Understanding the Use and Adoption of Home Energy Meters

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***Abstract*— This study aims to extend the understanding of energy management behaviour by focusing on how two commercial energy meters are used and adopted in domestic residential settings. Following the usage of home energy meters by six families in a major city in the United Kingdom, we investigate what information is important for the assessment of energy usage at home, how do information interfaces affect people's behaviour, the main motivations for regulating energy usage, and the emerging practices when using energy meters. Our findings suggest that visual forms of feedback allow users to better understand energy related information, allowing a relationship between domestic activities and energy usage to form. However, we found that technology usage decreased over time suggesting that the incentives of using this type of device eventually reduce. Home energy meters are found relevant to implement electricity usage regulations, and seen as a valuable, educational and entertaining technology for families. We briefly discuss the implications of our results for the design of new forms of energy meters.**

Keywords: energy meters, visual interfaces, home technology

I. INTRODUCTION

Optimal and responsible domestic energy usage is a goal that can be facilitated with appropriate information and communication technologies (ICT). The importance of feedback for modifying energy usage behavior is reported as successful in numerous experiences describing a variety of technologies, from simple paper reports to electronic displays [1]. Feedback is essential for individuals to make sense of their behavior and implement self efficacy and regulation mechanisms [2]. Paradoxically, current technologies for energy metering provide limited information and ineffective interactive models which prevent the development of energy usage literacy among householders. Traditional meters are difficult to reach for everyday interaction and constant monitoring, and they do not provide ways to link actual consumption with neither the effects to family finances nor the impact on the ecology [1, 3].

New home metering devices have recently come to light in the hope to encourage householders to manage their energy consumption over time. These technologies are presented as examples that promote sustainability in use providing adequate characteristics in terms of persuasion, usefulness, aesthetics, symbolic value and potential for critical reflection [4]. However there has been little evidence towards the effectiveness and level of adoption of these technologies, creating a focus for our research.

This study investigates the adoption of two commercial home energy meters in a residential domestic setting. Six families in a major city in the United Kingdom used one of the two devices for a period of eight weeks. We focused on how technology adoption affects behaviours towards energy management and analysed the motivations behind saving energy in the home. Furthermore, we investigated what information is important in assessing and understanding household energy usage, with the purpose of evaluating the value of different feedback and presentation methods.

The results from our study indicate that home energy meters were found to have an initial impact on all house members, however, over time interaction decreased or stopped throughout the majority of homes. We also found that saving financially was the main motivation for saving energy, which supports previous findings and perhaps can be explained by the recent economic downturn affecting the communities of those families studied. We discuss the implications of our results both in terms of extending previous understanding of technology adoption in family homes, as well as in terms of the requirements for new designs of energy meters to be successful.

II. THE HOME ENERGY METER CONCEPT

The typical meters installed today into many homes in the United Kingdom are electromechanical induction devices which measure usage in kilowatt-hours (KWh) and present an accumulated result since the time the device was installed at the property. These devices are meant to be used directly by householders who regularly take the readings, become aware of their usage, and then report it to the utility company. Unfortunately, using these meters to achieve energy usage awareness is not always easy. Typical meters are usually placed away from main areas, even in dark corners, meaning that people do not have easy and regular access to them. Furthermore, the accumulated measurement of KWh is not likely to be useful to residents who might want to have more specific reports such as *which* appliance is using more energy or *how much* is it going to cost. In contrast, a new generation of devices, the home energy

meters, has been created in order for people to start paying attention to their consumption by making their usage more visible, useful, understandable and approachable within the home.

The new energy monitoring technologies available in the market differ widely compared with previous digit-based interfaces, in terms of functionality and aesthetics, as they are aimed at making feedback about patterns of usage part of everyday domestic experiences [5]. Examples of these technologies, and the ones selected for this study are the Eco-Eye Elite, which provides information about real time and historical energy usage. It also provides cost comparisons by the hour, day, week or month. Eco-Eye's designer, Modern Moulds Ltd, assumes that the device will be used as a monitoring piece which will enable customers to realise their appliances consumption levels serving as a constant visual reminder to turn off unnecessary ones. On the other hand and also used in this study, is The Wattson. Designed by DIY-Kyoto Ltd, in the United Kingdom, the device is similar to the Eco-eye as it provides real time information about energy usage and historical records. The Wattson, however, introduces a unique information presentation approach and more aesthetic value which are meant to impact the way people use the product and place it in their homes. The Wattson involves a display presenting real-time energy consumption, by cost and KWh, along with a coloured interface which changes depending on the amount of energy being used. The Wattson aims to stimulate reflection, behavioural change, and conversation among users. More details on the functionality of both devices will be discussed later in this paper.

These two home energy meters, and many others commercially available, are based on the idea that real-time feedback is the most important functionality for energy saving. Studies such as the one conducted by Darby from the University of Oxford, have closely looked at different meter technologies, highlighting the importance of feedback for people's change of behaviour [1]. Furthermore, Darby found that the level of energy awareness of householders increases the likelihood that they would reduce usage not just by "switching off devices" but also by installing efficiency measures. In other words, energy meters are found to be important not just by increasing people's awareness but also as part of a model that can assist them in deciding what action to take to save energy.

Having a new generation of energy meters available with characteristics which are reported to be important to provide proper feedback [2,5] – technology being informative, understandable, usable and multi-functional – there is a lack of studies exploring the adoption of such devices and people's practices emerging when using the technology. Such studies would be relevant to extend our understanding of this type of personal information management in domestic settings as well as the best interactive systems to support it.

III. CHARACTERISTICS OF THE STUDY

A. Research Objectives

Within those studies exploring the usage of information and communication technologies in the home, and in the context of personal information management for energy usage, our study was guided by the following three research questions:

1. *How information interfaces affect people's behavior for regulating energy usage in homes?*

The two types of interfaces that we analyse provide energy consumption information in different ways; The Wattson focusing on rich visual feedback whilst the Eco-Eye presenting report based information.

2. *What are the main motivations for regulating energy usage in homes?*

Our objective is to identify the main incentives for people to save energy within the home.

3. *What are the usage practices emerging around the usage of energy meters in homes?*

We want to understand the types of reactions towards the technology and also the practices developed when the energy meter is used over a period of weeks.

B. Methodology

This study is based on an inductive research approach with an emphasis to create specific observations and qualitative measures of how home energy meters are adopted by different households and how energy is consumed as a result of technology acceptance. Six families in a major city in the United Kingdom were asked to participate in the study. All families have young children (ages 5-16) and lived in semi or detached houses with at least 3 bedrooms.

Contact was made with two UK home energy metering manufactures, Modern Moulds Ltd and DIY-Kyoto Ltd, that were both willing to provide us with the meters for the purpose of the study. The meters had to be installed into all of the participating homes and a demonstration of how they worked was given to each of the households. Home visits with each household were conducted, during which semi-structured interviews were used for data elicitation. The interviews were audio-taped and we took photos which were of interest. Three different interviews were carried out over the eight week period, each having a different focus; the first interview focused on general household energy consumption, the second targeted the reactions towards the technology and effective methods of feedback and the final involved questions related to long term practices and behavioural changes over the period.

Once all the data was collected each interview was transcribed and the data were analysed using a qualitative comparative approach, guided by the procedure of Categorical Analysis suggested by Gillham [6]. Similar to other techniques, Gillham's approach allows effective analysis of qualitative data in order to form patterns that emerge over the interviews and among the participants; however, we decided to choose this particular technique as it also provides a more structured procedure that we felt accelerated the analyses.

TABLE I. FAMILIES ADOPTIONG THE ENERGY METERS

	Participants Demographics		
	Number of people	***Adult: children ratio***	***Occupation***
Family 1 – PF1	7	2:5	Engineer
Family 2 – PF2	5	2:3	Nurse
Family 3 – PF3	3	2:1	Unemployed
Family 4 – PF4	4	2:2	Publisher
Family 5 – PF5	5	3:2	Self-employed
Family 6 – PF6	4	2:2	Government employee

C. Participants

The families participating in our study live in detached or semi-detached homes in middle class residential areas. All but one family owned their property. Table I shows some additional characteristics of the participants and their families.

D. Devices

Both energy meters are wireless. They use a sensor unit that is attached to the home power line and then connected to a transmitting unit which then communicates with the display units (as shown in Figure 1 and Figure 2). The maximum distance between the sensor unit and the display unit must not exceed 50 meters. Installation can be done by any user, without supervision of a technician, and takes no more than a few minutes. The display unit can placed anywhere within the range as it is battery operated.

The Eco-eye Elite display unit (Figure 1) displays current energy usage in Kilowatts-hour (KWh) in real-time or, at the press of a button, translates that same information into a total cost based upon hourly, daily, weekly monthly or yearly projections. The Eco-eye monitors also display the CO2 gas emissions and have a memory function which enables the user to view historical usage and resultant costs.

The Wattson display unit (Figure 2) also presents real-time electricity usage in KWh, and a quick tilt of the display unit backwards changes the display to cost mode (pounds). The Wattson has a coloured mood light, which pulses, changing colour based on the consumption of electricity: cool blue for small amount of electricity, purple for medium usage and warning red for high energy consumption. These thresholds and other settings can be adjusted using a web-based system connecting the unit to a computer using a USB interface.

IV. RESULTS

This section organises the results of the study by addressing the three research objectives guiding our investigation: the value of interfaces and information presentation, the motivation for using the devices, and the emerging practices around energy saving.

A. Energy Information Presentation and Interfaces

We found that information presentation was important to households in the assessment of energy consumption. Each device has a different style and characteristics for presenting information. Wattson presents information aesthetically using a coloured interface to represent one of three consumption levels as well as providing information on KWh or cost using red large digits on the top of the display unit. It is possible to switch off the top display or the light. In contrast, the interface of the Eco-eye display unit consists of large black digits to present KWh or cost (pounds) which can be viewed on a yearly, monthly weekly or daily basis. It is also possible to display the CO2 emissions or the current time. Figure 1 and 2 show close views of the way information is presented by each device.

Figure 1. Eco-eye display unit interface.

Figure 2. Wattson display unit interface.

Participants used just one of the devices, but within each group it was possible to detect similarities in terms of preferences for presenting information. Wattson's users preferred using the device in a mode displaying both digits and colour, but favoured to see the cost of the electricity instead of KWh. All users expressed that colour was the most important feature of the energy meter as they understood the colours in relation to their energy usage making their interaction easy and effortless: '*The colours are really good because…it's quite easy to understand…*'. Eco-eye's users, on the other hand, have a wide variety of choices

in terms of which data they would prefer to see on the display, but we also found that most users favoured to display the cost of electricity. Just one of them was undecided and alternated between cost and KWh. This may be due to the user being more knowledgeable and wanting to track and understand more precisely their consumption during the trial.

Overall we found that clarity of energy consumption information is valued by all of the households as they did not have it before, but particularly finding out, in real time, the cost of the electricity they are consuming:.

'*Yeah it was fine like I just get it one the price one to see the cost really…when I found the cost I just kept it on that.*'

The meter was useful not just in terms of understanding the overall cost of the electricity but in terms of detecting the consumption of particular appliances as indicated by one of the families: '*Just that we were surprised at how much the cost of everything shot up once you switched something on*' (P3F).

B. Motivations and Usage of Home Energy Meters

We explored with families what would be the motivations for using home energy meters and saving electricity. Three main groups of answers emerged. People were motivated for the money they would save, the impact their behaviour would have on the environment, and the comfort and satisfaction associated to have a new gadget. Interestingly all participants indicated saving money as the principal motivation, but just half of them pointed to environmental reasons. We believe that this can be explained due to the emphasis of the interfaces on presenting the cost of energy. Furthermore, just the Eco-Eye had information about the CO2 emissions, but nevertheless it did not seem to affect the results, as families using this device were not more concerned with the environment than those using the Wattson.

The way information was provided by the energy meters was one aspect that established the way the technology was used. The visual information offered by the Wattson supported users to decrease their physical interaction with the meter as they could view the information from afar whereas the Eco-Eye's variety of interfaces increased user's physical interaction on a regular basis.

Once the meter had been installed into the households the location of the energy meter was of initial importance to participants. The living room/kitchen area, defined as the central point in the home was the most popular place for the meter to be located as this was the place where they spent a lot of time. P3F describes:

'*We have put it in the front room on the coffee table so we can see it easier. This is the place where we spend most of our time so we feel that it would be best to put it in here.*' Another reason for placing it in this area was because a lot of domestic activities are carried out at the focus of the home enabling the household to monitor their usage P5F said: '*I think most of the time it was right by the kitchen sink, which is where we often are, whether it is preparing food and doing dishes…*' Figure 3 shows a picture of the location of the meter in one of the households.

Initially all of the households experimented with the meter to become familiar with it. P1F describes the curiosity about the device: '*when you first left it with us obviously everyone wanted to know what was going on, what it was…*' Initial experimentation involved switching an appliance on to see how it changed the display on the meter. Another participant described the process as: '*we were going around the house turning all the lights off to see how low we could get it down…*' (PF3)

Over time it was found that use with the energy meter became part of the family household's habits and routines because the meter had become integrated into home life: '*Yeah you know if has become a habit now and if it goes I think we'll miss it.*' (PF1) Furthermore, we notice that some participants were inclined to use the meter at particular times during the day as a routine. For instance, family P4F said: '*I definitely check it right before we go to bed when everything is turned off and I check it when I first come down...*'

Figure 3. Eco-Eye Elite in one of the homes.

Interestingly, we also noticed that meters are used when more people where in the house. Some participants said that they preferred using the meter in a group so they could understand the concept along with other people. Some found it particularly important to use the meter in a collective way because the interaction and discussions that developed as a group made use of the meter more effective: '*I think when we first got it we used it as a group quite a lot…I take more notice when other people are using it or talking about it.*' The collective use of technology enhanced interaction and understanding of the meter, because of the presence and help of others.

The amount of usage among family members fluctuated as some residents interacted with the meter more than others and that was particularly the case for the adult in charge of paying the bills: '*I think whoever is responsible for the bill is going to be more likely to use it…*' Other reasons for this were being less involved in the study compared to the main participant or as a result of being more interested in saving energy.

C. Emerging Practices and Impacts

The main effect that the energy meter had on households was to support changes out of the understanding on how they consumed energy. The alterations varied from household activities being carried out differently to reducing the time spent when using appliances. We noticed that over time technology's impact on energy usage seems to decline which indicates that the home energy meter may only be required for a specified period to inform the users of the unknown.

Two of the six families used the meter regularly and consistently throughout the study. We found that their use was not very intensive, but they reported that at least once every other day they checked the meter and explored the electricity used by different appliances. They felt that they had used the meter as effectively as possible, with no drastic changes to their interaction from week one. A number of other households usage changed over time, as their interaction gradually decreased throughout the period. Some felt that it was because they had lost interest in using the meter, while others felt they did not need to rely on the meter to tell them how much energy they were using anymore. This latter result seems to indicate that once people familiarise with their average consumption and its cost, they lose interest. Furthermore, we can notice that because the patterns of energy usage did not change much (during the period), the information provided by the meter becomes to some extent predictable.

Two household's usage stopped over time. These families were the most aware of their energy usage before the study; therefore this could have been due to them feeling that the energy meter had given them the maximum amount of help that it could provide and then discontinue its usage.

From interacting with the meter for a number of weeks the households developed new regulations within their home as an occurrence from adopting the energy meter. These rules emerged from the awareness created about energy usage, enabling people to make changes to their usage once they understood their consumption. Among the households some redefined how different appliances around the home were to be used and for how long. A mother from family P1F said referring to their children: '*…they know when they go into rooms and they know it all, like don't leave the light on whereas they used to…*' The households that were previously more aware of their energy usage believed that the meter reinforced and strengthened previous behaviour towards energy management. From using appliances, P4F explained: '*I'm always good at filling that up (washing machine) and this (the meter) would have encouraged me to do that...*' to reinforcing and creating discipline within the household in a way that has prevented them from using different appliances as previously: '*We always try to get our kids to turn a light off when they leave a room 'err' and you know this (the meter) has allowed me to reinforce that idea with them.*' (P5F).

The lasting impact of the energy meter can be seen in two main aspects: generating energy usage rules and increasing the level of awareness participants had about their energy consumption. We noticed that these aspects were more palpable during the first two weeks of the period, when people were exploring the technology. The initial impact created shock throughout all the homes as real-time information made users immediately conscious of their energy consumption: '*what it actually showed they were quite shocked at first at the amount of electricity we were using…*' However the long lasting impact of these technologies is more uncertain. Some families reported that the impact of the meter changed over time as once interaction decreased it consequently lost its importance which made old habits reappear: '*I think at the start everyone was interested in it but now it's just there and people take notice of it when it goes high.*' In contrast, other participants believed that the meter had a major influence on their households as they had decreased their energy sufficiently and learnt a lot from the information provided by the energy meter. P6F described: '*I just think it's been really positive for us genuinely…I thought it would be good to get bit more awareness really and I think it's done that.*' In general, many of them had positive feelings towards their use in the future as they felt they had learnt a lot from the meter and would continue managing their consumption as they had done previously.

V. Discussion

A. Usage and Adoption of Home Energy Meters

The energy usage habits that we found in this study can be explained in part by observing the operational structure within a home. A highly structured family can be understood as a social structure based on a high level of organisation and discipline, which rolled over to the execution of certain activities such as the organisation of payments (e.g. processing bills). On the other hand, other households can be described as using a semi operational structure, involving less organisation and discipline of household activities, where the management of home (e.g. bills) was also of little importance. That means that people in the latter type of structure do not manage their energy consumption effectively as this is generally ignored. This enables us to understand that co-ordinational differences among households affect the extent to which energy saving matters, and the chances of energy metering technologies to be adopted and used with regularity.

Previous studies have found that adoption of technology is more likely to happen if it is being incorporated within domestic activities and routines [7]. Our results present that families adopting and using the energy meter more regularly developed a routine when interacting with the device and incorporated its usage into existing patterns and processes of the home. For instance, a family added the action of checking the meter each night before going to bed, which then becomes a routine supported by technology.

In order to manage home activities particular locations have been found to be an important feature in the organisation of these routines [7]. Crabtree and Rodden call these locations 'ecological habitats' [7], "*places where communication media live and where residents go in order to locate particular resources*". In our study, as it has been

found in that of Crabtree and Rodden, energy metering technology was located in similar places such as the kitchen and living room areas. Interestingly, and spite the mobility afforded by a wireless device, our participants found a place for the home energy meter to 'live' allowing householders to locate information about their energy consumption, in a familiar place, on a habitual basis. The importance of place is that it allows the shared use of the device, an area that is accessible and recognised by all householders.

The wireless characteristics of the energy meter gave users the freedom to place the meter where they found appropriate and this was important for effective adoption of the energy meter. Particular locations allowed users to feel they were using the meter appropriately as they could interact with the device along with performing other organisational activities undertaken in these areas (e.g., commenting on energy usage while having dinner).

Clearly, the adoption of this type of technology involved a period of experimenting with the energy meter in order to understand its concept. Similar to other studies, we found that technology is embraced during the early stages of usage time [7-9]. Over the first few weeks the home energy meter was used on a daily basis by the majority of household members, highlighting the positive reactions towards new technology within the home over a short period. However our aim was to discover the adoption of technology over an extended period of time, and here the results were not very positive. Over the eight weeks the use with the meter stopped within the majority of the homes. Families felt they had learnt enough from the meter in order to manage their consumption effectively without additional support.

Our findings suggest that the home energy meter was not only used for energy management but also as a way to reinforce and create discipline within the homes. Research has found that technology can create a mean by which the role of a "good parent" is expressed through controlling the use of technology within the home [8], which our study mirrored. The discipline varied from ensuring that the children had switched off certain appliances that they were not using to how long a certain appliance was used for. From this, parents gained control of their children's additional technology usage by emphasising its level of energy consumption, which also provided additional reasons to implement this discipline.

B. Information Assessment

Previous studies have argued that "*appropriate feedback, real-time-information at salient times, and goal setting abilities households can have up to 10% energy savings with small changes in behaviour*" [3]. We did not collect any quantitative data from the study however, it was clear that the real-time information caused change in the actions taken to reduce the amount of energy used within all of the households. The changes included switching off appliances when they were not being used, using the necessary amount of lights only and using appliances for a shorter period of time. The meters allowed them to visibly see their usage decreasing and encourage energy management practices.

The participants in our study felt that real-time information was helpful in changing their behaviour because it allowed them to view their consumption 'in the moment' enabling a change almost instantly, with some type of immediate result. This immediate feedback has been shown to be important for changing energy consumption habits and attitudes, in a form that is easy to understand and relevant to users.

By providing users with real-time information this method was understandably more effective than utility bills. Visual coloured feedback was found to be the most effective method as users can make an automatic connection without having to made additional effort in understanding their usage which enhances interaction and it is a simpler method for understanding information.

Lee and his colleagues argue that the information that is provided by an energy meter should not be solely regarded as important but also the design of the user interface and type of energy report that is provided should be considered in the assessment of energy information [10]. The relevance of those issues was confirmed in our study. The general consensus between participants was that they way information was provided affects adoption of energy consumption information. The Wattson was received and taken to be a very efficient visual interface for energy usage feedback as the three colour displaying functionality enhanced the interaction of the participants who used the meter. They found this method of visualisation an effective way to present information, and were less concerned with the actual data presented on the top of the display unit. The coloured light provided initial information that could be seen from the distance, and make their judgments. More detailed understanding could come by people approaching the device and reading the display data. On the other hand, by having a larger display, Eco-Eye facilitated the reading from distance, but still people require approaching the device to interact with it. By using lights to inform users of their consumption enhances interaction with technology, establishing that the type of energy information provided along with the design of the user interface aids the effectiveness of feedback.

C. Motivations to Use and Adopt Home Energy Meters

Research describes that the motives for people wanting to save energy are usually based on financial incentives, whereas environmental factors or enhancing comfort are rarely mentioned [3]. In our case, it was clear that all the participants wanted to save energy for monetary reasons and by adopting the technology it encouraged them to do it. With the current economic recession having a direct affect on families it may have influenced the household's reasons for carrying out this study, but with rising energy bills it is also an obvious choice for UK households to make. Clearly, the main user of energy meters was the adult in charge of managing the family finances. We notice that those not involved in it or not very rigorous with payments are not similarly motivated to save. For those interested and motivated we noticed that they were more likely to enhance their understanding about energy consumption, define

strategies to improve their home and make it more energy efficient.

We found that the extended use of the technology was motivated and based on the educational effect it had on the house members, in particular on families and their children. Information Technology adoption in previous research has been established as enhancing children's and families learning experience [9]. We found that learning about energy consumption is a valuable outcome of the home energy meter and even though this may not have been a prominent reason for initial adoption it influenced peoples use over time.

D. Types of Users

We noticed that children were particularly receptive and happy with the adoption of energy meters. Previous research shows that children are becoming more aware of ICT and are more comfortable in adopting and interacting with technology [9]. Children are said to be a 'wired at birth' generation and are finding it easier to adopt technology as it is becoming part of their everyday lives [11]. Some families, particularly at the beginning of the study involved their children in the process of discovering the consumption of different appliances; something that produced fun and entertainment. Based on this we can assume that there is potential for developing interfaces that are more informative for children, interfaces which can have both the purpose of educating and entertaining its users.

For this study we explored previous research that informed the need to understand differences between genders when adopting technology. Previous research stated that men were more likely to adopt technology easily because of the label that they had developed when using technology [12]. In contrast, our results indicated that female participants seemed to adopt the technology quicker and over time they used the meter more often than the male roles within the homes. The reasons for this were unclear however the females in our study took the traditional role of housewife which caused them to manage the domestic routines consequently leading them to also control energy usage sufficiently by using the energy meter.

E. Regulating Behaviours

The main impact that the energy meter had on the participants was based on the new regulations that were established within some of the households. After achieving consumption awareness and defining possible usage modifications, rules emerged throughout these homes in order to manage these modifications towards energy consumption. Rules have previously been investigated and reported as established in local communities in order to prevent general over-consumption [13]. Those studies show that the management of energy consumption is successful within a community-like environment, which to some extent a family household reflects. The rules were observed and supported by the energy meter which worked as an instrument to measure the level of success of the modifications.

We observed that families were more willing to make more structural changes within their home after they had interacted with the energy meter and it was evident that they had made satisfactory modifications to their energy usage. Some of the families wanted to make additional home improvements including renewing their windows to be more energy efficient and installing central heating.

VI. CONCLUSIONS

We have clearly entered an age where thoughtless energy consumption has become part of our everyday domestic lives but with awareness being raised and a number of changes concerning society it seems that motivations to save energy are increasing. The role of information technologies on enhancing such awareness is evident from the results of this study.

Even though unintended by energy meter designers, the main motivation for using the energy meter and to save energy is financial. The branding schemes and marketing campaigns of the companies producing these devices have a clear emphasis on the impact that changes of behaviour can have in the environment. We agree with this, but at the same time highlight that some people might be concerned less with saving the planet and more concerned with saving their finances. This reality might lead to new forms of energy meters that combine the value of energy consumption awareness with functionality to help families to manage their finances and save money.

This study has contributed to the investigations of technology adoption, more specifically to how people adopt home energy meters over time in relation to how this affects energy management. We found that the adoption of the home energy meters was accepted by every household and it was particularly valued by families as it enabled them to integrate the technology into existing domestic routines in order to make energy saving and household organisation as obtainable as possible. Our findings support those of O'Brien and his colleagues, and Crabtree and Rodden, in the sense that technology adoption becomes successful if integration of technology within existing routines is attained [7, 8]. Once participants understood the information provided by the energy meters, then modifications towards energy saving appeared within the households, which, as in other studies, were identified as changes towards the way appliances were used [3].

We can also conclude that changes have to be implemented in energy metering technologies to guarantee that they remain of the interest of users in the long term. The meters we studied had an initial impact but gradually this decreased in due course and in the majority of cases the interaction completely stopped. This shows that informative mono-functional types of technology may only be needed and used for a specific amount of time unless it provides multi-functionality.

Further examination into home energy technology adoption in a variety of different contexts would allow our views to advance and take home operational structures into further consideration. That includes context such users of older generations, users with different family orientations or

students living in university accommodation. More research would also need to be carried out over a longitudinal period in the hope to find similar information to our study based on technology adoption over time.

Gaining a wide variety of information from our ethnographic study allowed us to obtain answers to the defined research objectives; however there were a number of limitations to the study. Even though the investigation was carried out over longer period of time compared to existing research the time period was still restricted. A longitudinal study would be an appropriate research method to allow extensive information to be collected making findings more internally valid and also in the hope to discover new effects. Another limitation was the type of sample that was used for the study, the participants were all volunteers, and we believe represent a good sample of families, however, given the small size of this sample, it makes our findings impossible to generalise towards the whole of the UK population. With our study specifically researching the area of energy management, the time of year that our study was conducted was an aspect which could have influenced the results. By carrying out the interviews in the winter period a lot more energy is consumed at this time compared to energy consumed in the summer. This naturally makes people more concerned about their energy usage in this season consequently affecting participant's feelings towards energy management.

Our future work in this area will focus on exploring the development of new interfaces for energy meters that can be used in the long term, by different users, and as part of the support for information management in domestic settings.

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