



Effects of customized consumption feedback on energy efficient behaviour in low-income households



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ABSTRACT

Smart metering and various consumption-feedback systems can be used as applicable technology to encourage end-use energy efficiency in the residential sector. Many studies have demonstrated the positive influence of socially contextualized feedback on the energy consumption of households, but not many such studies dealt with the specifics of low-income households. This paper evaluates the effect of customized consumption feedback and other information interactions on energy-behaviour patterns and energy savings in low-income households. The experimentation process was accompanied by an interactive awareness campaign, with the emphasis being on a proper understanding of the consumption feedback and other complementary energy services provided to low-income households. The feedback actions were customized to tackle the recognised needs of each specific target household, considering both the social aspects and the typology of the dwelling. The results clearly confirmed the importance of customized information and efficiency indicators for specific household groups, with a potential to increase knowledge and develop awareness with respect to established habits and their relevance to energy behaviour.

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1. Introduction

Energy efficiency has been recognised as an essential element of the European Union's (EU) energy and climate change mitigation policies. The EU has identified buildings as being the most promising target for improving energy efficiency and has quantified a significant energy-savings potential associated with infrastructure and equipment investments (27% in the residential sector and 30% in the services sector) (EC, 2006). As households and buildings are responsible for over 40% of energy usage, there is a need to develop new approaches that examine the energy use in homes and to encourage energy efficient behaviour, in addition to using energy efficient devices in households (Chen et al., 2013). Also, the soft organisational potentials for energy efficiency improvements are often neglected in policies both at the national and at the local level (Bukarica and Robič, 2013). Improvement of energy efficiency requires informed consumers and awareness among all segments of society as well as tailored information, education and training for selected stakeholders (Gynther et al., 2012). According to Urge-

Vorsatz et al. (2009), different non-technological determinants lead to different levels of energy consumption even within the same technological setting. Jonsson et al. (2011) have concluded that non-technological drivers can be as important, or even more important, than the technologies used in determining the energy consumption in buildings. Research conducted by Ouyang and Hokao (2009) has shown that about 14% of the energy savings in households could be achieved simply by improving the residents' energy behaviour. According to Wood and Newborough (2003), it is worth to invest additional efforts in optimising the design and assessing the use of energy-consumption indicators in households, in order to maximise the associated energy-saving potential. Darby (2006) has identified several behavioural-change programmes that have indicated that energy savings of up to 20% could be achieved by applying different information strategies or by using improved feedback. However, even though the behaviour of residential end-users is one of major determinants with respect to energy use in buildings, the energy-savings potential based on behaviour remains neglected (Levine et al., 2007). To effectively plan and execute energy-efficiency programs, a sound understanding of the determinants factors that drive household energy consumption (such as the type, number and use of appliances, floor area, average

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outside temperature, and number of occupants) is needed (Firth et al., 2008). A more individualized social understanding and the rationalities behind the households' energy consumption are needed in order to specify the different consumption patterns. It is important to be aware that a necessary precondition for information about the relationship between the end-user's behaviour and the corresponding energy use is the specification of the technical features of the appliances for a given household, in combination with individual monitoring (Vassileva et al., 2012). Furthermore, to take full advantage of energy-efficiency programs, they have to be adapted to the various segments of residential customers. Low-income households (LIHs) are one of those segments that have to be specially targeted, due to their social constraints, and are considered as far to reach through traditional public policies (Elih-MED, 2010). Understanding the fine-grained differences within a targeted income group can direct utility and municipal communication efforts with greater effect (Mazur-Stommen et al., 2013). This understanding has to be used when adapting local energy-efficiency policies to encourage energy-efficiency improvements and striving for a more sustainable society. A sustainable society can be assumed to be a society which consists of a sustainable production system, a sustainable community, a sustainable ecosystem, and a sustainable government (Shin et al., 2008). With this in mind, utilities can offer individualized consumption feedback to encourage people in LIHs to become more aware of their energy consumption and stimulate them to change their energy-related behaviour. Utility companies and municipal authorities should include an individual behavioural-assessment approach to the energy consumption of households when developing energy-savings strategies and measures (Vassileva et al., 2012). Local climate conditions also represent a significant factor for residential energy consumption. According to Vassileva et al. (2012), a household's income is one of the most important determinants with respect to consumer behaviour for northern European climate conditions, and it has been confirmed that a higher income results in greater electricity consumption. On the other hand, Kavousian et al. (2013) have recently shown that the residential electricity consumption in United States is primarily determined through the way households use electricity, and less by the way that they value energy efficiency and that there is no significant correlation between electricity consumption and income level. Research conducted by Beunder and Groot (2015) on a large sample of Dutch households, have confirmed that household's cultural background significantly categorized the level of electricity consumption. The general conclusion is that when analysing energy consumption, particular attention should be paid to the individual characteristics of the inhabitants, i.e., households should be treated individually. The consumption feedback and recommendations to reduce household energy consumption should be represented by different determinants that are important for the household, while leaving behind the unimportant, because those can have an adverse effect (Desmedt et al., 2009).

This paper evaluates the impact of customized and adaptive consumption feedback on energy-behaviour patterns and energy savings in LIHs in the Mediterranean region. In this context, LIHs are recognised as households that are most vulnerable to fuel poverty. The experiments and data presented in this paper are results of the EU-funded project ELIH-Med (Energy efficiency in low-income housing in Mediterranean). ELIH-Med project concluded in 2014 and has been identified as a strategic project within the MED Programme with the objective to identify innovative energy efficiency measures and financial instruments for LIHs in Mediterranean. Implemented feedback actions were customized to tackle the recognised needs of each specific target household, considering both social aspects and dwelling typology. The described research

work was inspired by the recommendations proposed by Caeiro et al. (2012), who suggested that future research should focus on the need to communicate effectively, to engage stakeholders and to address the complexity involved in the measurement and assessment of sustainable household energy consumption. The general objective was to check whether additional information about energy use provided to LIHs can stimulate them to reach measurable energy savings without any additional investments in new equipment. Selected households provided a real testing environment, with the full support of the occupants, and open access to all requested data for the validation of the customized feedback and for the promotion of electricity-consumption awareness in LIHs. According to Eisenhardt and Graebner (2007), this represents an opportunity with unusual levels of research access. It has to be aware the open access experimentation typically engages a much smaller sample than would normally be considered adequate for inductive hypothesis testing. However, as it was shown by Langevin et al. (2013), open access provides a rich foundation on which to base a follow up efforts, and identify key pieces of contextual information that would otherwise be missed by a purely quantitative method for behavioural data collection.

2. Energy efficient behaviour

When referring to energy-related behaviours, there are always two implicit dimensions, i.e., the behaviour in itself and the associated energy consumption, in which the second is a consequence of the first, and quantifies it (Lopes et al., 2012). While the adoption of new energy efficient technologies relates to investments, the regular use of appliances is related to habitual behaviour. This habitual behaviour is automatic and routine, and is the way in which individuals repeat and do things automatically without consciously weighing up the pros and cons, usually delivering suboptimal results in terms of energy efficiency (Fischer, 2008). In this context, the household can be seen as a system where system efficiencies rest on a combination of technology and behavioural "intelligence" that reacts dynamically to its surroundings (Elliott et al., 2012).

2.1. Impact of consumption feedback on behaviour

Strategies for promoting more efficient energy behaviour have been categorised as antecedent or consequence strategies (Abrahamse et al., 2005). Antecedent interventions are designed to change factors that precede behaviour and usually include a commitment and information to increase awareness. According to Ueno et al. (2006), the installation of an on-line Energy-Consumption Information System has an influence on the energy-saving awareness of consumers. Consequence interventions focus on changing the consequences following behaviour and usually include energy-consumption feedback and different rate systems (in the form of financial rewards). The role of consumption feedback is to provide information about energy consumption and to make it visible. According to Fischer (2008), successful feedback has to capture the consumers' attention, draw a close link between specific actions and their effects, and activate various motives that may appeal to different consumer groups (such as cost savings, resource conservation, emissions reduction, competition, and others). Consumption feedback has to activate a process called norm activation for new norms and considerations to enter the conscious decision-making process (Matthies, 2005). This means that inefficient habits must be broken and a person must realize that there are various options to choose from, and that norms and criteria are needed for evaluating these options

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