

The potential of smart meter enabled programs to increase energy and systems efficiency: a mass pilot comparison

Short name: Empower Demand

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Project funded by



Executive Summary

The European Union has set ambitious objectives for the year 2020 to lower energy consumption by 20%, lower CO₂ emissions by 20% and ensure that 20% of energy is generated using renewable resources. At the same time, it is actively engaged in creating road maps and investment plans for developing smart grids throughout Europe. A core element of the smart grid is the active participation of the demand side and only through the involvement and cooperation of the demand side can the 2020 objectives be met. Within Europe and indeed globally, smart metering is viewed as a key building block in the smart grid and the most cost/effective method for increasing end-consumer involvement and engagement.

The aim of the research whose results are presented in this report has been to discover the potential and limitations of a range of feedback and dynamic pricing programs enabled through smart metering technologies. VaasaETT's findings and conclusions based on a large pool of pilots are designed to gauge repeated results and surrounding requirements for success. The research involved collecting and comparing about 100 pilots. Typically, organisers divide participants in a pilot into sub-groups in order to test different solutions, for instance different feedback types, different dynamic pricing schemes, a group with home automation and one without, etc. Hence, the pilots were broken down into 460 samples. The samples were then analysed according to 22 different variables selected to gauge internal structural pilot variables influencing success as well as outside market factors which might also impact a pilot outcome. In total, over 450,000 residential consumers were involved in the reviewed pilots. Feedback pilots are designed to help participants reduce their overall energy consumption, lowering distribution and supply costs. In comparison with the other feedback channels, IHD resulted in the highest energy savings. The remaining channels for feedback, webpage, and informative bills produced almost equal consumption reduction levels. Quite possibly, the key advantage the IHD offers over the remaining channels for feedback is the almost real-time and visible aspects of the delivery of feedback. TOU peak reductions are the lowest, but they occur daily, while CPP and CPR produce the highest reductions but only for critical peak periods. The main findings demonstrate that consumers do react to feedback and dynamic pricing mechanisms positively, pilot results maintain over 2-3 years and they can also be effective in consumer groups of over 1,000 households. In addition, post pilot surveys show that on average 75 – 90% of participants were satisfied with the pilot in which they took part. That said, results vary widely within a given program type; an IHD pilot can attain 3% or 19% reductions. Therefore the research findings also confirmed the assumption that surrounding variables have a substantial impact on program success levels over and above the supportive technology used or program structure.

The findings of Empower Demand demonstrate that technology provides an important but enabling function in creating a successful demand side program. It is one of five factors which decide success. These factors are socioeconomic factors, participant consumption patterns, program content/structure, supportive technology and household load sources. In this, socioeconomic factors and consumption patterns can overcome supportive technology and program type. For example, a good informative billing pilot can lead to higher savings than an IHD pilot depending on surrounding circumstances despite the fact that on average an IHD is 50% more effective than an informative bill at reducing overall electricity consumption. It is therefore important to perform a comprehensive analysis of markets when creating demand side programs; matching the program structure with the market realities.

During piloting, there can be a technological focus or a preconceived opinion that the technology is what decides program success. Our findings challenge this focus. **The central difference we found between pilot success and failure is the ability of the program designers to meet consumer needs through the demand side program.** Meeting a need is the foundation of consumer engagement and thereby of a program success. The technology is the enabler within this value chain. Therefore, unless a technology is equipped to act as a support to consumer engagement, it will not create savings or improve systems efficiency. Smart meters fulfil their potential due to the fact that they can support consumer engagement to a market-appropriate level through feedback and dynamic pricing and/or home automation. It is very well expressed by Chris Johns, President of PG&E shortly after the company undertook the SmartRate Pricing Program pilot project in 2010: *"We thought we were undertaking an infrastructure project but it turned out to be a customer project"*¹.

Program success is directly dependent on consumer involvement and the Empower Demand findings indicate that "more is more" at every stage of the piloting and roll out process. For example, within marketing, programs using consumer segmentation to create directed marketing messages for a particular consumer group increase consumer uptake and results. In program structure, feedback and pricing together tend to achieve better long-term overall results than either program type alone. Education improves dynamic pricing and informative billing programs. Multiple types of information on a display or a bill (current consumption, price, historical consumption, etc.) tend to achieve higher results than a display or a bill with only one message. Program layering is little explored but there are signs that hidden potential lies in starting with a relatively simple program and gradually creating offerings of increasing complexity and value. Hence, we are far from having perfected program structures or perfectly matching program structures to regional market realities. This should be seen as encouraging as even though program development is not mature, results are already positive. This also puts into question the current tendency to emphasise technological development over and above all other factors in European pilot schemes while comparatively little funding is provided to studying the best messages to deliver to consumers, their cycles of learning through program layering or the impact of surrounding socioeconomic and cultural factors.

Empower Demand has reviewed 100 pilots. The selected pilots alone included 450,000 consumers but the resulting rollout from these pilots now includes over 4 million consumers. Smart meter enabled programs are consistently effective when developed in accordance with the needs of end-consumers and enabled through constructive regulation. Research questions set limits around what it is possible to learn from a pilot; organizers will only get answers to the questions they ask. This is as much a limitation as it is a resource. It is essential to move forward in pilot development through innovative questions, taking into consideration the results of past pilots and comparative studies such as this one. Pilot organisers can now focus their research on better understanding **who** is in the market and what can be done to maximise their participation within that market's reality. Long-term program success will require a comprehensive combination of marketing, technological support, directed communication and a constructive regulatory framework.

¹ Proceeds of Trials & Tribulations of Smart Grid Deployment, A Case Study That Hits Home, BECC Conference, 2010.

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1. Background to the study

The European Union has set ambitious objectives for the year 2020 to lower energy consumption by 20%, lower CO₂ emissions by 20% and ensure 20% of energy is generated using renewable resources. At the same time it is actively engaged in creating road maps and investment plans for developing smart grids throughout Europe. The core of the smart grid is the active participation of the demand side and only through the involvement and cooperation of the demand side can the 2020 objectives be met. Within Europe² and indeed globally, smart metering is viewed as a key building block in the smart grid and the most cost/effective method for increasing end-consumer involvement and engagement.

Smart metering helps to enable consumption feedback and dynamic pricing programs directed at end-consumers. Yet there is confusion and disagreement within the energy industry on exactly what can be achieved through various smart meter enabled programs, how long they remain effective, if the pilots show reliable results, if the programs can be cost effective, what type of feedback should be provided and in what format etc.

The questions are creating an aura of uncertainty surrounding the potential of smart metering to further the aims of the EU and its governments. It also raises questions as to whether smart meters are worth their cost and whether they can bring lasting benefits to consumers. It lowers the willingness of regulators to mandate smart metering deployment and for utilities to invest. The questions persist despite the fact that well over 150 successful pilots involving smart meters have now been carried out globally. The challenge lies in the fact that utilities and regulators do not have easy access to comparative data demonstrating the results of a large number of pilots. They only see the results of one pilot at a time and as any individual pilot leave many questions unanswered, overall trust in the technology remains an issue.

Therefore, ESMIG thought it necessary to fund an independent research study which collected and compared a large enough number of pilots to demonstrate repeated and consistent results and give answers to a wider variety of concerns. VaasaETT was selected by ESMIG to conduct such a large comparative study designed to add weight to the results of any single pilot. The “Empower Demand” study allows, for instance, utilities to know if their results are below or above average because they know the average results of some 30-40 similar pilots done globally. It will also help them create better pilots as it allows them to review the success factors in a wide range of other studies. From the point of view of regulators and policy makers, such a wide-ranging pilot comparison can be a useful tool, as it allows to identify proper support for smart metering in Europe and to stimulate demand driven programmes. Empower Demand was designed to be an in-depth research project comparing 100 pilots according to 22

² The EU’s “Third Energy Package” came into force on 9 September 2009 and consists of two Directives and three regulations which are intended to complete the liberalisation and integration of the EU energy market, as well as strengthen consumer rights and protection. The package includes Electricity and Gas Directives which require the EU Member States to ‘ensure the implementation of intelligent metering systems.’ The Electricity Directive foresees full deployment by 2022 at the latest, with 80% of consumers equipped with Smart Metering systems by 2020.

variables. The pilots were broken down into 460 samples and over 450,000 residential customers were involved.

VaasaETT's findings and conclusions as presented in the study are designed to gauge any repeated results and also surrounding requirements for success. The aim of the research has been to discover the potential and limitations of a range of feedback and dynamic pricing programs enabled through smart metering technologies using a large comparative sample. ESMIG solely provided the financial means to conduct the present study and in future will fund further follow-up research into other related aspects which could not be covered extensively in this study.

The Empower Demand study and its findings do represent VaasaETT's own independent analysis and opinion. The underlying methodology and sample base was developed by VaasaETT.

2. Sources and provenance of the base information

It is important to note that comparing pilots accurately contains many inherent complications. Pilots are not constructed in order to be comparable. They are constructed to fit the needs and budget of the utility or research institute and the methods as well as the quality differ substantially. For example, how energy savings are calculated differs, it can be based upon households' historical data or upon a control group's data. Sample sizes and selection methods also differ. Some pilots are large containing 30,000 customers and are representative of the utilities customer base while others focus on one customer group for instance customers with electric heating. Further differences will be discussed during the analysis this means that the findings below can only be taken as useful indications of which elements influence pilot results, not as an absolute recipe containing exact percentage numbers. They are meant to be seen as indications of what tends to work and not work and to this extent they are useful.

Data from 100 pilots was used for the purpose of this research. These pilots were selected from a larger pool which included pilots whose design or reporting of results were not sufficiently detailed or comparable with the others to be included. Final reports, presentations and academic papers analyzing the selected pilots were collected from numerous sources. Papers published in academic journals were collected from academic databases. Public pilots' reports were collected directly from the organizer (often local regulators or public utilities). In addition, VaasaETT drew on its extensive network of practitioners around the world to collect pilots whose results were not made public usually from technology providers or investor-owned Utilities.

2.1 Research categories and phases

The research involved collecting and comparing 100 pilots. Typically, pilot organisers divide participants to a pilot into sub groups in order to test different solutions; for instance different feedback types, different dynamic pricing schemes, a group with home automation and one without. Hence, the pilots had to be broken down into 460 samples. Each sample was therefore created and analysed as its own study. The samples were then analysed according to 22 different variables selected to gauge internal and structural pilot variable influencing success as well as outside market factors which might also impact a pilot outcome. In total, over 450,000 residential consumers were involved in the reviewed pilots.

Pilot structure variables:

1. Duration of pilots
2. Incentives to join pilots
3. Automation location
4. Education during pilot
5. Methods of communication for pricing alerts
6. Frequency of feedback

7. Format of feedback
8. Content of feedback
9. Pricing and feedback combined
10. Type of feedback
11. Questionnaires and Interviews
12. Length of peak hours
13. Multiple of peak price / base price
14. Number of participants
15. Pilot uptake rates

Market structure variables:

1. Climate/season of pilot
2. Regional differences between pilot results
3. Average national yearly Consumption Levels
4. Market competition levels
5. Capacity issues within market
6. Meter ownership
7. Data ownership

A four phase method was used to analyse the data and produce the results. The initial two phases, gathering the information and defining the categories, formed the framework of our research and enabled us to differentiate pilots and research articles, whereas phase 3-4 was geared towards our analysis and findings.



2.2 Data and methodology

Impacts on pilot participants were assessed from three perspectives:

- Energy conservation: the extent to which the experiment led to a reduction in overall energy consumption (in %)
- Peak clipping: the extent to which the experiment led to a reduction in energy consumption during peak periods (in %)
- Bill reduction: the extent to which the experiment led to a reduction in customer energy bills (in %).

Please note that pilot organizers rarely report the impacts of the experiments on all three perspectives. They usually report on what is of interest given the ultimate purpose of their experiment. For instance, critical peak pricing pilot organizers usually report on peak clipping whereas organizers of feedback pilots typically report on energy conservation.

Pilots organisers 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. Impacts of trials on individual samples were not calculated by VaasaETT. Instead they were calculated and reported by the pilot organizers in their final reports, academic papers and presentations. VaasaETT collected and took into account statistically significant results at a 90% confidence level and above. This review simply averaged the individual impacts in order to understand what the key determinants of successful pilots are. The average impacts are calculated by averaging the individual impacts on each sample 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

Please note that the numbers of samples the results relate to is of outmost importance in this report to assess the significance of the findings. For each graph and category, the sample size is expressed as "N=number of trials"

3. Program Definitions

3.1 Feedback Pilots

Background information

The role of feedback is to make energy visible and to make the consumption of energy visible, thus sharpening the knowledge of residential consumers about how, and how much, energy circulates in the household. Research indicates that households are scarcely knowledgeable on what energy efficiency entails and how much energy they consume (and certainly not appliance specific consumption), how much they actually pay for their energy, why and how they should save energy or when they should make energy efficiency investments (Thorne et al. 2006). Feedback therefore provides an opportunity to offer consumers a more direct, detailed, comparable and comprehensive information about their household's energy consumption pattern.

Feedback on energy consumption can influence the energy behaviour of residential consumers and lead to a conserving behavioural effect (Darby 2006). However, in order to make feedback more than only a visual reporting on the energy consumption, information given on display is just as vital as the device/display that the consumers receive their feedback from. In this report each individual feedback pilot sample was categorized into one of the following program types: informative billing, in-house displays (IHD), web pages, ambient displays, and a mixture of the program types. The type of feedback on display was also categorized into eight feedback type: peer comparison, historical comparison, up-to-date comparison, cost of energy (bill), environment (CO2 emission), savings compared to previous periods, and appliance specific consumption.

The above mentioned feedback formats enable us to research the feedback programs that resulted in the highest levels of consumption reduction, as well as the specific content of feedback information that led to the highest levels of consumption reduction. The assumption is that any reduction in overall consumption by the participants would be largely because of the format of feedback and the content of feedback information that the participants received.

Samples and data

A total of 74 feedback trials were analysed during this research. The total sample comprised of 290,000 residential households and were taken from five regions; Australia (3 samples), Canada (12 samples), Europe (35 samples), Japan (3 samples) and USA (21 samples). The majority of the pilots from Europe were conducted in Great Britain. Over 60% of the pilots took place within the last ten years and almost half after 2005.

Feedback program types

In-house displays (IHD) are displays which hang on the wall or sit on a counter and provide close to real time information about household electricity consumption. They also provide a variety of other data. For example the display provided in the "*Electricity Smart Metering Customer Behaviour Trials*" (see figure 1) allows people to set daily budgets for how much they want to spend, informs them of their success, what the current price of electricity is and provides information on how much they have spent so far this month³.

IHDs provide households with real-time and historical information on their electricity usage and costs. Additional feedback content that are sometimes offered on the IHD are peer comparisons (showing the consumption rate of neighbours or consumers with similar conditions), and appliance specific consumption (breaking down the energy usage of individual appliances in the home). The home screen for the dynamic display unit is the key screen that the customer always sees when the device is switched on, while further information can be gained if desired through navigating to other screens.



Figure 1: Display, Electricity Smart Metering Customer Behaviour Trials, Ireland (2011)

Ambient displays differ from IHDs in that they do not provide specific consumption information but rather signal to the customer messages about their general level of consumption and/or a change in electricity prices. Many ambient displays have the attributes of being attractive and intuitive which adds to their customer acceptance potential. An example of this is the Energy Orb sold by PG&E in the USA (see figure 2). Originally designed to track stock market prices, the Energy Orb can also be programmed to change from green to yellow to red depending on the current electricity price.

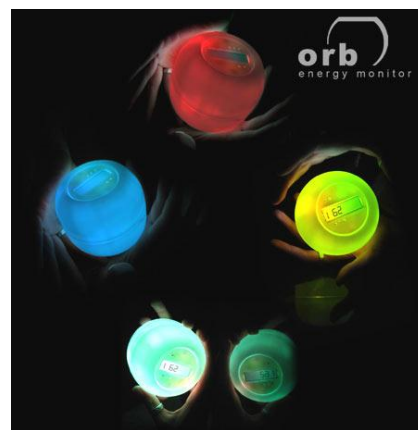


Figure 2 : The Energy Orb, PG&E

Websites offer an alternative way to provide the consumer with information about their electricity consumption. California and Finland⁴ are just two examples of such markets where websites are used for energy consumption feedback. Websites are chosen as a means of

³ The Commission for Energy Regulation, Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report, May 2011.

⁴ Fortum Finland, for instance, allows residential customers to track their consumption and visualise their historical usage from a dedicated website.

providing feedback because they are relatively cheap. They rely on smart meters to collect the necessary consumption data and therefore the granularity⁵ of data provided to consumers depends largely on how often the meters are read or how often the information is transferred from the meter to the utility (or retailer). For example, in Norway, the meters will have the capability of reading the electricity consumption in a household every 15 minutes but the communication system between the meter and the network company only supports hourly readings. The information is sent in a packet from the meter to the network company once a day (Stromback, Dromacque, Golubkina: 2010).

Informative billing is an example of indirect feedback. Most residential consumers in Europe now receive estimated bills which are adjusted for the time of year and the household's average consumption. They therefore do not accurately reflect the actual usage for a given month. The difference between the estimated average consumption and the actual usage is made up at the end of the billing period or when a resident changes electricity supplier. Informative billing will invoice for the actual consumption and provides either historical information comparing what the customer used this month to last month or to last year during the same period. The bill may also provide information on how much the household consumed in comparison to other dwellings of the same description. Unlike standard billing in which households receive their bill 4-6 times per year, informative bills can be sent as frequently as once per month.

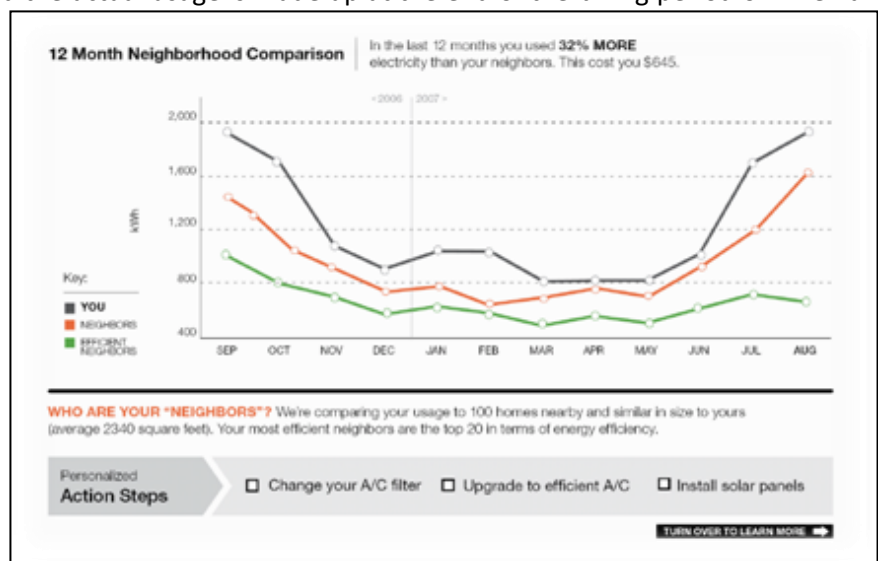


Figure 3: Example of informative billing. SMUD Power Choice label pilot, USA (2010)

Feedback information types

Information about consumption presented in the different feedback programmes typically included one or several of the following content types:

1. **Peer comparison:** Consist of comparison of household energy consumption levels between participants and similar-sized households. This information may include neighbours within near vicinities or households of similar size. It enables participants to see if they use more or less electricity than their peers.

⁵ Data granularity means how detailed the data provided is. Do they give real time readings, every 15 minutes, every hour, and every day?

2. **Price of electricity:** Indicate the current price of electricity per kWh. This does not include the up-to-date electricity bill.
3. **Historical comparison:** Shows the household's current electricity consumption levels in comparison to pre-pilot consumption levels. Participants can know if they reduced or increased their consumption compared to the same period last year for instance.
4. **Disaggregation of consumption:** The household's electricity consumption is broken down as per household electrical appliances. The depth and degree of the breakdown can vary but in most cases the consumption of the oven, the fridge, the TV, and the lighting are measured. It enables participants to see how much electricity individual appliances use and act upon it (and maybe buy more energy efficient ones).
5. **Up-to-date consumption level:** Presents the current up-to-date consumption level of the household in kWh. In itself, it does not include the cost of electricity or the current level of the bill. However, if coupled with consumption goals or targets not to exceed, it can be a powerful incentive to reduce consumption.
6. **Up-to-date Cost (bill):** Presents the up-to-date bill which enables households to gauge their current costs for their electricity and act upon it.
7. **Savings compared to previous periods:** Compares the energy savings of households to previous periods. Households would have a certain target for their energy consumptions which would be a percentage savings on previous energy consumptions.
8. **Environment (CO₂ emissions):** This shows the amount of CO₂ the households emits due to electricity consumption. This presents the environmental costs or consequences of the households' energy consumption.

Overall results

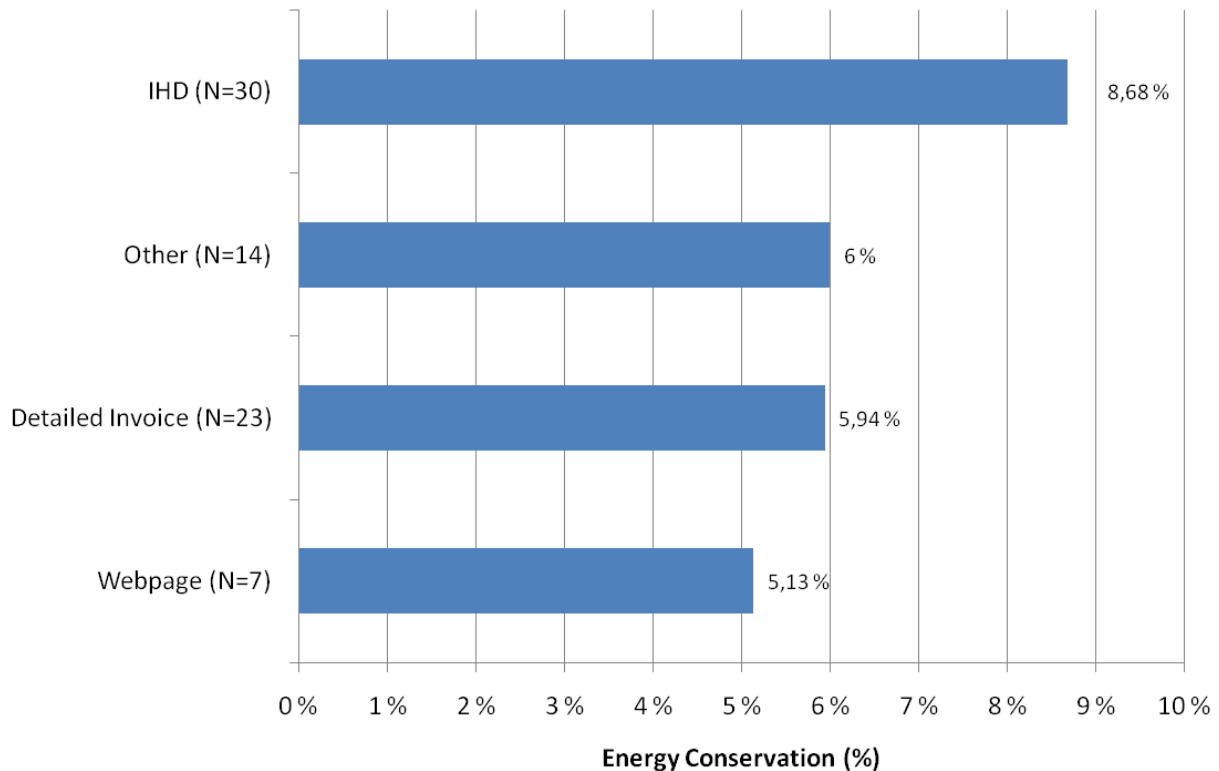
Feedback pilots are designed to help consumers reduce their overall energy consumption, lowering distribution and supply costs. In comparison with the other feedback channels, IHD resulted in the highest energy savings⁶⁷. The remaining channels for feedback; webpage, and informative billing; produced almost equal consumption reduction levels (in some cases they were used together in combination). Quite possibly, the key advantage the IHD offers over the remaining forms of feedback is the almost real-time

⁶ 40% of all the samples in our research focused on IHD programs

⁷ The numbers of samples the results relate to is of outmost importance in this report to assess the significance of the findings. For each graph and category, the sample size is expressed as "N=number of trials"

aspect which enables participants to link their actions to their energy usage practically in real-time. These are average pilot results. Success factors, such as the impact of average household consumption, location, feedback content, etc. within a particular market are not reflected in the graph. In order to be able to estimate the possible consumption reduction for a particular program, in a particular market, a larger number of variables must be taken into account.

Figure 4 : Overall consumption reduction as per feedback pilot type



3.2 Pricing Pilots

Background information

Pricing pilots are designed to encourage customers shift consumption away from peak consumption periods to lower consumption periods, lowering distribution and supply costs. This is achieved through dynamic pricing mechanisms which better reflect the cost of supplying electricity. The prices are raised at peak times and lowered (compared to single or flat tariffs) the rest of the time. There are several methods and degrees of dynamic pricing. The most commonly piloted pricing schemes are Time-Of-Use (TOU), Critical Peak Pricing (CPP) and to a lesser extent Critical Peak Rebate (CPR) and Real-Time Pricing (RTP). With regards to sample size considerations, pilots testing the impacts of other pricing structures such as pre-payment and increasing tariff blocks could not be included in our review.

Samples and data

As part of this research, we analysed 340 sample groups taken from pilots organised in the USA (186 samples), Canada (108 samples), different parts of Europe (30 samples), Australia (14 samples) and Japan (2 samples). The results are based on 250 TOU trials, 98 CPP trials, 27 CPR trials and 25 RTP trials (the total is greater than the number of samples because dynamic pricing schemes can be combined, for instance TOU and CPP). Over 60% of the samples were part of pilot organised after 2000 and 45% after 2005. Over 158,000 participants took part in the pricing pilots in total

Dynamic pricing program types

Time-of-Use (TOU): TOU tariffs induce people into using electricity during times when consumption is lower. Prices are therefore set higher during high consumption periods, typically during working hours, and lower during the rest of the day.

- TOU usually includes one long peak daily period or two shorter daily peak periods.
- TOU can have two level of prices (peak and off- peak prices) or three (peak, partial peak and off-peak prices) per day. The peak hours are known in advance by the customers. The prices may also vary according to the season.

TOU pricing schemes have been available to residential customers for decades.

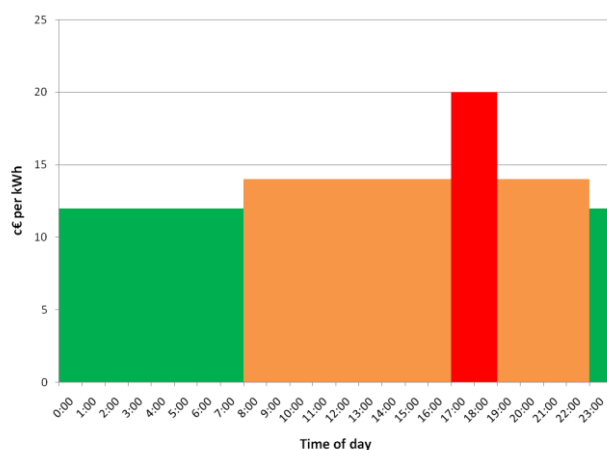


Figure 5 provides an example of TOU tariffs used in the "*Irish electricity smart metering customer behaviour trials*"⁸ in which week days were divided into three periods with an off-peak, partial peak and a peak period between 17:00 and 19:00. TOU prices can be offered in combination with CPP or CPR pricing schemes.

Figure 5 : Example of a three level TOU pricing scheme (based on the Electricity Smart Metering Customer Behaviour Trials, CER, 2011).

⁸ The Commission for Energy Regulation, Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report, May 2011.

Objective:

- Reduce energy demand during peak hours to avoid or defer investments in new production capacity
- Better reflect the true cost of supplying electricity at different times of day

Customer participation:

- Defer certain household activities to off-peak periods (typically laundry, dishwashers, lower electric heating and Air Conditioning (AC) usage, etc...)

Enablers:

- Smart metering technologies and automation of selected loads (AC/Electric heating/Electric water heater)
- Feedback on energy use and price

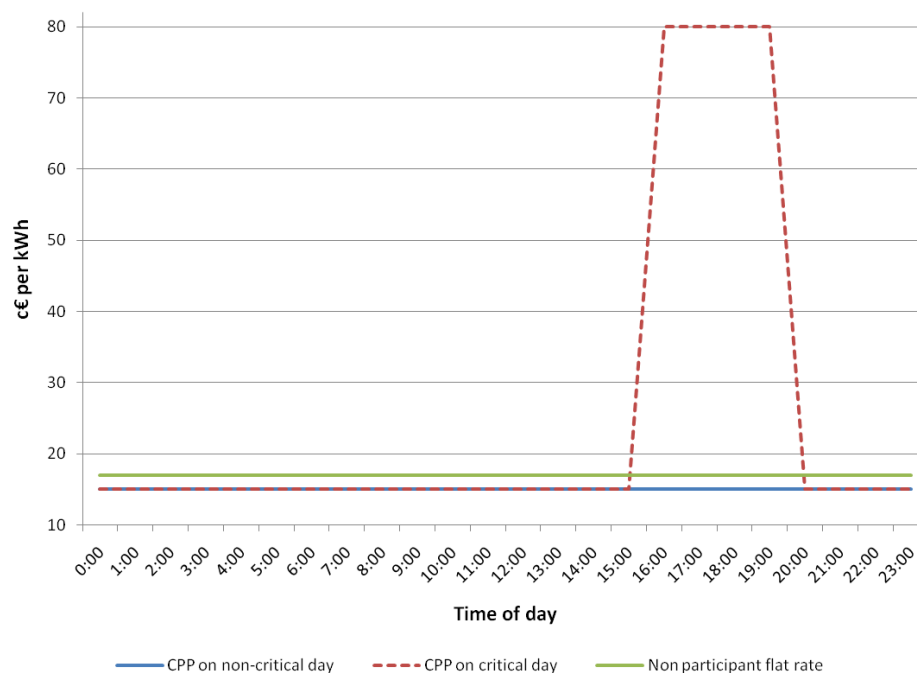
Customer reward:

- Reduced energy bill due to shifting activities to lower price periods
- Reduced cross subsidies as the price of electricity better reflects its cost
- “Green” attitude – doing the “right thing”

Critical Peak Pricing (CPP): CPP pricing schemes involve substantially increased electricity prices during times of heightened wholesale prices caused by heightened consumption (for example on very hot days) or when the stability of the system is threatened and black-outs may occur.

- In exchange for a lower tariff during non-peak hours (compared to customers on say single tariffs), participants agree to have substantially higher tariffs during critical peak hours.
- The number and length of critical peak periods which the utility is allowed to call is often agreed upon in advance in order to lower participant risk.
- The periods when critical peaks occur depend on conditions in the market and cannot be decided in advance. Residential customers are usually notified the day before that the next day will be a critical day.

Figure 6 : Example of Critical Peak Pricing scheme



The programs are effective but there are some questions as to the fairness for low-income consumers who may be especially impacted by the programs as well as for those for whom shifting load may be especially difficult (retired people or sick people who need to stay at home). This is why CPP is usually not a mandatory or opt-out tariff but voluntary for residential consumers. However, by looking at the 9 samples in our review which focused on low-income customers

(for example a sub sample of the massive California Statewide Pricing Pilot⁹), we found that low-income households shift an amount of load which is similar to the average overall impact of CPP pilots. This would indicate that low-income households are still able to benefit from CPP pricing. CPP tariffs can also be combined with TOU tariffs. Figure 6 provides an example of CPP tariffs compared to a standard flat rate tariff.

Critical Peak Rebate (CPR): CPR pricing schemes are inverse forms of CPP tariffs. Participants are paid for the amounts that they reduce consumption below their predicted consumption levels during critical peak hours. These programs tend to be more acceptable to the public and to regulators alike as consumers can only benefit from participation. CPR is a relatively new form of tariff and has not been used in a large number of pilots as yet. 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. Residential customers are usually notified the day before that the next day will be a critical day. CPR tariffs can be combined with TOU tariffs.

Objective (CPP and CPR pricing schemes):

- Reduce energy demand during peak hours to avoid or defer investments in new production capacity

⁹ Charles River Associates (2003): Impact Evaluation of the California Statewide Pricing Pilot- Final Report.

- Better reflect the true cost of supplying electricity at different times of day

Customer participation (CPP and CPR pricing schemes):

- Turn off selected appliances and delay certain household activities when notified of a critical peak period (typically laundry, dishwashers, lower electric heating and Air Conditioning usage, etc...)

Enablers (CPP and CPR pricing schemes):

- Smart metering technologies and automation of selected loads (AC/Electric heating/Electric water heater)
- Feedback on energy use and price
- Notification of critical peak periods

Customer reward (CPP and CPR pricing schemes):

- Reduced energy bill due to shifting activities to off peak periods (*CPP*) / Receive payment for lowering electricity usage during critical peak periods (*CPR*)
- Reduced cross subsidies as the price of electricity better reflects its cost
- “Green” attitude – doing the “right thing”

Real-Time Pricing (RTP): The price paid by participants is tied to the price of electricity on the wholesale market. However they do not lead to consumption reductions without feedback. Even then customers will sometimes tire of checking a price that only changes slightly from day to day. In order to encourage reductions during high price periods and reduce risk of high bill, participants are warned when wholesale prices reach a certain threshold decided upon in advance. A majority of household customers in Norway¹⁰ and a growing number in Sweden¹¹ are currently on spot tied contracts.

Objective:

- Reduce energy demand during periods of high prices to avoid or deter investments in new production capacity.
- Reflect the true cost of electricity and enhance its price signal.

Customer participation:

- Turn off selected appliances and delay certain household activities when notified of a period of high prices (typically laundry, dishwashers, lower electric heating and Air Conditioning usage, etc...)

¹⁰ in its "Report on regulation and the electricity market 2010", the Norwegian Water Resources and Energy Directorate reports that roughly 52% of customers had a contract that offers the average monthly area spot price with a mark –up in 2009.

¹¹ The Energy Markets Inspectorate reports in its latest review of the Swedish electricity and natural gas markets 2009 that 30% of residential customers have variable contracts in 2009 as opposed to 22% in 2008.

Enablers:

- Smart metering technologies and automation of selected loads (AC/Electric heating/Electric water heater)
- Real-time feedback on energy use and price
- Notification of high price periods

Customer reward:

- Reduced energy bill due to shifting activities to lower price periods
- Reduced cross subsidies as the price of electricity reflects its cost
- “Green” attitude – doing the “right thing”

Overall results

Figure 7 provides the average load shifting in percent during peak priced hours (excluding the effects of automation). TOU and RTP peak consumption reductions are the lowest but they occur daily while CPP and CPR produce the highest reductions but only for critical peak periods.

Figure 7: Dynamic pricing’s potential for peak clipping

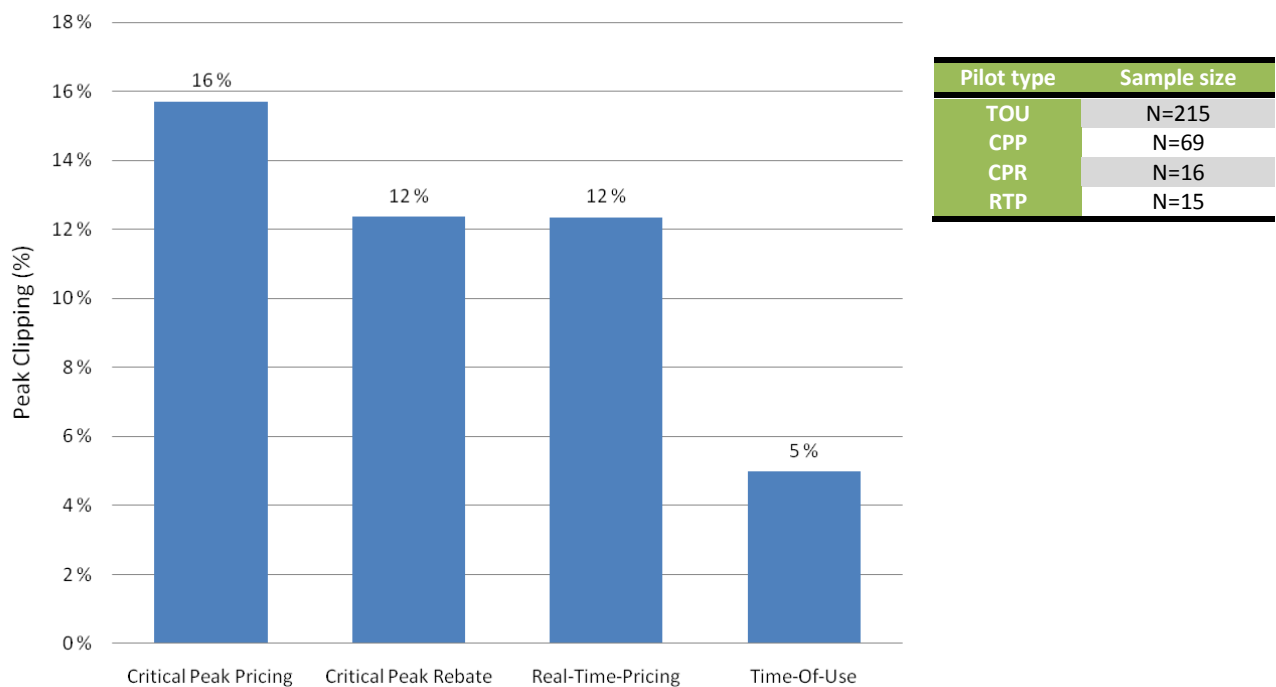
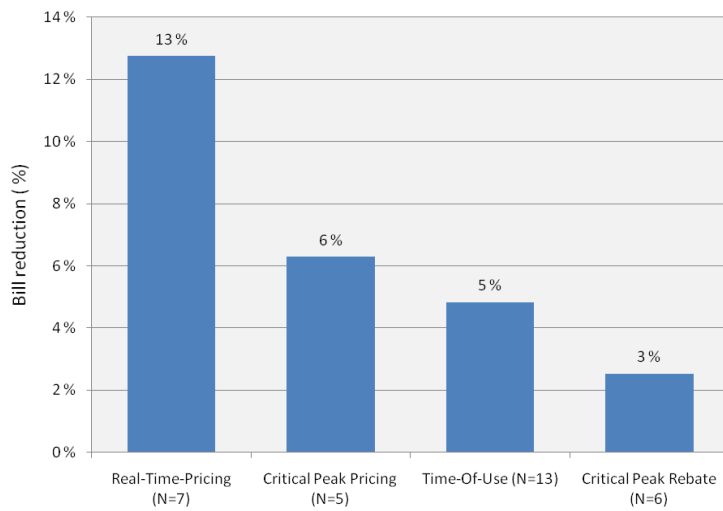


Figure 8 : Dynamic pricing's potential for customer financial savings



Every pricing schemes we looked at led to lower electricity bills over the duration of the pilot. Participants to RTP trials saved the most (on average 13% on their electricity bill) though this might be artificially high as some of the pilots took place during periods of ongoing abnormally low wholesale prices and were compared to consumers' adjusted historical bills. However, it is also one of the aims of RTP to enable customers to take full advantage of such periods of low prices.

4. Research findings

In this section, we present detailed results for both feedback and pricing pilots. Additional analysis and insight also accompany the graphs. The presentation of the results will focus on eight variables that played a part in both the feedback as well as in the pricing pilots. These are geography, length of pilot, number of participants, market characteristics, segmentation, education, and interactions with participants. In the final two sections of this chapter, our results focus exclusively on feedback pilots (and the type of feedback information), and pricing pilots (pricing scheme design and automation location). As with other similar studies the number of direct comparisons which can be made between pilots is limited due to the difference in the pilots' design and the reporting of results.

As mentioned earlier, impacts on pilot participants were assessed from three perspectives:

- Energy conservation: the extent to which the experiment led to a reduction in overall energy consumption (in %)
- Peak clipping: the extent to which the experiment led to a reduction in energy consumption during peak periods (in %)
- Bill reduction: the extent to which the experiment led to a reduction in customers energy bills (in %).

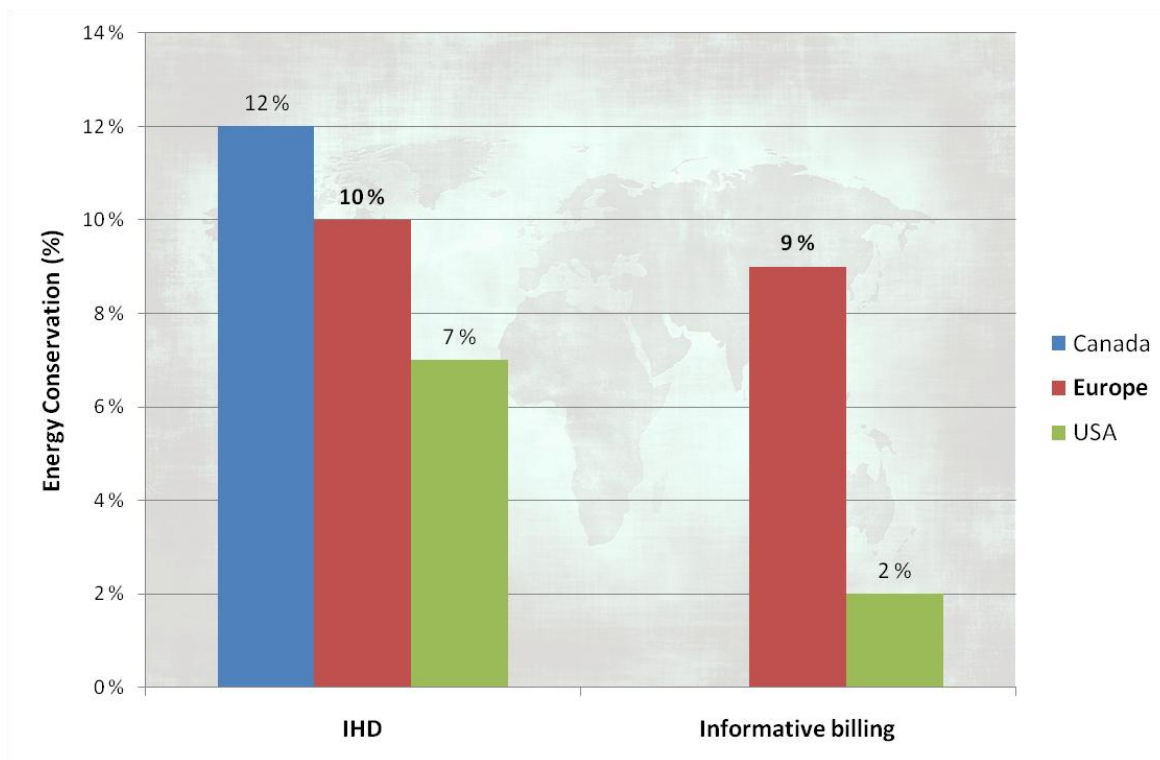
Please note that pilot organizers rarely report the impacts of the experiments on all three perspectives. They usually report on what is of interest given the ultimate purpose of their experiment. For instance, critical peak pricing pilot organizers usually report on peak clipping whereas organizers of feedback pilots typically report on energy conservation.

One of Empower Demand's aims was to ascertain which variables may influence customer behaviour and pilot success. However due to the fact that pilots are organized in varying ways, sample size varied widely, and many factors can influence customer behaviour, a variable was considered significant if it demonstrated a consistent impact across several pilot categories. Variables which produced a repeated, consistent response across pilot type were judged to be particularly important. Variables which produced contradictory results across pilot type were analysed further or judged to be inconclusive.

4.1 Regional comparison

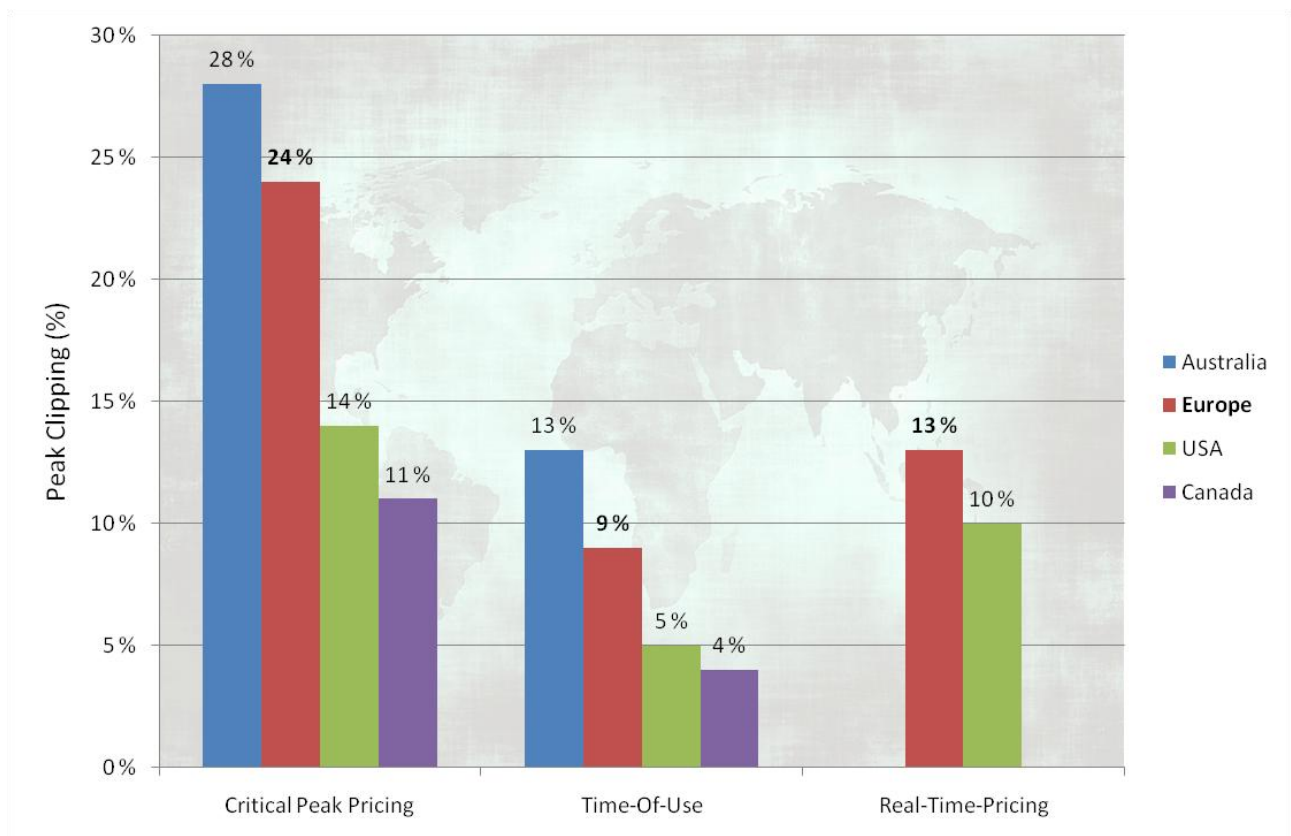
Though the sample sizes for some of the pilot types would be too small to demonstrate relevant results on their own, the aggregated results show that European participants are among the most responsive to smart meter enabled programs (see figures 9 and 10) and this despite relatively low national consumption. It has long been known that culture plays an important part in consumer reaction to programs and these findings serve to confirm this. Also, Europeans should be cautious about comparing themselves directly to other regions and making assumptions about the results of a similar program in Europe. Results could be consistently higher and program requirements will also be different. It is important to note that there is more of an emphasis on pilots testing feedback as well as pricing in the USA, as opposed to only feedback in Europe. In summary, programs should be adjusted to fit local culture and local requirements.

Figure 9 : Feedback pilots and area of trial



Sample size	Europe	USA	Canada
IHD	N=10	N=6	N=9
Informative billing	N=13	N=10	N/A

Figure 10 : Peak clipping in different regions of the world



Sample size	Australia	Europe	USA	Canada
TOU	N=10	N=15	N=84	N=106
CPP	N=6	N=4	N=54	N=5
RTP	N/A	N=3	N=12	N/A

Whether we look at feedback (figure 9) or pricing (figure 10) smart meter enabled programmes, Europeans' reaction seems to be consistently among the highest. It is especially obvious in feedback trials. The widely differing sample sizes call for caution when comparing the reaction of participants from different regions of the world to pricing signals. However, our results seem to indicate that dynamic pricing programmes could be more efficient in Europe than in other parts of the world.

Case Pilot 1: The Dutch Home Energy Management System (HEMS) Trials

Pilot Information: Conducted in 2008 for a period of 15 months and with a total of 304 residential participants.

Offering/promotion: people were given the option either to keep the energy monitor or to return it and receive a gift certificate of €25 instead.

Aims of the pilot:

- 1) What are the medium- to long-term results of Home Energy Management Systems (HEMS) on energy savings?
- 2) What is the influence of the design quality and usability of HEMS?
- 3) Is there a relationship between the amount of HEMS usage and achieved energy savings, and what role does the development of habitual behavior play?

Feedback information: Education and interviews before and during pilot, IHD feedback (real-time updates), and feedback information consisted of current up-to-date consumption and savings compared to previous periods.

Overall consumption reduction: 7.8%

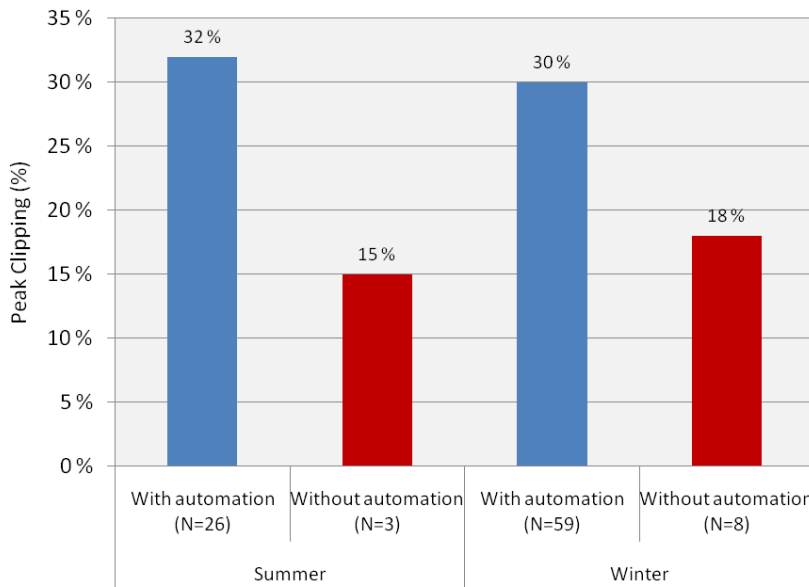
Participant feedback and information:

- Proactive: 38.9% of the participants in the case study indicated that they looked at the monitor at least once a day
- Future outlook:
 - 11 months after the initial trial, 264 participants received an e-mail asking them to participate in an online follow-up questionnaire. Of the 189 respondents, 93 had kept the monitor after the trial, and 96 had returned it.
 - Of the 93 respondents who kept the monitor, 80 indicated they still had a functional monitor in their homes, which was also in use
 - 17 of the 80 respondents indicated they used the monitor less than during the initial four-month trial, but 53 respondents said they checked it daily at a fixed moment in time.
 - Overall performance of Monitor: only 5% gave the monitor a negative' or 'very negative' score on ease of use after installation

Source: Van Dam, S. S., Bakker, C. A., Van Hal, J. D. M. (2010). Home energy monitors: impact over the medium-term. Building Research & Information. 38:5, 458–469.

4.2 Climate and season of peaks

Figure 11 : Peak season and peak clipping



Climate and the effectiveness of particular programs are often related. In order to measure the impact of different climates on the pilot results, we divided the samples according to whether system peaks tend to happen in the summer (California, Victoria etc...) or in the winter (France, Finland etc...). The rationale behind this variable is that extreme temperatures tend to cause more severe peak consumption hours either due to high usage of air conditioning or electric heating. However, the same appliances also provide a good single source of

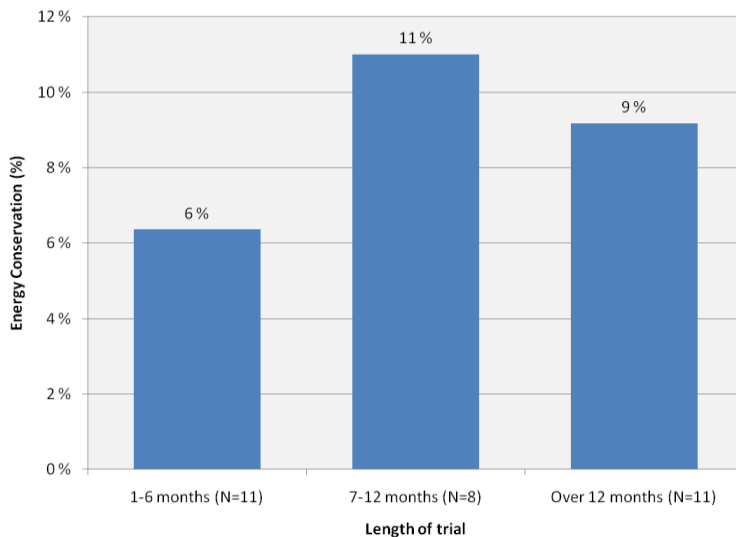
shiftable load. There is a wide spread assumption that people reduce a higher share of their load in warm climates than in cold ones (i.e. participants are more willing to feel abnormally hot than cold at home). Figure 11 shows the impact of CPP and CPR prices depending on whether critical peaks took place in the summer or in the winter. Our research indicates that the deciding factor is not hot or cold climates but automated sources of load. Indeed, when sources of load are automated (in blue), the impact of CPP or CPR prices is very similar whether peaks took place in the summer or in the winter. Although the sample size requires caution, it seems that even in the case where participants have to respond manually to critical peaks (in red), the difference between summer impact and winter impact is not large. Even though peaks tend to happen in the summer in hot climates and in the winter in cold climates this is not always the case. To conclude, it seems more appropriate to mind whether system strains tend to happen in the summer or in the winter (or any time during the year) rather than if participants are located in a hot or a cold climate.

4.3 Length of pilot

There has sometimes been discussion as to whether a program will continue to have an impact on consumer behaviour after it ends. In order to better understand this dynamic, pilot results were compared according to their length. However, our results show that, with the exception of the TOU pilot samples, longer pilots have similar or higher results than shorter ones. In theory, as participants must notify the organizers of their interest in taking part in the pilot and go through an application and selection process, this increases their interest in the program. Furthermore, the technology provided is also new and interesting. Therefore the first 1-3 months can have higher levels of consumption reductions than the rest of the pilot. If pilots terminate after 3 months results may be artificially high. After this point interest and results lower as new habits have not yet formed, the existing household equipment has not been replaced

and the newness has worn off. For longer periods of time, new habits have time to form and the incentive to buy appliances able to adjust to different electricity prices increases.

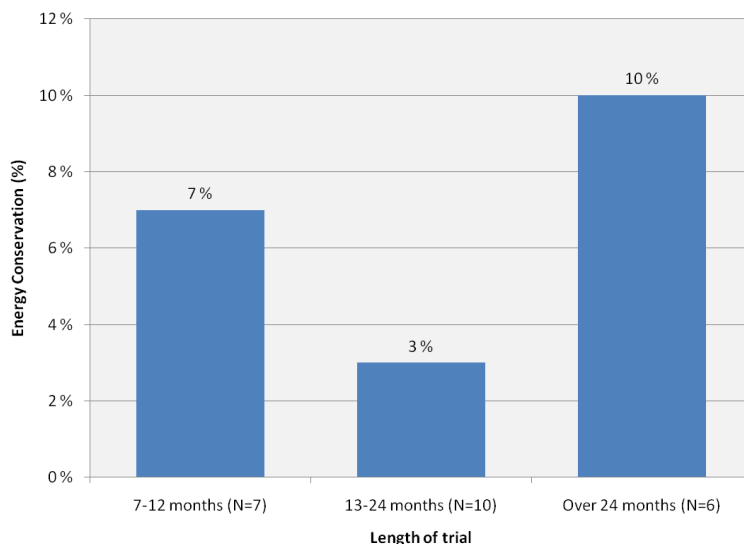
Figure 12 : Duration of IHD pilots and energy conservation



Longer lasting IHD pilots seem to yield better results than pilots lasting for half a year and less. This may be due to the technical nature of using an IHD. A new IHD device requires time for participants to adjust to the new display, understand the information on show as well as making it into a daily routine. It could also be explained by the fact that the longer the pilot went on, the easier it was for participants to notice a trend in energy consumption and directly link their action to their energy usage which might motivate them to continue or

increase their energy saving activities. More details about the learning process is given in section 4.6.

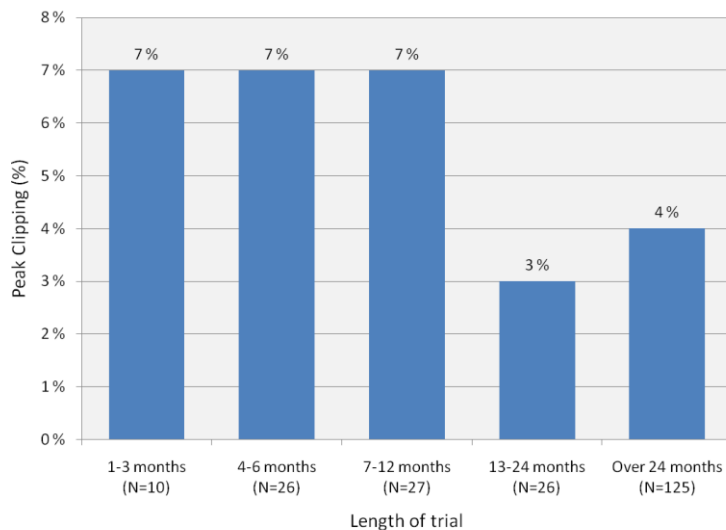
Figure 13 : Duration of informative billing pilots and energy conservation



We can see from figure 13, that pilot influence does not lower over the long-term. There seems to be a slight dip during the medium-term (13-24 months), however, energy conservation peaks once again when the pilot lasts more than 24 months. The potential reasons for this could be that customer's habits change, and increased awareness leads to more energy efficient purchasing choice. Apparently the learning process takes more time for Informative billing as for IHDs.

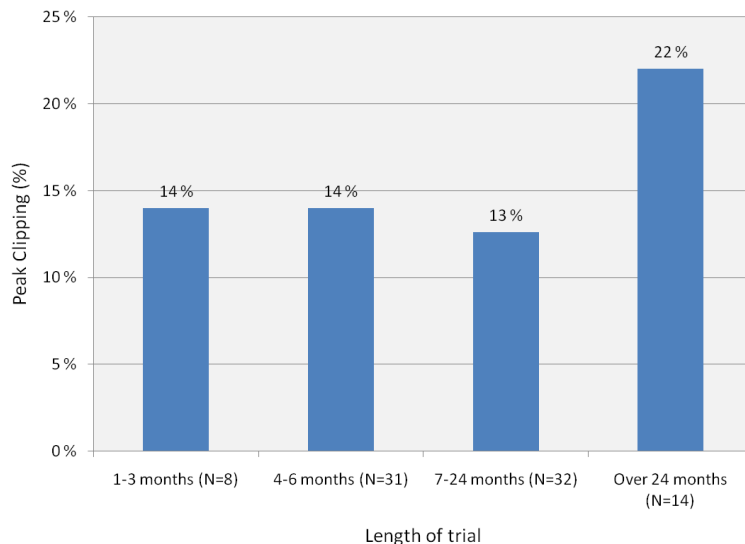
As mentioned above for IHD, we can determine that the greater the lengths of time, the more likely participants notice a positive trend in their consumption savings (easier for them to make historical comparisons). Longer pilots also give an opportunity for participants to develop an energy saving “habit” of keeping track of their consumption, and gaining awareness of their role in saving energy.

Figure 14 : Duration of TOU trial and peak clipping



The duration of the trial does not have a clear effect on the results of pricing pilots (see figure 14 and 15). Regarding the TOU trials, results in terms of peak clipping go down after 12 months but seem to be increasing again after 24 months. The reasons for this pattern are not clear and would require additional research. About half of CPP and CPR pilots lasted between 1 and 6 months and therefore focus on one season, understandably the season when the network is most likely to be under strain. Overall, it seems that CPP and CPR pricing impact does not falter with time.

Figure 15 : Duration of CPP and CPR trial and peak clipping



Case Pilot 2: The Canadian BC Hydro Advanced Metering Initiative (AMI)

Pilot Information: was conducted in 2007 for a period of 6 months and with a total of 2,000 residential participants.

Offering/promotion: "more control over electricity costs; and potential savings on electricity bills" and pilot "guaranteed" no increase in overall billing as part of the pilot agreement

Aims of the pilot: Gain an understanding of customer needs for information about and acceptance of available and affordable ways to save energy

Feedback information: Education and interviews during pilot, IHD feedback (hourly updates), and feedback information consisted of current up-to-date consumption and cost (bill).

Overall consumption reduction: 8%

Participant feedback and information:

Uptake rate: n/a. However, 2,070 pre-pilot surveys were sent to participants and 1,720 pre-pilot surveys were completed for a response rate of 88%. 1,870 post-pilot surveys were sent to participants yielding 1,305 completions for a 70% response rate.

Proactive: pilot participants were proactive in voluntary opting-in to the pilot. About 50% of them report having used the monitors at least several times each week in the first month of the pilot. This proportion, however, decreased to about 40% in the final two months.

Participant satisfaction: 81% assess their overall experience with the pilot as either "excellent" or "good".

Future outlook: 83% of treatment group participants indicate that they either "definitely would" or "probably would" continue for a second year of the program next fall if it is offered under the very same set of conditions

Overall performance of monitor: 43% rate it favourably and 31% rate in unfavourably.

Source: Sulyma, I., Tiedemann, K., Pedersen, P., Rebman, M., Yu, M. (2008). Experimental Evidence: A Residential Time of Use Pilot. ACEEE Summer Study on Energy Efficiency in Buildings.

4.4 Number of participants

There is some concern that pilots do have enough participants to provide conclusive evidence about the potential of smart meter enabled programs should they be offered to the general population. Many small pilots, of 50 households or less, have been carried out in Europe and it has sometimes been questioned whether the results can be translated into real programs for a large number of customers.

Figure 16 : Sample size and energy conservation in IHD pilots

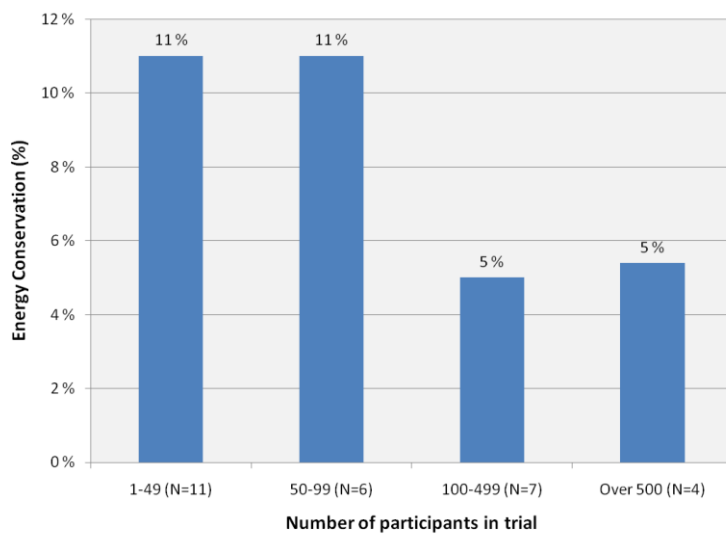


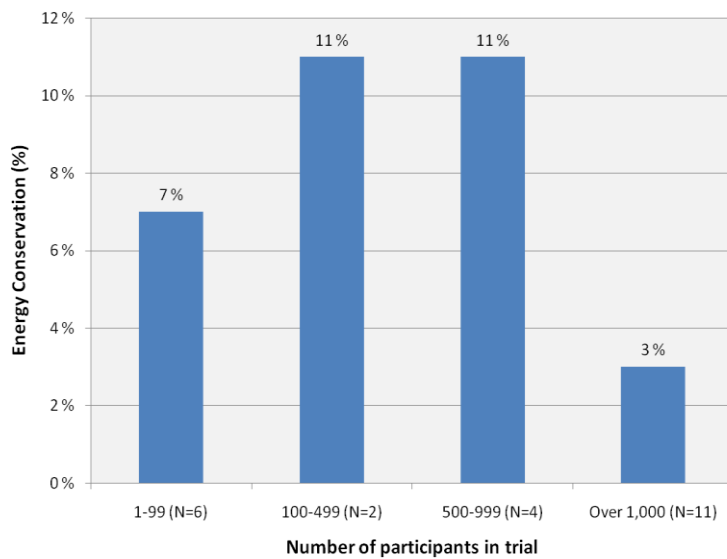
Figure 16 suggests that there is a direct correlation between the number of participants taking part in an IHD pilot and the reduction in electricity consumption. It may seem that the smaller the number of participants, the greater the level of consumption reduction.

However, this does not automatically mean that pilots with a large number of participants are not successful and do not provide a foundation for future initiatives. Our research shows that the largest pilots have mostly focused around offering only one type of feedback

information to the participants (possibly as an attempt to limit costs). To the contrary, the vast majority of the pilots with smaller number of participants offered at least two different forms of feedback on their displays. Almost 40% of IHD pilots had less than 49 participants.

Further analysis should be performed on how to maximize response rates within larger groups of customers, perhaps this could be achieved through offering a multi layered form of feedback such as that which has so far usually been used in smaller trials.

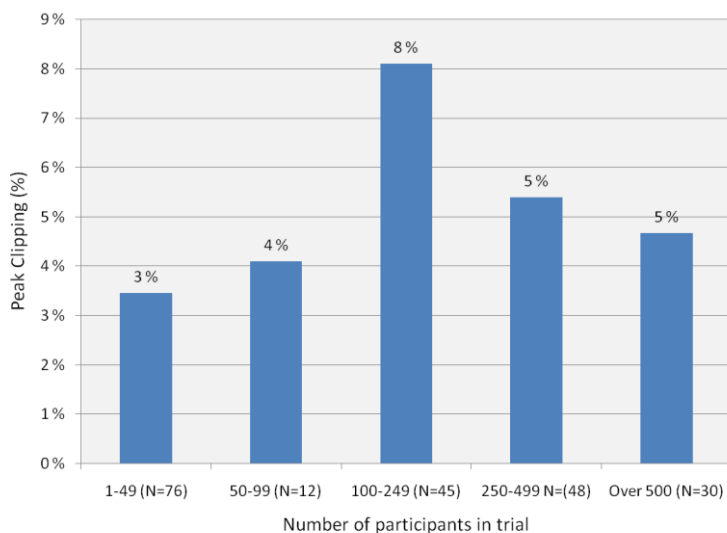
Figure 17 : Sample size and energy conservation in informative billing pilots



Unlike with IHD pilots, with almost 40% of the samples including less than 49 participants, almost 50% of informative billing pilots had over 1,000 participants, and those pilots reduced energy consumption by about 3%. Figure 17 seems to show that the number of participants in informative billing trials have a direct effect on the results which seems to corresponds to the previous graph. The level of energy conservation is highest under 1,000 participants and in the other 11 samples (over 1,000 participants) energy conservation rates are more moderate. Nonetheless, this

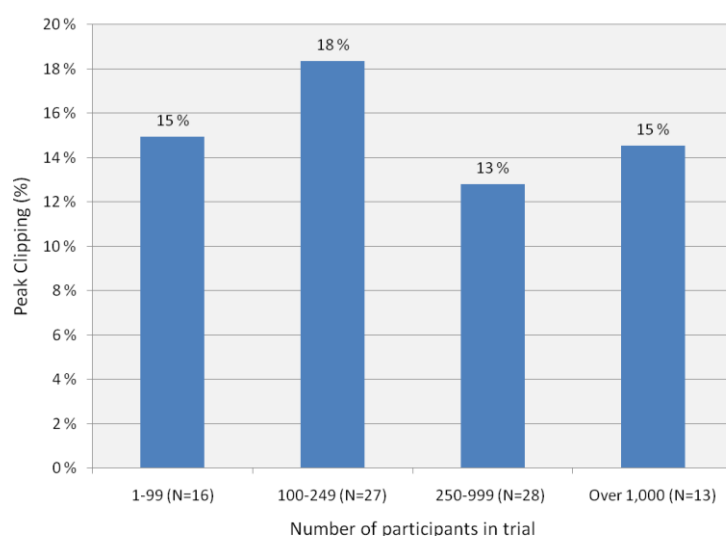
cannot be taken as the final conclusion as pilots with lower numbers of participants usually incorporated a higher number of types feedback in their informative bills. However, even taking the more moderate consumption level as a base scenario (taken as a national level) – a 3% consumption reduction through informative billing would be seen as dramatic and highly successful. O'Power in the USA is currently achieving reductions of between 1 and 2.5% depending on the market with over 1,500,000 consumers.

Figure 18 : Sample size and peak clipping in TOU trials



Figures 18 and 19 show that sample sizes have only a minor effect on the effectiveness of dynamic pricing pilots. It seems therefore plausible to say that pilot sample size does not significantly influence pricing pilot results.

Figure 19 : Sample size and peak clipping in CPP and CPR trials



The results of the comparison found that feedback pilots seemed to be adversely effected by a large sample size while pricing pilots were not. Further analysis of the pilots would be required to better understand what about the large feedback pilots lowered their impact and why this trend was not repeated in pricing pilots. One possibility may be that the larger IHD pilots tended to offer simpler less informative display and less information on the their displays whereas smaller IHD pilots offered more detailed informative on their displays. It may also be due to issues of mass marketing and engaging the interest of a larger number of customers in feedback displays and informative bills. In contrast, it is interesting that pricing pilots do not seem to be as impacted by pilot size. Pricing pilots offered a more even level of services both in the larger and the smaller pilots. One conclusion to draw from this is that feedback to large groups should avoid becoming “cheap feedback”. Even when offered to a large number of customers the quality and detail should be maintained as far as possible. It also brings up the importance of program uptake levels and appropriate consumer segmented marketing and education campaigns. This will be dealt with in further details in the following sections.

There is a very interesting dynamic between offering feedback with pricing. Pricing mechanisms seem to be an easier program type to communicate to large numbers of consumers, while including feedback in a pricing program will enable participants to both shift peak consumption and lower total consumption. More large pilots of 5,000 residents or more should be carried out in Europe with pricing and education could be combined in an effort to learn how to best maximise customer involvement within a large consumer group and at the same time maximize program results. Further research would also be needed to better understand the mass-education and mass-marketing requirements for both feedback and pricing programs.

Case Pilot 3: Sacramento's Residential Energy Use Behaviour Change Pilot (also known as the SMUD trial)

Pilot Information: was conducted in 2008 for a period of 20 months and with a total of 35,000 residential participants

Feedback information: Education was in the form of targeted tips that are customized based on the known demographic and housing type, and surveys were conducted at the beginning and at the end of the pilot. Feedback format was in IHDs and the feedback information was peer comparison, current up-to-date consumption, and historical comparison, presented in the forms of graphs and numbers.

Overall consumption reduction: 2.5%

Participant feedback and information:

Uptake rate: 800 of 35,000 decided to opt out, demonstrating the broad reach of this type of program (as compared to opt-in programs such as customer purchase/installation of in-home feedback monitors)

Proactive:

- Program manager reports increased customer engagement, requests for additional tips
- Taps into competitiveness (e.g., "I'm closing the gap between me and my neighbours")

Negative reactions: Few very negative reactions from customers that take offense to the comparative feedback-e.g. "you don't have the right to tell me"

Additional findings: Significantly higher savings achieved by:

- Higher energy consumers
- Green energy (renewable energy) customers
- Indication of correlation of higher savings for lower income population

Source: Summit Blue Consulting (2009). Impact Evaluation of Opower SMUD Pilot Study. Final report.

4.5 Participant segmentation

Customer segmentation involves dividing up a customer group according to differing variables – often this is done according to what technology the household owns (electric heating or cooling for example). When customers are segmented according to technological factors, the aim is usually either to find customers with particular load profiles or to better match the piloted technology with what is in the home. Customer can also be segmented according to social factors such as age, education, income, environmental interests etc¹². When this is the case, the program managers are trying to identify who reacted best to the program and who might be most interested during rollout. In order to maximize benefits from segmentation studies carried out during piloting, utilities can then create directed marketing messages and education techniques to fit a variety consumer segments.

Pilots that carry out customer segmentation tend to have better results than those who do not. However, customer segmentation is done in order to improve rollout results not pilots. It helps utilities improve programs to fit certain segments, design marketing and messaging campaigns. Successful programs have succeeded in meeting customers' knowledge levels and interests. The closer the gap between the knowledge level of the customer and the messages delivered by the program, the more successful it will be. Different customers have also joined a program for various reasons and will therefore be engaged by different information. Taking this into account becomes a central rather than side issue. Any smart meter enabled program rollout is costly and entails risk. It requires technology, data-handling and marketing. The cost/benefit of a program will therefore be directly impacted by the number of end-customers who successfully engage with it. Different customer segments will view the same information in different ways. This is a challenge but it has also holds potential for utilities willing to learn about their customers. It means however that though customer segmentation may not be a key focus during piloting, it will be the key to a successful program rollout. It will progress from a peripheral issue to being central. This should translate into serious research being done during piloting on not only the main load sources within the home but also on social, cultural and economic factors that may enable the creation of targeted messages and marketing campaigns.

Regarding the pilot review, our results indicate that customer segmentation does not improve pilot results unless it looks into what type of heating, cooling or other large sources of load are present in the house. Other reviewed types of segmentation include social factors such as age, income, education, household size, load profile and environmental factors such as house type, house size, house age etc.... If these could be very important during roll out, they do not have an impact on pilot results. However, it is interesting to note that only a minority of pilots were not only interested in factors related to electricity usage but in participants themselves which was captured by the social and environmental factors described above. In other words customer segmentation has actually rarely involved the customers but only their heating/cooling systems and consumption profiles. Pilot organizers rarely looked for information about who was living in the house and using the central air conditioning. It means that few pilots have been able to design targeted messages to particular customer groups in the way Amazon sends practically individualized messages and advertisements to their customers.

¹² An example is the Carbon Trust Field trial in the UK, which used segmentation to determine suitable samples as per electricity usage as well as electric heating.

All this seems to indicate that the reason behind the apparent irrelevance of social and environmental factors to the success of a pilot is not the lack of potential but the fact that it has rarely been done and when it has, it has rarely been used beyond statistical purposes in order to for instance develop targeted messages delivered to specific groups of participants.

4.6 Participant education

One of the main findings of the research is the central place of successful communication techniques in successful programs. An important element in this is customer education material and messaging, which largely revolves around educating the customer about the program and energy conservation, as well as providing tips and advice to better prepare the customer.

Understanding the experiential learning cycle of customers is not a purely academic exercise. Insight into how consumers learn, why feedback and pricing work, maximizes the impact of pilot studies and will eventually improve rollout results. Electricity is consumed as an invisible by-product of whatever is the main activity. Customers do not consider reading a book as an electricity consuming activity however, it often is. Electricity is consumed when consumers talk to friends on mobile phones, when they take showers, when they make toasts. Yet as electricity is never the focus of these activities customers are unaware of the direct impact an activity has on their consumption levels.

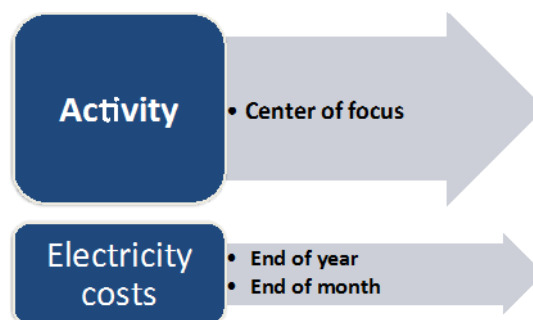


Figure 20: Current understanding of consequences of electricity consumption

As figure 20 depicts, the activity choices and costs never connect in the users' mind. In order for consumers to change their behaviour they need to connect these two and become aware of the consequences of their actions and motivated to adjust.¹³ A theory of experiential learning applies as one method for better understanding the mechanisms of this process.

Experiential Learning

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,

¹³ Within the electricity industry this is seen as the greatest barrier to successful energy saving and other efficiency programs (Darby 2006, Stromback 2010, Mourik 2009). Research carried out by the UK Economic and Social Research Council in 2004 concluded that 16 MtC could be saved in the domestic sector with a payback time of less than 5 years but that a major challenge remains in motivating behavioural change "A major area of research is how such a process of learning may be stimulated" (Darby 2006).

trying new experiments that further the idea of what they just learnt and noticing the results of those. The process is therefore cyclical and a spiral – the more upward turns people go through with experimenting and analysis, the more they learn.

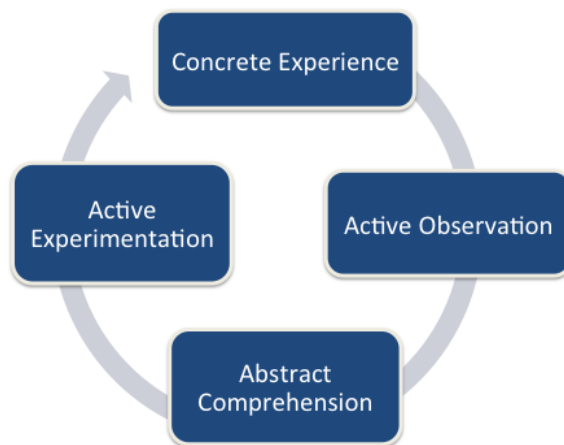
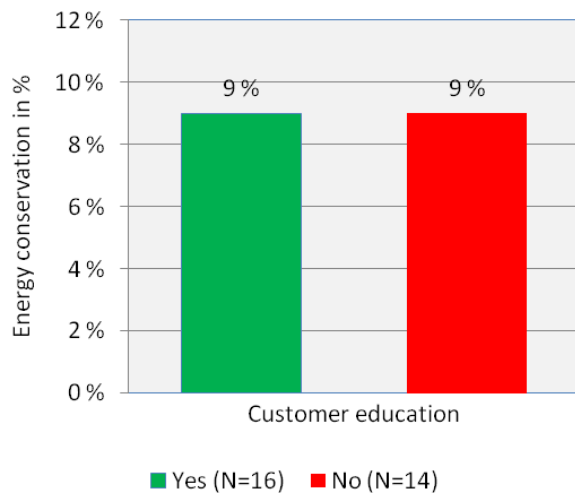


Figure 21: Kolb's experiential learning cycle

An example of the experiential learning cycle in action has been analysed by researchers developing displays at YelloStrom, Onzo and the Interactive Institute as they observed and interviewed customers 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. He actively observes what the display does (step 2), comprehends that 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 he turns on the lights or his daughter's hair dryer. This in turn leads to new realizations (hair dryers use a lot more electricity than lights) and a new cycle has started. This next cycle is actually teaching not only about the display but about how much different appliances use.

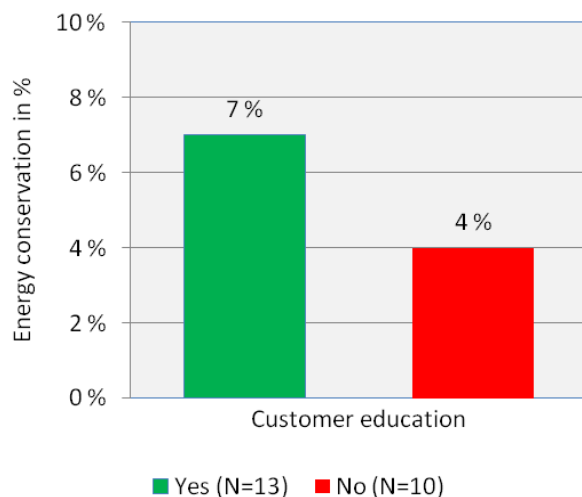
Education in feedback pilots

Figure 22 : Influence of education on energy conservation in IHD trials



As figure 22 shows, the use of education¹⁴ on IHD pilot participants has a negligible difference on their overall consumption reduction. IHDs offer enough opportunities to learn through the experiential learning cycle such that extra education is not as useful. Indeed, IHDs allow consumers to directly link their actions to their consumption in real-time. Provided that the display is user-friendly, consumers may learn a lot about their energy usage by "playing" and testing the display.

Figure 23: Influence of education on energy conservation in informative billing trials

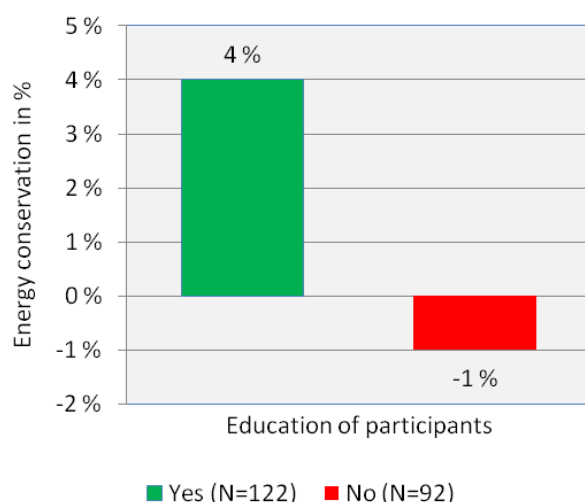


Informative invoices alone do not offer much opportunity for learning as the experiential cycle mentioned above for IHDs is not applicable for invoices. The results suggest that education is important in order to achieve better results when introducing informative billing. Due to its static nature, informative billing generally is more complex and needs more explanation than IHDs.

¹⁴ The Education material varied between pilots but tended to focus on energy saving tips, energy awareness, environmental issues, and advice on how to use IHDs.

Education in pricing pilots

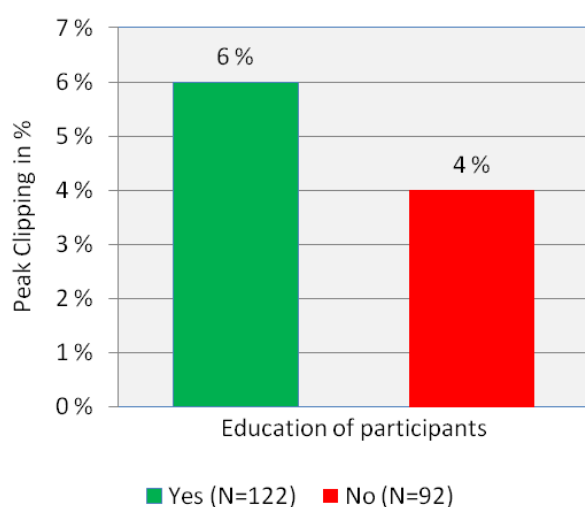
Figure 24 : Influence of education on energy conservation in TOU trials



Giving customers new dynamic tariffs and not taking the time and effort to properly explain them how to take advantage of them is to expose the program to a backlash as participants are unlikely to know how to adjust their behaviour and would therefore not be able to save energy and money. Well designed pricing pilots also put an emphasis on informing and educating their participants about the workings and advantages of dynamic tariffs and how to best benefit from them. Education materials in dynamic pricing pilots often take the form of brochures or websites containing conservation tips and are sent at regular intervals. In the case of TOU pilots, the organizers also need to make sure that participants are aware of the

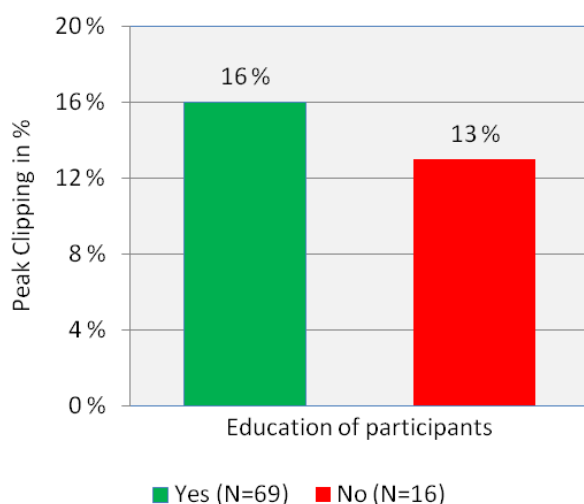
different prices of electricity during the day (fridge magnets and stickers have proved cheap and efficient¹⁵). Information meetings were also organized in some pilots. Participant education clearly determines the success or failure of TOU pilots in terms of energy conservation (see figure 24). It also has a significant impact on peak clipping since participants who received education decrease their on-peak consumption by an extra 50% for TOU pilots (see figure 25) and by an extra 23% for CPP/CPR pilots (figure 26) over participants who did not receive any education. It is interesting to note that only 57% of participants in TOU trials were told how to benefit the most from the new pricing structure whereas over 81% of participants in CPP/CPR trials were. As the results show, education is paramount to a successful pricing pilot. Its impact on different key factors of success will be further investigated throughout the report.

Figure 25 : Influence of education on peak clipping in TOU trials



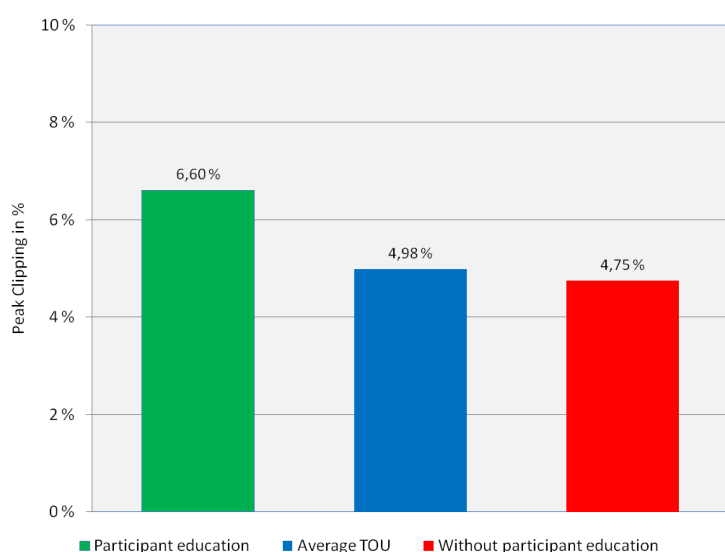
¹⁵ "The Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report" provides a good example of this.

Figure 26 : Influence of education on peak clipping in CPP and CPR trials



Pilot results indicate that households with AC conserve less electricity in percent than average but shift as much load during peak times.

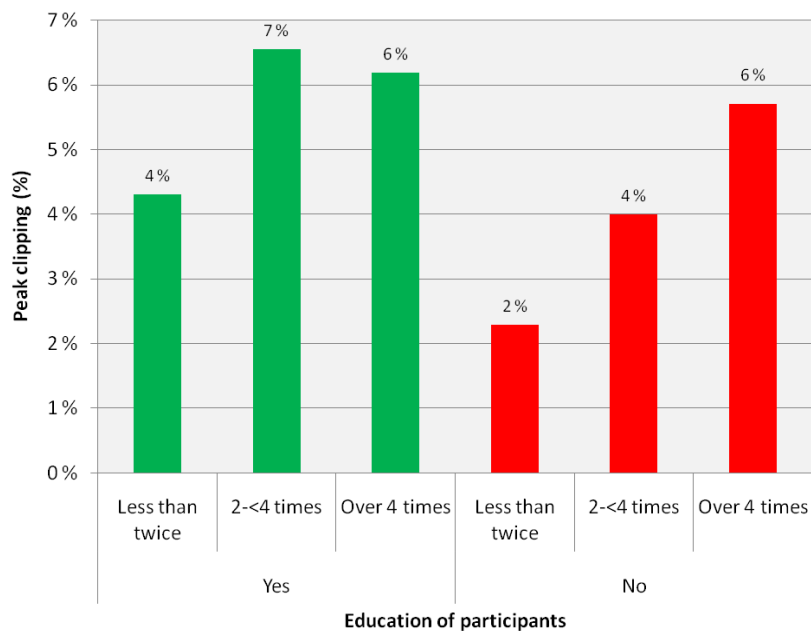
Figure 27 : Influence of education on peak clipping for participants with air conditioning (TOU trials)



However, as shown by figure 27, education of participants has a decisive impact on the results. It shows that households with air conditioning manage to reduce consumption at peak times by 6.6% when price signals are coupled with education whereas they manage to decrease consumption at peak times by only 4.75% when only price signals are used without education. Despite this intuitive fact, only four samples out of twenty two received some sort of education.

Pilot results indicate that overall, customers decrease consumption as the price differential between peak and off-peak prices rise (see section 4.9), however, the level to which they do so depends on a variety of factors which is why peak clipping does *not* increase in proportion of the price differential. Although price differentials are important motivators it cannot be used to the exclusion of other factors. Following this logic, an interesting finding arises if we separate participants subjected to the same price ratio between those who were told how to best benefit from dynamic tariffs (what we refer to as education in this report) and those who were not.

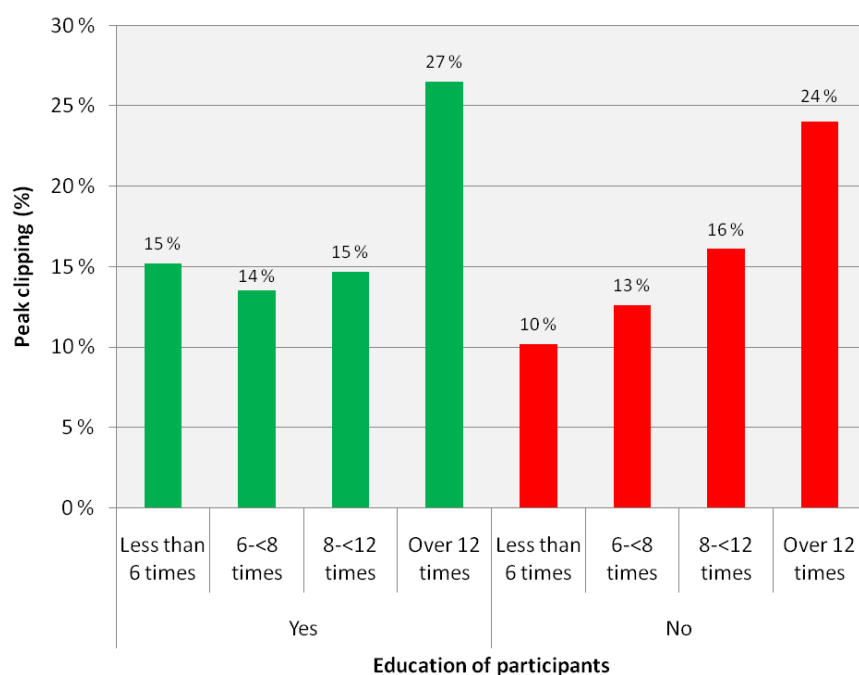
Figure 28 : Influence of education on response to price multiples in TOU trials



Figures 28 and 29 show that higher price differentials matter more if participants are not “educated”. Indeed we can see that “uneducated” participants switch more load as the peak / off-peak ratio increases (in red in the graphs). On the other hand, “educated” participants seem to consistently switch more load and the amount is unrelated to the peak / off-peak ratio (in green in the graphs). To conclude, education of participant seems to be as strong a motivator to peak clipping as the price ratio itself.

	With education	Without education
Less than 6 times	N=9	N=2
6-<8 times	N=30	N=2
8-<12 times	N=13	N=2
Over 12 times	N=6	N=2

Figure 29 : Influence of education on response to price multiples in CPP trials



	With education	Without education
Less than twice	N=14	N=18
2-<4 times	N=68	N=60
Over 4 times	N=40	N=14

In Europe, creating dynamic pricing programs can be a challenge due to the fact that consumption patterns are relatively flat and this may mean that the price differentials (the difference between base and peak price) may not be strong enough to create motivating TOU or CPP programs. Thus, if customers are not "educated", it may mean that in markets such as Great Britain and Germany where peak consumption is relatively flat, dynamic pricing programs would be ineffective. However, provided that customers are "educated", they will not react only to multiples of the base price and programs which do not have high price differentials can still be effective.

Case Pilot 4: Educating participant how to benefit from dynamic pricing

Pilots Information:

Ontario Energy Board Smart Price Pilot (2007) with 375 participants

Electricity Smart Metering Customer Behaviour Trials Findings (2011) with 3,958 participants

PowerCents DC program (2010) with 900 participants

As emphasized throughout this report, participant education is paramount to pilot's success. Well designed pilots put an emphasis on informing and educating participants about the workings of the dynamic tariffs and how to best benefit from them. Education of participants in dynamic pricing pilots often takes the form of brochures or websites containing conservation tips. These are sent at regular intervals throughout the pilot. In the case of TOU pricing schemes, it also needs to make sure that participants are aware of the price of electricity at any time of the day. Information meetings are also organized as part of some pilots. The organizers of the above mentioned pilots ensured that participants understood the reason behind the pilot and how to adjust their behaviour to dynamic prices.

Recruitment package: During the recruitment process, eligible participants were provided with a recruitment package whose design was researched through focus groups. They included:

- Invitation letter to provide a brief introduction to the pilot and to describe its key features.
- Fact sheet to provide an explanation of all the key features of the pilot, show the specific prices, provide a sample of electricity usage statements to be received by participants and provide a sample of the final settlement that will be provided to participants.

Participant information package and meeting: Participants once enrolled received:

- Cover letter to confirm that the participant is enrolled.
- Refrigerator magnet and stickers provide prices, times and seasons for the participant's price plan (see annex 2a).
- Electricity conservation brochure and / or website access in which participants can find a variety of conservation tips and further description of the trial(see annex 2b).
- User guide to electricity monitor if IHDs are tested in the trial.

In addition, the PowerCentsDC pilot organized in person meetings just before dynamic prices went live.

Sources:

IBM Global Business Services, eMeter Strategic Consulting (2007). Ontario Energy Board Smart Price Pilot. Final Report. Prepared for the Ontario Energy Board.

Commission for Energy Regulation (2011). Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report.

EMeter Strategic Consulting (2010). PowerCents DC Program Final Report. Prepared for the Smart Meter Pilot Program, Inc.

4.7 Interaction with participants (interviews, surveys and meetings)

Researchers sometimes conduct interviews with pilot participants to gauge their reactions to the pilot and to better understand how a pilot could potentially be improved¹⁶. Interviews might also be conducted during a rollout in order to better understand customer reaction and perhaps to either improve the offering, gain insight into potential new products or understand better how to improve the education or marketing packages. In pricing pilots, the impact of interviews, surveys and group or individual meetings is surprisingly similar to the effects of feedback. It is not to say that one can be a substitute to the other but they have in common the attribute of keeping participants interested and motivated.

Most pilots interviewed participants over the phone or sent them one or more questionnaires by mail or e-mail¹⁷. Some pilots organized focus groups or even individual interviews. These interviews often aimed at gathering data about the households' size, appliance ownership, etc... for statistical purposes. However the better pilots¹⁸ took advantage of being in touch to gather participants' views on the pilots looking for problems that may have arisen, criticism and asked for opinions as to how to resolve them. It then becomes possible to adjust for instance the way feedbacks are presented or the way participants are notified of critical events over the course of the pilot. It has been demonstrated that conducting interviews causes a peak in the interaction with IHD¹⁹. Overall pilots which included interviews with participants had higher results than those which did not. However the results seemed to be somewhat different between feedback pilot types and the results were seen as inconclusive as to when exactly an interview or interaction was best carried out.

Though interaction with participants improves program results as it helps to maintain engagement, interviews will not be stimuli which are repeatable during rollout. It may however encourage utilities to; for example, have an extra education campaign or launch new services after a program has already been launched which should help to maintain the cycle of learning and customer interest.

¹⁶ The majority of interactions with the participants during pilots were before and during the programme, only 18% of the samples researched conducted post-pilot interviews.

¹⁷ The "*New approaches for household energy conservation*" pilot in the Netherlands is an example of post-pilot interactions, with participants providing feedback via surveys.

¹⁸ See for example the "*Final report for the Mypower pricing segments evaluation*" prepared for the Public Service Electric and Gas Company.

¹⁹ An example of the experiential learning cycle in action has been recorded by researchers developing displays at YelloStröm, Onzo and the Interactive Institute, when they observe and interview customers who are given displays.

Case Pilot 5: Interaction and participant involvement (survey, interviews, meeting, support) in pricing pilots

Pilots Information:

Ontario Energy Board Smart Price Pilot (2007) with 375 participants

Electricity Smart Metering Customer Behaviour Trials Findings (2011) with 3,958 participants

MyPower pricing segments evaluation (2007) with 698 participants

Involvement at an early stage: The organizers of the Irish Electricity Smart Metering Customer Behaviour Trial involved potential participants at a very early stage. Potential participants were involved in the design of the time of use tariffs, the energy usage statement and the electricity consumption monitor during focus groups.

Meetings: The Ontario Energy Board Smart Price Pilot organized three focus groups and a survey in order to gather participant feedback. In addition the implementation team provided both telephone and email support for participants.

Regular update: As the MyPower pilot progressed; participants received program updates and information via mail and/or email. Participants were reminded of steps they could take to save energy and shift usage to lower price time periods. Prior to the summer months, participants were sent reminder letters and asked to verify and/or update their contact information to ensure they would receive critical peak notifications. Participants with smart thermostat were provided with their thermostat set-points for cooling to enable them to review their settings and program their thermostat to maximize savings during the summer high and CPP periods.

Participant feedback: Regarding the Ontario Energy Board Smart Price Pilot, the majority (78%) of survey respondents would recommend the Time-Of-Use pricing plan to their friends, while only 6% would definitely not. Respondents most frequently cited more awareness of how to reduce their bill, gaining greater control over their electricity costs and environmental benefits as the top three reasons behind recommending time-of-use pricing. While interest in the CPP and CPR plans was only moderate, less than 20% prefer the existing two-tier pricing used by Hydro Ottawa before the pilot. Most would not want to go back to two-tier pricing

Sources:

IBM Global Business Services, eMeter Strategic Consulting (2007). Ontario Energy Board Smart Price Pilot. Final Report. Prepared for the Ontario Energy Board.

Commission for Energy Regulation (2011). Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report.

Summit Blue Consulting (2007). Final report for the Mypower pricing segments evaluation. Prepared for the Public Service Electric and Gas Company.

4.8 Feedback information content

IHD trials as per feedback content

Every IHD pilot taken into account in the study offered up-to-date consumption levels as a form of feedback to the participants. The second and third most offered form of feedback were historical comparison and cost (bill) respectively. Though one can understand the advantages of offering up-to-date consumption levels on an IHD, it is interesting to note that up-to-date cost (bill) was only offered by a little over half of the pilots. However, historical comparisons has proven to be very useful information as they have achieved 10.4% energy conservation in comparison to pilots that did not (they achieved 6.8%), and several post-pilot surveys highlighted the positive reaction from participants.

It also seems that peer comparison is less effective. This may be because often, especially on informative bills, the categories are inappropriate. Households are compared to homes in a neighbourhood including those of a different size, age, type, etc. If comparisons are to be made then it must be to households of a like description and only for consumers who use more than their neighbours.

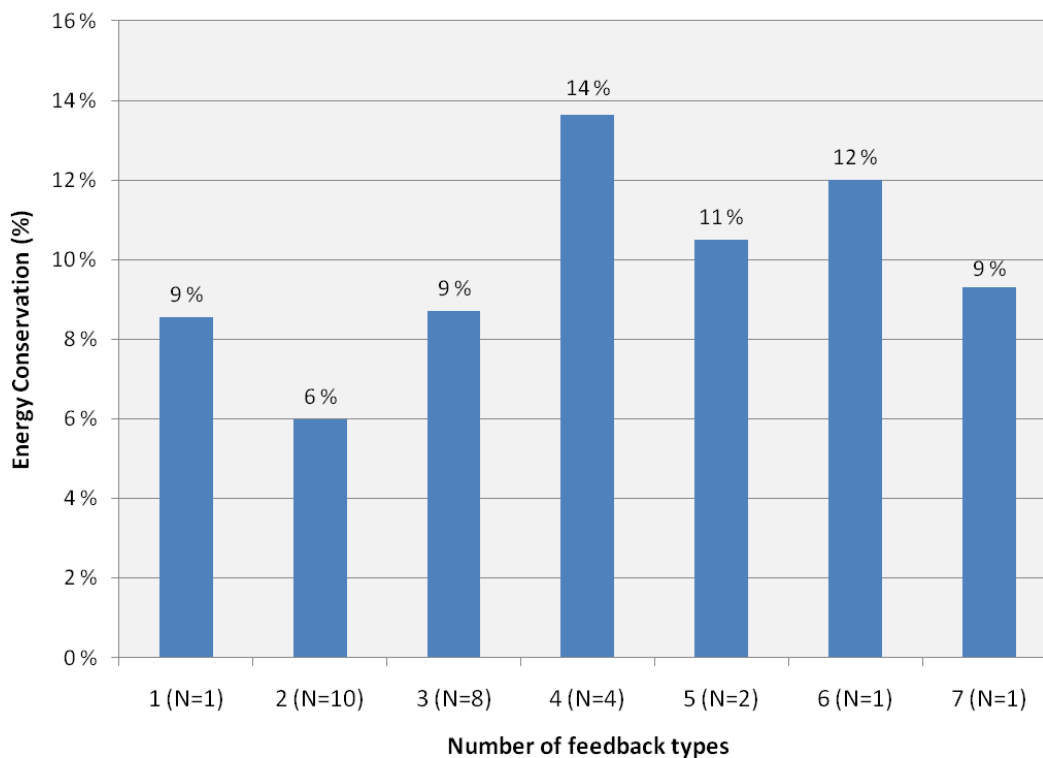
Almost without exception, every form of feedback information led to a higher level of consumption than when it was not offered. In a sense, all forms of feedback enable participants to lower consumption, the key issue being, what offers the most reduction and which ones did the participants react to favourably. An additional point of note, 64% of the IHD pilots used a combination of 2-3 different forms of feedback information. In only 12% of the cases, one type of feedback was offered (up-to-date consumption).

Energy conservation of IHD as per number of feedback type combinations

81% of the IHD pilot samples offered a combination of 2-4 types of feedback to the participants. In Figure 30, we can see that the best combination seems to be 4 different types of feedback. The three most common types of feedback for IHD pilots that offered 3-5 different types of feedback were up-to-date consumption, historical consumption, and cost (bill)²⁰.

²⁰ Up-to-date consumption was provided by every single IHD programme, historical consumption was offered by 56% of the IHD programmes, and cost(bill) was provided in 53% of all the IHD programmes.

Figure 30 : Number of feedback type and energy conservation



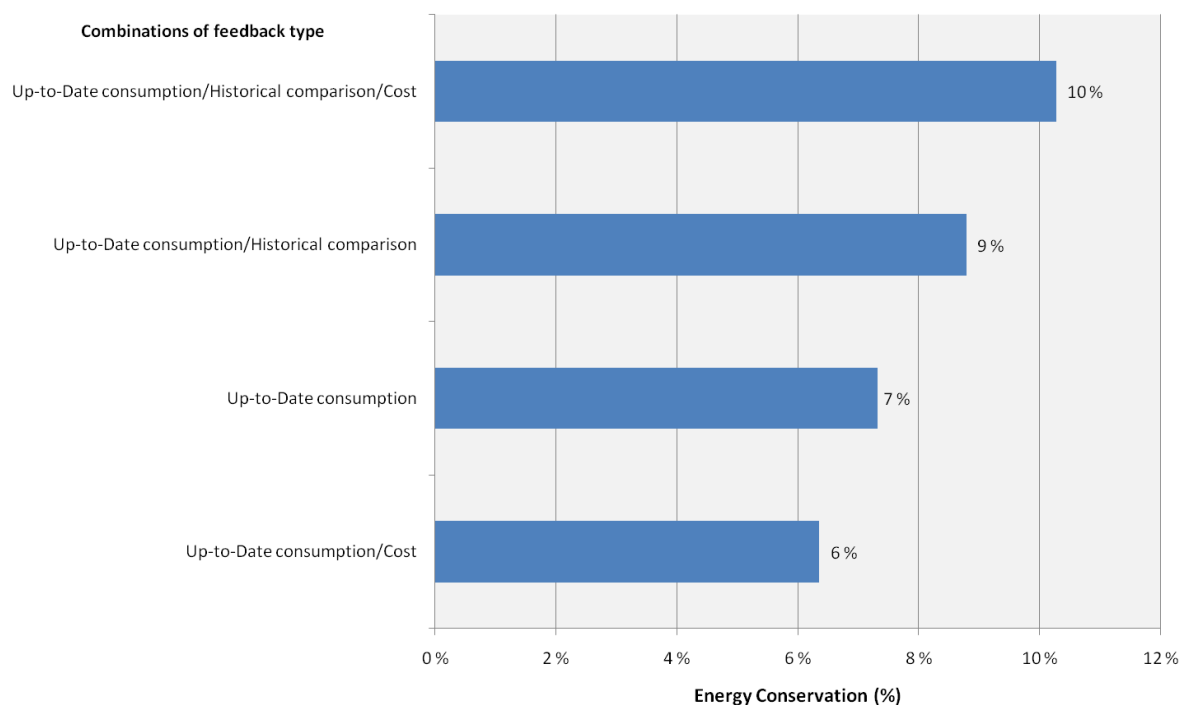
IHD trials as per three most used feedback contents

Figure 31 below, offers a further insight into the combinations of the three most used feedback type as used by IHD pilots. The highest level of consumption reduction is achieved when a combination of up-to-date consumption, historical consumption and cost (bill) are offered to participants. These three forms of feedback lead to the highest energy conservation level (10.3%) than any other combination, and more than any other feedback format (that was offered by more than 3 pilots). What participants respond to best, and what they value most in our review is:

1. Up-to-date consumption level (i.e. how much energy they have used between the last bill and now)
2. Up-to-date cost or bill (i.e. how high is their bill since they last paid)
3. Historical consumption (i.e. how much electricity have they used during this period compared to the previous periods)

However, it must be emphasized that the pilot samples are too small to provide a definitive result between these particular feedback content variables and program results. What is indicated is that there may be a connection between content information and program type results and that this area should be researched further.

Figure 31 : Three most common feedback type combinations in IHD pilots and energy conservation



Sample size	
Up-to-Date consumption/Historical comparison/Cost	N=9
Up-to-Date consumption/Historical comparison	N=8
Up-to-Date consumption	N=6
Up-to-Date consumption/Cost	N=7

IHD trials as per feedback format

All the IHD pilots showed the information via numerical data²¹. The analysis showed that there is very little difference in consumption reduction when participants are shown feedback in the form of numbers or a combination of numbers and graphs. It seems that both formats offer good results, and certainly in the case of IHD Pilots, the presentation format does not seem to be the most importance in reducing consumption reduction.

Informative billing trials and feedback information content

The three most efficient feedback contents for informative billing seemed to be cost (bill), up-to-date comparison, and historical comparison. Up-to-date consumption feedback was offered in all the pilots. Considering they receive their informative bills on a periodic rate (varying between monthly and several times a year), participants may already have been storing their informative bills as a more practical way of keeping track of their historical comparison. As such, adding this form of feedback did not gain any additional changes in the results. A key note of interest, less than 7% of informative billing samples offered

²¹ In 33% of the cases, graphs and numbers were both used as a combination

cost (bill) as a form of feedback²². However, informative billing samples that received cost (bill), alongside other forms of feedback, produced the highest results. Clearly this could be an avenue for future analysis.

Feedback in pricing pilots

The role of feedback in pricing pilots somewhat differs from its role in pure feedback pilots described above. In pure feedback pilots, the role of feedback is primarily to raise awareness of overall consumption patterns within a household and encourage consumption reductions. Feedback in pricing programs is often seen as a tool which can raise awareness of critical peak periods thereby helping consumers to shift their consumption away from peak periods. Dynamic pricing programs encourage consumers to lower their consumption at certain times when prices are high. In practice, they may adjust the thermostat on an AC unit or electric heater, when prices decrease the appliance is turned back on at extra high until the temperature in the room is returned to normal. Also, they may put off turning on the dishwasher which they will turn on after the peak hours are over. There is therefore little room for energy savings, the aim being to shift load rather than lower total consumption.

Figure 32 : Impact of feedback on energy conservation in TOU trials

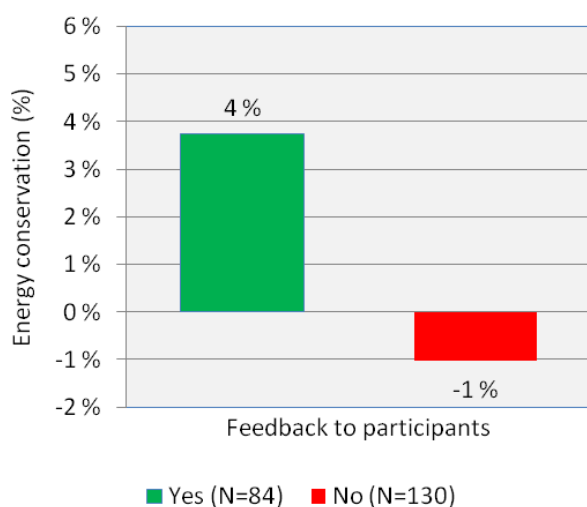
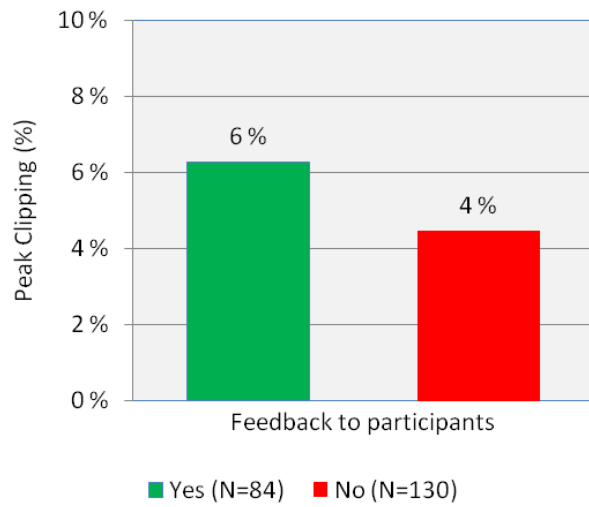


Figure 32 shows that providing participants with feedbacks (be it information about the price they are paying for electricity at different times of day, how much they are using, how much is their bill at regular intervals) seem to determine whether participants to a TOU trial will conserve electricity or not, in other words it determine the success or failure of a TOU pilot. Furthermore, reduction at peak hours is 40% higher when participants are able to somehow connect their actions to their level of consumption or their electricity bill through feedback (figure 33). Perhaps surprisingly given that the influence of feedback on customer

response is well documented, 54% of the samples did not receive any feedback about their usage besides their regular bills. Following this logic, real time and hourly updates (often displayed on IHDs or ambient displays) are most efficient at lowering overall energy usage in TOU trials as participants are able to see immediately the link between their actions and their electricity consumption.

²² It seems that the participants would receive an informative bill (with consumption levels, historical comparison and/or peer comparison), and a separate bill that only included their cost (bill).

Figure 33 : Impact of feedback on peak clipping in TOU trials



Feedback is therefore an important element in all pilot types and the connection between pricing and lowering overall energy consumption through feedback should be better researched and understood.

Case Pilot 6: The Irish Electricity Smart Metering Customer Behaviour Trials (CBT)

Pilot Information: was conducted in 2010 for a period of 12 months and with a total of 4,300 residential participants.

Aims of the pilot: The overall objective of the Customer Behaviour Trial was to Ascertain the potential for smart metering technology, when combined with time of use tariffs and different DSM stimuli.

To effect measurable change in consumer behaviour in terms of reductions in peak demand and overall electricity use.

The Residential Customer Behaviour Trial included the additional objective of seeking to identify a “Tipping Point” that is a point at which the price of electricity will significantly change usage.

Feedback Information

Interview: A survey was used at the beginning of the pilot with a €25 credit on their energy bill for completing it

Feedback format: A fridge sticker and magnet showing times of the day where electricity was the cheapest and most expensive. An electricity monitor was used too. In addition, informative billing was also used.

Feedback type: kWh hours savings, cost savings, historical consumption, and peer comparison

Overall consumption reduction: The data gathered from the Trial shows a reduction of 2.5% in overall electricity usage and 8.8% in peak electricity usage for residential participants on TOU tariffs and DSM stimuli relative to the control group.

Participant feedback & information:

Customer Behaviour: As a result of the trial,

74% of participants made minor changes to the way they used their electricity,

38% made major changes,

79% became more aware of the amount of electricity used by appliances,

78% became more aware of the cost of electricity used by appliances.

In addition, 75% found the fridge magnet to be useful and 63% found the stickers useful.

Monitor feedback: The electricity monitor was found to be effective and easy to use by most participants with 84% stating that it helped them to reduce the amount of electricity they used and 84% stating it helped them to shift usage.

Additional information: A finding of the qualitative research undertaken prior to the Trial was that residential customers are not good at estimating the proportion of their usage during peak or translating between a tariff and the bill impact. Therefore, it seems likely that the participants expect a much greater impact, not realizing the overall proportion of usage that occurs during the peak hours.

Source: Commission for Energy Regulation (2011). Electricity Smart Metering Customer Behaviour Trials (CBT) Findings Report.

4.9 Dynamic pricing pilot design

Customers do not react to price changes in uniform ways as they are impacted by cultural and social factors as well as their own financial situation and access to source of shiftable load (such as an AC unit). This dynamic must be tested in each market. Their responsiveness also depends on the amount of time that the prices stay high.

Price differentials in TOU and CPP pilots

Research has shown that customers react mainly to changes in the price of electricity rather than to the price of electricity. Customer's reaction to the jump in electricity prices at peak is therefore best measured using multiples of the base prices (i.e. the difference between base price and peak price).

Figure 34 : Influence of peak / off-peak price multiples on peak clipping in TOU trials

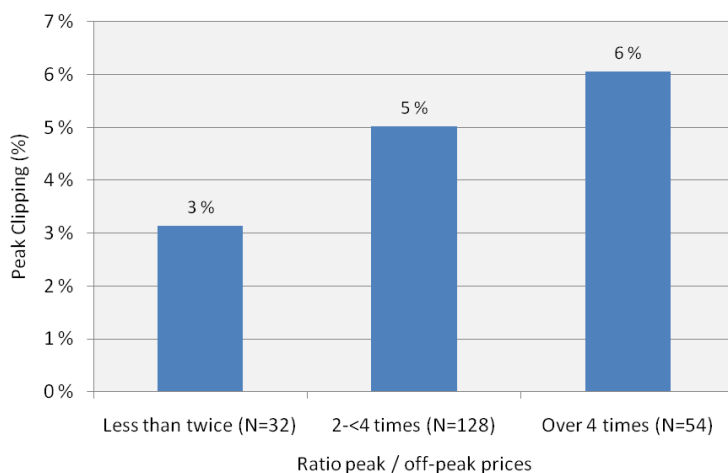
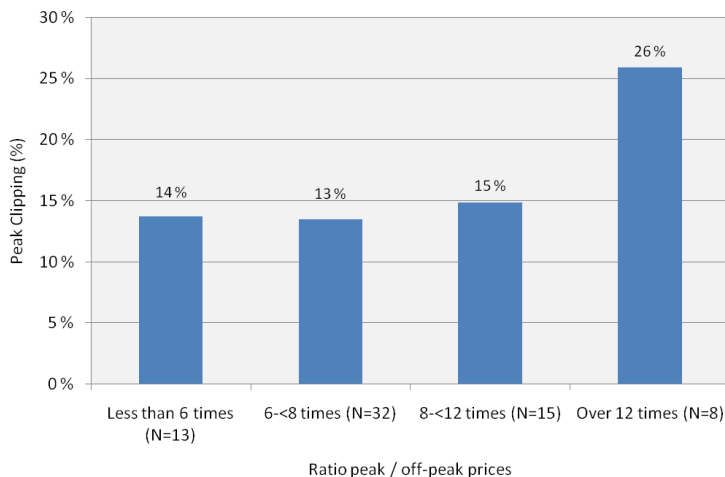


Figure 35 : Influence of peak / off-peak price multiples on peak clipping in CPP trials

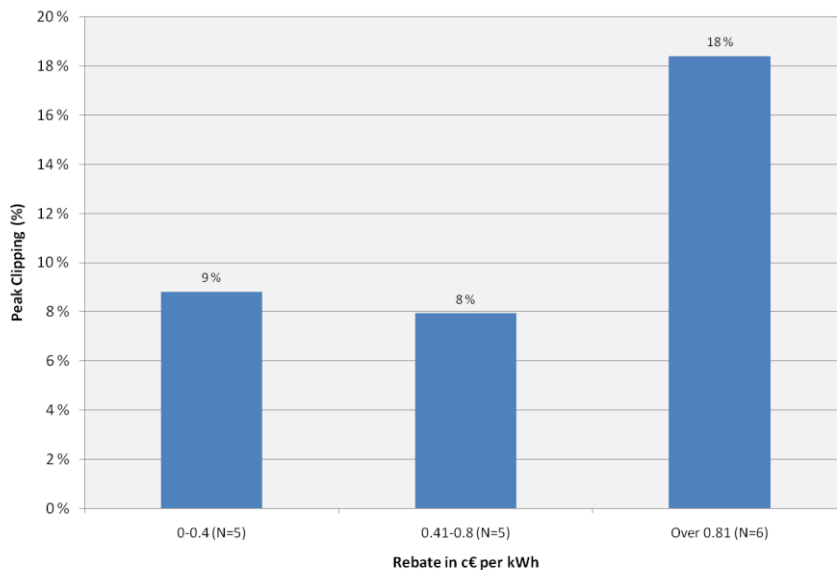


Perhaps predictably, figures 34 and 35 show that larger price differentials between peak and off-peak periods lead to more load being shifted away from high price periods to lower price periods. TOU pilots tend to have peak prices two to four times higher than off-peak prices whereas CPP pilots tend to have peak prices between six and eight times higher than off-peak prices. Overall, participants decrease consumption as prices rise but the level to which they do so depends on a variety of factors which is why peak clipping does *not* increase in proportion to the price differential which is shown by the graphs. This means that although price differentials are important motivators it cannot be used to the exclusion of other factors such as education, interaction and feedback to cite the most important ones.

Rebate and peak clipping in CPR pilots

Participants to CPR pilots are paid for every kWh they do not use during peak hours compared to what they would normally use on a similarly hot or cold day without price incentive. In practice, pilot organisers compare the electricity consumption of participants during critical peaks to their consumption on such critical days prior to the introduction of the dynamic pricing scheme or alternatively to the consumption level of a control group which is not subject to CPR prices. As part of this research we looked to which

Figure 36 : Size of rebate and peak clipping in CPR pilots



extent the amount per kWh paid back to participants influence their response. The results show, perhaps unsurprisingly, that the more participants are rewarded for shifting load away from critical peak hours to off-peak hours the more they did so. As figure 36 shows, when participants were paid over c€ 85 for every kWh they did not use during critical peak hours (in comparison to what they would have normally used on a similar peak day), they reduced consumption by 18.4%

compared to an 8.8% reduction when they were paid less than c€ 40 per kWh shifted.

Participants to CPR pilots usually receive a payment after each critical peak periods or see their electricity bills lowered by the same amount. It has the advantage of making the results of their efforts perhaps more concrete than the concept of savings which might be less easily perceived.

Impact of length of peak periods

Figure 37 : Impact of length of peak periods on energy conservation for TOU trials

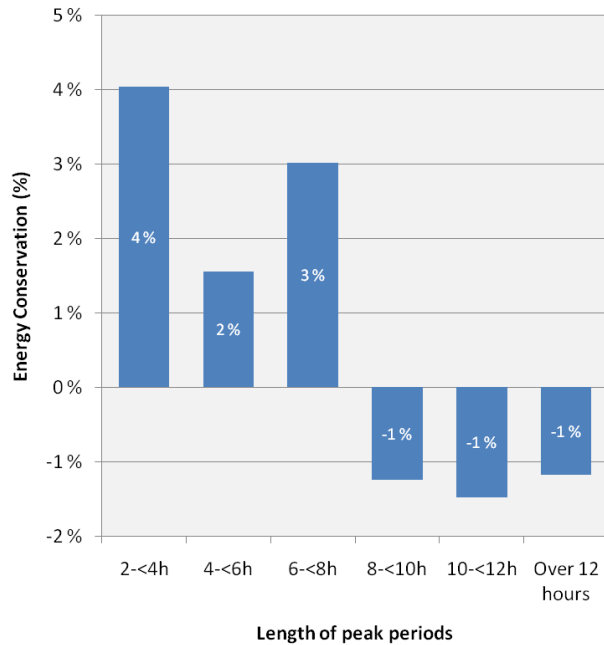
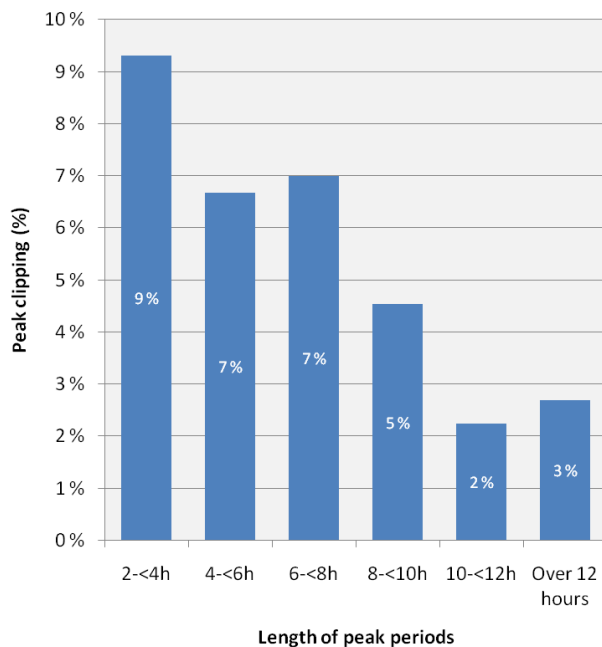


Figure 37 shows a clear change of pattern when peak periods exceed 8 hours in TOU pilots. This change is visible for both energy conservation and peak hours (figure 38). Regarding CPP and CPR pilots, though caution is required due to the small sample size, the change of pattern takes place after 4 hours. Participants seem to tire and are unable or unwilling to delay household activities when peak periods are perceived as too disruptive. However, it might also partly have to do with the fact that pilots with longer peak periods understandably have lower peak / off-peak price differentials than pilots with shorter peak periods. However, it is difficult to separate the effects of the two factors on the results.

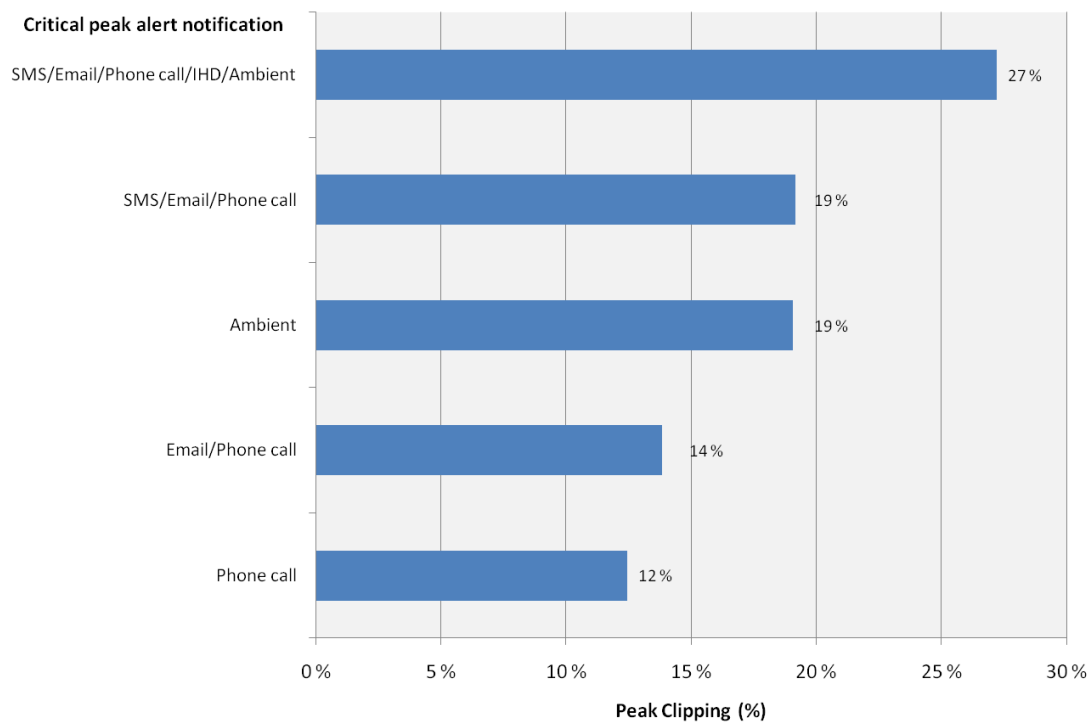
Figure 38 : Impact of length of peak periods on peak clipping for TOU trials



Sample size	
2-<4h	N=13
4-<6h	N=62
6-<8h	N=41
8-<10h	N=28
10-<12h	N=17
Over 12 hours	N=53

Critical peak notifications

Figure 39 : Five most common critical peak alert notifications and peak clipping (CPP, CPR and RTP trials)



Sample size	
SMS/Email/Phone call/IHD/Ambient	N=5
SMS/Email/Phone call	N=11
Ambient	N=6
Email/Phone call	N=19
Phone call	N=25

In Figure 39, CPP, CPR and RTP pilot results are shown according to how participants were alerted about the coming pricing event²³. There is a general pattern between the number of ways participants are alerted of the event and their response. Again here, generally more is more. However, the exception to this rule is ambient notification which seems to be a particularly efficient and effective way to notify participants of upcoming high prices. As can be seen, ambient displays are as effective as sending an SMS, email, phone call and having an IHD. The reason for this may be that nice looking ambient displays tend to sit where everyone in the house can see them which make them noticeable. They therefore communicate with the entire family at once and keep reminding all family members the day of the event not just the day before.

²³ In Critical peak events programs, participants are typically alerted in some way one day prior a critical peak day with extra high prices. This gives them the opportunity to prepare for the event.

Case Pilot 7: Information Display Pilot within the California Statewide Pricing Pilot

Pilot information: The well documented California Statewide project tested one sub group Energy Orbs, one of the many ambient displays that have been developed and tested to inform customers of changes in electricity prices using colour signals.

Real-time information on electricity prices: Energy Orbs are small glass globes that change colour to indicate the price the customer is paying for electricity in real-time. The orb was blue during off peak periods, green during daily peaks and red during super peak times. In addition, it also flashed as a warning for four hours before each critical peak price period. Such ambient displays have the advantage of being a constant reminder to reduce electricity consumption and if well designed can also be seen as “cool and trendy” and deserving a visible and central spot in the living room for everyone to see (and not at the bottom of a drawer).

Participant feedback: After using the orb, pilot customers were asked how they would prefer to be informed of changing electricity prices and super peak events in the future. Respondents were allowed to indicate more than one form of notification. The orb was the overwhelming preference of method notification, with some of these respondents also asking for both orb and telephone notification.

Source: Nexus Energy Software, Opinion Dynamics Corporation, Primen (2005). Final Report. Information Display Pilot. California Statewide Pricing Pilot.

Case Pilot 8: Tempo by EDF

Pilot information: Tempo was first tested by French utility EDF in 1989 and then offered to its residential customers starting from 1995.

Pricing scheme: The utility experimented with a six-rate tariff which divides the year into three types of days and each day into two periods. The number of days of each type is known in advance but the type of any particular day is announced only at the end of the preceding day which is in effect similar to having a TOU coupled with a CPP price structure. The three groups of days are marked by colours; blue, white and red with blue being the cheapest and red the most expensive.

Peak price notification: An interesting feature relates to the way participants are informed of the day-ahead price. Once the colour of the next day is decided, the signal is transmitted to the customer and displayed both on their meter and on a small box which can be plugged into any power socket. The box also indicates the day's colour and the current hourly rating. This system of “traffic light” coupled with various energy control systems offer a cheap and efficient way to inform participants.

Pilot results: On average, participants reduced daily consumption by 15 % on a white day and by 45 % on a red day compared with blue days.

Participant feedback: A survey evaluated customer satisfaction's level with the following results:

- 84% of the customers have been quite or very satisfied with this option,
- 59% have said that they had made savings (average or substantial for ¾),
- 53% have considered the option as slightly restrictive or entirely unrestrictive,
- 87% have understood the tariff principle very well.

Source: EFFLOCOM (2004). Energy efficiency and load curve impacts of commercial development in competitive markets. Results from the EFFLOCOM Pilots. 60-68.

4.10 Automation of appliances

There are limits to the speed with which customers can manually react to price signals. Less than half an hour reaction time is considered too fast for commercial customers to participate manually in a demand-response event. Virtually all CPP and CPR pilots notified participants that critical peak prices would be in force one day in advance. This means that a utility can only ask residential customers to shift load manually if they know this will be necessary a day in advance. This decreases the value of the load which is to be shifted and might lower the profitability of a program. Through remote controllers in appliances which can communicate with each other and react to outside information, such as electricity pricing signals, the response of a household will approximately double (see figure 40). This is called automation. In most pilots the automation are an AC or electric heating thermostat which is set to turn down or off during peak periods. However, automation systems can be more advanced and include lighting, white goods and entertainment equipment. 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 customers are able to take action (when they are away or asleep for instance).

In the review we conducted, two types of automation were used:

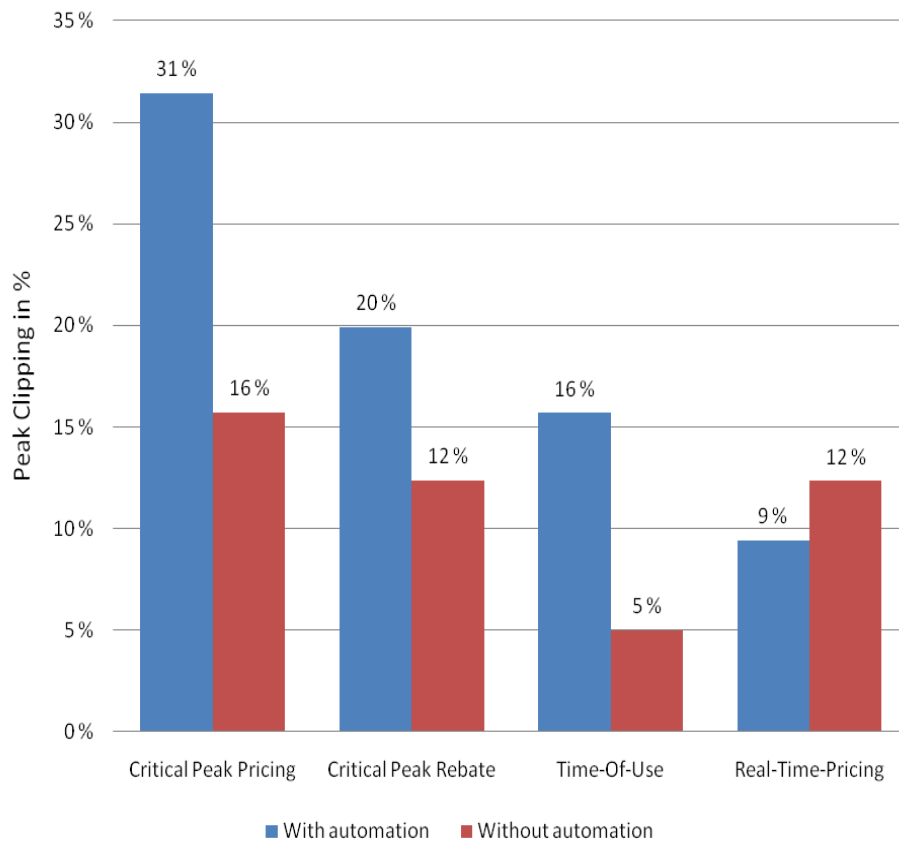
1. The most common type involved the Utility remotely-controlling some participant appliances and therefore did not require any customer involvement besides its agreement to participate.
2. The other type let participants freely choose the extent to which they want their appliances to react to price signals through more or less user-friendly interfaces such as smart thermostats or websites.

Letting companies control household appliances inside one's home might be seen with suspicion even though participants are always allowed to overrun the program. On the contrary, letting customers choose if and how much they want to respond to price signals might be seen as less intrusive. Furthermore, there is no evidence that the load shifted when participants choose the extent of their participation to critical events was any lower than when appliances were controlled by the Utility. A good example of this is the Gulf Power's Residential Select variable Pricing pilot (RSVP)²⁴ in which the Floridian company tested a locally controlled thermostat coupled with CPP prices on some of its large residential users. The pilot achieved among the highest results in our review in terms of peak clipping and was praised by participants. So much so in fact that the Utility now offers the thermostat together with CPP prices as part of a package called "*energy select*" available to its large residential customers.

Figure 40 shows the impact of automating certain household appliances such as AC, electric heaters etc... on peak clipping. TOU peak consumption reductions are the lowest (though still very high) but occur daily whereas CPP and CPR pricing schemes produce greater reductions but only during critical peak periods. With the exception of RTP, automation improves the results of the pilot by 60 – 200%.

²⁴ Borenstein, S., Jaske, M., Rosenfeld, A. (2002). Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets. Center for the Study of Energy Markets, University of California Energy Institute, UC Berkeley. Appendix B.

Figure 40 : Impact of automation on peak clippings



Sample size	With automation	Without automation
TOU	15,68% (N=35)	4,98% (N=215)
CPP	31,42% (N=29)	15,69% (N=69)
CPR	19,89% (N=11)	12,36% (N=16)
RTP	9,4% (N=10)	12,34% (N=15)

Figure 41 : Peak clipping and automated load (TOU trials)

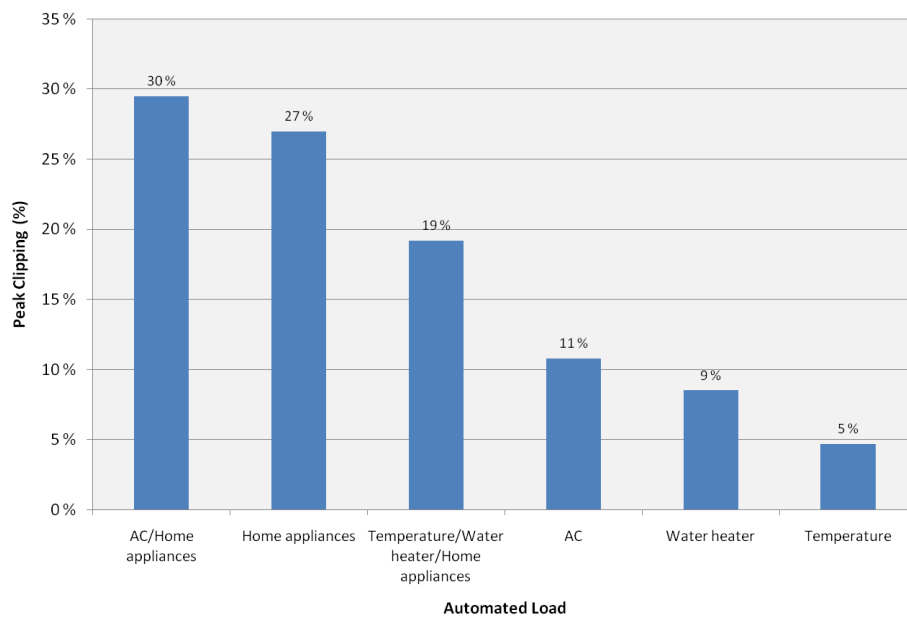
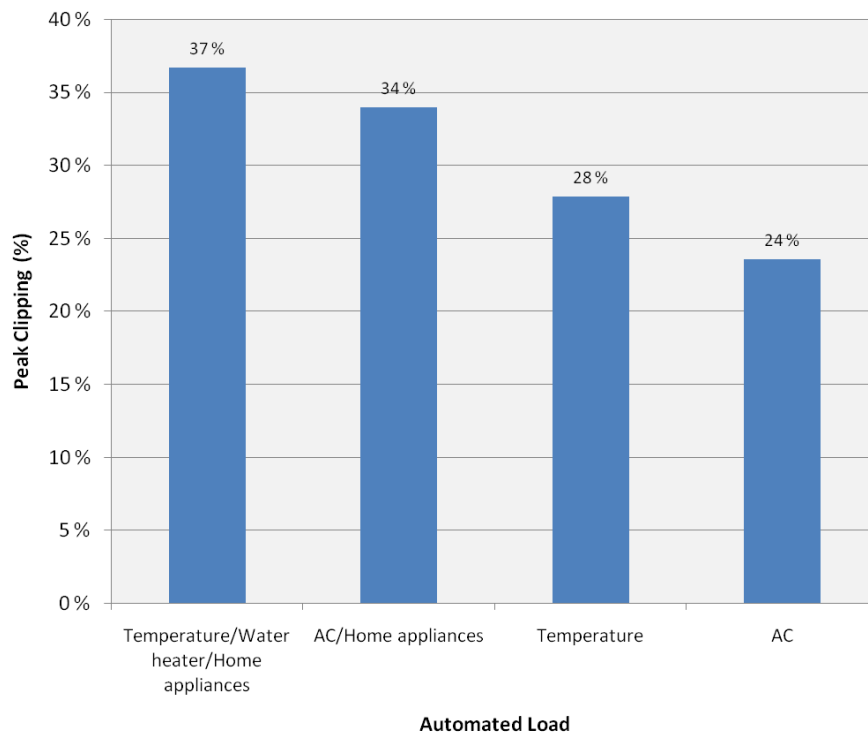


Figure 41 and 42 show the load shifted at peak times depending on the source (or sources) of automated load. Globally, automating several sources of load is more effective than a single source especially if the sources use significant amounts of electricity. The category "home appliances" include pool pumps, spas, freezer etc.... The category "temperature" includes automated AC and electric heating.

Sample size	
AC/Home appliances	N=4
Home appliances	N=7
Temperature/Water heater/Home appliances	N=11
A/C	N=4
Water heater	N=2
Temperature	N=5

Figure 42 : Peak clipping and automated load (CPP/CPR trials)



Sample size	
Temperature/Water heater/Home appliances	N=4
AC/Home appliances	N=7
Temperature	N=11
A/C	N=11

Case Pilot 9: Automation in pricing pilots (Gulf Power's Residential Select variable Pricing and Efflocom Norwegian project)

Pilot Information: Gulf Power Company from Florida tested a customer controlled thermostat coupled to TOU and CPP prices with 2,300 participants in 2002. The settings could be programmed directly from the thermostat or from a secured webpage.

Automated load: Two elements made this trial outstanding, first the degree of sophistication of the technology; all the major sources of load could be automated (air-conditioning, electric heating, spa, pool pumps, heat pumps and electric water heater) and second participants had to pay a participation fee of \$4.53 a month to cover for equipment and operational expenses.

Participant feedback: After the success of the different tests and pilots, Gulf Power started to offer the thermostat and the dynamic tariffs as part of a package to its residential customers for a fee which currently stands at \$5 per month. Gulf Power Company said *“to date, customers have not considered the fee a barrier to participation. In fact, they regard the automation and energy management benefits they receive as being well worth the monthly fee”*.

Pilot results:

- Average energy reduction = 22% during high price period
- Average energy reduction = 41% during critical period
- Customer satisfaction = 96%, highest ever for Gulf Power program.

Pilot Information: The European context is very different from Florida and the largest loads in European homes are often electric heaters and / or electric water heaters. In a 2004 Norwegian pilot, organizers installed remote control of electrical floor heaters and water boilers coupled with different options of dynamic network and electricity tariffs at 318 participants' premises.

Pilot results: The organizers report that customers with remote control, TOU network tariffs and spot price based energy tariffs achieved savings of up to 35% during the morning and 31% during the afternoon.

Source:

Borenstein, S., Jaske, M., Rosenfeld, A. (2002). Dynamic Pricing, Advanced Metering and Demand Response in Electricity Markets. Center for the Study of Energy Markets, University of California Energy Institute, UC Berkeley. Appendix B.

EFFLOCOM (2004). Energy efficiency and load curve impacts of commercial development in competitive markets. Results from the EFFLOCOM Pilots. 122-135.

5. Conclusions

The aim of Empower Demand has been to discover the potential and limitations of a range of smart meter enabled feedback and dynamic pricing programs using a large comparative sample. Due to the repeated findings within the 100 pilots and 460 samples involving 450,000 residential households, the project has been able to reach robust conclusions on the overall effectiveness of differing program types as well as central success factors. The findings of Empower Demand demonstrate that technology provides an important but enabling function in creating a successful demand side program. It is one of five factors we found which decide success. These factors are socioeconomic factors, consumer consumption patterns, program content/structure, supportive technology, and household load sources. In this, socioeconomic factors and consumption patterns can overcome supportive technology and program type. For example, a good informative billing pilot can lead to higher savings than an IHD pilot depending on surrounding circumstances despite the fact that on average an IHD is 50% more effective than an informative bill at reducing overall electricity consumption. It is therefore important to perform a holistic analysis of markets when creating demand side programs; matching the program structure with the market realities.

During piloting, there can be a technological focus or a preconceived opinion that the technology is what decides program success. Our findings challenge this focus. The main difference we found between pilot success and failure is the ability of the program designers to meet consumer needs through the demand side program. Meeting a need is the foundation of consumer engagement and thereby of a program's success. The technology is the enabler within this value chain. Therefore, unless a technology is equipped to act as a support to consumer engagement, it will not create savings or improve systems efficiency. Smart meters fulfil their potential due to the fact that they can support consumer engagement to a market-appropriate level through feedback and dynamic pricing and/or home automation.

Program success is directly dependent on consumer involvement and the Empower Demand findings indicate that "more is more" at every stage of the piloting and roll out process. For example, within marketing, programs using consumer segmentation to create directed marketing messages for a particular consumer group increase consumer uptake and results. In the program structure, feedback and pricing together tend to achieve better long-term overall results than either program type alone. Education improves dynamic pricing and informative billing programs. Multiple types of information on a display or a bill (current consumption, price, historical consumption, etc.) tend to achieve higher results than a display or a bill with only one message. Program layering is little explored but there are signs that hidden potential lies in starting with a relatively simple program and gradually create offerings of increasing complexity and value. Hence, we are far from having perfected program structures or perfectly matching program structures to regional market realities. This should be seen as encouraging as even though program development is not mature, results are already positive.

Finally, it is important to emphasise the central place of program uptake during program rollout and the difference this creates between a successful pilot and a successful rollout. Pilot results reflect the response of customers who have agreed to participate in a given program. What is not accounted for in pilot results is the response of the people who would not be interested in the program. During rollout, the numbers of customers willing to take part in a feedback or in a pricing program will largely decide its success. The potential uptake rate of a program is therefore central. For example, a 10% electricity consumption reduction by 1% of the population will lead to a 0.1% total reduction whereas a 10% electricity consumption reduction by 10% of the population will lead to a 10% total reduction.

Potential program uptake can be estimated by the percentage of people who are willing to take part in the pilot. If this number is high, say around 30%, as it was the case in the CER pilot in Ireland, this means that a national rollout of a similar program is also likely to gain good customer support²⁵. However, it should also be remembered that the involvement of the entire population is not required for programs to have a measurable positive impact on national consumption patterns. EDF's Tempo tariffs, launched in 1989, is appropriate for large households with electric heating, yet, it still cuts total national peak consumption by 4% 22 years after it's launch.

5.1 Summary of findings

Below is a summary of the main findings of the research. Figure 43 shows the average results of each program type. Feedback pilots are designed to help consumers reduce their overall energy consumption, lowering distribution and supply costs. In comparison with the other feedback channels, IHD resulted in the highest electricity savings. The remaining feedback channels, webpage and informative billing produced almost equal consumption reduction results. Quite possibly, the key advantage the IHD offers over the other feedback channels is the almost real-time and visible aspects of the delivery of feedback. TOU peak reductions are the lowest, but they occur daily, while CPP and CPR produce the highest reductions but only during critical peak periods.

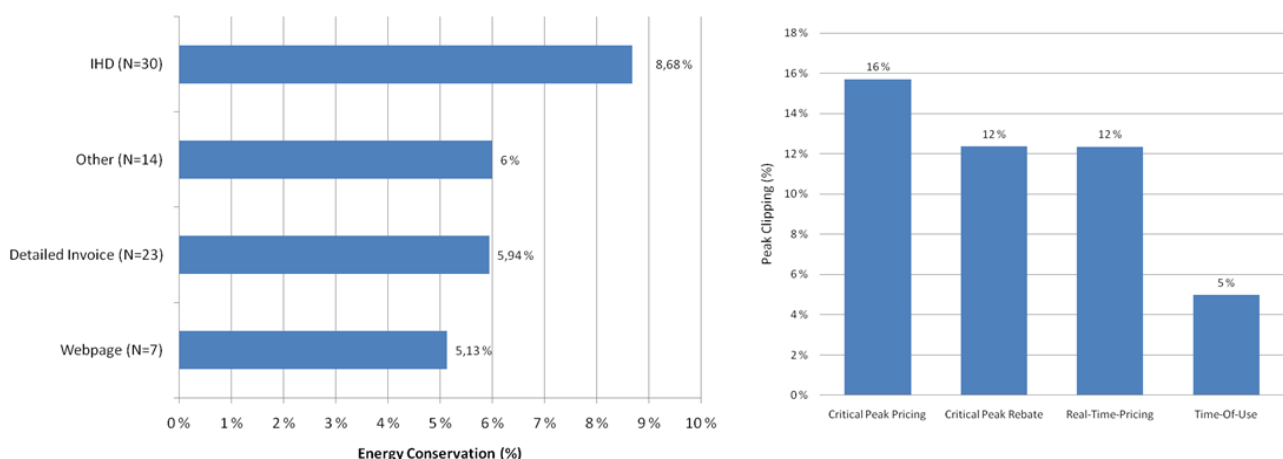


Figure 43: Summary results of feedback and dynamic pricing pilots

Pilots include a wide range of disparate variables (sample sizes, duration, feedback, location, etc.), any of which could theoretically influence pilot outcome. Therefore a variable was not considered significant unless it demonstrated a consistent impact across pilots. The most robust findings from this research are summarized below and ranked according to their degree of robustness.

²⁵ During rollout, success can be utility dependent. Some utilities have simply been better than others at communicating and marketing pricing programs to their customers and will succeed better with the same offering in the same market than their competitors. This can be seen in comparing the relative successes and failures between the main California utilities (PG&E against SCE).

Some variables were found to have produced a repeated and consistent response from consumers across pilot type (both feedback and pricing pilots) and were judged to be particularly important. Their chart is **green**. Some had a varied impact across pilot type but the results were nonetheless robust in one of the pilot types. Their chart is **blue**. Some variables provided interesting results but the findings were not robust enough to be judged definitive. They are presented here because we believe they deserve further research and the fact that they are not conclusive is in our opinion interesting in itself. Their summary chart is **black**.

Structural variables

Below is an overview of three structural variables and their impact on pilot results. These include the region in which the pilots were conducted, the length of the pilots and the number of participants. The variables in this section are considered robust though their impact may vary between feedback and pricing pilots.



Region of pilot

Section 4.1: page 24

Findings: Australia carried out the most successful TOU and CPP pilots probably due to their high price differentials. Canada was the most successful with IHDs with 12% reductions; Europe was second with 10% and the USA third with 7%. Informative billing in Europe was 4.5 times as effective as in the USA. Dynamic pricing programs overall were again more successful in Europe.

Conclusion: Europeans should be cautious when comparing themselves directly to other regions and making assumptions about the results a similar program in Europe would achieve. Results may be higher and program requirements may also differ. Programs should be adjusted to fit local cultural specificities.



Length of pilot duration

Section 4.3: page 27

Findings: The aim of this variable was to establish if pilots maintain their results when they last longer. In all but TOU pilots, results were higher in pilots which lasted longer. This was true in CCP, CPR pilots and also in IHD and billing pilots which rely on behavioural change and purchasing choices.

Conclusion: Program results usually maintain over extended periods of time (over two years). This is significant as it means that behavioural changes can become permanent. Consumers' learning cycles and the potential of using this to introduce more and more advanced programs in order to establish a smart grid should be researched further.

Number of participants

Section 4.4: page 31

Findings: Pricing pilots with over 1,000 participants were at least as successful as smaller pilots. Even with very large populations (of over 1 million consumers), consumption reductions are still achieved and lower the need for systems investment in generation and network capacity. Feedback pilots of over 1,000 participants had lower results than those with less than 1,000. This demonstrates the challenge of successful communication with large groups of consumers in order to engage their interest in a program and ensure success during rollout. It was also noticed that the IHDs and the bills provided in the larger pilots tended to be simpler and provided less information. This may also partly explain the lower results, however, further research is required to draw firm conclusions.

Conclusions: Dynamic pricing may be easier to communicate to a large number of consumers than feedback. More knowledge is needed on segmented and directed messages for large consumer groups. An increased number of large and robust pilots should be performed in Europe involving at least 5,000 participants.

Customer communication and segmentation variables

Program success is largely dependent on successful consumer engagement and acceptance. Programs will increase consumer involvement if they can use a variety of program dynamics such as feedback, pricing, education, interaction etc. The findings from SEAS-NVE's social segmentation and marketing techniques demonstrate that the same program should be marketed in a variety of ways to increase the number of customers who engage with the smart meter enabled offering in much the same way as car companies will market the same car to a variety of customer groups using a variety of sales messages²⁶. The central contribution of education on billing and pricing programs is reviewed.

²⁶ Stromback and al (2010)

Participant segmentation

Section 4.5: page 35

Findings: Pilots that carry out customer segmentation tend to have better results than those who do not. However, customer segmentation is done in order to improve rollout results not pilots. It helps utilities improve programs to fit certain segments and design marketing and messaging campaigns. Successful programs have succeeded in meeting customers' knowledge levels and interests. Considering the decisive importance on successful customer communication and its direct impact on public acceptance, uptake and long term engagement in smart meter enabled programs; customer segmentation in pilots was either under-researched or under-reported. With a few exceptions, such as SEAS-NVE, there is little evidence in utility program rollout that customer segmentation has been fully exploited to create directed marketing messages and educational materials.

Conclusion: If customers do not find a program interesting, accessible and attractive, it will fail. This is equally true for every type of smart meter enabled program. Customer segmentation offers utilities and technology providers the opportunity to study which customer groups are reacting best and how programs could be improved during rollout. This knowledge can then be used to create directed marketing messages and educational material which have a direct and central impact on the number of consumers who successfully engage with a program in a given market. Customer segmentation techniques are improving, as the large CER pilot in Ireland attests, however this is still an under-researched and underfunded area, and would require further research.

Participant education

Section 4.6: page 36

Findings: Pilots which included customer education material performed better than those which did not. However, almost all pilots that included education were of a higher overall quality and this may have impacted the findings. Education seems to have a positive impact on both billing and pricing pilots. Billing pilots with education were over 70% more effective than those without. TOU pilots without education actually **increased** total energy consumption while TOU with education **lowered** total energy consumption by 4% and improved peak consumption reductions as well. This in effect doubled the benefit of the TOU pilot as they both lowered total consumption and peak consumption. Education material provided during a pilot did not have a positive influence in IHD pilots. This may be due to the fact that IHDs are in

themselves an effective form of education and extra printed material is not as important.

Conclusions: Education should be included within dynamic pricing programs, especially those involving automation, as it helps to decrease total consumption rather than only peak consumption. Further research should be carried out into the impact of education on pricing program development and especially on the ability of one program type to educate and prepare consumers for more advanced programs, involving for example electric vehicles or micro-generation. Further research should also be performed on how to best educate various customer segments in order to maximize program results across a wide range of consumers.

Interaction with participants

Section 4.7: page 44

Findings: This variable measured whether interaction between pilot organisers and participants in the form of interviews, meetings and questionnaires improved results. In both pricing and feedback pilots, where participant interaction was high, results were higher. However, more details are needed as to what type of interaction works best, what type is most cost effective (it is hard to imagine utilities organising meetings or interviews with all their customers) and when is it more effective.

Conclusions: Though interaction with consumers improves program results, it will not be a stimulus which is 100% replicable during rollout. However the fact that interim interaction seems to improve customer engagement should be studied further. It may encourage utilities to have an extra education campaign or introduce new services after a program has already been launched. This could potentially increase the cycle of learning and consumer interest.

Other variables specific to pricing or feedback pilots

Automation

Section 4.10: page 57

Findings: The inclusion of automation, whether it is controlled by participants or the utility, in a dynamic pricing pilot can double or even quadruple the amount of load shifted. It also increases the amount consumers save on their electricity bills.

Risk: Automation also increases the risk that total consumption increases (rather than decrease) in combination with TOU, CPP and CPR programs as for instance the AC uses extra amount of electricity to cool down the house once the peak period ends. This was successfully overcome in pilots that included education and consumption feedback. It argues for the combination of feedback and automation and points to the central role of technology contributing to consumer awareness. The larger the load which is automated the more effective and cost effective is the automation. This is why AC units and electric heating are effective sources of automation.

Conclusions: Automation is highly effective as a means of shifting or lowering load. Currently it can also be difficult to pay for in low consumption markets. However this should change as the technology becomes more affordable and/or the price of electricity increases. Automation designed to enable load shifting should always be combined with education on how to lower total consumption in order to avoid increased overall consumption levels which happened in a number of pricing pilots with automation.

Feedback content

Section 4.8: page 46

Findings: These findings were inconclusive but interesting. There seems to be a correlation between the content of feedback (i.e. the messages provided) and the results. The most effective combination of messages on an IHD was up-to-date consumption, historical feedback and current level of the bill. It also seems that comparing consumption with neighbours was ineffective and perhaps had a negative impact (this may be partially due to irrelevant comparisons between houses of differing sizes, ages, etc.).

Conclusion: If comparison to neighbours is made, the comparison should be directed and consumer appropriate. It should be between houses of a similar size and age and the feedback message should be avoided completely for households with below average consumption. Feedback content and consumption reductions is an under researched area and should be explored further. It may mean that a lower priced

technology could produce higher results simply by refining the content of the feedback. This could have important implications for smart meter enabled consumption reductions.

Combining dynamic pricing and feedback

Findings: Dynamic pricing programs help consumers shift load during times of system strain. The rest of the time, the household's electricity prices are slightly lower than average. It seems that this can sometimes lead to households shifting peak load but actually consuming more electricity than they would normally do. However when a pricing program is combined with feedback and education this tendency seems to disappear and consumers tend to lower overall consumption as well as shift peak load. This is an important finding. Feedback programs appear to have difficulty maintaining results as they get larger which is not the case with pricing programs. Therefore, combining feedback with dynamic prices has the potential to enhance the impact and uptake of program rollout.

Conclusion: The specific advantages of dynamic pricing and feedback seem to hold when the two are combined. This should be explored further with large and robust European pilots which have yet to be conducted. An increased number of large and robust pilots should be performed in Europe involving at least 5,000 participants. In addition, pricing and feedback should be tested together. They seem to have a mutually beneficial impact and help to engage larger populations in lowering overall consumption while at the same time encouraging peak shifting.

5.2 Ideal roll out strategies for utilities

Ideal program structures are market specific and will depend on the requirements, regulatory structures and strategic goals of the utility. It would therefore be inappropriate to attempt to make a one-size-fits-all blue print of program best practice. With that being said, ten strategic points have emerged from the research.

- 1) **Define "success":** Before designing a program, a utility should decide exactly what success would look like. Improved company image? Shave X % of peak load? Achieve XX amount of avoided investment. Demand side programs are tools appropriate for different aims and it is central to design the tool around the aim.
- 2) **Creating a win/win situation through segmentation:** After a utility begins to have a clear idea of their definition of success, for example, meet a government requirement to lower consumption, they need to match it with their customers' needs and potential. The program must create a win/win situation through smart meter enabled programs. However, it is difficult to sell a product to a consumer who is not known. Therefore, it is important very early in the process to begin

thinking strategically about who are the utility's customers and how they can contribute to the strategic requirements of the utility. This may lead to strategic program developments of a particular customer group or the development of several programs or products to allow customers to choose, thus reaching a wider population.

- 3) **Mix and match consumer groups:** Commercial and (small) industrial customers may be under-served although they have the best cost/benefit ratio for certain program types and may benefit most. It is possible to create programs for industrial and commercial customers or commercial and large residential customers such as lowering peak load through automation. Strategically directing smart metering programs at a cross cut of consumer groups is an under-explored area with a high potential.
- 4) **Exploit segmentation in marketing:** The same car can be advertised in different ways to attract different customers. For example, SEAS-NVE²⁷ managed to accomplish this through their programme called "Meter Hunt". The Danish Utility conducted segmentation research in their market and created four different advertising campaigns for one internet site. The work is highly successful.
- 5) **Involve the media early on:** Media response to a program will decide to a certain extent customer acceptance and engagement. Therefore, involving media during piloting is wise. It can potentially improve future marketing campaigns by helping the utility to hone marketing and education messages as well as avoid some future negative publicity.
- 6) **Successful customer communication leads to successful programs:** Positive messages, timely, directed, containing the appropriate information, combinations of information (bills, feedback displays), etc. all increase customer participation. They argue for using computing intelligence to offer consumers feedback at appropriate moments and content which is relevant to them. IHD's have already shown good progress and the new mobile phone applications and use of other technologies hold good future potential.
- 7) **Pricing should include education and feedback:** Combinations of feedback and pricing programs strengthen the results of both. In this case more is more. Utilities could help increase responses and cost benefit in low consumption markets such as the UK, Denmark and Germany.
- 8) **Be Cool - Remember the entire family and a range of consumer types:** Whilst program design should be strategic and need not include the entire population, once a household is involved including the entire family and a range of consumer types is important. One reason ambient displays, such as coloured lights, may be effective is that everyone sees them and everyone can understand them. Many feedback and pricing program visuals are still designed to involve technically minded adults.
- 9) **Be Cheap – get creative:** It is not necessary to provide all services to all customers in a market if only a few will benefit and/or are willing to pay. However, it is good if costs can be hidden rather than upfront and obvious. Within dynamic pricing programs, utilities provide automation

²⁷ Bisgaard (2011).

technology and then split the money from the resulting savings. In the end both the utility and the consumer win. Feedback displays may be “free” or paid off over an extended period of time. Sometime however, a utility will not rollout any programs at all because they will be too expensive for a significant portion of the population. This is often a strategic mistake.

- 10) **Consumer growth and added services:** Consumer knowledge when starting a program is low, however this changes and knowledge increases over time. What will be seen as too complicated one year will be appropriate the next. A key difference between piloting and rollouts is that rollouts do not end. If they are successful, they will continue. Utilities could make use of this by planning added services, which would capitalize on the increased knowledge of consumers, bringing them forward in a positive cycle of learning.

5.3 Recommendations for future work

When comparing a large group of pilots collected from many differing regions of the world and including a wide range of variables, certain patterns are repeated and clarified. The findings of Empower Demand demonstrate that technology provides an important but supportive function in creating a successful demand side program. It is one of five factors which decide success. These are socioeconomic factors, consumption patterns, program content/structure, supportive technology, and access to load sources²⁸. Socioeconomic factors and consumption patterns can overcome supportive technology and program type.

Informative billing has lowered consumption rates anywhere between 1% and 12%. Informative websites have lowered consumption between 0.5% and 17%. It is not the website itself which create these shifts and it is not the size of the pilot or longevity of the program. The 17% consumption reductions involved 55,000 households in Denmark over 3 years²⁹. Our research has led us to conclude that the main difference between pilot success and failure is the ability of the program designers to meet consumer needs through the program. Meeting a need is the foundation of consumer engagement. The technology is a support. It puts into question the current tendency to emphasise technological development over and above all other factors in European pilot schemes while comparatively little funding is provided to studying the best messages to deliver to consumers, their cycles of learning through program layering or the impact of surrounding socioeconomic and cultural factors on program success.

Below are a few of the many areas of research which could be explored further:

- **Customer segmentation:** European pilots tend to be small in comparison to their Australian, Japanese or American counterparts. More large pilots, involving between 4,000 and 5,000 participants should be conducted in Europe. The increased size and scope should be used to better understand customer segmentation and socioeconomic factors leading to improved marketing messages and program design.
- **Learning cycles’ impact:** A large long lasting pilot could test the potential learning cycles of

²⁸ Accessible load sources are particularly important in dynamic pricing programs.

²⁹ Bisgaard (2011).

consumers. This would mean that rather than offering one static program for the entire duration of the pilot, a group of participants would be brought through a cycle of programs starting with simple feedback and pricing and progressing towards becoming more sophisticated prosumers involved in electricity trading and smart grid activities. This would provide a more realistic understanding of the long-term potential of demand side participation in Europe.

- **Pricing pilots and feedback:** Critical peak pricing is under-piloted in Europe. As peak consumption increases and wind intermittency creates large fluctuations with the wholesale market prices, dynamic pricing overall and critical peak pricing in particular will become more important. During these pilots, feedback and education should also be included to maximise the long-term influence of the pricing programs and encourage overall consumption reductions.
- **IHD analysis:** The role of IHDs in reducing overall consumption has been well researched, however a deeper analysis concerning the messages and information provided on IHDs would allow for a more meaningful comparison of IHDs. The analysis should include consumer segmentation studies to verify and understand which socioeconomic factors influence consumer engagement through particular messages.
- **Opt-in vs. Opt-out:** As governments are in the process of deciding what should be mandated for all consumers and what should be left to market development, additional research should be conducted regarding the effect that opt-in and opt-out program participation has on both dynamic pricing programs and feedback programs consumer engagement levels.
- **Education / feedback / interaction analysis:** The importance of involving participants in both pure feedback and pricing pilots is not to be overlooked as they often make the difference between a successful and a failed pilot. Following this statement, research into what type of education material and feedback content and channel are most efficient as well as how to best keep participants motivated. The results would provide useful insights for the design of both future pilots and potential commercial offers by utilities. The research could be based on real life offerings and examples and results of pilots in terms of customer acceptance and preferences.
- **Move away from “Will consumers participate?” to “How do we maximise participation?”** Empower Demand has reviewed 100 pilots. The selected pilots alone included 450,000 consumers but the resulting rollout from these pilots now includes over 4 million. Smart meter enabled programs are consistently effective when developed in accordance with the needs of end-consumers and enabled through constructive regulation. Research questions set limits around what it is possible to learn from a pilot - organisers will only get answers to the questions they ask. This is as much a limitation as it is a resource. It is essential to move forward in pilot development through innovative questions, taking into consideration the results of past pilots and comparative studies such as this one. Pilot organisers can now focus their research on better understanding who is in the market and what can be done to maximise their participation within that market's reality. Smart meter enabled demand side programs successfully engage consumers in a wide range of market types and requirements. Long-term program success will require a holistic combination of marketing, technological support, directed communication and a constructive regulatory framework.

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Annex 1: Glossary of Terms

Ambient displays: Differ from IHDs in that they do not provide specific consumption information but rather signal to the customer messages about their general level of consumption and/or a change in electricity prices. Many ambient displays have the attributes of being attractive and intuitive which adds to their customer acceptance potential.

Bill reduction: Extent to which the experiment led to a reduction in customers energy bills (in %).

Critical Peak Pricing (CPP): CPP pricing schemes involve substantially increased electricity prices during times of heightened wholesale prices caused by heightened consumption (for example on very hot days) or when the stability of the system is threatened and black-outs may occur. In exchange for a lower tariff during non-peak hours (compared to customers on say flat tariffs), participants agree to have substantially higher tariffs during critical peak hours. The number and length of critical peak periods which the utility is allowed to call is often agreed upon in advance in order to lower participant risk. The periods when critical peaks occur depend on conditions in the market and cannot be decided in advance. Residential customers are usually notified the day before that the next day will be a critical day.

Critical Peak Rebate (CPR): CPR pricing schemes are inverse forms of Critical Peak Pricing tariffs. Participants are paid for the amounts that they reduce consumption below their predicted consumption levels during critical peak hours. The number and length of critical peak periods which the utility is allowed to call is often agreed upon in advance in order to lower participant risk. The periods when critical peaks occur depend on conditions in the market and cannot be decided in advance. Residential customers are usually notified the day before that the next day will be a critical day.

Customer, consumer, participants: Unless specified otherwise, these terms always refer to households.

Data granularity: Level of details of the data provided. Do they give real time readings, every 15 minutes, every hour, and every day?

Disaggregation of consumption: The household's electricity consumption is broken down as per household electrical appliances. The depth and degree of the breakdown can vary but in most cases the consumption of the oven, the fridge, the TV, and the lighting are measured. It helps participants see how much electricity individual appliances use and act upon it (and maybe buy more energy efficient ones).

Energy conservation: Extent to which the experiment led to a reduction in overall energy consumption (in %).

Environment (CO2 emissions): This shows the amount of CO2 the households emits due to electricity consumption. This presents the environmental costs or consequences of the households' energy consumption.

Historical comparison: Shows the household's current electricity consumption levels in comparison to pre-pilot consumption levels. Participants can know if they reduced or increased their consumption compared to the same period last year, for instance.

Home Automation: Traditionally, homes have been wired for four systems: electrical power, telephones, TV outlets (cable or antenna), and a doorbell. With the invention of the electronic micro and auto controller and the widespread uptake of digital communication technology, the cost of electronic control

is falling rapidly and its uses are increasing. Through remote controllers in appliances, which can either communicate with each other and/or react to outside information, such as electricity pricing signals for example, the price responsiveness of a household will approximately double. This is called automation. In most pilots the automation are an AC or electric heating thermostat which is set to turn down or turn off during peak periods. However, automation systems can be more advanced and include lighting, appliances, and entertainment equipment. Residents can be informed when their equipment is malfunctioning or be able to turn it on and off remotely.

Informative billing: Example of indirect feedback. They therefore do not accurately reflect the actual usage for a given month. The difference between the estimated average consumption and the actual usage is made up at the end of the billing period or when a resident changes electricity supplier. Informative billing will invoice for the actual consumption and provides either historical information comparing what the customer used this month to last month or to last year during the same period. The bill may also provide information on how much the household consumed in comparison to other dwellings of the same description. Unlike standard billing in which households receive their bill 4-6 times per year, informative bills can be sent as frequently as once per month.

In-house displays (IHD): Displays which hang on the wall or sit on a counter and provide close to real time information about household electricity consumption. IHDs provide households with real-time and historical information on their electricity usage and costs. Additional feedback content that can be offered on the IHD are peer comparisons (showing the consumption rate of neighbours or consumers with similar conditions), and disaggregation of consumption (breaking down the energy usage of individual appliances in the home).

Overall consumption reduction: Extent to which the experiment led to a reduction in overall energy consumption.

Peak clipping: Extent to which the experiment led to a reduction in energy consumption during peak periods (in %).

Peer comparison: Consist of comparison of household energy consumption levels between participants and similar-sized households. This information may include neighbours within near vicinities or households of similar size. It enables participants to see if they use more or less electricity than their peers.

Price of electricity: Indicate the current price of electricity per kWh. This does not include the up-to-date electricity bill, only the current price of electricity per kWh.

Real-Time Pricing (RTP): The price paid by participants is tied to the price of electricity on the wholesale market. However they do not lead to consumption reductions without feedback. Even then customers will sometimes tire of checking a price that only changes slightly from day to day. In order to encourage reductions during high price periods and reduce risk of high bill, participants are warned when wholesale prices reach a certain threshold decided upon in advance.

Savings compared to previous periods: Compares the energy savings of households to previous periods. Households would have a certain target for their energy consumptions which would be a percentage savings on previous energy consumptions.

Time-of-Use (TOU): TOU tariffs induce people into using electricity during times when consumption is lower. Prices are therefore set higher during high consumption periods, typically during working hours, and lower during the rest of the day. TOU usually includes one long peak daily period or two shorter

daily peak periods. TOU can have two level of prices (peak and off- peak prices) or three (peak, partial peak and off-peak prices) per day. The peak hours are known in advance by the customers. The prices may also vary according to the season.

Up-to-date consumption level: Presents the current up-to-date consumption level of the household in kWh. In itself, it does not include the cost of electricity, or the current level of the bill. However, if coupled with consumption goals or targets not to exceed, it can be a powerful incentive to reduce consumption.

Up-to-date Cost (bill): Presents the up-to-date bill which enables households to gauge their current costs for their electricity and act upon it.

Websites: Offer an alternative way to provide the consumer with information about their electricity consumption. Websites are chosen as a means of providing feedback because they are relatively cheap. They rely on smart meters to collect the necessary consumption data and therefore the granularity of data provided to consumers depends largely on how often the meters are read or how often the information is transferred from the meter to the utility (or retailer).

Annex 2a: Fridge magnet showing different time bands



Different times, different prices

DAY	PEAK *	DAY	NIGHT
8am - 5pm	5pm - 7pm	7pm - 11pm	11pm - 6am
14c	20c	14c	12c

* Peak rate applies Monday to Friday only excluding Public Holidays.
Time of Use pricing will apply from 1st January - 31st December 2010.
Rates may be subject to change in line with ESB Customer Supply tariff changes.
Prices exclude VAT.

Source: Electricity Smart Metering Customer Behaviour Findings Report, CER (2011)

Annex 2b: Electricity conservation and trial guide brochure

The second page

The second page of your bill will provide you with extra information and tips on how you can reduce your electricity usage and reduce use during Peak hours. You can also see how you are doing compared to others in the area.

Shows Peak, Day and Night times.

Shows the cost of using appliances at different times.

Get some hints and tips on electricity use.

See how you are doing compared to others.

Shows your average use by day and by time of day.

If you would like more information, please contact us at ESB Customer Supply on 1850 21 16 50, or email us at smartmeter@esb.ie

CER

The National Smart Meter Plan is supported by the Commission for Energy Regulation with the support of the Department of Communications, Energy & Natural Resources, Sustainable Energy Ireland, ESB Energy and the community and grid industry in Ireland.

The public will receive a smart meter which is provided free of charge. It will be installed by a qualified technician.

Your Guide to the Smart Meter User Trial

ESB Customer Supply

Time of Use prices and our guarantee to you

At first glance, you will see at different times of day the Time of Use price is higher and at other times it is lower than the rate charged up until 31st December 2009. This is to encourage use outside of Peak times. You may feel, however, that you cannot move a lot of your electricity usage into night or away from Peak times.

Don't worry - over the period of the trial we will ensure you won't pay any more for your electricity than you would if you had stayed on your normal electricity price.

To help you in this we will credit your bill for December with €100. Then in January 2011 we will give you a second credit of €100. When the trial period has ended, we will calculate you have still paid more than you would have on your normal electricity price, we will give you a final credit for this amount. Please note that these credits are in addition to the two €25 credits for completing the trial survey.

Smart energy tips

To get you started there are a number of actions you may consider:

Try to use washing machines / dishwashers when the Day rate applies or at the Night rate. For safety reasons it is best not to leave appliances on when you are asleep or when your house is unoccupied.

Think before you use something in Peak time. Remember Peak is only two hours - could you move some of your appliance use outside of this time?

We would like you to try and use less electricity during the trial. Are there any additional actions you can take? Are there "latent users", for example, the immersion, lights and appliances left on in unoccupied rooms, especially during Peak time?

How do you save money?

You can save money and reduce your carbon emissions by either reducing your overall electricity use, or by moving some of this use outside of the 2 hours Peak time. Peak time is when electricity demand is at its highest and when more expensive generation sources are needed to meet demand. This results in more expensive electricity during this time and in turn generates higher carbon emissions.

Save even more

Using electricity outside of Peak time will reduce your bill, but by using less electricity overall and being more energy efficient, together with the credits added to your bill at the beginning and the end of the trial, you will save more.

Understanding your Smart bill

During the User Trial of the National Smart Meter Plan you will receive a more detailed bill than your current one. This new bill and the information it provides will help you to identify where and when you are using the most electricity, and what usage you can move outside of the Peak period to reduce your bill. There will be 2 pages in your new bill:

The first page

The first page will be very similar to your existing electricity bill with just a few small changes.

Meter Readings
Because smart meters collect your usage regularly throughout the day and can be read remotely, all of the bills you receive during the User Trial will be based on actual use. This removes the need for estimated readings.

Standing Charge and PSD levy

Standing Charges and PSD levy remain unchanged from your previous bills.

This shows the number of units used and their costs at the different rates: Peak, Day or Night.



The new period covered by your bill (Jan/Feb, Mar/Apr, etc.) and the new date on which your payment is due.

What are the new prices?

There are three different prices for electricity, depending on the time of day you use it. You can save money by choosing to use electricity when the price is lower.

Time of Use prices from January 2010

Timeband	Day Rate	Peak Rate	Day Rate	Night Rate
	8am - 5pm	5pm - 7pm	7pm - 11pm	11pm - 8am
Unit Rate (incl. VAT)				

Peak Rate:

Applies only 2 hours per day on weekdays only (excluding public holidays and weekends).

Day Rate:

Applies from 8am to 5pm and from 7pm to 11pm weekdays. Day rate also applies from 8am to 11pm on weekends and public holidays (no Peak rate at weekends or on public holidays).

Night Rate:

Applies from 11pm to 8am every night.

The Peak rate is the highest while the Night rate is the cheapest.

Unit rate until the 31st December 2009 (incl. VAT) is 14.15c - 24 hour rate.



Time of Use prices will apply from 1st January - 31st December 2010. These rates may be subject to change in line with CSB Customer Supply tariff changes.



Smart Meters

Smart meters are the next generation of electricity meters. They monitor and record how much electricity you use and when you use it. They use their communication link to send this data automatically to your electricity supplier. The National Smart Meter Plan User Trial is being undertaken to understand how the use of smart meters can help in reducing the amount of electricity customers use.

Your guide to residential Time of Use prices

As part of the National Smart Meter Plan User Trial, electricity will be charged per unit, based on the time of day it is used (Time of Use pricing).

Using your Electricity Monitor

Your Electricity Monitor can help you in being energy efficient by giving you information about your electricity use and how much it is costing you. The home screen gives you the following information at a glance:

Shows how you are doing against your daily budget.

Indicates how much your electricity has cost this month (does not include standing charge and VAT).



Indicates the current cost of electricity per hour (does not include standing charge and VAT).

Indicates price per unit at Peak (red), Day (orange) and Night (green) rates.

Daily budget setting

The home screen display includes a daily budget gauge to help you in your budget planning. The amount on the gauge is the amount set by you to help you manage your daily electricity costs. You can set this amount at any time, based on your budget and the level of electricity use in your home. The gauge indicates how close to the target your usage is. When the target is exceeded it is displayed as 'Over Budget'.



The Budget Gauge

See how much you have used

Using the scroll keys on each side of the Electricity Monitor, you can see your daily, weekly and monthly costs and usage. This will help you track how you are doing.

The Electricity Monitor is fitted with a rechargeable battery and can be brought into other rooms while still working. The battery will last for up to eight hours before it needs to be recharged. It is recommended that you leave it plugged in.

Source: Electricity Smart Metering Customer Behaviour Findings Report, CER (2011)

About the VaasaETT Global Energy Think Tank

The VaasaETT Global Energy Think-Tank is a unique and independent collaborative concept based on the philosophy of mutuality. Through its network of thousands of senior executives, officials, researchers and other experts who are for the most part known and trusted personally, the Think-Tank provides value-to-all by combining an interactive Community and Collaborative Projects. The Think-Tank focuses broadly on practical strategic business and market issues, as well as envisioning state of the art innovations and developments. The VaasaETT Global Energy Think Tank brings together utilities, authorities, universities, NGOs and other players in the energy industry. **More Information at www.vaasaett.com**



The VaasaETT Global Energy Think-Tank offers knowledge sharing through its extensive online knowledge centre, unique data sharing through various projects such as the Household Energy Price Index for Europe and the Utility Customer Switching Research Project, networking integration through its intimate high level events, the VaasaETT Community and world leading round-tables and coalitions such as the Smart Energy Demand Coalition based in Brussels.



The VaasaETT Global Energy Think-Tank also publishes an array of free reports, on its own or in partnership with other organizations such as Capgemini, and its collaborative projects such as the renowned Respond 2010 smart metering and demand response project, and incorporating the best partner organizations and experts that the world has to offer.

This knowledge sharing, best practice identification and collaboration ultimately leads to outstandingly innovative strategies, solutions, methodologies, and tools and visions such as the Utility Churn Radar, which is the most advanced loyalty/disloyalty prediction tool available in the energy utilities market. It has been developed through 14 years of research and collaboration in over 35 liberalized energy markets around the globe.

"We are particularly impressed with VaasaETT's in-depth knowledge and understanding of consumer related issues in European energy markets, the degree of professionalism VaasaETT has shown and the attention to detail they demonstrated.
...We can highly recommend VaasaETT Global Energy Think Tank."

Walter Boltz, Director General, E-Control (Austrian Energy Regulator)

About ESMIG

The European Smart Metering Industry Group (ESMIG) is the European industry association that provides knowledge and expertise on Smart Metering and related communications at a European level. ESMIG's members are the leading companies in the European Smart Metering Market: meter manufacturers, IT companies and system integrators. ESMIG covers all aspects of Smart Metering, including electricity, gas, water and heat measurement. Member companies cover the entire value chain from meter manufacturing, software, installation and consulting to communications and system integration. By giving support to European Union Institutions, Member States and Standardisation Organisations, the industry group aims to assist in the development of national and European-wide introduction, roll-out and management of Smart Metering solutions.

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