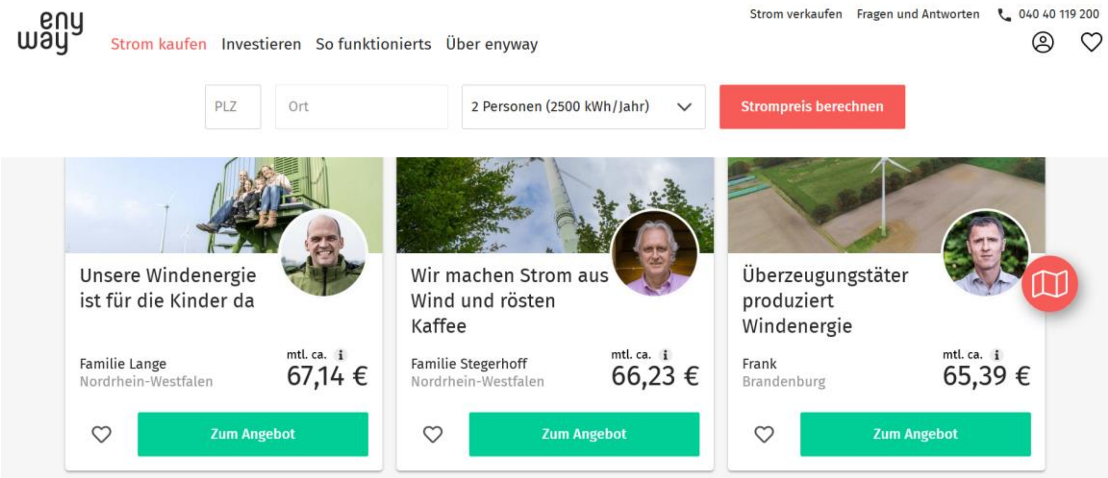


Figure 31. Excerpt from the Enyway webpage. Accessed 2 October 2018.

In more technical terms, Enyway is a peer-to-peer marketplace for green energy generated by prosumers and small scale local distributed producers. Enyway acts essentially as a coordination platform and can also handle as necessary a variety of supplier obligations on behalf of its producers that traditional suppliers would usually have. Its clients tend to come from the greener segment of citizens, the adverts above read:

First window: Our wind energy is for our kids.

Second window: Me make electricity from wind and roasted coffee beans.

Third window: Radically motivated producer of wind energy.

Enyway needs high granularity and precise measurements as it is a pre-requisite for the platform to function, that the renewable electricity is actually available when someone signs up to buy it. Hence, the business model from Enyway's perspective is not to produce energy, but to make sure that renewable energy which is produced is also consumed by peers.

The use of the marketplace is free when a customer signs up two additional customers and is otherwise priced at €3.99 / month which is the financial model to maintain and develop the platform.

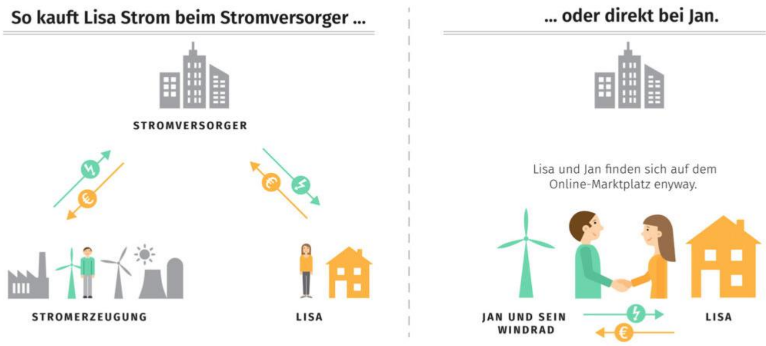


Figure 32. Enyway advert: "Either Lisa buys her electricity from a utility - or directly from Jan".

Homepage: https://www.enyway.com/de/strom (in German)

4.3 Powerpeers – Community Building and Trading (Netherlands)

Figure 33. Powerpeers mobile app.

Powerpeers is a Dutch company funded on the principles and ideas of the Founder, Lars Falch, stating that: "*With the current tech surely it must be possible to share the electricity from your solar panels!*"

With this simple notion, Powerpeers was launched as a community sharing platform of energy in June 2016 in the Netherlands focusing on residential consumers and small energy producers. As the community thinking is the core of the platform, the work is now focused on enlarging the platform to offer the integration of an even wider uptake of small-scale sustainable electricity generation, like for example community owned solar power plants.

On the Powerpeers platform, small-scale producers and consumers form a network. The access to energy data provides all members with an opportunity to view in near-real-time how much electricity they have shared and used; from or with whom – and if there is more demand than supply, Powerpeers meets the excess demand with electricity from other sustainable sources, which is also shown on the dashboard of each consumer.

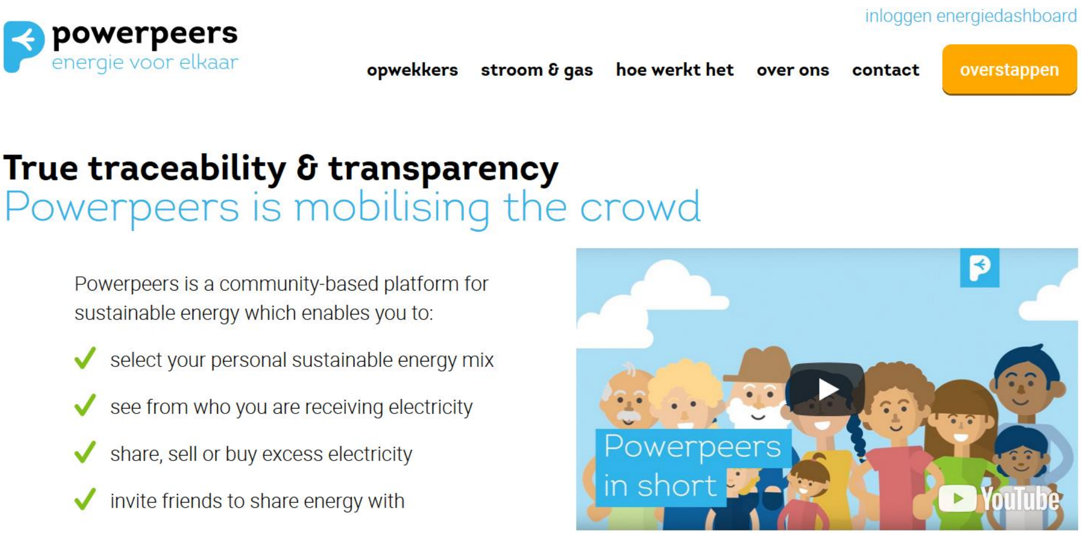


Figure 34. Excerpt from Powerpeers' internet page. Accessed 2 October 2018.

Homepage: https://www.powerpeers.nl/over-ons/ (Primarily in Dutch)

4.4 Tibber – Home Automation and Energy Optimization (Norway/Sweden)

Based on the idea that the cheapest and cleanest electricity is the electricity not used, Tibber offers a comprehensive digital solution based on near-real-time data to reduce energy consumption in homes.

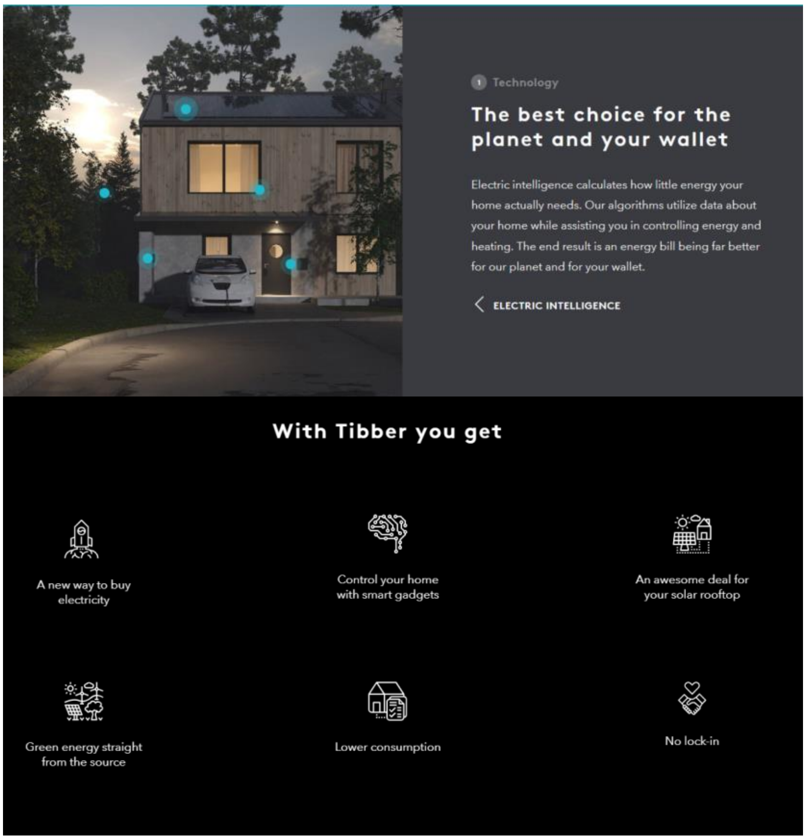


Figure 35. Presentation of Tibber services.

The Tibber solution brings together technologies potentially already present in homes, e.g. smart meter, solar photovoltaic (PV), electric vehicle, smart thermostat and other connected devices, but also acts as a retailer. However, Tibber's business model is not volume-based (it does not make more money from selling more kWh) but subscription-based (39 NOK/month or about 4.15€/month) plus the actual cost of the energy sourced on NordPool, the regional wholesale market. Furthermore, being a balance responsible party, they have an interest in demand response aggregation. Storage is seen as the natural next step in the offering and will according to the company become available as soon as there is a mature offering on the market.

If customers do not have the necessary smart home infrastructure or appliances, Tibber will offer to sell it to them, making money from the margins on the sale of equipment.

In this respect Tibber is a proof of concept of what has long been anticipated in the industry; that the power in itself would no longer be able to support margins which would instead come from added-value services.

Homepage: https://international.tibber.com/

4.5 Voltalis – Residential Demand Response (France)

Voltalis is a French flexibility aggregation platform provider. Founded in 2006, it now claims over 1,000,000 devices connected real-time to its platform worldwide. In the residential segment, Voltalis connects and aggregates appliances such as electric heaters, air conditioners and water boilers and offers services to retailers, DSOs and TSOs in addition to providing real-time consumption feedback to the household:

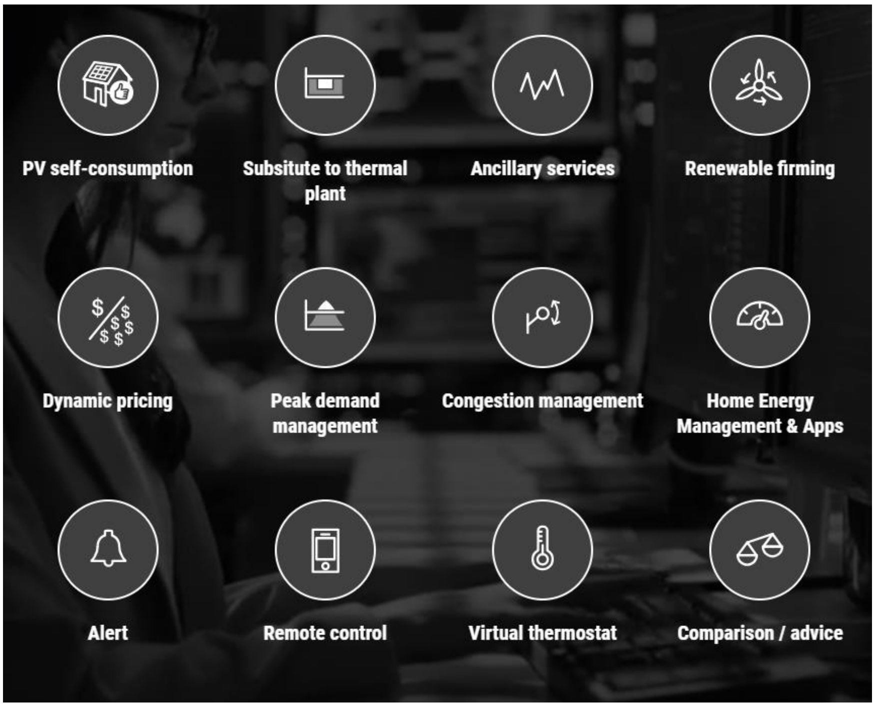


Figure 36. Presentation of Voltalis solutions.

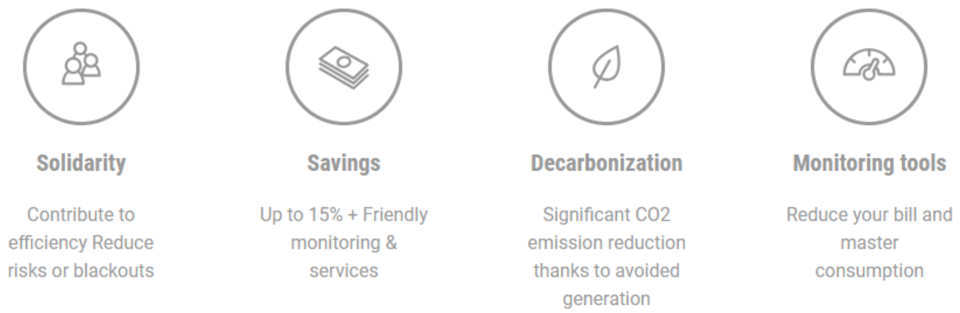


Figure 37. Presentation of Voltalis' value propositions.

Household consumers are not financially rewarded for connecting appliances to the platform. Instead they receive a box which is installed free-of-charge and the promise of energy savings through the ability to monitor electricity consumption in real-time as well as the ability to contribute to grid stability. It is noteworthy that the offering can be provided regardless of the household's energy supplier.

Voltalis presents an interesting and rare case of a successful DSF-based business model in the residential segment. It also proves, that real-time measurement at household level can cost-effectively contribute to grid stability and impact the whole value chain of the energy system.

Homepage: http://www.voltalis.com/corporate

4.6 Sonnen – Self-Sufficiency Through Storage and Flexibility (Germany)

Sonnen is a German company founded in 2013 with a focus on storage in combination with Solar PV production. Real-time measurement makes it possible for Sonnen to also act as an aggregator and thus to further benefit from selling flexibility services to the grid operators. Sonnen recently opened an affiliate business in Australia, since Australia's PV market is booming – and claims to have 30,000 batteries installed in households across Europe, US, Asia and Australia.

The base offering consists in a Sonnen battery or a battery + rooftop PV, and a flat rate electricity tariff. Clients are charged €9.99 to be part of the community and €0.23/kWh. Solar panels and batteries can be purchased from Sonnen but it is not a prerequisite.

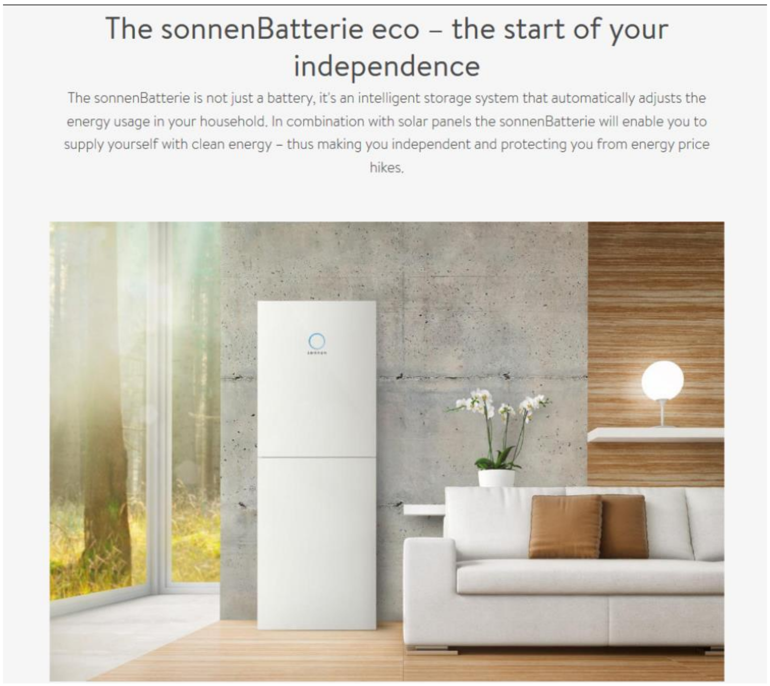
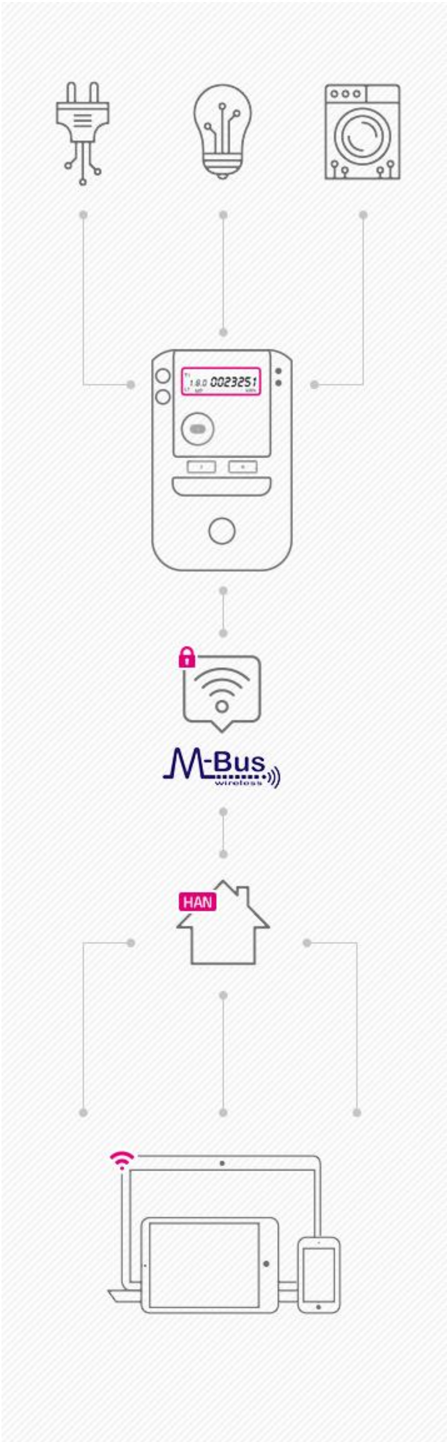


Figure 38. Advertisement for Sonnen´s battery and PV offering.

Sonnen communicates on the ability to be self-sufficient and independent from the grid (see advertisement above) – but also acknowledges the current difficulties – especially with regards to regulation.

The battery is developed as a multi-stage storage system that can be adapted to most energy needs. With storage sizes ranging from 2 kWh to 16 kWh the capacity is enough to power both a detached house or multi-family households. Energy capacity can be individually expanded in blocks of 2 kWh.

4.7 Tauron – Safety and Guidance (Poland)



Tauron is one of Poland's leading energy providers. Its distribution branch, TAURON Dystrybucja, is behind one of the largest implementations of services based on real-time energy data to residential customers using Networked Energy Services' AMI solution. The initial deployment was about 330,000 customers, now about 400,000.

The solution allows for remote activation of the wireless communication interface in a smart meter after which near-real-time (30 seconds) consumption data is sent directly from the AMI electricity meter to the household receiving device.

TAURON thus gains the ability to monitor and control connected devices offering flexibility, feedback and security services (through remote control of appliances).

Every resident of Wroclaw who has a smart meter installed and has their own home HAN network equipped with a Wireless M-Bus wireless module has the option of activating the HAN communication interface in the AMI meter and connecting it with its home network. This can be done via the TAURON eLicznik platform available as a web portal or a free application.

Figure 39. The Tauron HAN and mobile application

Homepage: http://amiplus.tauron-dystrybucja.pl/Strony/start.aspx (in Polish)

Market research company Statista [24] *expects revenues in the European home energy management system business to grow at an annual rate of 26% between now and 2022; resulting in a market volume of €4 billion. By then, 10.5% of households are expected to use products and services for the control and reduction of energy consumption (e.g. automated heating control and timers) as well as connected sensors (e.g. temperature, sunlight, and precipitation sensors) up from 3.5% today.*

The case studies show that innovative business models in the electricity industry revolve around two main themes sometimes offered in combination to maximise customer benefits: a) providing households with the ability to automatically increase and decrease energy demand and be rewarded for providing grid flexibility and prepare the grid for an increasing electrification of transport and heating (e.g. electric cars, heat pumps) and b) enabling and maximising independence from traditional suppliers by optimising local generation (typically solar PV), battery storage and home control. In the case of gas, new services often focus on remote control and scheduling of water boilers and heating. It is also important to note that near-real-time measurements are a pre-requisite for these business models to function.

Annex 1. List of Analysed Public Pilots

PILOT NAME	PILOT ORGANISER	COUNTRY	PILOT YEAR
BC Hydro's Advanced Metering Initiative (AMI)	BC Hydro	Canada	2006 - 2007
ENERGY WATCH	Idaho Power	USA	2006 - 2007
MYPOWER	Public Service Electric and Gas Company (PSE&G)	USA	2006 - 2007
Household Response to Dynamic Pricing of Electricity	Xcel Energy	USA	2006 - 2007
Integral Energy smart meter trial	EnergyAustralia	Australia	2006 - 2007
Energy Australia Strategic Pricing trial	Energy Australia	Australia	2006 - 2008
Western Sydney Pricing Trial	Integral Energy	Australia	2006 - 2008
Hydro One Networks' TOU pricing pilot project	Hydro One Networks Inc.	Canada	2007
PowerCost MonitorTM Pilot Program	Blueline innovations	USA	2007 - 2008
Beyond the Price Effect in TOU Programs	Research Into Action, Inc. and Sacramento Municipal Utility District (SMUD), sponsored by the United States Government	USA	2007 - 2009
PowerChoice Residential Customer Response to TOU Rates	Research Into Action, Inc. and Sacramento Municipal Utility District (SMUD), sponsored by the United States Government	USA	2007 - 2009
PSE pilot	Puget Sound Energy (PSE)	USA	2007 - 2009
Energy demand research project (EDRP)	Managed by Ofgem on behalf of DECC	UK	2007 - 2010
Electricity smart metering customer behaviour trials (CBT)	CER (Commission for Energy Regulation)	Ireland	2007 - 2010
Adelaide Solar City	Australian Government	Australia	2007 - 2013
Power Smart Pricing	Ameren Illinois Utilities	USA	2007, 2008, 2009
BGE's SMART ENERGY PRICING PILOT	BGE, the Brattle Group	USA	2008

Home energy monitors, impact over the medium-term	Delft University of Technology	Netherlands	2008
Opower SMUD pilot study	Municipal Utility District (SMUD), Opower	USA	2008
Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage	Sacramento Municipal Utility District (SMUD) and electricity and natural gas (Puget Sound Energy (PSE) in cooperation with Positive Energy/oPower	USA	2008
PowerCentsDC Program	Smart Meter Pilot Program, Inc. (SMPPI)	USA	2008
Smart Energy Management for Households	Delft University of Technology, Faculty of Architecture and The Built Environment	Netherlands	2008 - 2009
Conservation Improvement Program (CIP)	Franklin Energy	USA	2008 - 2010
Hydro Quebec Projet tarifaire heure juste (PTHJ)	Hydro-Québec Distribution	Canada	2008 - 2010
Puget Sound Energy's Home Energy Reports Program	Puget Sound Energy	USA	2008 - 2011
E-DEMA	E-Energy (publicly funded)	Germany	2008 - 2013
Residential SmartRate Program	Pacific Gas and Electric	USA	2008, 2009, 2010
Residential Smart Energy Monitoring Pilot	Cape Light Compact (CLC)	USA	2009
PLAN-IT WISE	Connecticut Light and Power Company (CL&P)	USA	2009
Positive Energy's Home energy reports	Connexus Energy partnered with Opower (formerly Positive Energy)	USA	2009 - 2010
Field study on smart metering	Fraunhofer Institute for Systems and Innovation Research	Germany/Austria	2009 - 2010
Perth Solar City	Australian Government	Australia	2009 - 2011
Central Victoria Solar City (CVSC) project	Australian Government	Australia	2009 - 2012
Opower Home Energy Report (HER) program	National Grid (NGRID) and NSTAR	USA	2009 - 2012
Alberta real-time electricity consumption monitoring study	Alberta Innovates – Technology Futures (AITF), sponsored by Alberta Department of	Canada	2010

	Environment and Water Alberta Department of Energy		
CUB Energy Saver Program	Efficiency 2.0	USA	2010
OG&E Smart Study Together	Oklahoma Gas and Electric	USA	2010 - 2011
A Field Experiment Assessing the Potential for Savings and Persistence	Sébastien Houde, Annika Todd, Anant Sudarshan, June A. Flora, K. Carrie Armel±	USA	2010
Home Energy Reports	Ameren Illinois, CADMUS	USA	2010 - 2012
Pacific Gas and Electric Company's (PG&E's) Home Energy Reports (HERs) initiative	Pacific Gas and Electric, evaluation by FSC	USA	2010 - 2012
Energy Efficient e-Houses	Project co-funded by the European Commission within the ICT Policy Support Programme	Spain, Germany, UK	2010 - 2013
SmartView	Entergy	USA	2011 - 2012
Residential Summer Solutions Study	Herter Energy Research Solutions, co-funding from Sacramento Municipal Utility District (SMUD) and Demand Response Research Center at Lawrence Berkeley National Laboratory.	USA	2011 - 2012
BECA (Balanced European Conservation Approach)	EMPIRICA (EU funded)	Serbia, Germ any, Czech Republic, Sp ain, Sweden, Bulgaria, Italy	2011 - 2013
SSE feedback pilot	SSE	UK	2011 - 2013
Smart Metering Early Learning	Department of Energy and Climate Change (DECC)	Great Britain	2012
100koll E.ON Smart Electricity Meter Pilot	E.ON	Sweden	2012
eTelligence	EWE	Germany	2012
eSESH: Saving Energy in Social Housing with ICT	EMPIRICA	France, Spain, Germany, Austria, Belgium, Italy	2012

Pacific Gas and Electric Company's Home Area Network (HAN) Pilot	Pacific Gas and Electric	USA	2012 - 2013
Enel Info+	Enel Distribuzione	Italy	2012 - 2014
Customer-Led Network Revolution	Led by Northern Power Grid in collaboration with British Gas, Durham University and EA Technologies, funded by regulator Ofgem's Low Carbon Network (LCN) Fund	UK	2012 - 2014
Opower/Honeywell Thermostat Trial - PG&E's Emerging Technologies Program	Pacific Gas and Electric	USA	2012 - 2014
Greenlys	Enedis	France	2012 - 2016
E.ON Customer Engagement Toolkit Pilot	E.ON	UK	2013
Ontario's Time-of-Use Rates	The Brattle Group, Mountain Economic Consulting and Associates, eMeter	Canada	2013
Nest Thermostat Heat Pump Control Pilot	Energy Trust of Oregon	USA	2013 - 2014
Energy Savings from the Nest Learning Thermostat	Nest labs	USA	2013 - 2014
Nest® thermostat pilot program	Vectren Energy Delivery (Vectren)	USA	2013 - 2014
Nevada Dynamic Pricing Trial (NDPT)	NV Energy and the federal Department of Energy (DOE)	USA	2013 - 2015
Home Energy Reports and Manage-Act-Save Programs	San Diego Gas & Electric	USA	2013 - 2015
Smart Energy Manager Program	Baltimore Gas & Electric	USA	2014
DTE Insight & Retro-Commissioning	DTE Energy	USA	2014 - 2015
DTE INSIGHT: ENERGY BRIDGE	DTE Energy	USA	2014 - 2015
Home Energy Report (HER) pilot program	Eversource New Hampshire (Navigant)	USA	2014 - 2015
Smart Thermostat Pilot	Energy Trust of Oregon	USA	2014 - 2015
EMPOWERING customers to save energy by informative billing	Project co-funded by the European Commission within the IEE Programme	Italy, Spain	2014 - 2016

Power Off & Save Pilot	Electric Ireland Customer Innovations	Ireland	2016 - 2017
Nest Thermostat Seasonal Savings Pilot	Energy Trust of Oregon, CLEAResult, and Nest Labs (Nest)	USA	2016 - 2017

List of References

[1] D. Parker, M. Mazzara and J. Sherwin, Monitored energy use patterns in low-income housing in a hot and humid climate. Proceedings from IBSHHC ´96: Tenth Symposium on Improving Building Systems in Hot Humid Climates, Fort Worth, 1996.

[2] S. Barr, “The household energy gap: examining the divide between habitual and purchase-related conservation behaviours,” *Energy Policy,* vol. 33, pp. 1425-44, 2005.

[3] L. Steg and C. Vlek, “Encouraging pro-environmental behaviour: an integrative review and research agenda.,” *Journal of Environmental Psychology,* vol. 29, pp. 309-17, 2009.

[4] S. Darby, “The Effectiveness of Feedback on Energy Consumption: A Review for Defra of the Literature on Metering, Billing and Direct Displays,” Environmental Change Institute, University of Oxford, 2006.

[5] W. Abrahamse, L. Steg, C. Vlek and T. Rothengatter, “A review of intervention studies aimed at household energy conservation.,” *Journal of Environmental Psychology,* vol. 25, pp. 273-91, 2005.

[6] A. Langenheld, “Advanced metering and consumer feedback to deliver energy savings –Potentials, Member States experience and recommendations”.

[7] [Online]. Available: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8.pdf.

[8] J. Stromback, C. Dromacque and M. Yassin, “The potential of smart meter enabled programs to increase energy and systems efficiency: a mass pilot comparison,” Prepared for ESMIG, www.esmig.eu/press/filestor/empower-demand-report.pdf, 2011.

[9] P. A. C. 2. EPRI, “Understanding Electric Utility Customers - Summary Report: What We Know and What We Need to Know.”.

[10] K. Ehrhardt-Martinez, K. Donnelly and J. Laitner, Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity-Saving Opportunities, In American Council for an Energy-Efficient Economy, 2010.

[11] Eurostat, 2018.

[12] I. Ajzen, “The theory of planned behavior.,” *Organizational Behavior and Human Decision Processes,* vol. 50, pp. 179-211, 1991.

[13] B. Verplanken and W. Wood, “Interventions to break and create consumer habits,” *Journal of Public Policy and Marketing,* vol. 25, pp. 90-103, 2006.

[14] W. Wood and D. Neal, “A new look at habits and the habit-goal interface,” *Psychological Review,* vol. 114, pp. 843-863, 2007.

[15] T. Schatzki, “The site of the social: A philosophical account of the constitution of social life and change,” University Park: Pennsylvania State Univestiy Press, 2002.

[16] E. Shove, “Comfort in a lower carbon society,” *Building Research and Information,* vol. 36(4), pp. 307-311, 2008.

[17] E. Shove, "Beyond the ABC: climate change policy and theories of social change," *Environment and planning A,* vol. 42(6), pp. 1273-1285, 2010.

[18] [Online]. Available: https://ec.europa.eu/energy/intelligent/projects/en.

[19] [Online]. Available: http://www.smartgrids-cre.fr/index.php.

[20] C. Fischer, "Feedback on household electricity consumpiton: A tool for saving energy?," *Energy Efficiency,* vol. 1, no. http://dx.doi.org/10.1007/s12053-008-9009-7, pp. 79-104, 2008.

[21] [Online]. Available: www.natconsumers.eu.

[22] VaasaETT and Joule Assest Europe, "Demand Side Flexibility Through Smart Homes," http://esmig.eu/resource/report-demand-side-flexibility-through, 2017.

[23] [Online]. Available: http://www.odyssee-mure.eu/publications/efficiency-by-sector/households/household-eu.pdf.

[24] [Online]. Available: https://www.statista.com/outlook/284/102/energy-management/europe.

About VaasaETT

VaasaETT is a future-focused research and advisory firm focusing on the interplay of consumer behaviour, competitive energy market dynamics, and the development of smart and other offerings in energy markets globally. Research projects are tailor-made to client needs and form the basis of sound decision-making and guidance on complex issues facing the energy sector today. Through our global network and 20 years of experience and market monitoring, VaasaETT brings best practice from over 60 markets to our clients across five continents.

Contact us:

Christophe Dromacque
+358 (0)4 4906 6822
christophe.dromacque@vaasaett.com

VaasaETT Oy Ab Ltd
Sörnäisten rantatie 29, 00500 HELSINKI, Finland
www.vaasaett.com

About ESMIG

The European Smart Metering Industry Group (ESMIG) is the European voice of smart energy solution providers. Our members provide products, information technology and services solutions for Electricity, Gas, Water or Heat metering, data transfer or and security, display and/or management of energy consumption and generation at consumer premises. We advocate for a regulatory framework that accelerates the introduction of our members' innovative products and services, which are fundamental to the smart energy and water systems of Europe's future.

Contact us:

ESMIG Secretariat
Phone: +32 2 7068257, Fax: +32 2 7068250
Email: secretariat@esmig.eu
European Smart Metering Industry Group
Boulevard A. Reyers 80, 1030 Brussels, Belgium
www.esmig.eu