



# Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term

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## ABSTRACT

This paper reports on how, over a 12-month period, UK householders interacted with feedback on their domestic electricity consumption in a field trial of real time displays or smart energy monitors. Drawing on the findings of 11 follow-up qualitative interviews with householders involved in a 'Visible Energy Trial', the paper suggests that: (i) over time, smart energy monitors gradually become 'backgrounded' within normal household routines and practices; (ii) the monitors do increase householders' knowledge of and confidence about the amount of electricity they consume; (iii) but, beyond a certain level and for a wide variety of reasons, the monitors do not necessarily encourage or motivate householders to reduce their levels of consumption; and (iv) once equipped with new knowledge and expertise about their levels of electricity consumption, household practices may become harder to change as householders realise the limits to their energy saving potential and become frustrated by the absence of wider policy and market support. The paper concludes by reflecting on the policy and research implications of these findings in relation to future transition pathways to a low-carbon economy.

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## 1. Introduction

Almost all transition pathways to a low-carbon economy in the UK rest upon the development of a 'Smart Grid' capable of handling large amounts of distributed and renewable energy supply and offering improved demand side management. The crucial first step in developing such a grid is the roll-out of 'smart meters' which the UK Department for Energy and Climate Change (DECC) intend to install in all UK households by 2020 (DECC, 2009). By accompanying all smart meters with an in-home display or Smart Energy Monitor (SEM) that provides real-time feedback to householders about their energy consumption patterns, it is hoped that this roll-out will encourage householders to monitor and manage their energy use to save money or reduce their carbon emissions. Despite acknowledging that these measures will: "affect everyday life for millions of people and will empower individuals, businesses and communities to choose how they will play their part in reducing the UK's carbon emissions, while also minimising what they pay for their electricity use" (DECC, 2009, 8), there remains a startling lack of understanding or empirical evidence about how feedback from SEMs will be used by householders, how it will (or will not) translate into changed

consumption patterns or, and crucially, about whether or not any changes made will prove durable over time.

We began to address the first two of these questions in a previous paper in this journal (Hargreaves et al., 2010) in which, through qualitative interviews with 15 householders taking part in a trial of SEMs, we highlighted the importance of the social dynamics of household energy use, exploring how SEMs become embedded within household routines and relations leading to negotiation and conflict that hinders energy saving efforts, as often as to rational-planning and cooperative steps to cut consumption. This paper extends this previous analysis by tackling the third question: whether or not the impacts of SEMs are durable over time. It presents the empirical findings of follow-up qualitative interviews, conducted exactly 12-months later, with 11 of the same householders who took part in the initial study. Whilst a few others have previously considered the longer-term impacts of SEMs and begun to raise serious questions about the durability of their impacts (e.g., Van Dam et al., 2010; Van Houwelingen and Van Raaij, 1989; Mountain, 2006), to the best of our knowledge this paper represents the first time in-depth qualitative techniques have been used to examine how usage of SEMs develops over the longer-term and how this impacts on energy use.

The paper begins by examining relevant literature on feedback and energy consumption, emphasising studies that focus on household practices and the social dynamics of energy consumption and those that have considered the longer-term impacts

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of SEMs. Section 3 then introduces the Visible Energy Trial that forms the context for this research and the methodological techniques used. Section 4 reports the empirical results of 11 follow-up interviews with participants in the Visible Energy Trial focussing specifically on how their usage of the SEMs evolved as the trial went on and how this impacted upon their energy consumption. Finally, Section 5 considers the implications of our findings for future research and policy, raising particular questions about the relationship between contemporary patterns of energy consumption and demand and future transition pathways to a low-carbon economy.

## 2. Energy feedback and household dynamics over the long-term

The provision of information and feedback on domestic energy consumption is seen as perhaps the key means of overcoming energy's so-called 'double invisibility' — that it can be neither seen nor connected to everyday actions (Burgess and Nye, 2008). Although feedback can take a variety of forms — from more informative bills (Wilhite and Ling, 1995) to the face-to-face provision of advice (Darby, 2003) — current policy hopes, in the UK at least, are pinned heavily on the provision of real-time feedback from smart energy monitors (SEMs — e.g., DECC, 2009; National Audit Office, 2011). A recent review of a range of SEM-trials from across the US revealed savings of between 3 and 13% with an average saving of 7% (Faruqui et al., 2010) with Fischer (2008) suggesting that the effectiveness of feedback depends on its frequency, duration, content, breakdown, medium of presentation, social comparisons and combination with other interventions. In the UK, the final analysis of the large-scale Energy Demand Research Project, involving some 60,000 households including 18,000 with smart meters, observed no statistically significant savings from standalone SEMs and just 3% savings from SEMs when they were accompanied by smart meters (AECOM Limited, 2011)<sup>1</sup>. These kinds of findings reveal the considerable difficulties involved in realising significant savings in domestic energy use through forms of information provision.

In our previous paper (Hargreaves et al., 2010), we highlighted the rationalist and individualistic nature of the linear 'information-deficit' model that underpins the majority of these feedback studies. As Strengers observes, these studies "assume that individuals act as 'micro-resource managers' weighing up the costs and benefits of consuming resources in accordance with their desires, opinions, values, attitudes and beliefs" (2011, 36). By focussing narrowly on individual decision making processes, such studies effectively render households as 'black boxes' (Darby, 2003) in that they fail to account for the ways in which feedback must be made sense of, negotiated against, and acted upon (or not) amid existing domestic situations often involving multiple household members. For example, in our previous paper we highlighted the importance of the social dynamics of households, revealing how energy feedback must be 'domesticated' into a wide range of different household 'moral economies' (Silverstone et al., 1992) — the particular sets of household values, routines and practices that have developed over time and typically remain unquestioned — causing conflict between householders as often as

cooperation, and thus challenging the smooth, linear cause-effect progress of the information-deficit model.

Since our paper, others have also focussed on the social impacts of SEMs, and the ways in which they must be 'appropriated' into myriad household circumstances, each time with complex and varying impacts on their overall effectiveness (Wallenborn et al., 2011; and see also Grønhøj and Thøgersen 2011). Further, research has also begun to focus on the ways SEMs interact with household habits, routines and social practices and the technological configurations they involve. For instance, studies have highlighted how different technological configurations provide different 'affordances' for energy saving (Darby, 2010); how household habits and routines are often unconsciously carried out and thus do not respond in a straightforward manner to rational and conscious information provision (Pierce et al., 2010); and how existing social practices can potentially render energy saving socially unacceptable by demanding high levels of energy consumption just to uphold an appearance of 'normality' (Bartiaux, 2008; Gram-Hanssen, 2011; Strengers 2008, 2011). Arguably, these studies contribute broadly to a new interest in theorising the 'energy cultures' (Stephenson et al., 2010) of particular contexts, such as homes or workplaces, that moves the debate some way beyond a narrow focus on the decision-making processes of individual energy users.

Whilst these new modes of theorising energy consumption have made significant progress in opening up the black box of the household, a key shortcoming is that, empirically at least, most fail to keep it open for a sustained time period. As Van Dam et al. (2010) argue, most studies of energy feedback devices last for periods of less than 4 months, with the very few longer-term studies, such as by Van Houwelingen and Van Raaij (1989) or by Mountain (2006), reporting 'indecisive results' (Van Dam et al., 2010, 460). Reviewing several studies to assess the longer-term impacts of SEMs, Van Dam et al. suggest that even over relatively short time periods 'the general trend seems to be that feedback devices slowly drift into the background', and note that 'the exact cause of this finding has not been studied' (2010, 460). In their own 15-month trial, Van Dam et al. confirm this general trend, concluding that 'an energy monitor is not effective over a longer period (more than 4 months) for a majority of users' (2010, 467). Whilst they suggest several causes for this — that people revert to their previous behaviour, that people purchase new appliances raising overall levels of consumption, or the rebound effect — they also acknowledge that their reliance on questionnaires and self-reported meter data left them unable to fully explain how or why it is that SEMs 'drift into the background'. To the best of our knowledge, there are currently no in-depth, qualitative studies that track the usage of SEMs over anything more than a 4-month period, exploring how use of SEMs develops and changes over time, how this differs between different households or what effects this has on energy consumption. This paper attempts to begin filling this important gap in the literature. The next section introduces the Visible Energy Trial (VET) from which the empirical results came.

## 3. Methodology: The Visible Energy Trial

Throughout 2008–2010, 275 households from across eastern England were recruited to trial three different standalone (i.e., without an accompanying smart meter) SEMs of differing levels of sophistication for at least a 12-month period. Participants were recruited in various ways including through newspaper and internet advertisements, at energy events and fairs, and through local authorities and housing associations. All participants were offered the SEMs at discounted rates. The monitors themselves

<sup>1</sup> Participants in this study received standalone SEMs that were not accompanied by smart meters. As an anonymous reviewer noted, and as the AECOM Limited (2011) results confirm, there is an apparent difference between how standalone SEMs that have been available for a few years and integrated smart metering systems are received by householders. How these differences are explained is certainly worthy of further exploration but was, unfortunately, beyond the scope of this study.



Fig. 1. The monitors (showing, from left to right, the Solo, the Duet, the Trio).

(see Fig. 1) were designed and manufactured by a small company called Green Energy Options (GEO) and consisted of:

- The *Solo*, trialled by 75 households, which comprises a single monochrome display that includes a 'speedometer' to indicate instantaneous levels of energy use (expressed in kWh, pounds sterling or CO<sub>2</sub> emissions), a 'milometer' which shows the amount of energy used each day, and a 'fuel tank' which allows householders to set a daily budget and indicates whether or not this is being met by displaying a tick or a cross symbol;
- The *Duet* ( $n=75$ ) which is exactly the same as the Solo on its left-hand screen, but also contains a right-hand screen that monitors boiler usage and, through 6 'PlugBug' devices that wirelessly transmit data to the Duet unit, monitors up to 6 individual household appliances.
- The *Trio* ( $n=76$ ) which has a full-colour display and can monitor heating, hot water use, all electrical circuits in the home and, through PlugBugs, up to 100 individual appliances. The Trio can then display this data in graphical form over 24 hour and monthly periods.

Both the Solo and Duet units can be self-installed by clipping a transmitter onto the electricity meter and, in the case of the Duet, to the boiler, whilst the Trio requires professional installation by a qualified electrician and computer/wi-fi specialist. In addition, the VET also involved a control group ( $n=49$ ) who had the Trio installed into their home but did not receive the visual display unit.

Real-time energy use data were collected by the monitors during the trial and the results of the quantitative analysis are discussed in Nye et al. (2010a). In addition to the quantitative results, however, a sub-sample of 15 households were recruited from the total sample to take part in two rounds of in-depth qualitative interviews. For the initial interviews – conducted in October–November 2009 and reported on in Hargreaves et al. (2010) – four households were recruited from each of the Solo, Duet and Trio groups and three households from the control group. For the follow-up interviews, the same 12 households from the Solo, Duet and Trio groups were again approached exactly 12-months later (October–November 2010). Of these 12, 11 agreed to be interviewed again, and these interviews form the empirical basis of this article.

The follow-up interviews lasted for between 15 and 45 minutes and, due to time constraints in completing the fieldwork, were all conducted by telephone. In each case, interviewees were asked to comment on whether they were still using the monitors, and whether or not the monitors had affected their energy awareness, knowledge or their behaviour and routines. They were also asked how their use of the monitors had developed over the course of the trial, and to reflect on any frustrations they had experienced or recommendations they could make for improving the monitors. All of the interviews were digitally recorded and

transcribed verbatim. The analysis presented here broadly followed a grounded theory approach (Charmaz, 2006), although specific attention was paid to how usage of the monitors had developed and changed over the course of the trial, and to any associated effects on energy awareness, knowledge or household behaviour and routines. The next section reports the findings of these interviews for the first time.

#### 4. Findings: Keeping energy visible?

This section is divided into three parts focussing, respectively, on how usage of the monitors changed during the trial, the effects the monitors had on energy awareness, behaviour and household dynamics, and on the limitations and frustrations interviewees reported.

##### 4.1. How did usage of the monitors change?

Only three of the 11 follow-up interviewees reported that they had completely stopped using their monitor during the course of the trial. Of these, two had stopped unwillingly for practical or technical reasons (one had moved home and been unable to have the Trio wired in at the new home, the other had not got round to replacing the batteries in the clip-on transmitter) and only one had consciously decided to stop using the monitor and pack it away. Whilst the eight other interviewees reported they were still using their monitors, they all also noted that their usage had dropped off considerably after an initial period in which the device had been something of a novelty:

Occasionally I would say really. I look at it probably about once a week. One reason I suppose is just that you get interested in it to start with and then you slowly lose interest. (S3<sup>2</sup>, p1)

One interviewee described this as like a 'honeymoon period' (D4, p5).

A number of different reasons were offered for this gradual reduction in usage including general laziness, forgetfulness, slipping back into old habits and also becoming frustrated by minor technical issues. Most commonly, however, interviewees suggested they had stopped using the monitors because they had stopped offering new information — although none went on to specify exactly what form this 'new' information might take. For example:

As it's more of a novelty you definitely check it more, but I think it's definitely part of the background now. It's become part of the fabric really....and also it doesn't really change that

<sup>2</sup> To preserve anonymity, all interviewees have been assigned a unique identifier. The letter refers to the type of monitor device they were using (S=Solo; D=Duet; T=Trio) whilst the number distinguishes between users of the same type of monitor.

much any more, so I don't feel I have a need to keep monitoring it. I sort of feel I have a reasonable view of what it's going to be anyway. (T1, p1).

Importantly, when asked to describe how often they used the device, and how this fitted in with their daily routines, accounts in the follow-up interviews differed significantly from those offered in the initial interviews a year earlier. In the initial interviews, the 'nag factor' was of crucial importance as the monitors were extremely conspicuous around the home and served to 'focus the mind', making their users far more conscious of their energy consumption. A year later, however, a very different kind of account had become dominant. Instead of emphasising how the devices were a conspicuous and nagging presence around the home, they now appeared to have become embedded in the 'background' of everyday life. Although interviewees were still aware of their energy consumption patterns and were still using the monitors, this awareness had become less explicit. The feedback provided by the monitors appeared to have been incorporated into everyday life in an almost unthinking and routine manner, suggesting a drift from the discursive consciousness (the level of consciousness that allows people to reflect on and tell rational stories about their actions), to the practical consciousness (automatic, habitual knowledge about how to 'go on' in the world without having to make new decisions at each moment; see Giddens, 1984), as has been also observed in other spheres of environmentally significant behaviour (e.g., Hobson, 2003). One interviewee described this as a 'casual' (T4, p1) form of use.

These findings both confirm and extend those of Van Dam et al. (2010). The monitors did indeed appear to drift gradually 'into the background', but our findings show that this occurs because the monitors stop offering new or sufficiently detailed information. Crucially, however, the monitors had not simply been forgotten or discarded. Rather, interviewees appeared to have rapidly learnt what their domestic energy consumption patterns were, often in some considerable detail (see Section 4.2), and only after this initial learning period had the monitors stopped exciting regular interest.

To maintain this learning process, some interviewees emphasised the importance of keeping the monitors in a communal area, such as the kitchen, hallway or lounge, where they are a conspicuous, nagging presence and can be seen by all householders. As the trial went on, however, several interviewees noted that at least some household members had begun to find the monitors annoying and 'in your face' (T2, p7). As a result, several interviewees reported having moved the monitors out of communal areas into more private, back-rooms, such as a study or office, where they were typically only seen by a single householder:

Yes, it has moved rooms, it's now in my office rather than in the living room. Basically we had a bit of a tidy up in the house and my wife decided she didn't like it in the living room (laughs) so, but I spend an awful lot of my time in the office so it's sort of monitored I suppose most daytimes now at least, if not sort of in the evening. (D4, p1)

Interestingly, as this quotation illustrates, the movement of the monitor around the home had led to new forms of monitoring – during the daytime rather than in the evening – and thus to new kinds of learning suggesting that the 'backgrounding' of the monitors mentioned above is far from permanent, and can quite easily be undone in an ongoing process of the monitors becoming de- and re-embedded into the normally unquestioned values, practices and routines that make up 'moral economies' (cf. Wallenborn et al., 2011).

Another key way in which monitor usage changed during the trial was in a gradual shift from, at first, using the monitors in a

general sense to learn about how much energy was normally used for different household practices, towards a more specific form of use in which the monitors were used to keep a close eye on the energy use of particular appliances that were considered either wasteful or unnecessary. Several interviewees noted, for example, that having learnt their basic patterns of consumption in the first few weeks or months of having the monitor, they had subsequently taken to using the monitors for very precise purposes, such as to tell whether or not electric heaters, computers or outdoor lights had been left on. Thus, instead of keeping a general track of normal routines, interviewees started to use the monitors to help them keep a specific eye on breaks in or disruptions to these normal patterns. Indeed, one interviewee expressed frustration that the monitors did not automatically learn his 'normal' usage patterns:

It penalises you for normal usage, so, if you happen to decide to do the washing on a Thursday, whereas last week you did it on a Wednesday, erm, you'll show up extraordinarily good on this Wednesday, but extraordinarily bad this Thursday and all you've done is the washing. It can't distinguish between good usage and bad usage. (D1, p2)

As the trial went on interviewees appeared to want to use the monitors to focus only on what they saw as discretionary, wasteful or 'bad' usage and thus leave 'normal' or good usage un-penalised. This finding has at least two important implications for SEMs overall effectiveness in saving energy. First, it suggests that there are real limits to how strongly the monitors can express normative and judgemental 'save energy' messages before becoming annoying to householders and being disregarded. Second, in a context of the increasing normalisation of more and more energy-consuming personal and household appliances, the monitor's apparent inability to challenge 'normal' levels of use suggests they will struggle to reverse and may even serve to reinforce rising levels of domestic energy consumption — an idea we explore further in the next section.

#### 4.2. What effects did the monitors have?

Where Section 4.1 focussed on how the monitors were being used by the interviewees, this section considers the effects the monitors were having by focussing, in turn, on levels of energy awareness, forms of behaviour, and household social dynamics.

Across all interviewees, the monitors appeared to have had a profound effect on levels of awareness about energy consumption. For example:

I think it's permanently altered mine and my wife's use of power. It's made us far more aware than we ever were before. (D2, p3)

Whilst interviewees discussed heightened levels of energy awareness, however, just as the monitors themselves had become 'backgrounded' within household routines, these new levels of awareness were also reported as being part of the unthinking practical consciousness rather than something that prompted regular conscious attention or discussion. After a year with the monitors, high levels of energy awareness appeared to have become something, for our interviewees, that was always 'in the corner of my eye' (D4, p1) or that 'we don't think about':

We have changed and I think we've changed forever, because we don't think about it these days. It's part of life now to make sure that you're not using too much power, and we're all aware of it. (D2, p5)

This is not to suggest, however, that our interviewees' energy awareness was not extremely detailed or accurate. Indeed, almost



all of the follow-up interviewees reported great pride in just how precise and detailed their knowledge of their normal energy consumption levels had become. For example:

When the meter goes up and shows that there's more usage, sort of if it's up a couple of kilowatts, it's rather obvious to me and if anybody else is in the house I sort of question straight-away 'what's been turned on?' (D4, p1)

I think it's interesting now that I can actually spot anything over about a 60 or 70 W increase, I'm really good at it, and so can my wife. (D2, p2)

What appeared to have happened over the course of the trial, therefore, was that interviewees had become very familiar with what they considered to be the 'normal' or 'base level' (T2, p2) of energy use for their household. In this respect, although not something that prompted regular conscious attention, levels of energy use had become a salient part of routine household decision-making, and something that could be used to help distinguish between 'good' or 'bad' routines and practices.

Crucially, after an initial period of reducing 'bad' usage and switching things off when the monitor was new, over the course of the trial interviewees had come to accept their normal consumption levels and patterns as exactly that, 'normal' and thus not in need of further change or reduction. Indeed, whilst in the initial interviews the 'nag factor' had been seen as helpful in prompting householders to go round and switch things off, as the trial had developed this continual nagging had become less useful and even risked becoming annoying and irritating.

I don't need that nag factor because my cooking habits don't change significantly, erm my electrical consumption in the lounge doesn't change unless I've got the telly on, so my consumption is very very static. (T4, p2)

Overall, therefore, over the course of the trial, the monitors appeared to have generated heightened levels of energy awareness, with interviewees closely aware of what was normal for their household although not necessarily motivated to reduce it further.

With regards to the monitors' impacts on behaviour and levels of energy consumption, in the initial set of interviews we identified three main ways in which they had effects (see Hargreaves et al., 2010):

- i) 'Using it hot' — the monitors provided an immediate prompt for householders to go round and switch things off.
- ii) Making considered decisions — the monitors helped householders to identify particularly wasteful appliances or behaviours and then to use them less, or replace them.
- iii) Spillover effects — the monitors empowered householders to discuss energy consumption with family and friends, and encourage them to save energy too.

The same basic effects were also identified in the follow-up interviews and thus do not require further repetition. Where in the initial interviews the devices had been used in quite a general manner to keep a check on overall levels of energy consumption, however, as the trial had gone on monitor usage had become much more specific as interviewees had learnt the precise things in their households that they tended to leave on or which used energy wastefully. Although the precise thing differed in each case, interviewees variously reported using the monitors to keep a specific eye on the heater in the greenhouse or garage, lights in children's bedrooms, the oven, the outdoor light, the printer etc. A key point here, and one stressed by several interviewees, was that once this specific usage of the monitors had been identified

and established, the savings that could be realised by switching these things off tended to be very small:

I think I could probably be really good and switch stuff off and be very conscientious and save a few pounds, but I don't think it's going to be saving me tens of pounds or hundreds of pounds. (T1, p2)

Whereas in the initial round of interviews interviewees had often mentioned the steps they were taking to reduce their base level of energy use (e.g., installing low energy lightbulbs, replacing old fridges and boilers etc.), this was far less apparent in the follow-up interviews. Several interviewees did again mention the steps they'd taken when they'd initially received the monitor, but after this initial burst of energy saving activity, the monitors appeared unable to motivate further steps to reduce consumption levels. Indeed, once the base or normal level of consumption had been identified, there was very little sense among interviewees that it either could or should be reduced further. Only one interviewee stressed his intent to further reduce his base level consumption and, in this case, he was strongly motivated by environmental goals, which was quite unusual in this small sample. Whilst this interviewee (T2) stated he was willing to accept lower levels of comfort (e.g., by turning down the thermostat), in all other cases interviewees emphasised that their base level consumption was made up of things that they needed and, therefore, that to stop using them would have significant effects on their levels of comfort or convenience:

I wouldn't say we were trying very hard to do much more at the moment. I mean I guess we could but it's a matter of just balancing convenience of life against what you're willing to pay I suppose. (S3, p2)

You can go a certain distance when you first get one of these devices and you can probably reduce your use...but then, you know, you get to a certain level and, you know, you don't want to not use the dishwasher because that has other implications...so you've gone a certain distance but then it's just, you know, have I made a mistake this week? Have I left anything on that I shouldn't have? (D1, p5)

As these quotations illustrate clearly, the devices had been used to learn about normal and base levels of consumption and had done this extremely effectively. Beyond this, however, they did not appear to have a strongly motivating effect to encourage at least this group of interviewees to change their behaviour further. Here, several of the interviewees explained how after an initial period of interest in which a few changes had been made, the devices were now useful largely to keep them on a 'level keel' and to ensure that the normal, base level consumption did not rise:

I think I'm at the stage now where...I think generally it's a good reminder. It will help you save energy if you want to use it that way, but if nothing else it will at least keep you on a level keel. (D3, p5)

I think we've plateaued out to be honest, I think it's fairly consistent now. I think when we first got it we made a few changes [replacing an old inefficient freezer and switching to a cheaper tariff] and they made a big difference, and now I think the changes would be very minimal....so I think we're fairly consistent now to be honest. (T1, p8)

As these quotations illustrate the monitors appear to have enabled the interviewees to learn what is 'normal' for their household and to try and stick to it. Unfortunately, due to inconsistencies in reporting and the application of baseline protocols outside of our control, our own quantitative analysis of energy usage patterns across all

participants in the trial (including those interviewed for this paper) is unable to conclusively confirm what level of quantitative savings, if any, were realised by our interviewees (Nye et al., 2010a). What is crucial, however, is that interviewees perceived the monitors as useful to help them control and reduce particular abnormal, unusual or wasteful forms of consumption, but there is then a base level of energy use which most of our interviewees appeared to accept and showed little interest in reducing further. Worryingly, and following Strengers (2008, 2011), these findings suggest that the monitors may in fact serve to reinforce and harden existing and potentially unsustainable levels of energy consumption as 'normal', making subsequent challenges to everyday practice and reductions in usage still more difficult to achieve.

In addition to these effects on levels of awareness and types of behaviour, a key theme running throughout several of the follow-up interviews, much more strongly than in the initial set of interviews, was the ways in which the monitors had given rise to new forms of social interaction around energy use both within and beyond the household. Most commonly, interviewees stressed that the monitors had made it easier for them to communicate the impacts of energy use – either on their bills or on their carbon emissions – to other, less interested household members. Here, several interviewees mentioned the kinds of proof or 'evidence' provided by the devices that enabled them to give presentations in order to 'demonstrate' how much might be saved through relatively simple actions:

I'm still quite a pushy Dad when it comes to 'you've left things on' and if they say 'oh yeah yeah, whatever', I will say 'look it shows you there how much we're using....if you're leaving that light on, it does have an effect'. They can see it now, there's more evidence. (D4, p5)

In this respect, the devices had helped to provide information to the interviewees that could then be discussed and negotiated amongst householders as a potential means of generating savings. Although, and as the next section will explore, such negotiations were by no means simple or straightforward.

This section has explored the effects of the monitors on awareness, behaviour and social interactions as reported in the follow-up interviews. In all three cases, the devices were found to have significant effects but in ways that differ importantly from what would be predicted by linear and rationalist deficit-model assumptions, and also in ways that evolved over the course of the trial. Most notably, the monitors appeared to have made interviewees aware of what was a 'normal' level of energy consumption for their household and, after an initial period of attempting to reduce this through behavioural changes or improvements in efficiency, the monitors then helped households to keep their normal level of consumption stable, consistent and on a 'level keel'. A crucial question arising from these findings, therefore, is the extent to which monitors such as those used in this trial will be able to deliver substantial and ongoing energy savings by challenging and reducing what is considered to be normal.

#### 4.3. Limits and frustrations

The initial interviews identified a number of limitations that interviewees faced that prevented them from making further changes to save energy. These included: certain appliances being considered either essential or at least desirable and justifiable; certain household routines and rhythms being impossible to change; negotiations with other household members making changes difficult; and a lack of support for change within the wider regulatory or market context. Each of these limitations was still apparent in the follow-up interviews and indeed many had

become heightened during the course of the trial. This section will focus specifically on three such limitations that appeared to have developed since the initial set of interviews: negotiations with other householders; that certain appliances cannot be lived without; and that the broader context is unsupportive.

First, whilst the difficulty of encouraging other householders to change their behaviour was a key theme in the initial interviews, in the follow-up interviews this appeared to have developed and two distinct trends were now apparent: in some cases initial conflicts had been overcome and compromises had been reached about acceptable levels of energy use; in others, resistance to the monitors was ongoing and the monitors had often been moved to another part of the house whilst negotiations continued. In the first case, interviewees again repeated that their (typically) wives or children paid little attention to the device but that they could not make changes or realise savings without first consulting them and gaining their consent. For example:

I couldn't go ahead and do a lot of changes without her agreeing. I mean she's been rather resistant to putting in the new kind of electric light bulbs... we're now sort of 9/10ths the way, but she still wants one or two in certain places...It's illogical, but there it is (laughs). (S3, p4)

In this, and in other instances, initial 'resistance' to the monitor had been overcome by reaching a compromise position in which energy saving was accepted as important, but only to the extent that it did not threaten existing conventions of comfort, cleanliness or convenience (cf. Shove, 2003).

Whilst the first trend points to gradual energy savings over time, in other instances compromises had not been reached and negotiations were ongoing. This was especially true in cases where the devices themselves were seen as annoying and intrusive by other household members. For example:

My wife hasn't even taken the slightest bit of interest in it. I'll be honest with you, and it's quite disappointing really because I'm trying to educate her but it's just not working (laughs).... I think she sees it as being a bit of a threat to her because she has a comfort level, she doesn't want to go below that comfort level, and I'm always going to be pushing the boundaries... she's very very (laughing) preoccupied about the [Trio], she was trying to get it out of the house and trying to say 'it doesn't really need to go there'. (T2, p3)

In this case, the monitor had subsequently been moved to a different part of the house where it was less visible and intrusive, and the interviewee reported that his attempts to save energy had not yet been especially successful.

It is important to note that, over different issues, both of these trends were discernable often within the same household. For example, compromises may have been reached over leaving lights on but not over heating levels or tumble dryer use. Further still, and as mentioned earlier, these trends appear to develop over time as the monitors are moved around the home and new patterns of energy usage are picked up, as children have school projects on energy saving, or as energy prices rise. In this respect, whilst the two sets of interviews conducted in this trial provide valuable insights into these developments, further longitudinal and ethnographic research is necessary to explore in greater depth how the monitors are constantly being embedded, dis-embedded and re-embedded in particular household situations.

The crucial point to emerge from these household negotiations, however, is that whilst the monitors may be predominantly read and used by a single household member, these individuals should not be treated as existing in isolation, but instead as part of broader household 'communities of practice'

(e.g., Wenger, 1998) or 'energy cultures' (Stephenson et al., 2010). As well as requiring further empirical research into the inter-relationships between householders, for example that focuses on the relative success of different approaches householders use to get others to cooperate with them, this observation demands new modes of theorising household energy consumption that go beyond narrow understandings of individual decision-making about energy use, and begin instead to account for the full range of household dynamics and practices, many of which ostensibly have little or nothing to do with energy.

The second limitation we will highlight was that certain appliances cannot be lived without. Whilst this was also a strong theme in the initial set of interviews, the key development in the follow-up interviews was that interviewees spoke of their 'necessary' usage within the newly established context of their detailed awareness of what was considered 'normal' for their household. Within this context, interviewees stressed that they were already doing all they could to reduce or control their energy consumption levels and that they neither could nor should go much or even any further:

I'm starting from a point of virtually nothing anyway...the only thing I could reduce is the amount of cups of tea I drink, I could make myself a flask but come on, I've got to have some benefits to life! (laughs) (T4, p3)

Whilst it is very interesting to monitor how much the television costs and stuff, that's not going to change my behaviour because to me I need those things, I use those things every day and, you know, I need them really. (T1, p6)

As was found in the initial set of interviews, precisely what constituted a necessity differed enormously between households and variously included kettles, tumble dryers, fridges and freezers, fishtanks, bread makers, games consoles, electric pianos etc. Vitally, however, within the follow-up interviews these various uses had come to be seen as an unavoidable part of the normal, base level energy consumption. In turn, interviewees appeared to have developed a more heightened sense that these 'necessities' should not be challenged, and were more prepared, in several instances, to defend their continued use.

Indeed, in some cases, and particularly with lower-income and older interviewees, an undercurrent of defensiveness ran throughout parts of the interview that they should not be singled out or made to feel guilty about what they considered to be normal levels of consumption, especially as long as other households, government or industry remained considerably more profligate in their energy consumption. To an extent, therefore, after having identified their normal level of consumption, this appeared to have become hardened or ossified by the constant background monitoring that the monitors permitted, and interviewees reacted quite defensively to further requests to reduce consumption.

The final limitation we will highlight is that the wider policy and market context was considered unsupportive of energy saving measures. In those cases where interviewees did appear to feel targeted and singled out by suggestions that they should reduce their energy usage, they often hit back at others who they saw as more wasteful in their use of energy. Countless examples were offered in the interviews, from supermarkets wasting energy to heat their entrances only for the freezer sections to be extremely cold, through kettle manufacturers starting the "scale of the kettle way too high up" (D2, p3), to frustration with the broader system of electricity pricing:

Can you explain why my first 350-odd units are priced at 17p each, and all subsequent units are 12p? Now wouldn't it be better to say, actually your first 350-odd units are charged at 12p, and then we're gonna sting you, and I bet you somehow

my consumption will find a way to drop off from almost nothing to something lower. (T4, p7)

Indeed, it is worth noting here that the only interviewee that had completely rejected the monitor and packed it away, had done so at least in part because he saw the whole system of providing a device that uses electricity in order to tell people to save electricity as both extremely hypocritical and excessively wasteful:

If you have an electricity bill, let's just say £100, and if that [monitor] can save you £12 that's got to be good. But put that £12 against what that [monitor] costs. How many years before that even breaks even? That's pointless....You might as well have a pee against the wind. You're getting nowhere. (S2, p6)

These general observations reinforce a key finding of the initial set of interviews that the devices are only as useful as the broader contexts in which they are used. To the extent that they are seen as part of a broader collective effort to save energy, reduce waste, or cut emissions, they appear able to engage householders in attempts to reduce their own energy consumption. At present, however, several interviewees appeared to feel as if the devices singled them out, asking them to make energy savings that would harm their normal everyday life, whilst others in society did nothing. As such, further consideration might be given to the ways in which devices like the Solo, Duet and Trio might be provided to households as part of broader collective efforts and partnerships to save energy more generally across society. Engaging households as part of such collective efforts, these interviews imply, might be one means of overcoming the otherwise quite justifiable defensiveness over normal patterns of consumption reported here.

## 5. Discussion and conclusions

To the best of our knowledge, this paper represents the first attempt to use in-depth qualitative methods to explore how householders use SEMs, and how this usage changes over a 12-month period. Despite the different levels of sophistication of the three SEMs used in this trial, all of the monitors rapidly became 'backgrounded' and embedded into everyday household routines such that an initial and conspicuous 'nag factor' quickly gives way to a 'casual', unthinking and routine form of use. Far from ignoring or forgetting the SEMs, however, during this process the households in our sample appeared to learn what counted as 'normal' consumption for their household in quite considerable detail. Whilst the SEMs prompted some initial behavioural changes to cut out unnecessary and wasteful energy use, once this 'normal' level of consumption had been learnt, the monitors then appeared to be used only for very specific reasons and to provide little or no motivation to reduce energy consumption further — especially in the absence of wider policy and market measures to save energy. Further, and perhaps worryingly, the monitors appeared in some cases to have reinforced and hardened this 'normal' level of consumption, leading householders to react defensively to any subsequent calls to cut their energy use. These findings confirm those of our earlier paper (Hargreaves et al., 2010), and those of many others (e.g., Shove et al., 1998; Strengers, 2008, 2011; Gram-Hanssen 2011) which dismiss the rationalist 'information-deficit' model of energy consumption as far too simplistic. In short, simply making energy visible, and even managing to keep it visible, is not enough. Our findings show that energy consumption in households involves multiple rationalities and logics, performed by multiple householders, often in complex and dynamic negotiations with one



another, and in ways that change over time in response to different contextual forces (e.g., Guy, 2004).

These findings are of course based on a very small sample size and, as such, further research is required. Fully understanding the ways SEMs become embedded within household practices and decision-making processes, and teasing out the full implications for broader transition pathways to a sustainable energy system, will demand new modes of researching and theorising household energy consumption. Whilst this paper has concentrated on reporting new empirical findings, we feel there is significant promise in approaches that examine how information and feedback on energy use changes the place and significance of energy within pre-existing household 'moral economies' (Silverstone et al., 1992) that are themselves comprised of bundles of social practices jointly performed and negotiated by groups of householders. Our findings call for new forms of interdisciplinary working and collaboration capable of combining the insights of qualitative social science about the multiple and complex rationalities of micro-scale household energy use with the macro-scale engineering and economic models of the energy system that are currently fundamental to scenario-building and policy-making in this area (cf. Hargreaves and Burgess, 2010; Shove, 1998). More specifically, significant further research on the dynamics of household energy cultures and moral economies, particularly in a context of Western, consumption-oriented lifestyles, is required. Such research could usefully add detail to the process outlined above and explore if it differs across different types of household moral economy; employ more in-depth ethnographic techniques to shed further light on micro-scale household interactions and dynamics; and examine how the impacts of SEMs might be improved or made more durable through combination with other interventions such as behaviour change campaigns or community-led modes of distribution and installation (e.g., Hargreaves et al., 2008; Mulugetta et al., 2010).

With regard to energy policy, at least three core issues arise from our findings. First, and perhaps most obviously, even within our small sample we found a diverse range of responses to the SEMs. Different householders used the monitors in different ways to address different household practices and forms of energy consumption. Future transition pathways will therefore, and necessarily, be both bumpy and changeable, with different households and social actors following different trajectories and routes, at different rates and even potentially switching between different pathways periodically. One size most definitely will not fit all, in a way that will seriously frustrate socially ill-informed attempts at demand-side participation and management.

Second, the challenges our interviewees faced in using the monitors to reduce their energy consumption, and the perceived lack of support they received from within the wider policy and market context suggests that whilst still conceivably possible, a bottom-up, demand-driven transition pathway is extremely improbable. Making energy visible and hoping this will drive reductions in energy use or that it will fuel demand for further innovations in energy efficient and low-carbon technology (cf. Nye et al., 2010b) appears to be fundamentally inadequate in the absence of wider, and significant reforms in the broader energy 'regime' or 'landscape' (Rip and Kemp, 1998).

Finally, and perhaps most contentiously, our findings suggest that in the context of Western lifestyles and socio-culturally driven consumption patterns, the limits of making energy visible by providing householders with feedback on their energy use will be very quickly reached. Our findings show that after a relatively short time period, SEMs become used primarily to help householders control their discretionary energy use, whilst leaving 'normal' usage unquestioned and even potentially reinforced. At the same time, these normal levels of energy use continue to

rise (DECC, 2011) as demand for energy-consuming appliances to meet escalating conventions of comfort, cleanliness and convenience grows (e.g., Shove, 2003). In this context, establishing transition pathways to a sustainable and low-carbon energy economy will demand policy measures that, rather than leaving the complex dynamics of energy consumption unquestioned and thus tacitly supporting and sustaining 'normal' patterns of consumption that are known to be unsustainable, seek instead to challenge these trajectories. Potential measures might include exploring and experimenting with radical policy measures that seek to arrest rather than promote continual growth in levels of material and energy consumption e.g., personal carbon allowances (e.g., Seyfang et al., 2007) or alternative metrics of well-being (e.g., New Economics Foundation, 2009), as well as more creative and systemic use of existing policy techniques, for example considering how building guidelines and planning controls might be used to generate and promote low-carbon social practices and lifestyles (cf. Shove, 2010). In any case, whatever specific approaches are adopted, this will demand opening up 'energy policy' as it is currently conceived to consider complex and fundamentally political questions about the role of consumption and energy in everyday life.

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