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Communication

A qualitative study of users' engagement with real-time feedback from in-house energy consumption displays

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HIGHLIGHTS

- We explore how householders interact with energy consumption displays.
- Users' level of engagement with the display influence achieved savings.
- User's motivation, level of involvement and prior attitudes are key elements.

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ABSTRACT

Recent developments in feedback technologies and smart meters have advanced the introduction of energy consumption displays in the home. This could facilitate a significant amount of energy saving for the maximum number of homeowners. But empirical studies show that achieved savings in electricity consumption from in-house displays range approximately from 0 to 20%. In order to qualitatively explore the factors underlying such variation in the achieved saving, this paper studies how a small sample of householders interacted with the feedback from an energy consumption display. Following a heuristic model based on prior energy-related behavioral research, we explore the effects of the in-home display on household electricity. Results indicate that saving might be moderated by the level of user's engagement with the display, preceded by user's motivation to save energy, prior attitudes and, importantly, the level of involvement generated by the intervention.

1. Introduction

The effect of providing feedback on energy consumption on users' behaviors and attitudes has been a matter of research for the social sciences since the 1970s (Gardner and Stern, 2002). According to the theory of feedback, effective feedback devices let people teach themselves how to save energy, promote self-efficacy and reinforcement and result in energy conservation (Gardner and Stern, 2002; Wilson and Dowlatabadi, 2007). Feedback experiments during the 1970s demonstrated that households cut their energy use by around 10% immediately after feedback (Gardner and Stern, 2002). It is assumed that direct feedback on energy consumption provides more specific, valid and credible information, making energy saving visible and catching people's attention more than any other form of information (Gardner and Stern, 2002). Instead of telling people to save energy, feedback devices offer higher quality information about how much electricity a household is already using.

Recent developments in feedback technologies and smart meters have advanced the introduction of in-house energy consumption displays in the home (Fischer, 2008; Wood and Newborough, 2003). Current in-house displays, often integrated with smart meter technologies, provide information on the cost per hour for energy, past and present energy usage, carbon dioxide emissions, energy efficiency tips and can even link the user with web-based information portals with real-time information. The key premise is that better designs of the human–computer interface for energy consumption displays will facilitate the greatest amount of energy saving for the maximum number of homeowners (Wood and Newborough, 2003). European governments and companies have promoted the installation of smart meters to homes and small businesses.[1] Directive (2006/32/EC) on energy

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[1] Some of these smart systems promoted by energy companies may not include in-house energy consumption displays. Assuming that these systems will

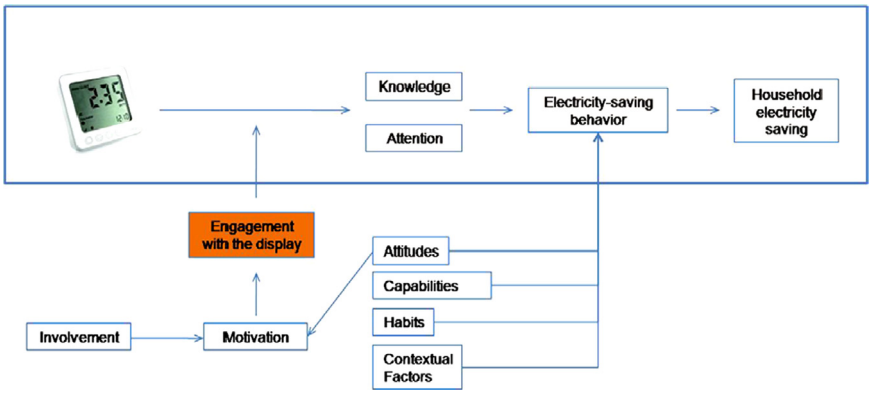

Fig. 1. Heuristic model on the effects of feedback from in-home displays in energy saving behavior. Based on: Stern (2000), Gardner and Stern (2002).

end-use efficiency and energy services (Energy Services Directive) requires Member States to introduce informative billing and other types of feedback. There is a window of opportunity for the deployment of in-house energy consumption displays available (Fischer, 2008).

Along with these developments, a significant body of social research has recently studied the effectiveness of these new displays on energy consumption (Fischer, 2008; Burgess and Nye, 2008; Faruqui et al., 2010). Foster and Mazur-Stommen (2012) found that residential electricity savings from real-time feedback ranged from 0 to 19%, with average saving across the pilots of 3.8%. Ehrhardt-Martinez et al. (2010) found household electricity savings ranging from 4 to 12%. Darby (2006) has found that improved feedback may reduce consumption by up to 20% and Fischer (2008), in an excellent review, found that usual savings are between 5 and 12%.

Why does direct feedback through in-house energy consumption displays produce such diverse results? Studies have identified various factors, generally associated with two broad categories: the display and the user. Factors related to the feedback design may include the frequency of the information provided, the type of data, the presentation format, the location of the feedback, the type of visual design, whether the display allows comparisons of consumption, the existence of additional information, as well as other instruments such as social sharing sites and information tips (Fischer, 2008; Froehlich, 2009).

Factors related to the user that moderate the effect of feedback on energy saving behavior may include users' values, beliefs and norms, user's routines, personal capabilities, level of prior household energy consumption, household background and contextual characteristics (Midden et al., 1983; Stern, 2000; Wilson and Dowlatabadi, 2007; Hargreaves et al. 2010, 2012). The level of motivation of participants to engage in the process and save energy may also influence the effects of feedback on household electricity saving, as has been found in psycho-social research (Gardner and Stern, 2002). We have integrated all these elements in a heuristic model on the effects of feedback from in-home displays in energy saving behavior (see Fig. 1).

In this paper we investigate three research questions: How do participants interact with the feedback provided by the in-home display? What factors might cause the different levels of engagement with the display among participants? What are the preferences and needs of households concerning the electricity display? The study was conducted between November and December 2011 and designed in the context of the EU Pachelbel Project, focused, among others, on the investigation of the nature of lay practical reasoning and behaviors about sustainable consumption. The data was collected as a part of a real time feedback pilot project in Barcelona carried out by the Barcelona Energy Agency. The results in this paper are part of an ongoing research project and represent one of the few attempts to explore qualitatively the consequences on individuals' attitudes and everyday behavior of introducing smart energy monitors in households (see also Hargreaves et al. 2010, 2012; Kidd and Williams 2008; Anderson and White 2009a, 2009b).

(*footnote continued*)
induce changes in electricity related behaviors is misleading. We focus in this article on devices providing real-time feedback to the user and not only to the electricity company.

2. Design of the study and data collection

The design of this study was based on a qualitative design with three research strategies: reconvened focus groups, interviews and diaries. The design followed the methodological approach developed in the context of the above mentioned EU project. This approach drawn extensively on previous work developed by Horlick-Jones (2007, 2008), and Horlick-Jones et al. (2010).

For this specific study, and in order to understand users' interaction and real behaviors with in-home displays, participants were divided into two groups. Participants in group one installed an in-home display providing information about their electricity consumption one week before the first group session and used it during three weeks. During these weeks, participants reported their daily interaction with the in-home display by means of focus groups and diaries.

Participants in group two reported their daily behaviors and concerns regarding household electricity consumption during three weeks, without the aid of any feedback display. They received and installed an in-home display after the last group session. They were interviewed to report their interaction with the in-home display three weeks after the installation of the display.

2.1. Sampling

We recruited seventeen individuals through a combination of snow ball and convenience sampling. Decisions about recruitment were made in close collaboration with the Barcelona Energy Agency. The first group was composed of volunteers recruited through a local participatory energy plan. The second group was recruited in the same neighborhood through a specialized agency. According to the Agency's criteria, participants in both groups shared the same building typology. In terms of gender, all groups were mixed. Table 1.