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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.

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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[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.

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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

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