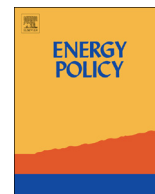




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Feeding back about eco-feedback: How do consumers use and respond to energy monitors?

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HIGHLIGHTS

- We conduct qualitative analysis using online reviews about energy monitors.
- We examine how consumers use and respond to energy monitors.
- Energy monitors are used to increase awareness and knowledge of consumption.
- Consumers report that the monitors lead them to engage in energy saving behaviours.
- Disadvantages of the monitors raise questions about their long-term sustainability.

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ABSTRACT

To date, a multitude of studies have examined the empirical effect of feedback on energy consumption yet very few have examined how feedback might work and the processes it involves. Moreover, it remains to be seen if the theoretical claims made concerning how feedback works can be substantiated using empirical data. To start to address this knowledge gap, the present research used qualitative data analysis to examine how consumers use and respond to energy monitors. The findings suggest feedback may increase both the physical and conscious visibility of consumption as well as knowledge about consumption. Accordingly, support was evident for the theoretical assertions that feedback transforms energy from invisible to visible, prompts motivated users to learn about their energy habits, and helps address information deficits about energy usage. We conclude by evaluating the feasibility of feedback to substantially reduce consumption and discuss ways in which feedback could be improved to aid its effectiveness in the long term before discussing the implication our findings may have for government policy.

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1. Introduction

One of the assumptions behind current multi-billion pound initiatives to introduce smart meters into residential homes in Europe, the USA, Canada, New Zealand and Australia (Darby, 2010) is that providing households with real time feedback about their energy consumption will motivate them to reduce it (Wallenborn et al., 2011)¹. Existing research has addressed this assumption by examining the effect of feedback on consumption (e.g., Abrahamse

et al., 2005) but in doing so it has overlooked a key question pertinent to the validity of this assumption, namely—how does eco-feedback work? To date, there is a paucity of empirical data examining the processes that receiving real time feedback on energy use may prompt. Yet, without knowing how eco-feedback works it may be difficult to design effective feedback displays and to successfully implement programmes that will produce the 20% reduction in energy consumption demanded by the UK's energy strategy (DECC, 2013a). Indeed, Wilson et al. (2013) have observed that there is a lack of research focusing on end users responses to smart home technology. Hence, a more detailed understanding of how feedback works is needed so that future devices or other interventions can be designed from a robust, theoretically grounded evidence base and to ensure that their potential effectiveness can be accurately modelled. Consequently, both the relevance and timeliness of this issue have prompted the present paper to examine how feedback works using archival data to

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E-mail addresses: kbucha@essex.ac.uk (K. Buchanan), russo@essex.ac.uk (R. Russo).¹ We note that in the UK this is just one of the assumptions as smart meters are intended to communicate information about consumption to energy suppliers and network operators with in-home displays showing feedback provided as an optional extra to the consumer.

perform an in-depth analysis of (a) the motivations for acquiring energy monitors, (b) the processes occurring when interacting with them and (c) the subsequent outcomes associated with their adoption.

1.1. What is feedback and can it decrease energy consumption?

In its most basic form feedback refers to the provision of information about the quantity of energy a household consumes over a given period of time. Over several decades, many empirical studies have examined the influence of feedback on energy consumption. The findings from such research suggest that the anticipated energy savings typically fall in the region of 5–20% (Abrahamse et al., 2005; Darby, 2006; Fischer, 2008; Ehrhardt-Martinez et al., 2010; Faruqui et al., 2010; Roberts and Baker, 2003; Spence et al., 2014). In particular, one review has estimated that if well-designed residential programmes were implemented across the US the equivalent of 100 billion kilowatt-hours of electricity savings could be achieved annually by 2030 (Ehrhardt-Martinez et al., 2010). Nonetheless despite these potential energy savings, the impact of feedback on energy consumption remains a point of contention. Some authors have noted that the effects sizes found in meta-analyses are small (Abrahamse et al., 2005; DECC, 2012a) and that feedback devices may only appeal to those who are environmentally motivated (Wallenborn et al., 2011) raising questions over the generalizability of the results and potential effects at the population level. Others have raised questions about the long term sustainability of reductions, especially in situations where energy use is non-negotiable (Darby, 2006; Strengers, 2011). More recently, Wallenborn et al. (2011) stated that it is difficult to reach conclusions about the effectiveness of eco-feedback without knowing what people learn and do differently through their interactions with energy monitors. Indeed in line with this we suggest that in order to more effectively design feedback systems and devices, we need to know not just *that* feedback works, we need to know *how* it works. Yet to date, surprisingly few studies have strived to examine the process underlying feedback to establish how feedback might (or might not) work. Indeed, several researchers have noted how little is known about how such feedback works (e.g., Hargreaves et al., 2010, 2013; Katzev and Johnson, 1987).

1.2. How might feedback work?

To date relatively few studies have examined the processes underlying feedback. However, we provide a brief overview of several assertions and a theoretical model (Fischer, 2008) explaining how feedback might work.

1.2.1. Filling the information vacuum

One of the most frequent explanations proposes that providing consumers with feedback will fill the 'information vacuum' (Wilhite and Ling, 1995, p.146). Inherent in this explanation are two assumptions; (1) that consumers lack information about their consumption and (2) that when provided with information consumers will respond to it in an appropriate way. The first assumption is supported by the often cited criticisms of existing consumption information as infrequent and lacking in detail (Brandon and Lewis, 1999; Chiang et al., 2012; Faruqui et al., 2010). Indeed, Kempton and Layne (1994) suggest that the utility billing systems are comparable to a supermarket that fails to provide customers with an itemised bill. The second assumption has led to various claims that providing consumers with feedback will equip them with information to identify energy conservation opportunities (Abrahamse et al., 2005), 'correct their errors'

(Becker, 1978, p.428) and make 'better informed choices' (Kempton et al., 1992, p.1217).

1.2.2. A learning process

Other explanations of feedback suggest that it is a learning tool which can 'bridge the environmental literacy gap' (Froehlich et al., 2010, p.1999). This differs from the information vacuum explanation as it suggests that consumers lack understanding rather than information. Moreover, it suggests that consumers are not simply passive receivers of information rather they are actively trying to make sense of the world. Indeed, there is some indication that individuals may utilise their own naïve folk theories to explain certain aspects of energy consumption (e.g., Kempton, 1986). As such feedback can be seen as a learning tool which allows user to teach themselves through experimentation (Darby, 2006).

1.2.3. Transforming energy/increasing visibility

Another frequently employed explanation is that feedback works by transforming energy consumption from something that is 'abstract, invisible, and untouchable' (Fischer, 2007, p.1873) to a process that is 'transparent, dynamic and controllable' (Faruqui et al., 2010, p.1598). Put simply, feedback may increase visibility (Hargreaves et al., 2010). Notably, such an explanation is grounded in the inherent characteristics of energy. In particular, researchers have proposed that energy is typically invisible both physically and consciously (Burgess and Nye, 2008). It is physically invisible because we cannot see what we use as we use it and it is consciously invisible because most of our energy consumption occurs automatically and unconsciously as a result of routines or habits (see also Shove, 2003). Moreover, energy consumption tends not to be a goal in itself, rather it occurs indirectly as a result of everyday activities such as cooking or washing (Froehlich et al., 2010). As such providing feedback allows people to visibly see their consumption in real-time and makes the link between actions and effects salient (Chiang et al., 2014; McKerracher and Torriti, 2012).

1.2.4. A theoretical model

To the best of our knowledge there is only one theoretical model explaining how feedback may work. On the basis of Matthies' (2005) heuristic model of environmentally relevant behaviour Fischer (2008) proposes that feedback will involve several processes, namely—increased awareness of energy consumption, conscious consideration of environmental problems, realisations of the relevance of one's own behaviour and an increased sense of personal control over consumption. In addition, Fischer notes that the type of feedback that is presented will influence how the environmental problem is perceived (e.g., as wasting money or energy), the motives it activates and the reasoning process that individuals engage in. However, despite Fischer's (2008) commendable use of existing theory to extrapolate the processes that feedback may involve, there is no empirical support explicitly provided for each of the processes specified. Accordingly, one of the aims of this paper is to determine whether there is empirical support for the model or for any of the explanations concerning how feedback might work.

1.3. How do consumers use energy monitors?

As far as we are aware, only two studies have investigated *how* consumers use energy monitors (Hargreaves et al., 2010, 2013). The first study interviewed households about their experience of owning one of three different types of energy monitors (Hargreaves et al., 2010). The findings confirmed some of the assumptions regarding how energy monitors work as interviewees

reported heightened awareness of consumption and, using the information they had learned to identify appliances that required adjusting or to make rational decisions regarding appliance replacements. A follow up study (Hargreaves et al., 2013) conducted one year later concluded that feedback can increase knowledge about energy use but that this knowledge alone does not necessarily motivate occupants to reduce their consumption. Moreover, this increase in knowledge may even lead to frustration as individuals realise the limitations of their own efforts in the absence of a wider social and political context. Although these initial findings advance existing research by illustrating how households use energy monitors the data are based on a small sample size ($N=11$). Given this, further research is needed to replicate and extend Hargreaves et al.'s work to identify any additional processes that receiving feedback may prompt and to further identify ways in which feedback may (or may not) influence consumption. The remainder of the paper describes how this was achieved through the innovative use of information volunteered by consumers to an online review site.

1.4. Using consumers' reviews to study feedback processes

The primary objective of the present research was to examine how consumers use energy monitors with the aim of enhancing existing understanding about the processes involved in feedback. To meet this objective, we conducted thematic analysis using qualitative data obtained from reviews of energy monitors on Amazon.co.uk. Although our primary focus was on the processes involved in feedback we also examined reviewers' motivations for purchasing the energy monitors and how effective feedback appears to be according to consumers, by examining the outcomes and drawbacks that were noted.

1.5. Using archival internet based data

While the use of existing archival data obtained from the internet is relatively novel, several published paper have utilised this approach (e.g., Bylund, 2005; Harvey et al., 2007) and researchers have noted that the potential of voluntarily provided internet sources is only just beginning to be realized. This is surprising given that internet sources provide instant access to a wealth of rich data (Robinson, 2001) that has been publically and voluntarily self-disclosed potentially negating the need for informed consent (see Seale et al., 2010). In addition such data may be less vulnerable to social desirability biases than traditional interview situations as the internet can provide a space for freedom of expression (Seale et al., 2010) which, should the author choose, can be disassociated from their real identity. However, there are also two keys disadvantages to the use of archival data. First, research questions may not always fit with the scope of the data (Seale et al., 2010). Second, the sample itself may be biased since it may represent only those with access to the internet (Goldfarb and Prince, 2008) and/or with a specialist interest in the topic – in this case early adopters of in-home energy feedback displays. Given this, we note that our results are unlikely to be generalizable to the whole population. Moreover, we suggest that to increase the credibility of archival data it is important to supplement internet-sourced data with interview data and thus we place our findings in the context of previous interview-based findings (e.g., Hargreaves et al., 2010, 2013).

2. Method

2.1. Data selection criteria

A search on Amazon.co.uk for energy monitors/meters with 15 or more reviews, conducted between the 1st and 14th July 2013,

yielded four products²: 'Eco-eye Mini 2 Eco-eye Wireless Power Electricity Smart Monitor', 'Efergy Elite Wireless Energy Saving Meter/Power Meter', 'Owl+USB Connectivity CM160 Energy Saving Wireless Power Electricity Smart Meter/ OWL CM160 with USB Wireless Electricity Monitor Now with New Upload Facility' and 'Current Cost Black/White EnviR Energy Monitor'. Each product displayed the number of average stars provided by reviewers along with the number of reviews (See Table 1). Across the four products there were a total of 206 reviews. We ordered the reviews for each product starting with the most recent dates first and downloaded them to our data archive lest reviewers should subsequently edit or delete their commentaries. According to Amazon's policy³ this data is owned by reviewers, however given that the reviews are intentionally placed in the public domain, we did not seek permission before utilizing the data for analysis. We have however anonymised the archive so that specific quotes are not attributed to named individuals.

Before we conducted our analysis we excluded reviews according to two criteria: reviewer ranking⁴ and numbers of products reviewed. We selected these exclusion criteria on the basis that some sources have found that highly ranked or prolific reviewers may be approached with free merchandise (David and Pinch, 2006). We excluded one reviewer that was ranked among the top one thousand reviewers and five reviewers who had written fifty or more reviews. Additionally, where duplicate reviews were found, both the original and their subsequent counterparts were excluded from the sample.

2.2. Approach to qualitative analysis

We performed thematic analysis using the five step process outlined by Braun and Clarke (2006) in which analysts (1) familiarize themselves with the data, (2) code it, (3) generate initial themes, (4) review these themes and (5) define and name them. We employed an inductive approach consistent with an essentialist/realist method whereby the themes identified were strongly linked to the data. Hence, themes were largely identified at the semantic level and where relevant were linked back to theoretical assumptions regarding how feedback works (see Table 2). Reviews were analysed until data saturation was reached at review number 125 whereby no new themes continued to emerge.

2.3. The data sample

Our final sample consisted of 125 reviews. The names of the reviewers suggested that 56 of these reviewers were written by males and 17 by females. It was not possible to discern the sex of the remaining 52. The other products reviewers had also purchased and written about tended to be functional (e.g., tire pressure guards, door stop, torches, combination locks) and/or technological gadgets (e.g., wireless headphones, notebooks, laptops etc). There was no strong evidence that the sample was biased such that reviewers were particularly passionate about the environment as only two reviewers appeared to have purchased other eco-friendly products.

² While there were just 4 products these were sometimes known by various names for instance 'Owl+USB Connectivity CM160 Energy Saving Wireless Power Electricity Smart Meter' was also known as 'OWL CM160 with USB Wireless Electricity Monitor Now with New Upload Facility'. However, the product details clearly indicate that despite slight differences in names the products were identical.

³ See: (http://www.amazon.co.uk/gp/help/customer/display.html/ref=footer_cou?ie=UTF8&nodeId=1040616)

⁴ According to Amazon their reviewer rankings are based on the extent to which other customers find a review helpful. The rankings are updated frequently and take into account the number of reviews that each customer has written as well as how recently it was written.

Table 1
Information about the reviews used for thematic analysis.

Product names	No. of reviews used in analysis	Date reviews range from
Energy saving eco-eye Mini 2 eco eye ecoeye wireless power electricity smart monitor meter eco friendly	27	28/07/2008 to 04/01/2013
Efergy elite wireless electricity energy monitor/power meter or efergy elite wireless energy saving smart meter	36	14/03/2009 to 01/04/2013
Current cost black EnviR energy monitor (electronics) or current cost white envr energy monitor (electronics)	17	16/04/2011 to 12/02/2013
NEW!!! Owl+USB connectivity CM160 energy saving wireless power electricity smart monitor	45	26/10/2011 to 29/03/2013

Note: Each of these products were sold by 'EnergyMonitorWorld' and either distributed by 'EnergyMonitorWorld' or Amazon.

Table 2
The main themes in relation to each topic of interest.

Topic	Themes
Motivations	Financial. <ul style="list-style-type: none"> ● Because of a large bill ● To corroborate billing ● To save money
Processes involved	Environmental. Seeing – Increasing physical visibility & linking cost to consumption Awareness – Increasing conscious accessibility Investigating and discovering – Learning through experimentation
Outcomes	Eco Actions: <ul style="list-style-type: none"> ● Switching off appliances. ● Using appliances less, differently or not at all. ● Eco purchases. ● Encouraging others to use less electricity.
Drawbacks	Saving money. <ul style="list-style-type: none"> ● Technical difficulties ● Questionable accuracy ● Novelty wears off. ● Must use to benefit

3. Results

3.1. Thematic analysis

Table 2 shows the themes that emerged from our qualitative analysis in relation to each topic of interest. In the following section we elaborate further on these themes but before we do so we discuss the motivations for acquiring feedback monitors that the reviewers revealed.

3.1.1. Motivations for purchasing an energy monitor

Many reviewers reported purchasing an energy monitor to keep an eye on their electricity usage. This was often prompted by one or more of the following three reasons. Either a large electricity bill (E.g., ID11: “I bought this after receiving the most horrendous electricity bill”), the need to corroborate billing (E.g., ID9 “I had to do something to find out if I had a faulty meter”) or the desire to save money (E.g., ID24: “the main point of buying it was to see if we could save money”). In other words the primary motivation for purchasing an energy monitor was to gain further information for financial rather than environmental reasons. Such findings replicate previous research which noted that ‘financial considerations were upmost in people’s mind’ when households

decided to participate in energy monitor trials (Hargreaves et al., 2010, p.6113). However, unlike Hargreaves et al. (2010) we found little indication that environmental concerns were one of the reported drivers for purchasing energy monitors. Indeed, just three reviewers cited environmental motives and in two cases these were mentioned second, after financial motives (E.g., ID 35: “With energy prices rising and our increasing impact on the environment...”).

3.1.2. The processes involved

3.1.2.1. Seeing: increasing physical visibility. Being able to ‘see’ electricity use emerged early on in the data analysis as a predominant theme with many reviewers reporting that physically seeing their consumption had proved effective (E.g., ID 20: “To my mind, being able to see exactly how much power you are using is by far the most effective way of teaching people to be ‘energy conscious’”, ID 133: “Seeing numbers increasing is really effective”). Indeed, reviewers reported that the monitors helped keep them informed by highlighting devices that were left on or being used (E.g., ID 11: “it is a very useful indicator if anything has been left on by mistake”, ID 22: “I can tell when the kettles on...whose left a light on somewhere” and ID 17: “can tell if someone’s left lights on upstairs”) and in some cases without even being in the room (e.g., ID15 “Meter now sits by the PC, and I can pretty much tell what the wife is using based on the reading. Arrgh! I think the cooker has just gone on!”). Such findings suggest that the monitors enabled users to become familiar enough with their energy use patterns to be able to detect un-necessarily active appliances. Indeed, Hargreaves et al. (2010) observed that the energy monitors resulted in householders identifying a ‘normal’ baseline that was necessary to keep their home up and running.

Aside from increasing physical visibility the energy monitors also appeared to increase financial visibility and many reviewers seemed to appreciate being able to see their consumption in a medium that they could relate to: money. Indeed, some reviewers commented on this feature (e.g., ID 6: “Once its working you can sit and watch your money whizzing away”, ID 16: “Just what does a kg of CO2 look like...Who cares? You might as well calibrate it in how many more seconds of life the planet has left in it...But MONEY saved? – now you’re talking!”). This provides some support for the notion that feedback may work by providing users with relatable information (McKerracher and Torriti, 2012) and replicates previous findings that ‘money is the metric of choice’ (Hargreaves et al., 2010, p.6114).

3.1.2.2. Awareness: increasing conscious visibility. A large number of reviews reported that the energy monitors had increased their awareness of electricity consumption. E.g., ID 23: “makes you much more aware of how much power your using”, ID 80: “Has definitely heightened my awareness of what my electrical energy use profile is”,

ID 52: “does make you aware of how much electricity that you are using at any one time”. Such statements imply that before acquiring the energy monitor using energy was a habitual process that occurred unconsciously, with little thought or attention. Indeed, such implications support Shove's (2003) observations that energy practices are deeply engrained within our daily routines. However, the prevalence of reviewers mentioning increased awareness provides support for the notion that feedback can increase conscious awareness of energy practices. Two reviewers explicitly acknowledged this noting that, “it honestly makes you conscious of the electricity you use” (ID 10) and that “it's guaranteed to make you very energy conscious” (ID 20). In a similar vein, other reviewers reported that the energy monitors had made them think about their energy consumption (e.g., ID8: “helps you to think about what you do and how often”, ID 4: “has certainly encouraged us to think where we can use less and at cheaper times”, ID 12: “it really makes you think about switching appliances off instead of leaving them on standby”). This replicates previous findings that energy monitors can increase the visibility of consumption and provide visual prompts for behavioural responses (Hargreaves et al., 2010).

3.1.2.3. Investigating and discovering: learning through experimentation. Shortly after receiving their energy monitor many reviewers appeared to use them to conduct mini investigations into their home's energy consumption. Typically this entailed walking around the house and switching various appliances on and off (e.g., ID 11: “I spent the first few hours switching just about every electrical thing in the house on and off”, ID 26: “Just done a walk around the house turning things on and off”). Other consumers went further in their investigations and concentrated on identifying high electricity use items, frequently referred to as “culprits” (e.g., ID 108: “I turned the oven off at the mains, it went to £0.00. I had found the culprit”). Such comments replicate the findings that energy monitors are used for investigational purposes whether this is to identify ‘greedy’ appliances or pinpoint un-necessary consumption (Hargreaves et al., 2010). Interestingly, it emerged that users appeared to gain satisfaction from their energy investigations. One reviewer referred to this process as “playing” (ID 43) indicating that seeking and then finding the previously hidden energy consumption was enjoyable. Reviewers also described the energy monitors as “fun” (ID's 20, 25, 55, 78) “fascinating” (ID's 26, 78, 90), “interesting” (ID's 55, 63, 109), and even “addictive” (ID's 13, 15, 35, 62). Such comments imply the monitors were used almost as if consumers were in an interactive investigative style game in which the feedback they received could help them gain knowledge and save money.

As one might expect the investigations sometimes prompted discoveries about, “what's going on in the world of electricity” (ID 51). Indeed, many reviewers used the phrase “eye-opener” (e.g., ID 9, 11, 16, 27, 57, 132) to emphasize the revelations that owning an energy monitor had prompted. Discoveries included reasons for bill increases (e.g., ID 107: “I discovered the reason why my bills went up over the last 6 months...my electric shower was malfunctioning and using up more than twice what it should”), ways to conserve energy (ID 96: “I quickly found that we needed to only use electrical equipment that heats when required”), and to reduce costs (e.g., ID 22: “I discovered that by simply turning off my power adapters of products I'm not using all the time...I was saving money”). Interestingly, several reviewers commented that these discoveries were accompanied by feelings of surprise (e.g., ID 106: “my wife and I were surprised at how much we wasted, the microwave on standby uses 1p an hour”) or amazement (e.g., ID 9: “I was gobsmacked when I saw the kilowatt figures go mad when the wife put the oven and hob on”). Such comments offer new insight into how feedback might work as it indicates the involvement of an emotional component which may impact the retention and/or effectiveness of the

information. However, the presence of investigating and discovering as themes within the data lend support to Darby's (2006) assertion that feedback is used as a learning tool via the process of experimenting.

3.2. Reported outcomes of using an energy monitor

The most prevalent themes to emerge as outcomes were claims that the energy monitors had saved households money and increased a range of eco-actions.

3.2.1. Saving money

Given that saving money emerged as one of the primary motivations consumers had for purchasing the monitor it is perhaps unsurprising that saving money was frequently mentioned as an outcome. However, the claims made about savings varied considerably. Many reviews stated that they believed the energy monitors would help them save money (e.g., ID 11: “no more horrendous bills hopefully”, ID 9: “I honestly believe my new found awareness will reduce this years bill substantially”). Others reported the monitor had helped them save money but failed to specify further (e.g., ID 64 “has certainly bought my bills down”, ID 42: “I'm definitely saving money”). Only a few reviews reported the exact amount of money they had saved. E.g., ID 62: “I have managed to reduce my electric bill by £20 a month so far”, ID 106: “We have checked our bills for the last 3 months and we are saving approx. £15 a month so far”. Interestingly, many reviewers appeared to view the energy monitor as an investment and considered whether the money they had paid for it had been regained through the savings they had made by reducing their consumption. Some reviewers reported that “it will take a while to recoup the cost of the meter” (ID 14) whilst others reported that the cost had already been recouped (e.g., ID 102: “cost of unit already saved”). Only one reviewer (ID 24) reported that it would not save him/her money without having, “to compromise on comfort or buy different appliances” and another noted that it might even increase costs due to the six batteries needed to operate it (ID 49: “supposed to save me energy but battery bill will go up?”).

3.2.2. Taking eco-actions

Reviewers were sometimes vague about the exact eco actions the energy monitors had prompted, but instead they noted that the device had “changed” the way they viewed their usage (ID 43) or that it had made them behave “in a more informed ‘greener’ manner (ID 14)” or that it decreased their energy use (e.g., ID 118: “I managed to cut down my energy use by 20%”). However, several sub-themes emerged as concrete actions that consumers reported taking. We list these below in the order of frequency with which reviewers reported them.

3.2.2.1. Switching off appliances. The most prevalent eco-action listed by reviewers entailed switching off unnecessary appliances and/or avoiding leaving appliances in standby modes (e.g., ID 25: “we are now meticulous about turning lights off etc”, ID 59 “we don't leave anything on standby anymore”). Appliances were also used less (e.g., ID 17: “it has made me use the tumble drier a lot less”), changing the way in which certain appliances were used to ensure efficiency (e.g., ID 96: “We now only use the dishwasher when full or use a lower temp setting”) or not at all (e.g., ID 28: “I now know that 2 freezers we have are costing about £180 a year to run – so one of 'em is going for sure”).

3.2.2.2. Eco purchases. A less frequent action was the purchase or intended future purchase of energy efficient appliances (e.g., ID 21: “We have also replaced bulbs that were eating electricity”,

ID 131: “*plan to reduce it with a more energy efficient A+item*”). Interestingly, on one of the rare occasions that eco-purchasing emerged as an outcome the reviewer (ID15) described themselves as “*having now bitten the bullet*”, indicating that whilst this may have been a welcome long term outcome, it was and one that involved considerable effort and an initial financial outlay. Other reviewers purchased additional eco-gadgets such as timer switches to ensure unused appliances were not left on (e.g., ID 14) or plugs to monitor the cost of individual appliances (e.g., ID 9).

3.2.2.3. *Encouraging others to use less electricity.* To a lesser extent the energy monitors also prompted reviewers to try to get others to reduce their own energy use. E.g., ID 21: “*I am slowly managing to get my children to turn off light, unplug the laptop....*” and ID18: “*the wife complains because I can now show her how much electricity she wastes leaving all the lights on all the time*”. Indeed, one reviewer (ID 49) advised others to place it in “*a prominent position*” noting that this means “*everyone becomes paranoid about what is running and using the electricity*”. Other reviewers simply spread the word, ID 6 noted that it was a “*great talking point*”, ID 67, that “*others family members have also purchased*” and ID 25 reported that, “*we may pass ours on to my daughter and give her a wake up call*”. This provides preliminary support for the idea that community knowledge networks may play a role in reducing consumption as the personal experience and recommendations of close others can be used to share practical advice on energy saving actions (Catney et al., 2013).

3.3. Reported drawbacks of the energy monitor's

3.3.1. Technical difficulties

A common complaint about the energy monitors was the technical difficulties encountered. Often these related to the installation process or the software packages including, figuring out “*what goes where*”, pairing the transmitter with the monitor, and setting prices. The latter seemed especially problematic when consumers were on split price tariffs. Evidently this is a key drawback given that consumers initial experience of the energy monitors were somewhat negative.

3.3.2. Questionable accuracy

Several reviewers questioned the accuracy of the energy monitors. E.g., ID 41, “*I don't know how accurate the meter is*”, ID 112: “*It records totally inaccurate readings*”, and ID 71: “*it is monitoring at low levels that are not that accurate, not a million miles off but not accurate*”. One reviewer (ID 16) pointed out the reason for this inaccuracy is that the energy monitor infers power from the measures of current it takes. Inaccuracies bothered some reviewers more than others. E.g., ID 42: “*Much worse though is the fact that it records totally inaccurate readings as regards the amount of electricity you use! It is showing me as only using 35 kW per week when I am using twice that.*” and ID16: “*So—does this error matter? Not if all you are interested in is a trend, not really, no*”. Such findings are in line with past comments from householders who expressed dissatisfaction with apparently inaccurate figures (Hargreaves et al., 2010). This suggests that trust in the source is essential if the information is to be considered reliable (see also Simcock et al. (2014); Wynne (1992)).

3.3.3. Novelty effects

On receiving their energy monitors reviewers often seemed enthused and appeared to enjoy engaging with them (see comments in ‘Investigating and Discovering’). However, a few reviewers noted that in the long-term their initial enthusiasm for the energy monitor had waned. E.g., ID 32: “*Indeed I felt a bit*

flat after I found out what uses up the most electricity in my house. Basically essentially once you know there's not a lot of need for it any more”, ID 114: “*One is typically enthusiastic for the first few days looking at 'live' readings but one later on tends to let it collect data unattended with occasional inspections*”, and ID 25: “*But once you're aware of the cost of a cup of tea etc. the novelty wears off! Shame you can't hire it for a month*”. Such comments indicate that these energy monitors may only have succeeded in engaging consumers in an initial period and replicate Hargreaves et al.'s (2012, p.128) observation that after an initial ‘honey moon period’, when the monitors stopped presenting new information their novelty wore off and they faded into the background of everyday life. Reviewers' comments also hint at the difficulties faced by users in reducing their consumption beyond a certain point. Indeed, while the monitors enabled consumers to identify their energy consumption patterns they may also have prompted realisations that further energy reductions could not be achieved without either purchasing energy efficient appliances or compromising living standards. For instance, having discovered the high consumption of her kettle one reviewer humorously acknowledges the limitations to her conservation efforts, “*Plan to heat water with a match under the tea mug in future!*” (ID 5).

3.3.4. Reaping benefits requires engagement

Some reviewers astutely noted an obvious but perhaps overlooked point, that in itself energy monitors cannot decrease energy consumption. E.g., ID 34: “*Does not really save you money in itself*” and ID 14: “*It does not save money by itself*”. In other words these devices simply provide information that the consumer then has to process and take action on in order to decrease their energy consumption. This notion is summarised by ID 224 who noted, “*it works but you have to make it work for you*”. Similarly ID 14 commented, “*you do have to use it to take advantage of the benefits of running your house more economically*”. This suggests that in order for energy monitors to effectively decrease energy use occupants must engage with the feedback provided by these devices and also feel able to change through understandable energy-reduction actions that they consider available to them.

4. Discussion

This paper is amongst the first to employ qualitative analysis to examine how feedback might work and is the first to do so by exploring consumers' voluntary reviews of their experiences with energy monitors. In the following section we consider our key findings about the processes underlying feedback and how these relate to existing explanations of how feedback works. We then evaluate the feasibility of feedback to substantially reduce consumption and speculate how it might be improved if it is to remain effective in the long term. Finally, we consider the novelty of the methodology we employed before concluding by considering the implications our findings may have for policy.

4.1. How does feedback work?

Overall, the primary themes that emerged in our data analysis provided the most support for the idea that feedback transforms energy from invisible to visible (both physically and consciously) as well as enabling users to learn about their energy consumption habits. There is also some support for the information vacuum explanation as reviewers appeared to purchase the energy monitors to gain information for various financial reasons. Although, as reviewers observed the information provided by the energy monitor in and of itself was not enough to reduce their consumption. Additionally, it emerged that users gained a sense of reward

from learning about their consumption through using the monitors as a tool to investigate and discover. Many reviewers mentioned that using the monitors was fun, fascinating, and even addictive and that discoveries were accompanied by surprise or shock. Curiously, previous theoretical approaches have not noted the various emotions receiving feedback may prompt yet these emotional responses were evident in our data and indicate that one way in which feedback may work is by keeping users actively engaged with the information gleaned from interacting with the energy monitors.

Overall, our data provided partial support for Fischer's (2008) theoretical model of feedback. Specifically, our analysis supported the ideas that energy monitors may lead to an increased awareness of their energy usage, reflection about energy consumption, realisations about the relevance of one's own behaviour, and an ability to link consumption to specific appliances. However, we found very little support for other aspects of Fischer's model. Specifically, the energy monitors did not appear to empower consumers with an increased sense of personal control. Neither did they prompt individuals to be confronted with an environmental problem or to activate specific motives. Rather, consumers had previously encountered various problems (e.g., 'horrendous bills') which had already activated certain motives (e.g., desire to save money) and prompted them to purchase an energy monitor.

4.2. *Is feedback the answer to decreasing consumption?*

Examining how consumers use energy monitors demonstrates that the processes that receiving feedback invokes can be translated into a number of tangible benefits. For instance owning an energy monitor enables users to physically observe consumption in real time, equate energy use to cost, identify 'greedy' appliances and increase consciousness of household energy patterns. Moreover, according to reviewers, feedback decreases consumption and saves money as it prompts concrete actions such as switching off unused appliances and purchasing energy efficient appliances although without linked empirical quantitative data it is hard to substantiate these claims.

However, despite these apparent benefits there are still grounds for questioning the effectiveness of feedback as mechanism for reducing consumption. The largest drawback appears to be that in and of itself feedback cannot decrease consumption because it is simply the provision of information. Indeed, Locke (1991) notes that unevaluated feedback is effectively neutral. As such it is ultimately the consumer's responsibility to react to this information. This is problematic for both practical and theoretical reasons. Practically it is problematic as while feedback may enable households to associate energy savings with their behaviours there is still a substantial period of time between engaging in an eco-action and being rewarded for doing so where consumers pay for electricity in arrears and/or via fixed monthly payments. Theoretically it is problematic because it presumes an inherent degree of rational, conscious decision making that may be unrealistic (see also Shove, 2003, 2012; Strengers, 2011; Strengers, 2013) as much energy use may not be open to easy re-configuration due to norms of comfort, household dynamics or socio-cultural norms and structures. Indeed Hargreaves et al. (2010) concluded that there is no simple cause and effect relationship such that providing feedback leads to rational decisions to reduce consumption.

4.3. *How can feedback be improved?*

Examining the processes involved in consumers' experiences of the energy monitors revealed both notable advantages and disadvantage to the use of feedback as method for decreasing consumption. Importantly however, these evaluations offer some

insight as to how feedback might be improved to increase its effectiveness.

Both the data we analyzed and previous findings (Hargreaves et al., 2010, 2013) suggest that after an initial stage of enthusiasm even motivated consumers start to pay less attention to the monitors and they fade into the background. This is obviously detrimental as energy consumption may then regress to its previously invisible state. Hence, if feedback is to maintain its effectiveness over time then it is crucial that consumers continue to engage with the energy monitors. This may be achieved by ensuring that energy monitors offer diverse information using a variety of presentational styles and mediums tailored to the specific requirements of individual users in a form that is meaningful to them. Indeed, a recently published paper using in-depth qualitative data found that individuals were most likely to report that the information provided was useful when it was 'tailored and contextualised to their personal circumstances' (Simcock et al., 2014).

Additionally, we found that the energy monitors rely on a certain degree of motivation and effort from the consumers as they are required to familiarize themselves with their energy consumption patterns to a point where they can discover 'wasted' energy and identify the source before intervening. We speculate that if energy monitors are to reduce energy consumption for less motivated and/or skilled users then the effort required should be reduced, perhaps by alerting consumers to abnormal usage or specifying which appliances are on, or even providing specific energy saving recommendations. If implemented such suggestions may increase the likelihood that energy monitors will have a substantial and long term impact on reducing energy consumption as the easier and less time consuming an initiative is the more likely people will be to incorporate it into their daily lives.

4.4. *Evaluation of the methodology employed*

The methodology employed by the present research is relatively unique as currently only a few published papers have used reviews as a source of data (Dellarocas et al., 2007; Hu et al., 2006). Given this we took a number of pre-cautionary steps to increase confidence in the data we obtained. Specifically, we established exclusion criteria and placed our findings in the context of previous interview-based findings (e.g., Hargreaves et al., 2010, 2012). However, the methodology we used did not enable the collection of any background information on the reviewers including their demographic characteristics or their motivations for writing the reviews, both of which may have influenced their commentary. In addition, our sample may be representative of the kinds of people who write product reviews rather than of the general population. Indeed, it is known that online consumers write reviews for a variety of reasons including concern for other consumers, to vent negative feelings, to obtain recognition, or simply for the sheer enjoyment of sharing opinions (Hennig-Thurau et al., 2004; Yoo and Gretzel, 2008). While past research has examined both the demographics and motivations of online reviewers (Hennig-Thurau et al., 2004; Yoo and Gretzel, 2008) we suspect that these features vary depending on both the consumer platform and product in question. Consequently, we avoid drawing inferences from these past studies about the present sample in our conclusions and in our discussions of implications for policy, we are careful not to claim generally applicable results.

Perhaps a more problematic aspect of the present methodology is that participants elected to purchase an energy monitor. This suggests that (a) reviews may have been biased by a desire to justify the financial outlay and (b) the sample may have had an active interest in their energy consumption. However, such problems are not unique to this research as in the studies conducted

by Hargreaves et al. (2010, 2013) participants also purchased their own energy monitors. On the other hand, if reviews were unduly influenced by the desire to justify financial outlay, one might expect overwhelmingly positive commentaries and yet it was possible to identify several reported weaknesses of the energy monitors in both the present research and in the Hargreaves et al. studies. Nonetheless, further research is needed to ascertain if less interested and motivated consumers will also respond to energy monitors in similar ways.

4.5. Implications for policy

Present government policy requires energy suppliers to install 53 million smart meters in domestic homes by 2020 (DECC, 2013a). Whilst the exact nature of the technologies to be installed is still unclear, it appears that consumers will also be offered in-home displays (IHD), which will provide real-time information on energy consumption in a manner similar to the devices described in this paper. One of the main justifications for this policy is that the smart meters and their associated IHD will help 'consumers have more control over their energy use and spending, while also helping meet environmental and security of supply objectives' (DECC, 2012b). Yet, our findings still cause us to question the capability of IHD to empower *all* consumers to control (and reduce) their consumption. A primary cause for our concern stems from the differences between our sample of energy monitor users and the much wider range of domestic consumers who may receive an IHD as part of the smart meter roll out. Our sample consists of consumers who actively sought out and purchased an energy monitor and their enthusiastic reports of experimenting, investigating and analyzing their energy consumption suggest that the sample was motivated to engage with the energy monitors from the outset. This is highly unlikely to be the case for *all* consumers who receive a free IHD as part of a compulsory smart meter roll out. Indeed, a recent research report commissioned by the government found that consumers who had received energy monitors as a free gift were less inclined to engage with them than consumers who had actively sought them out (DECC, 2012b) presumably due to their higher intrinsic motivation. Yet in our data we found that if consumers are to benefit from feedback it is crucial that they actively engage with it especially as substantial effort is required to comprehend consumption patterns and identify areas where adjustments can be made. Thus whilst the option of a free IHD will reach those motivated consumers who have not (yet) acquired their own electricity monitoring devices and will, in particular, provide feedback on gas consumption, our results suggest that it will offer little to the rest of the less-motivated consumer population and nothing at all to the 59% of bill-payers who have expressed no interest in having one installed (DECC, 2013b) and thus may forego the IHD completely⁵.

Our findings are also discouraging given that even when our 'early adopting' sample of users were motivated to engage with the feedback, simply obtaining information on energy consumption did not automatically lead to the realisation of actions that could be taken. Not only are energy-using habits rarely conscious acts (Shove, 2003; Strengers, 2011, 2013) but these habits are often embedded in normative or temporal social structures that prevent straightforward adjustment. Thus, we should not expect the wider population of less motivated consumers to be able to determine which courses of action may be open to them even if the 'energy

content' of their ways of life are made plain. Whilst this argument supports the UK Smart Meter programme's focus on providing advice and guidance based on consumption levels (DECC, 2012c – lever 3) provided this is tailored to individual (and motivated) customers rather than generic 'segments', it also suggests that levers 1 and 2 (direct and indirect feedback) may be relatively ineffective in supporting energy demand reduction across the whole population.

Finally even the highly motivated early adopters from whom we collected data reported that interest in the energy monitors waned and that any achieved adjustments and the 'feedback processes' that produced them may have faded over time. This is of critical concern for the evaluation of the effectiveness of the investment in the programme as a whole. Whilst current policy documents lay out information needs in this regard (DECC, 2012b) and there is a clear focus on monitoring the progress of installation, the timing of the assessment of the effectiveness in reducing energy consumption is currently unclear (AECOM, 2011). If, as suggested, a sample of newly smart metered homes are to be compared with a control group (ibid, p25) then it is crucial that data is collected over a long enough period of time to control for initial novelty effects and to allow for long term energy use adjustments to be revealed.

5. Conclusion

The present research provides valuable insight into how consumers who were both motivated to acquire an IHD and also provide online reviews use and respond to energy monitors. Specifically, we found that such consumers used energy monitors to increase the visibility of energy and to learn more about their household's consumption using a process of investigation and discovery. As such, the results provide some support for the hitherto largely unsubstantiated claims regarding how feedback works; mainly that it increases visibility, prompts users to learn about their energy habits, and helps address information deficits about energy usage. In addition our results also suggest that even among motivated consumers several limitations emerged which undermine the capability of energy monitors to yield significant and lasting energy reductions. These include the level of analytic competence and motivation required to 'make sense of' personal energy consumption, reported difficulty in determining which, if any, energy-saving actions might make a significant difference to consumption and the relatively rapid fading of interest in monitoring and reduction. This is especially important where the financial returns are invisible until a subsequent monthly or even, in the case of fixed direct debits, yearly bill payment. Consequently, we advise considerable caution in expectations that smart meters and their associated IHD will produce substantial energy demand reductions. Whilst in principle they may empower consumers across the UK to engage with the levels and patterns of their energy demands, the reality is that only a minority are likely to be motivated and equipped with the necessary competences and flexibilities required to implement significant and lasting changes to their consumption. Consequently, we argue that in order to credibly assess the impact of in home displays on energy consumption the evaluative framework applied must be capable of detecting both initial novelty effects and longer term adjustments as well as consumers' motivations.

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⁵ Of course, while consumers are not obligated to have an IHD they may not feel inclined to refuse one given that there are no upfront costs. Indeed, recent research funded by the government found that the appeal of receiving 'something for nothing' gave consumers little reason to refuse a free in home display (DECC, 2012a,b,c).

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