Occupant behaviour and building performance: Policy background and literature

Policy background

In January 2007, the EU Commission set ambitious targets, known as the 20-20-20 strategy. The threefold aim of this was by 2020, to reduce energy consumption by 20% of projected levels, to reduce greenhouse gas emissions below 20% of 1990 levels and for renewable sources to constitute 20% of energy consumption (EU Commission, 2008a). In the longer term, the EU also aims to reduce greenhouse gas emissions between 60-80% by 2050 (EU Commission 2007a; EU Commission 2007b p.2).

The Directive on the Energy Performance of Buildings (EPBD) of 2002 was revisited in 2008. This emphasis on the need to promote increasing the energy efficiency of residential and commercial buildings, was in recognition of the fact that the building sector is the largest user of energy in Europe being responsible for around 40% of energy use and CO_2 emissions (EU Commission, 2008a). The UK's housing stock has been found to be amongst the least efficient in Europe with domestic residences contributing to over a quarter of energy usage, a third of which is estimated to be wasted (POST 2005). Domestic residences in the UK have also been found to contribute to 27% of CO_2 emissions (DEFRA 2006).

Studies have found that it is feasible to meet government targets through the use of various technical measures - largely in relation to refurbishment of existing housing which (i.e. those built in the 20th century) has been estimated will constitute a large majority (65-70%) of the housing stock in 2050. It has been argued that an increase in demolition rates may not therefore be necessary in order to make sufficient cuts to carbon emissions from residential buildings (Lowe 2007). However, the extent to which the will of government and industry is set to achieve this has been the subject of debate. In addition, the role of the consumer is critical. Potential barriers are evident in relation to the lack of consumer demand for low carbon measures (UK Green Building Council 2008). But perhaps more crucially, and up until recently, largely neglected, is the role of the occupant once actions have been taken to install energy efficient measures. There is, however, increasing recognition of the potential impact of occupant behaviour upon the subsequent energy performance of buildings, and the need to measure this (Janda 2011; Stevenson and Leaman 2010). This is discussed in reference to relevant literature in the next section. The following section then focusses on influences on energy consumption related behaviour.

The role of occupant behaviour on building performance

"What is essential now is to concentrate on household behaviour, not just the building." (Vale and Vale 2010 p.586)

Numerous studies have shown a gap between energy predictions and reality. Alongside complexities in buildings and weather, this is often attributed to the difficulty of predicting occupant behaviour, or a failure on the part of building professionals to adequately recognise and take variations in occupant activities into account (Elzenga et al.2010). The difficulty with predicting occupant behaviour can therefore pose difficulties for the analysis of building performance. Turner and Frankel (2008 p.2) for example, found that outliers with exceptionally high energy use were attributed to occupant activities rather than basic building systems, and therefore had to be considered separately.

One example of a study which highlights the significance of occupant behaviour upon the gap between energy predictions and reality was that conducted by Demanuele et al. (2010). They show how the building performance of schools differed from design assumptions owing to variations in human behaviour and argue that effective handover and user-education are crucial in order to improve efficiency. Several other studies focussing on domestic residences have also suggested that it is the human factor which is ultimately most influential on the energy efficiency of the buildings following installation of technical energy reduction measures. Sparatu and Gillott (2011) for example, conducted a case study of a fully monitored 1930s replica three bedroom semi-detached house and conclude that focussing solely on building performance is insufficient. They emphasise the importance of understanding and influencing the behaviour of the resident who is in control of the appliances, lights, heating and ventilation. They argue that the collection of long-term data is necessary for the identification of general behavioural trends.

Gill et al. (2011) found in a study of a low carbon design housing development, that significant variations in heat and water use between minimum and maximum consumers remained, even when differences in building type were taken into account. Similarly, Stevenson and Leaman (2010) demonstrate how energy consumption can vary enormously when comparing neighbours living in exactly the same type of home. They emphasise the need for users not only to be challenged about excessive consumption but also to be aided by improved usability and control. They also argue for the need for occupancy feedback and evaluation to become routine, in order to improve our understanding of the attitudes and reasons behind occupant behaviour.

Although recent literature reflects a growing consensus of the need to give more attention to social factors, rather than focussing solely on technical solutions (Cole et al. 2010), there are disagreements as to the extent to which occupant behaviour matters, with researchers

presenting varying estimations. Killip for example suggests that occupant behaviour is responsible for approximately one quarter of the influence on building energy use, whilst Schipper et. al estimate occupant behaviour to account for 50% of energy use (cited in Janda, 2011). On the basis of a literature review, Uitdenbogerd et al. (2007) suggest that changing energy related behaviour can potentially reduce household gas consumption by 12% and electricity consumption by 7%. Gill et al. (2010) in a study of new homes, estimate that energy efficient behaviours accounted for 51%, 37%, and 11% of the variance in heat, electricity, and water consumption respectively. They conclude that the issues around the human influence on building performance need to be addressed more adequately as part of low energy design. Janda (2011 p.17-18), however regards human behaviour as even more significant – and to be understood as accounting for 100% of energy use, with personal choices accounting for 50% and non-personal or institutional 'choices' accounting for the other 50%.

However we are to understand the extent of human impact, it is clear that greater emphasis should be placed on the role of human agency in residential energy use. As Janda (2011) argues, "buildings don't use energy: people do." Buildings and technologies may enable or constrain the energy implications of the choices of the occupant, but the choices themselves should be the primary focus. It is the occupant who has, in most cases, control over the internal temperature, ventilation, lighting, hot water, use of appliances and so on. Although opinion is divided, many academics and others therefore believe that absolute demand reductions will be delivered only if energy efficiency is coupled with measures that encourage consumers to limit their overall energy use (Boardman 2007; Rees 2009; Wilhite and Norgard 2004). Boardman (2007) for example estimates that two thirds of energy reduction can be achieved through reduction in demand, and one-third from the use of low-carbon technologies (including micro-generation).

Some researchers have given examples of where technical measures aimed at increasing energy efficiency have had minimal or no impact on reducing energy consumption. This is largely due to 'rebound effect', notably in terms of the 'temperature take-back factor' where residents convert increased efficiency into increased comfort rather than energy/ cost savings (Hamilton et al. 2011; Hong et al. 2009). In terms of the remit of energy reduction, this 'take-back' effect could be particularly problematic when focussing on reducing consumption through increasing the efficiency of residences occupied by low-income households (since these are likely to be in fuel poverty and thus under-heating homes prior to technical adaptations). In fact, following the 'Warm Front' retrofit, researchers found that fuel consumption actually increased (Green and Gilbertson 2008 p.19). It could be argued that despite a lack of energy savings, retrofit measures are nevertheless justified on the grounds of associated health and psycho-social improvements for those in fuel poverty (Green and Gilbertson 2008; Wilkinson et al. 2009). However, as

Summerfield et al. (2010) argue, in terms of efficacy in energy reduction, it may be more effective to focus energy policy on higher income households, which have on average higher levels of consumption and therefore greater potential for making reductions.

In any case, the large gap between predictions of and actual changes in consumption as have been identified in many cases, suggests a lack of understanding of the ways in which occupants interact with technology in the home, and of the relationship between this behaviour and energy consumption. Some researchers have studied the impact of occupant type and behaviour upon consumption. Guerra-Santin and Itard (2010), for example, show that demographic and lifestyle factors had significant impact on energy use. They also highlight how differing interaction with heating systems in the home had an important impact on consumption e.g. they found that usage hours of heating have a greater impact on consumption than temperature increases and that those with programmable thermostats were more likely to keep radiators turned on for longer, than those who controlled heating with a manual thermostat or with radiator valves. Nevertheless as Bourgeois et al. (2006) argue, there is in general a limited knowledge on how people perceive and control their environment in many space types (apart from single offices). Further study in relation to occupancy control patterns is therefore required, particularly in relation to the more complex dynamics evident through social interaction of multi-person households.

Influences on occupant behaviour

There are also gaps in knowledge around how energy related behaviour can be influenced. A common strategy in attempting to change behaviour has been through aiming to increase awareness. The EU Commission (2008b) identifies “the lack of consumer awareness” as one of the main obstacles to achieving the target on reducing energy by 20%. A study by Attari et al. (2010) emphasises the importance of awareness in showing how participants tended to underestimate energy usage, especially for high energy activities. Al-Mumin et al. (2003) also attribute high energy consumption in buildings in large part to “energy-unconscious behaviour”.

Feedback on energy consumption has been recognised as one way to increase and reinforce awareness. Research since 1970’s has shown that providing consumption info through feedback can reduce energy consumption by up to 15%. Direct feedback such as through energy monitors has been found to be more effective (leading to a reduction of 5-15%) than non-immediate indirect feedback such as from bills (0-10% reduction) (Darby, 2006). Feedback has also been found to be have more effect on summer electricity consumption (10-15%) than winter gas consumption (0-10%) (Socolow, 1978). However, research has also shown that the impact of feedback through energy monitors can be greater at first but that

the novelty can wear off. Van Dam et al. (2010), for example, found initial reductions in electricity of 7.8% were not sustained over the longer term.

Some studies have shown that the focus on increasing awareness through increased information to be insufficient, as Genovese (2008) states: "having a high level of awareness of climate change does not necessarily translate into concern or taking personal action." Linden et al. (2006) found in their study of Swedish households, that residents wanted more information in some aspects of energy saving behaviours but that it was particularly important "to promote behaviours in line with recent trends in lifestyles, e.g. time saving behaviours, latest fashion for energy efficient technology or a cosy indoor environment" (p.1926). Dahlbom et al. (2009) argue that there needs to be a greater focus on practical support, clarity of links between community, individual change and wider change in other sectors. Creating awareness is only seen as one of a number of motivating factors. In addition, the importance of enabling factors, such as external constraints on behaviour, financial, technical and organisational resources, and the development of new skills are also emphasised. In addition, reinforcing factors are also necessary in order to maintain behaviour change. These could include continued messages received through energy monitors as well as feedback from peers and 'powerful actors'. A behaviour change model, being applied by Defra, emphasises the importance of encouraging, enabling, engaging and exemplifying factors (Collier et al., 2010). Similarly, Bakhaus and Heiskanen (2009) set out a number of behaviour changing factors which, alongside creating awareness of habits include using emotional and rational appeals, changing aspects of the users' environment, using 'fun' initiatives to motivate people (e.g. competitions), giving feedback and goal setting. They also note the importance of addressing not only individual behaviour but that of the local community and wider society.

In relation to feedback through monitoring devices, Darby (2010) emphasises the importance of designing user friendly devices and accompanying feedback with appropriate guidance and support, information and advice in order to ensure effectiveness. Feedback has also been found to be more effective when combined with goal setting (Seligman, 1978; Becker, 1978). Stevenson and Leaman (2010) state:

"It is not enough to presume that information from 'smart metering' will encourage people to reduce their energy consumption any more than a car speedometer will reduce speeding, unless the speed limit is made clear along with the severe consequences of breaking it" (p.440).

Vale and Vale (2010) argue that feedback needs to be taken further in order to be effective, e.g. through directly telling residents if they have exceeded a quota and even imposing limits.

Another potentially motivating factor, particularly in deprived neighbourhoods, is the potential cost reduction related to reducing consumption. Messages around this have been particularly focussed on by government and voluntary sector and housing association energy reduction inititatives and projects with the aim of incentivising residents to take measures to reduce consumption (some examples of organisations promoting such messages include, The Energy Saving Trust: www.energysavingtrust.org.uk, the Newlon Housing Trust: http://www.newlon.org.uk/residents/save-money-save-energy/ and Origin housing: http://www.originhousing.org.uk/myorigin/save-energy-money.aspx).

However, cautionary messages relating to the emphasis on financial savings have also been expressed, in terms of the wider picture of energy conservation. Genovese (2008) argues that the idea that people are motivated through monetary rewards is overrated. Linden et al. (2006) in their study of residential energy behaviour suggest motivational factors to be more complex than is sometimes thought, with monetary rewards not necessarily being the most prominent. Most residents, for example, turned down heating at night because of reasons around comfort rather than in order to save money. McMakin et al. (2002) suggest that behaviour change in energy conservation can be achieved through altruistic and egoistic rather than financial influences. Steg (2008, p.4450) emphasises the importance of normative and environmental concerns in relation to behaviour change, since if people are motivated only by cost, this may change as circumstances change. In addition, without a change of beliefs or awareness about environmental issues, money savings may be reinvested into carbon intensive activities, thus effectively transferring rather than reducing energy consumption. Such potential and backfire phenomena which may minimise carbon reductions are discussed in Druckman (2011). When designing social projects to reduce domestic energy use, it is therefore important to reflect on these broader considerations in order to maximise impact on energy conservation.

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