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Unraveling everyday heating practices in residential homes

Christine Eon[a,]*, Gregory M. Morrison[a], Joshua Byrne[a]

[a] *Curtin University Sustainability Policy Institute, Perth, Western Australia, 6102, Australia*

Abstract

Recent research has found that low-emission buildings do not necessarily meet their full theoretical energy saving potential and one of the reasons for this discrepancy is related to occupancy. Inside the building, users interact with technologies and are influenced by everyday practice and subsequent behaviour. This research aims to unravel the layers of complexity in everyday practice with regards to heating and the use of renewable energy. For this purpose, ten Australian houses were established as embedded Living Labs and monitored for over a year. Results show that the studied households use climate control at different times of the day depending on lifestyle. However, individuals in the same household may have different heating practices according to motivations, attitudes and subjective norms. The combination of quantitative monitoring and qualitative assessments revealed that lifestyle, family structure, habits, comfort and the presence of renewable energy all impact on the frequency, timing and intensity of heating and cooling practice. This research provides a better understanding of intra-home and everyday practices, helping to inform the transition from energy efficient houses to energy efficient home systems.

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Keywords: Living Labs; Everyday Practice; Behaviour; House; Home; Heating Systems; Thermal Comfort, Renewable Energy

1. Introduction

Recent research has found that low-emission buildings do not necessarily meet their full theoretical energy saving potential and one of the reasons for this discrepancy is related to the effect of occupant behaviour [1-3]. Whilst energy efficient technology and house design exert an impact on domestic energy consumption, occupants can negate energy efficiency measures through rebound effects [4].

* Corresponding author. Tel.: +61 466-447-551.
E-mail address: christine.eon@curtin.edu.au

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The understanding of behaviour change in households has traditionally been informed by socio-psychology theories, such as the theory of planned behaviour [5], social norms [6] and the theory of cognitive dissonance [7]. These theories consider humans as rational beings, making decisions based on their attitudes, values, norms, knowledge and intentions. Accordingly, socio-psychology practitioners have attempted to influence behaviour through persuasive methods, such as feedback delivery, information provision and social norms [8]. The emerging field of practice theory has challenged the traditional persuasive approaches, arguing that the effects of persuasion are short-lived and do not become part of users' routines [9]. Practice theory advocates that everyday practices are directly influenced by technology, knowledge, motivations and habits [10, 11]. Practices are also fluid, changing over time and in accordance to the context [12], the evolution of infrastructure and social networks [13]. For instance, the practice of maintaining warmth is not only dependent on attitudes but also on available equipment (e.g. fire place, warm clothes or mechanical heating). Practice theory aims to enable change rather than persuade change and develop technology that meets user needs while promoting sustainable behaviours, rather than expecting change to occur without a change in context [9].

While the two schools of thought discussed above have been viewed as misaligned, they are now converging in Living Laboratories (Living Labs) [14] as researchers attempt to obtain a deeper understanding of the layers affecting occupant everyday practices and behaviour at a home level. Living Labs are real-life places (e.g. homes or workplaces) that support the co-creation and testing of technical and social innovations while also providing insights into user behaviour and daily practices [15-17]. Living Labs enable the observation of users in their own environment, interacting with other household members and familiar objects in an everyday situation.

The 10 House Living Labs project, consisting of ten Australian embedded Living Labs [18], uses mixed methods to understand intra-home dynamics, practices and behaviours and how these affect total energy use. A better understanding of the home system might accelerate the implementation of social innovation and technology to help close the gap between theoretical and actual energy use in low-carbon houses. This research focuses on heating practices and the use of rooftop photovoltaic (PV) panels.

2. Methods

2.1. 10 House Living Labs

The ten Australian Living Labs are located in the City of Fremantle, Western Australia, within close proximity to each other and therefore in the same microclimate. They consist of single detached dwellings, which are the predominant residential typology in Australia, and have mixed occupancies and designs (Table 1). The mix of houses include older houses that have been retrofitted to become more energy efficient through the installation of insulation and renewable energy; modern houses that were built to meet the minimum current Australian building standard of 6-Star or deemed-to-satisfy; and high performance houses, which are rated 7 or more stars. The higher the star rating, the lower the need for artificial heating or cooling per square meter to keep houses thermally comfortable, that is, in the range between 20 and 25^{o}C [19].

Nine of the selected houses possess solar panels and eight houses possess a solar hot water system, enabling us to study user practices and behaviours under the influence of home energy systems with a significant renewable contribution.

2.2. Mixed methods

Several techniques with varying levels of user engagement can be employed in Living Labs depending on purpose. These can vary from the observation and understanding of daily practices to the co-creation and testing of new technologies and solutions where the user is central to the process [20]. The first level of integration involves sporadic user engagement and is mostly descriptive as it aims to generate knowledge about baseline practices [20]. The 10 House Living Labs are positioned at this first level of integration and a merging mixed method approach was