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Low-energy housing: are we asking the right questions?

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Abstract: Purpose-built low-energy homes have been the subject of policy and researcher scrutiny for many years, and there is plenty of evidence that they deliver substantial energy and carbon emission savings. But are these the best metrics to assess their benefits? What do the occupants think are the most important aspects of living in low-energy and near net zero energy homes? This paper investigates the stories told by households living in purpose-built low-energy homes in the UK, and examines the user experiences that are most important to them. What we find is that the user experience is highly personal, is strongly linked to health and wellbeing experiences, and is focussed around family outcomes rather than rather abstract energy or environmental outcomes. This research has led to the conclusion that we may be asking the wrong questions about purpose-built low-energy homes, and using the wrong metrics to assess the benefits.

Keywords: low energy homes, user experiences, thermal comfort.

1 Introduction

1.1 Background

Housing is influenced by many policy drivers and by many actors. Environmental concerns such as global climate change, energy challenges such as peak energy demand, and economic concerns including housing affordability are amongst a plethora of issues that shape housing policy. In addressing environmental concerns through policy developments, the metrics used to determine regulatory standards for new homes typically assess carbon emissions or energy use or economic indicators such as net-present-value.

Housing researchers have similarly focused on assessing the environmental, energy or economic impacts of purpose-built low-energy homes. While such research has identified a range of benefits across environmental, financial and social criteria, few studies have sought to understand the most important impacts from the perspective of the end-user, the household. This is not to argue that researchers haven't surveyed or interviewed households to seek evidence of those benefits of high performance homes, as many have, but rather to argue that low-energy and low-carbon homes provide other more personal meanings to end-users that may not align easily with the researcher or policy driven indicators. This paper begins to address this gap by

investigating household's own stories, communicating those benefits and issues that are most concern to them from their experience living in purpose-built low-energy homes.

1.2 Literature review

The performance and impact of purpose-built low-energy housing has been the subject of much research, particularly through engineering style quantitative approaches. For example, the housing literature provides plenty of evidence that purpose-built low-energy homes deliver substantial and sustainable energy use reductions [1-6]. Similarly, the literature demonstrates that the combination of passive solar design, energy efficient appliances and renewable energy technologies can greatly reduce the environmental impact of housing [7-9]. The affordability of low-energy and low-carbon housing has also been the subject of extensive research, from both the perspective of the household and public-good, using a range of economic indicators such as net-present-value, payback-periods and return-on-investment [10-12]. This engineering style analysis, built on a strong evidence base of in-situ monitoring, has also been used to assess other impacts such as the value of nearly net zero energy or net zero carbon homes on the management of peak energy demand, and the sizing of plant and equipment [13]. Typically it is this type of evidence which has been used to shape minimum building energy standards and to frame policy debates about the feasibility of environmentally sustainable housing as we transition to a low carbon future.

Complementing this engineering style quantitative analysis has been an emerging body of literature seeking to understand the energy and carbon impact practices of end-users, including the residents of purpose-built low-energy homes [14, 15]. Much of this literature describes or explains patterns of behaviours, rather than describing the thoughts, feelings and experiences of those households to the new situation of high performance housing, often loaded with unfamiliar technologies. Within this body of work there are fewer examples of personal storytelling, communicating the householder's perspective of living in near and net zero energy homes [16-18].

And whilst policy makers and the building sector just assume, given the environmental, energy and economic benefits that residents will want to live in low-energy and net zero energy homes, where is the evidence documenting that households enjoy that experience? Also, where is the understanding of how such housing will impact on how they use the space and how it might shape, or reshape meanings of home and thermal comfort?

This paper seeks to address this gap in the literature by exploring the question: what do end-users perceive to be the key benefits of living in purpose-built low-energy homes. This paper gives voice to a set of UK residents who are living in purpose-built low-energy homes, and explores the experience from their perspective.

2 Methodology

2.1 Purpose-built low-energy homes

In the context of commitments within the United Nations Framework Convention on Climate Change, and community expectations from the Stern report “Review on the economics of climate change”, the UK Government announced in 2006 the transition to ‘Net Zero Carbon Homes’ by 2016, and the introduction of the Code for Sustainable Homes to facilitate performance assessment. Although this policy was rescinded by a later government in 2015, the program to support industries preparation for the new standard contributed many demonstration projects, from single homes to large residential estates, each investigating specific building design and technological solutions that could contribute to the goal of net zero carbon operating performance. This policy window has enabled a relatively large and geographically distributed sample of near net zero carbon homes across the UK from which to draw on new knowledge.

For this research project, households living in purpose-built low-energy homes designed to achieve ‘Code for Sustainable Homes’ Level 5 or 6 were interviewed. All homes were located in a relatively central area of the United Kingdom, including the Midlands region and Yorkshire, and has a temperate maritime climate, with cold, cloudy, wet winters and comfortable, mostly dry, mostly sunny summers.

2.2 The interview approach

Four purpose-built low-energy housing estates were visited and in most cases multiple residents were interviewed. The interviewee households were chosen by local social housing associations, who were either the owners of the properties or the estate developer. The interviews took approximately one hour each and were conducted in the resident’s homes. In most circumstances the interviews included multiple residents from that home. This process was not intended to enable a statistically representative sample of households in purpose-built low-energy homes, but rather identify some of the key issues and themes that may be common across various medium and large-scale low-energy housing demonstration projects.

The semi-structured interviews [19], utilised open-ended questions with few prompts to provide a replicable focus on the research question, and were designed to collect the resident’s experiences and perceptions from within their own storytelling as opposed to answering survey questions determined by the interviewer. The goal of each interview was to enable households to communicate the issues of importance to them, with particular emphasis on those experiences unique to living in a purpose-built low-energy home and interacting with the various energy technologies and systems.

3 Householder stories

3.1 Deeply personal stories

The first theme that can be drawn from the interviews is that the impact of living in purpose-built low-energy homes is uniquely personal to the household. No two households told the same story, although many communicated positive health and wellbeing outcomes. Some stories related to direct health benefits, such as reductions in the occurrence of asthma and other respiratory illnesses, whilst others talked about indirect health and wellbeing benefits, such as positively impacting family relationships. For some, health and wellbeing benefits were prominent and front of mind, while for others the message was woven into stories of day-to-day experiences.

Whereby a building energy engineering perspective may discuss factors such as improved air quality and the ability to maintain higher levels of thermal comfort, the stories of the residents described personal benefits that had meaning to their lifestyle. For example, one elderly householder told us that moving into a (dry and warm) low-energy home allowed their grandchildren to visit more often and stay overnight. For that household, and their direct family, living in a purpose-built low-energy home had a direct personal life-changing benefit.

From a building energy engineering perspective the application of mechanical ventilation with heat recovery facilitates higher volumes of fresh air without heat loss. To the residents this means the more personal experience of clothes drying more quickly, the elimination of mould growth, and improved respiratory health. The benefits and impacts were always communicated as an experience rather than a discussion about a technology or design element. In the case of one household, they were inspired by the improved dwelling performance to give up smoking, recognising that smoking inside the home negated many of the benefits of the improved air quality.

From an engineering perspective increased levels of insulation in wall systems, triple glazing and improved air tightness facilitate reduced heat transfer and the ability to control thermal comfort. From a resident's perspective they talked about experiencing fewer draughts and cold spots or having a more even temperature throughout the home and across the seasons, allowing the family to use more of the house more often. The difference is that the experience is personal and relevant to the end-user, whilst energy transfer through materials is abstract and not meaningful to households. Although some acknowledged lower utility bills, for many of the residents the stories told are not so much about energy efficiency or energy savings, but about what that delivers in outcomes to their family and lifestyle. This might be a subtle difference, but it points researchers to a different way of seeking and processing information from end-users, and to valuing the benefits of low-energy homes.

The resident's stories typically described improvements to their quality of life, and they often compared to this to the experience of their previous housing, recognising the differences, in many cases significant differences, between standard and low-energy housing in relation to those impacts.

3.2 Benefits beyond the house

The second theme that can be drawn from the interviews is that purpose-built low-energy homes provide economic empowerment to low-income households, and deliver benefits beyond the confines of the house. In particular, the absence or reduction of energy bill stress enabled choices that are deeply personal and effect lifestyle activities both within the house and beyond. For example, one household talked about the family unity and social integration benefits of being able to afford annual family holidays, even overseas holidays. To this family, the financial empowerment of a purpose-built low-energy home resulted in an improved level of mental wellbeing associated with being able to live more like their peers, in this case illustrating the point through the aspiration of annual holidays. Similar economic empowerment stories focused on personal impacts such as affording school excursions, buying 'PlayStation' type devices, or 'better' food and medicines.

As researchers, we might dismiss this as a macro-economic rebound effect, voiding many of the energy and environmental benefits. But to households the impacts relate to personal health and wellbeing benefits such as a closer and stronger family unit, or the ability to be able to make the types of choices available to others in their community. The consequences of economic empowerment may have environmental impacts, but this does not dilute the real benefits experienced by the households, or the potential for associated macro-economic benefits.

The experience of living in a purpose-built low-energy home can also raise environmental awareness and inspire other changes in lifestyle that improve environmental sustainability, including non-house related impacts. For example, one household talked about being more environmentally conscious to the level of being inspired to change transport and shopping behaviours, and eliminating the use of a tumble dryer. This awareness extended to appliance purchasing where they deliberately sought appliances with a higher efficiency to complement their low-energy home. Many residents expressed the 'feel-good' benefit of 'doing their bit' for the planet.

Another resident spoke of how they identified a way to improve economic outcome for their household through seeking out better solar feed-in-tariffs. Due to the coincidental knowledge of the energy sector, that household ended up registering their house as a power generator within the national electricity grid and were able to receive significantly higher financial returns. This process demonstrates a sense of ownership of the sustainability of the home, and their engagement in the outcomes of self-generation.

3.3 Transition to new technologies is not always easy

Purpose-built low-energy homes are technology rich and expose residents to unfamiliar technologies and systems or different building performance outcomes. The experience of residents is not always positive, and the interviews uncovered some frustration about dealing with some new technologies or performance outcomes. For example, the operation of air-sourced heat pumps confused some residents who were more comfortable with traditional boiler based hydronic heating systems, whilst

others were unsure about the benefits of the mechanical ventilation with heat recovery systems.

Many of the stories provided new insights into the relationship between people, energy technologies and low-energy buildings. For example, the interviews discussed how ‘easy-to-understand’ feedback can empower household choice making, with one household explaining that the installation of a simple light that turned green when the solar photovoltaic system was producing sufficient electricity allowed them to exploit free electricity and make financially useful decisions on when to operate high-powered appliances and equipment. Some expressed concern that the solar thermal water heating system provided lukewarm water in winter.

Residents faced new thermal comfort challenges due to the improved thermal efficiency of the dwellings. Several households communicated a new struggle with summer overheating, and because of the relatively new nature of the problem, they had not fully developed building operational techniques or behaviours to avoid or manage overheating. It was also evident that building design strategies such as fixed or seasonal shade devices had not been adopted probably due to the newness of the problem to the building sector. In some cases residents had installed internal blinds to block summer sunlight, a behaviour that is relatively normal in Australia, but novel to households living in Yorkshire or the UK Midlands.

3.4 Different metrics

To the residents the impacts are personal and relevant to their daily activities, and may not be easily explained by or translated to the typical metrics (energy, carbon, economic) we use to discuss purpose-built low-energy homes. For example, the residents did not talk about carbon emission savings or use the metric of tonnes of CO₂ emissions, but they did communicate the improved wellbeing they received from ‘doing-their-bit’ for the environment. Here we can see that a better metric might be related to mental health rather than a quantification of emissions abated.

Similarly, residents were conscious about the economic empowerment provided by purpose-built low-energy homes but communicated this not through a calculation of direct energy cost savings, although many were cognisant of savings, but rather by discussing the choices that became available, or the health and wellbeing benefits that resulted from having additional choices.

The quantification of energy savings was not an indicator raised by the residents, but instead residents communicated the outcome of energy use in these purpose-built low-energy homes such as improved levels of thermal comfort, or improved air quality. Another metric closely related to energy savings that was communicated by several households was the amount of time that heating was typically used, or the length of season that heating was not used. It was clear that the residents recognised that less energy was used to satisfy their various energy service needs, but the metric of choice related to the outcome of energy use rather than a measure of energy use.

So the question we need to ask ourselves as researchers, and that policy makers should consider, are current approaches to evaluating and measuring sustainable housing costs and benefits the right metrics? Clearly there are stories from households which challenge some of these traditional engineering and economic metrics, and

suggests more needs to be done to understand low-energy housing from the perspective of the user. This is particularly important if we believe low-energy housing standards will dominate our future housing landscape.

This is not to say that existing metrics do not have their place. They clearly give a way to systematically compare and contrast different policy and housing performance outcomes, albeit from a limited set of performance outcome characteristics. They have also been responsible for delivering the high quality, low-energy housing outcome experienced by the interviewees. However, it is about asking if there are improvements which can be made by listening to those early adopters of low-energy housing, or additional metrics that should be employed, which could help inform how future housing is conceived and regulated.

4 Conclusion

This research set out to identify what end-users perceive to be the key benefits of living in purpose-built low-energy homes. The evidence indicates that households value what low-energy homes deliver in outcomes to their family and their lifestyle. The benefits are not communicated in the energy, carbon or economic metrics of policy makers or quantified in the way researchers often calculate and compare, but in the deeply personal impacts that have positively changed their family's quality of life.

The benefits in health and wellbeing associated with living in purpose-built low-energy homes are real, and are celebrated by the residents. Those benefits appear to be more important to households than the typical metrics used for calculating the impact of low energy homes because they are meaningful in the day-to-day activities and challenges faced by households. This does not mean that energy savings, carbon emission abatement or lower energy bills are not valued by households living in low-energy homes, but rather the experience of an improved quality of life is the way they express the outcome.

This research highlights the importance, in the transition to low-energy and low-carbon homes, of not forgetting about the people who will live in the homes. The goals and metrics used to determine the success or otherwise of purpose-built low-energy homes may not be those researchers have measured for many years – we may be asking the wrong questions. Improving resident's 'quality-of-life' maybe a better goal for low-energy and low-carbon housing policies, and quantifying that 'quality-of-life' improvement may be a more useful research task.

Last but not least, although the technology and house design solution used by each estate developer may be different, overwhelmingly households expressed their joy from living in purpose-built low-energy homes, and recognise the benefits that flow to their family. As one resident told us, she loves it so much "They will need to carry me out of this house in a box!"

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