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Social barriers to the adoption of smart homes

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HIGHLIGHTS

- Smart homes and related technologies can provide a variety of benefits.
- Technologies need to be reliable and fit into householders' lifestyles.
- Public concerns relate to cost, control and privacy.
- Trust in energy companies and government is important.

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ABSTRACT

The aim of this paper is to explore social barriers to the adoption of smart homes through the analysis of expert views and public attitudes. Smart home services aim to improve the comfort, convenience and safety of householders, as well as allowing them to use energy more efficiently and cope with increasing costs. Despite the existence of smart homes and smart home technologies for some time, their prevalence is not widespread, and thus their potential largely untapped. Using a combination of in-depth deliberative public workshops, expert interviews and a review of the existing literature, this paper explores social barriers to smart home diffusion, including how these vary by expertise, life-stage and location. The research highlights the importance of barriers such as control, security, and cost, providing insights for policymakers as well as smart-home designers and developers as to how these might be addressed.

1. Introduction

Smart homes and other smart technology, such as smart grids and smart meters, have existed as concepts for many years, but have gained increasing attention over the last decade. Policy objectives encouraging or mandating energy efficiency, climate change objectives at both the national and the EU-level, as well as advancements in communication technologies such as high-speed internet and wireless devices, have driven recent developments. The smart home provides a new way of looking at the role energy plays in everyday life, the evolving relationship between energy utilities and consumers, and its development may create opportunities for consumers and utilities alike.

Today, the "traditional home" has appliances that are operated locally and manually, usually by flipping a switch or pushing a button. These devices have limited controls and managing energy use can be difficult. The smart home, on the other hand, allows for remote electronic control and management of smart appliances (heaters, air conditioners, washing machines etc) and represents the convergence of energy efficient appliances and real-time access to energy usage data, facilitated by a network of sensors and computers (ITU, 2010). Increased visibility of energy and cost information through interactive displays can enable consumers to proactively monitor and manage energy use in ways that are convenient, cost-effective, and environmentally beneficial. This is consistent with the wealth of literature focusing on how provision of feedback to households on energy use data can facilitate energy savings (Darby and McKenna, 2012; Hargreaves et al., 2010; Hargreaves et al., 2013; Meyers et al., 2010). Complementary to this, the deployment of smart meters may enable householders to benefit further from more differentiated, dynamic tariffs and demand response programs more directly as part of transition to a smart grid (Darby and McKenna, 2012; Faruqui et al., 2010). Smart homes can also deliver other services such as assisted living, home security or entertainment, as well as facilitating two-way communication between the grid and electric vehicles and any on-site micro-generation (e.g. rooftop solar panels). Finally, they can contribute to the delivery of social policy goals by helping provide better living standards for elderly, sick, and disabled homeowners (Pragnell et al., 2000).

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Despite all these benefits, the literature informs us that the impacts of new technologies are often unexpected and predicted benefits may not be realised, as insights about important interactions between technology and society are neglected (Geels and Smit, 2000). More specifically for smart homes, their development is subject to further interdependencies between policy (type of incentives to enable the uptake of technologies), regulatory (who can access consumer data, at what frequency, enabling of emergence of new actors and services), commercial and market frameworks as well as investment conditions (having the funds for the installation of communications and grid infrastructures). For a discussion on the importance of these issues on the development of smart home market in the UK, please see (Balta-Ozkan et al., 2013). Hence, it is not surprising an extensive body of literature focuses on how innovations take place as a result of the interplay of these factors (for instance, a multi-level framework as advocated by (Geels, 2005), diffusion curves by (Rogers, 2010), and a constructive technology assessment framework by (Schot and Rip, 1997)).

Yet, the importance of public values, beliefs, skills and practices in respect of energy consumption and management is well documented (Hargreaves et al., 2013; Nye et al., 2010; Whitmarsh et al., 2011). Specifically for smart homes, though, few studies have examined challenges facing the industry or, specifically, social aspects of smart home technology adoption and diffusion (Edwards and Grinter, 2001). Furthermore, given that smart homes encompass diverse technologies (sensors, communication platforms, appliances, etc.), products and services (time-of-use tariffs, remote monitoring, efficiency, etc.), no attempt has so far been made to draw together insights from disparate disciplines or expertise to understand how these technologies/services and challenges may interact with values, behaviour and society. In particular, whether smart homes, through these technologies/services and products, have the potential to reduce social inequalities or exacerbate them. The fact that disadvantaged social groups have limited means (including financial, physical or educational) to interact with these systems needs to be analysed further.

The aim of this paper is to contribute to understanding the social barriers to adoption of smart homes, including shedding light on their implications for social equity, based on expert interviews and public deliberative workshops. In doing this, we begin by taking a holistic approach to smart home services, with a view to drawing out conclusions for energy consumption and management services. The study contributes to the literature by grounding, comparing and contrasting social barriers highlighted in the literature to those identified through expert interviews and public workshops. The paper is structured as follows: Section 2 reviews the literature with regards to both definition of smart homes and social barriers; methodology is discussed in Section 3; Section 4 presents the results from both the expert interviews and the public deliberative workshops; and Section 5 concludes with lessons for the energy industry as to how addressing these challenges may affect the future of the smart home market and, to a large degree, the energy industry as a whole: "Successful innovation is the result of a specific socio-economic and technological constellation, i.e. the right product, on the right market, at the right time and in the right combination where specific requirements in terms of user needs, user-friendliness, price, attractive supply, standards, interoperability, and so on have to be met. If they are not, the commercialization will certainly fail." (Friedewald et al., 2005).

2. Background

Through a review of existing literature on the subject, this section sets out the context to this paper, providing a working definition for the term 'smart home'; illustrating the types of services smart homes might provide; and identifying potential social barriers arising from the wider challenges acknowledged to be facing smart home development today.

2.1. Definition of smart home

A smart home is a residence equipped with a high-tech network, linking sensors and domestic devices, appliances, and features that can be remotely monitored, accessed or controlled, and provide services that respond to the needs of its inhabitants (Chan et al., 2008; King, 2003; Li et al., 2004; Reinisch and Kofler, 2011; Taylor et al., 2007).

The term 'smart home' may, in principle, refer to any form of residence, for example, a standalone house, an apartment, or a unit in a social housing development. In the definition set out here, *sensors* may be used to detect the location of people and objects, or collect data about states (e.g. temperature, energy usage, open windows); domestic devices, appliances and features can include anything from washing machines or lighting to a user interface providing access to and control of smart home data and services; and smart home services are the benefits that the smart home provides to the user. The network, through which each of the technological components and information about them is connected and coordinated, is what distinguishes the smart home from simply the high tech-equipped residence.

2.2. Smart home services

Smart home services are the benefits that the smart home provides to the user and the system provider (e.g. the ability to manage demand), facilitated by the smart home's network of technological components. Services may be categorised based on the user's needs they target, e.g., security, assisted living, health, entertainment, communication, convenience and comfort, and energy efficiency.

An assisted living smart home, for example, might provide an elderly or disabled occupant and their friends and relatives with greater independence and peace of mind, monitoring the occupier's activity and contacting a nominated carer in case of unusual activity (e.g., not turning on the kettle in the morning) signalling a potential accident or illness. Of the literature examined, a substantial proportion focuses predominantly on the assisted living applications of smart homes[1] (e.g. (Chan et al., 2009, 2008; Demiris and Hensel, 2008; Ding et al., 2011; Eriksson and Timpka, 2002).

Smart home security services, on the other hand, might offer the ability, using sensors, to monitor movement in the home and identify potential intruders, to be alerted about open doors and windows, or to program random room lighting patterns to deter thieves from a temporarily unoccupied property. Smart home energy efficiency services assist homeowners in reducing energy demand, whether directly (through automated energy-saving mechanisms, such as reducing the heating on hot sunny days) or indirectly (e.g., by providing the user with centralised access to data about their real-time energy usage and energy bill). Table 1 presents a selection of smart home features and services from the literature and a range of case studies. This wide variety of services

[1] One of the UK experts also made a distinction that while 'assisted living' covers all that smart technology might offer in health terms, 'tele-health' and 'tele-care' are different. The former refers to statutory services that are paid for by the health services at source and is generally free at the point of use (being paid for by through taxation). Tele-care on the other hand is paid for by users and charged for by the social services or by the companies providing it.