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The question of energy reduction: The problem(s) with feedback

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HIGHLIGHTS

- We provide a comprehensive critique of feedback and in-home-displays (IHDs).
- We find limited evidence of the efficacy of feedback in reducing energy consumption.
- Problematically the success of IHDs depends entirely on user engagement.
- The unintended consequence of IHDs may undermine their energy reduction capabilities.
- We call for new IHDs to be developed and evaluated with user engagement in mind.

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ABSTRACT

With smart metering initiatives gaining increasing global popularity, the present paper seeks to challenge the increasingly entrenched view that providing householders with feedback about their energy usage, via an in-home-display, will lead them to substantially reduce their energy consumption. Specifically, we draw on existing quantitative and qualitative evidence to outline three key problems with feedback, namely: (a) the limited evidence of efficacy, (b) the need for user engagement, and (c) the potential for unintended consequences. We conclude by noting that, in their current form, existing in-home-displays may not induce the desired energy-reduction response anticipated by smart metering initiatives. Instead, if smart metering is to effectively reduce energy consumption there is a clear need to develop and test innovative new feedback devices that have been designed with user engagement in mind.

1. Introduction

Across Europe, the USA, Canada, New Zealand, and Australia, multibillion pound initiatives to install smart meters into residential homes are gathering momentum. For example, current UK government policy requires energy suppliers to install smart meters in every domestic property by 2020 (DECC, 2013a). The proposed smart meters will send accurate meter readings directly to energy providers and also allow consumers to monitor both their electricity and gas consumption using an associated in-home-display (IHD). One of the main justifications the UK government has given for the smart meter initiative is that IHDs will help "consumers have more control over their energy use and spending, while also helping meet environmental and security of supply objectives" (DECC, 2012; see also DECC, 2009).[1] Clearly implicit in this justification is the expectation that providing consumers with IHD-based feedback will equip them with the information they need to help reduce their overall energy consumption (see also, Darby, 2010; Strengers, 2013), shift it away from periods of peak demand, and/or respond flexibly to periods of "over" supply.

It seems to us that tremendous faith is being placed in the capabilities of feedback delivered through current IHDs to produce substantial energy reductions. Yet, we think such faith is misplaced and argue that there is considerable cause to question the plausibility of claims based on it. We have arrived at this viewpoint after conducting a qualitative analysis of consumers' self-reported experiences with

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[1] We note that there are other justifications too, for instance another benefit mentioned is the gradual implementation of time of use tariffs that could potentially help shift peak loads (DECC, 2013b). Whilst this might not reduce overall energy consumption, it may reduce the need to construct new generation facilities (ibid) or reinforce existing networks. However, in this paper we do not intend to provide a holistic evaluation of the smart meter initiative but rather to critically consider if feedback delivered via IHD constitutes an effective strategy for energy reduction.

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IHDs (Buchanan et al., 2014), which ultimately led us to identify substantial limitations that centred on the necessity of user engagement for effective outcomes. Moreover, in reviewing the available literature we also observed several additional feedback related problems that caused us to question whether current IHDs are really an appropriate tool for household energy reduction.

In the following viewpoint piece, we therefore aim to provide a comprehensive overview of the potential pitfalls of existing IHDs from a practical and applied perspective.[2] Notably, we do not seek to deny that feedback may have benefits, but rather we intend to encourage some healthy scepticism about the ability of *existing* IHDs to support substantial reduction in domestic energy consumption. In choosing to focus on identifying the problems associated with feedback, we provide an alternative perspective from the previous literature, which has largely concentrated on ascertaining the effectiveness of feedback and the conditions under which it may best work (e.g., Fischer, 2008).[3]

In this paper, we first review quantitative research that examines the efficacy of feedback in reducing energy consumption. We then draw primarily on qualitative evidence to outline the challenges that feedback faces from a user engagement perspective, before considering some unintended consequences that may undermine the capabilities of IHDs to reduce energy demand. We conclude by reflecting on the implications that these evidence threads have for future policy and research. In consequence, although feedback encompasses a variety of communication strategies distributed via different media (Fischer, 2008), our reading of the relevant UK policy documents (DECC, 2014) leads us to focus predominantly on feedback that is presented using an IHD that displays the kind of information about real-time, historical and cumulative consumption in both energy (kWh) and monetary (£) terms. In doing so we note that (over) concentration on these economic aspects appears central not only to the UK governments proposed plans but also to other global smart metering initiatives.

2. The efficacy of feedback: limited evidence

A multitude of empirical studies have examined the extent to which feedback can reduce energy consumption whether delivered via an IHD or other means. Results have varied and effect sizes have differed both within and between studies (Vine et al., 2013). While some studies have not found statistically significant effects (e.g., Alahmad et al., 2012; Allen and Janda, 2006; Scott, 2008), others have reported that energy savings range from 3% to 20% (e.g., Abrahamse et al., 2005; Darby, 2006; Ehrhardt-Martinez et al., 2010; Fischer, 2008; Harries et al., 2013). Such variation may be attributable to differences in study design as feedback has taken a variety of forms (e.g., marketing campaigns[4] vs. electronic communications) using diverse study groups (ranging from self-selected volunteers to random population samples). Indeed, a recent meta-analysis (Delmas et al., 2013) demonstrated that from a methodological perspective, less robust studies without controls ($N^5=75$) yielded higher energy savings of 10% ($SD=12.1$, ranging from savings of 55% to increased consumption of 8%), whereas more robust studies that used either a control group and/or also took into consideration either household demographics and/or weather ($N=22$), yielded lower energy savings of 2% (SD: 1.05, ranging from savings of 5% to increased consumption of 5%).[6] Such findings underscore the importance of employing rigorous methodological designs to ensure that any energy savings are attributable to feedback rather than to self-selection bias and/or Hawthorne effects, whereby participants change their behaviour as a result of being involved in an experiment or study. For example, simply sending weekly postcards to remind residents of their participation in a domestic consumption study caused a 2.7% reduction in electricity use (Schwartz et al., 2013). To the best of our knowledge, existing studies have not used weekly reminders in their control conditions and people in the "no treatment" control conditions may therefore forget that they are even participating in a study. Consequently, it is unclear whether even robust studies with control and treatment group designs have disentangled Hawthorne and feedback effects. Yet without this distinction, the differences in consumption between the control and test condition may be overestimated. Moreover, without isolating the Hawthorne effect it is not possible to establish a deeper understanding of it within the domestic energy context. Yet, such knowledge could be used to derive the most effective aspects involved in the Hawthorne effect (e.g., increased interaction, social presentation concerns), so that they could be implemented in subsequent interventions to bolster the overall effectiveness of feedback.

In addition, researchers have also critiqued the short-term durations of existing feedback intervention studies (e.g., Delmas et al., 2013 note that 60% of studies had durations of just 3 months) and the use of multiple feedback strategies within a single treatment condition (Abrahamse et al., 2005; Delmas et al., 2013; Fischer, 2008). Evidently, such issues make it difficult to ascertain whether the effects of feedback persist in the long term and to pinpoint exactly which aspect of feedback was most effective or if it only worked because a combination of strategies were simultaneously utilized.

Perhaps most crucially for the smart meter roll-out programmes, few trials have assessed the contribution of real-time feedback to energy reductions despite the fact that such trials have the most relevance for identifying the energy savings obtained from IHD initiatives. For instance, only 1 (Alcott, 2011) out of the 22 "high quality" studies from Delmas et als'. (2013) meta-analysis examined the effect of real time feedback on energy consumption and even then the study focused on the impact of real time pricing rather than basic consumption information. Perhaps more relevant are findings from the Energy Demand Research Project (AECOM, 2011), a large scale trial involving over 60,000 households, that was conducted between 2007 and 2010 by the UK's 4 main energy suppliers with the aim of establishing the impact of various information based interventions. Interestingly, in the trials where households were *only* provided with a real-time display, just one out of four of the energy suppliers reported finding a significant reduction in consumers energy use. Curiously, these reductions only occurred for electricity and not gas consumption, which raises important (and as yet unaddressed) questions about why IHDs may differentially affect gas and electricity reduction. Moreover, the reduction was small at just 1% suggesting that IHDs (on their own) have a very small part to play in the 20% reduction in energy consumption demanded by the UK's energy strategy (DECC, 2013a).

To summarize, (i) there is a scarcity of research that can be classified as both relevant and robust, and (ii) the evidence that there is does not make a compelling case for the efficacy of

[2] While we draw on some theoretical insights from practice theory (e.g., Shove and Walker, 2014), affordance theory (Darby, 2010) and Fischer's theory of energy feedback (2008) this paper does not intend to provide an exhaustive review of each of these approaches and as such does not constitute a theoretical paper. Rather, we use these theoretical insights to identify the practical implications that may affect the capabilities of IHDs to reduce energy consumption.

[3] We note that both Pierce et al. (2010a) and Strengers (2013) have also critiqued various aspects of the feedback agenda.

[4] In this context "marketing campaigns" refers to large scale advertisements which are designed to raise awareness of efficient energy consumption.

[5] *N* refers to number of reviewed studies.

[6] Albeit significantly different from 0, $t(21)=9.04$, $p<.01$