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The design of an energy and water advice programme for low-income households

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ABSTRACT

Occupants of residential buildings are not always fully aware of the potential to save energy or water in their homes since they do not know much about their consumption profiles neither do they know all the measures they could apply and behaviours they could adopt for this purpose. Numerous behaviour change programmes have been developed in the past years, that help occupants exploit their home's saving potential by providing feedback, information and advice. Many of these programmes rely on Information and Communications Technology (ICT) as an enabling technology for energy and water efficiency.

This paper presents an energy and water advice programme designed specifically for social housing. Advice is provided as part of an ICT service providing feedback and information to social housing occupants aiming to improve behaviour-based energy and water efficiency. Provision of advice supplements direct feedback with the aim of achieving the maximum savings possible. The service was developed based on a commonly followed methodology that included collection of requirements for the service design and user evaluation of the service after it had been used. Utilities were monitored along with indoor environmental parameters to ensure that health and comfort of the occupants is not compromised in favour of saving.

1. Introduction

Housing contributes to the man-made greenhouse gas emissions [1,2] through the everyday energy-related behaviours and the use of energy-intensive products and services by occupants [3]. Therefore, household energy consumption, and associated emissions, can be reduced partly if energy-saving behaviours are adopted by the occupants [1,3–6]. Proof for this lies in a recent study carried out on behalf of the European Commission's Directorate-General for Climate Action [1,4] which confirmed the great potential for reducing climate emissions through changes in consumer behaviour in the area of transportation, food and housing in the EU-27. Three behavioural options for housing are specifically investigated in [1,4]; reduction of space heating temperature by 1 °C and by 2 °C, optimization of thermostat settings and optimization of ventilation behaviour.

The literature on human behaviour and behaviour change is vast. A diligent and comprehensive review on behaviour theories, models, and frameworks is presented by Darnton [7]. Darnton [8] distinguishes models of behaviour from theories of change. Theories and models of behaviour identify and analyse the factors that influence behaviour, while theories of change explain how behaviour can be changed over time. Frameworks for change are built around models and theories and provide a practical approach for designing, implementing, and evaluating interventions. Behaviour-based energy-efficiency programmes are programmes that use interventions intended to affect consumer energy behaviours to achieve energy and/or peak demand savings [6]. In the last decade there has been a clear trend toward behaviour based energy efficiency projects that apply social and behaviour science to energy research [2,6,9–13].

Information and Communication Technology (ICT) can be considered as an enabling technology, i.e. a technology that enables processes to become more efficient (such as in terms of time or natural resources) and impels structural and behavioural changes mainly as a result of the increased efficiency [14]. In alignment with its energy efficiency objectives, the European Commission (EC) promotes the use of ICT in projects that aim to improve energy efficiency in social housing using ICTs. The effectiveness of such projects is determined by the energy savings achieved, but also on the change in behaviour achieved, through the provision of high level information and feedback. Although water conservation is not profoundly targeted, it is considered and evaluated in many of these projects.

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Smart meters are one of the main components of ICT systems. They have the ability to connect with in-home display systems through a home area network enabling the raising of the consumption awareness, the understanding of each end-use consumption and the improvement of monitored utility literacy and management [15]. The supplementing of this improved feedback with other instruments including the provision of advice may increase further the prospects for energy saving [15] and for user satisfaction [16]. Fischer [16] separates consumer feedback projects into those designed for explicitly providing feedback to end-users (e.g. through meter displays or bills) and to broader approaches where feedback is supplemented by other features such as advice or community learning. Especially, in cases where the renovation of a dwelling to standard measures is difficult and expensive, and tenants are already careful in their habits, feedback alone is not enough [17]. Along with feedback, advice, expertise and finance are also necessary in such cases [17]. Low-income households are an example of users where this applies. In a review of 38 feedback studies carried out between years 1975 and 2000, four programmes in which direct feedback was supplemented with some form of advice or information gave savings around 10% in low-income households indicating the potential for feedback to be incorporated into advice programmes on a regular basis [18]. Yet, the provision of advice to disadvantaged householders, like low-income householders, has technical, economic and behavioural dimensions [5]. Disadvantaged householders that receive advice on a certain subject are most likely to: face difficulties in following advice that are associated with some level of investment, usually live in rented accommodation, are likely to have low level of basic literacy and numerical skills, may prefer advice to be given verbally rather than in printed format, may benefit from a home visit and need to trust the adviser [5]. These limitations are all factors that should be considered when designing an advice programme for disadvantaged households.

This paper presents an advice programme developed in the framework of the ICE-WISH project [19], an Information and Communication Technology (ICT) project aiming to improve behaviour-based energy efficiency in social housing. Feedback relied on utilities measured through installed smart meters and indoor environmental conditions monitored through sensors and was provided through a graphical user interface shown in the household's TV screen. The advice programme was developed as a supplement to direct feedback on energy and water consumption and indoor environmental conditions. A simpler version of the advice programme was released in the first half of service implementation. A more sophisticated version of the programme was released in the second half, after considering user evaluation feedback. The simpler version of the advice programme is named the General Advice programme and is presented in detail this study.

Section 2 gives an overview of types of energy and water related behaviours and conservation measures that were considered for the advice programme. Section 3 describes the ICT service of which the advice programme was part. The end-user requirements on which the design of the advice programme was based are presented in Section 4. Section 5 describes the General Advice Programme. Finally, the results of the evaluation of the advice programme by the users are presented in Section 6. The main conclusions are summarized in Section 7.

2. Types of energy and water related behaviours and conservation measures

There are many different types of behaviours and conservation measures that residential building occupants can adopt to save energy and water. Rahman et al. [20] categorize the conservation measures according to their associated level of investment into: zero investment measures, minor investment measures and major investment measures. Similar grouping is also made by [21] where measures are grouped into Low- to No-cost measures, Medium-cost measures and High-cost measures. Low- to No-cost measures require negligible investment and design input and include actions such as modification of thermostat settings, use of windows for natural ventilation, shifting of activities to off peak hours. Medium-cost measures require some level of investment in the form of works expenditure and therefore more time before they are implemented but still require little or no design input [21]. High-cost measures require detailed study and design [21] and thus a considerable amount of investment for their implementation [20]. High-cost measures are often implemented through building or system retrofitting and before deciding between different solutions parameters such as pay-back period and associated energy or water savings should first be evaluated [20].

Abrahamse et al. [3] categorize behaviour changes according to their cost in terms of time, effort and convenience. Namely a relatively low-cost behaviour may involve the changing of the thermostat setting and the efficient use of appliances, while a relatively high-cost behaviour may be the reduction of the number of car trips.

In their book "Environmental problems and human behaviour", Gardner and Stern [22] categorize the behaviours related to energy conservation into: efficiency and curtailment. Efficiency behaviour involves the adoption of energy-efficient equipment while curtailment behaviour involves the less extensive use of equipment already acquired [22,23].

Fred et al. [24] classify the energy use of a household into three energy-related behaviours: purchase-related, usage-related and maintenance-related behaviour. Purchase-related behaviour, refers to 'energy efficiency choices' [25] when purchasing household durables such as refrigerator, heating system, air-conditioning system, etc. According to Barr et al. [26] purchase-related behaviour may include long-term alterations to the structure or to the building systems and appliances that require the utilization of economical and often technical sources. Usage-related behaviour relates to the frequency, duration and intensity of use of domestic appliances and of the home itself [24]. Such behaviours are related to decisions that humans make on a daily basis and are based on habits and previous experience [26]. These include measures of minimal cost such as: use of a clothes line instead of a tumble dryer, thermostat setting modification, switch off of equipment or lighting in unused rooms. Maintenance-related behaviour involves the maintenance undertaken on systems and appliances (i.e. boilers and washing machines) to ensure their energy efficiency.

Dietz et al. [27] prefer to separate usage-related behaviour actions into those involving equipment adjustments and to those involving daily usage behaviours. The difference between them lies in the ease of maintaining their effect; daily usage behaviours must be repeated on a constant basis in order for them to be effective, while the effect of an equipment adjustment is maintained automatically. Dietz et al. [27] also separate purchase-related actions into those involving one-time investments for building shell and systems energy-efficiency upgrade and to those involving the purchase of energy efficient household equipment, appliances and motor vehicles. The latter offers product attributes, additional to energy savings and cost that an upgrade to the building shell and systems also offers, that matter greatly to consumers.

The different types of energy and water related behaviours can be used as determinants of advice types in energy advice programmes while conservation measures can be considered as the actual advice provided through the programme.