Home comfort and 'peak household': implications for energy demand

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Abstract:

This paper draws on a study of Scottish householders living in 'zero carbon' homes. It explores how broader understandings of home comfort may explain changes that result in home life becoming increasingly energy demanding, despite householders' intentions to save or decarbonise energy. The paper argues that domestic energy research must engage with the dreams, aspirations and images of home that ultimately drive energy consumption and impact investment in housing and home energy improvements. This is done by examining the interrelationship between energy retrofitting and installing microgeneration technologies alongside discussing meanings of home comfort and visions of ideal homes with householders. The study argues that an important aspect of home improvements is due to accommodating the 'needs' of the peak household. The paper concludes by discussing how a

much wider range of people and interventions could be pursued to reduce domestic energy demand such as promoting downsizing or working with home or lifestyle companies.

Keywords: domestic energy research, home improvement, home comfort, privacy, retrofit, renovation

1. Introduction

Up to 40% of a nation's energy consumption relates to domestic buildings (Golubchikov & Deda, 2012), and thus homes form a central part of nations' decarbonisation, energy security and affordability plans. In view of the importance of domestic buildings and the large percentage of owner-occupiers (e.g. 62.9 percent of UK housing stock (ONS, 2018)), determining how to encourage householders to reduce demand and invest in renewable energy has understandably been a priority in energy research and policy. Echoing existing arguments regarding the huge potential for energy savings and decarbonising the energy supply by improving material features of homes (e.g. insulation, double-glazing, microgeneration technologies), it is worth recognising the tendency of engineers, economists, and behavioural psychologists to gloss over expectations of home comfort and homemaking that are fundamental to decisions to change the physical house (Aune, 2007; Ellsworth-Krebs *et al.,* 2015; EST, 2010; Gram-Hanssen & Darby, 2018; Madsen & Gram-Hanssen, 2017; Wilson *et al.,* 2015).

In this paper, we explore the tension between the desire to save energy through investing in the fabric of the building, energy efficiency and microgeneration technologies and how this is reconciled with householders' images of desirable home life. The contradictions between environmental concern and a failure to curtail standards of living (Aro, 2017; Hitchings *et al.,* 2015), including in the context of energy retrofitting homes (Judson & Maller, 2014; Maller & Horne, 2011; Maller *et al.,* 2012), is not new. Indeed, scholars from sociology, anthropology, history, geography and socio-technical studies writing on energy and sustainable consumption have long evidenced that energy use is inherently social, and the materiality of the home co-evolves alongside changing perceptions of basic standards of living, ways of displaying social status, and notions of modernisation (Gram-Hanssen, 2014a; Haines & Mitchell, 2014; Kerr *et al.,* 2018; Munro & Leather, 2000; Wilhite and Lutzenhiser, 1999; Wilson *et al.,* 2018). However, while these studies identify home comfort and homemaking as key considerations in decision making, going further to articulate what these expectations of home comfort *are* has received little attention in energy debates (Ellsworth-Krebs *et al.,* 2015). This is where we offer a novel way forward for domestic energy research by homing in on expectations of privacy as a significant home comfort (Ellsworth-Krebs *et al.,* 2018) of importance to domestic energy research and policy. This aspect of home comfort both supports the drive for investment in home energy improvement and simultaneously has the potential to increase energy demand due to needing 'enough' space to comfortably accommodate peaks in household size. The significance of privacy and the 'peak household' emerged from a qualitative study with 21 Scottish households living in 'zero carbon' homes[1], the subject of this paper, in which participants discussed energy saving activities within the broader context of homemaking and expectations of home comfort. Considering that few homeowners start a project for energy-related reasons (EST, 2010), energy retrofit, low carbon policies and research must invariably engage with the dreams, aspirations and images of home that ultimately drive energy consumption and impact investment in home energy improvement (Box 1).

The paper begins by exploring literature on energy retrofitting, especially the growing body of scholarship that argues for the utility of situating such activity within a wider discussion of home improvement. The third section explains the methodology, data collection and sample characteristics of the 21 Scottish households in this study. The fourth and fifth sections explore the tension between householders' energy saving activities and their expectations of home comfort, comparing the paper's findings with recent literature on home energy improvement. The final section summarizes and offers concluding remarks, emphasising the recommendation to engage with changing demographic trends

[1] This research project was designed, and data collection carried out, before the Code for Sustainable Homes was abandoned, a policy that would have required all new homes in England and Wales to be built to a zero-carbon standard by 2016. At that time there was a relatively strong commitment to require microgeneration technologies and renewable energy investments currently has less resonance in UK energy policy and discourse. Thus, the term 'zero carbon' homes refers to households that have made significant improvements to the building fabric (e.g. insulation, glazing, upgraded boilers) and/or installed a microgeneration technology. This did not translate to reduced or 'near zero' consumption overall.

which have implications for increasing expectations of personal privacy, domestic space per person, and parts of the home being left on 'standby'.

Box 1. Definitions and terms

Like Munro and Leather (2000), in this paper little distinction between repair, maintenance, and improvement is made and the term 'home improvement' is used in a broad sense. This is because for the most part home *repair* and *improvement* are 'inextricably intertwined' in the sense that a *repair* problem, such as ill-fitting windows, is often accompanied by a solution involving an *improvement*, such as redecoration alongside upgrading windows (Munro and Leather, 2000, p. 515).

Likewise the terms 'retrofit', 'renovation', and 'refurbishment' are used interchangeably in this paper. The phrase 'home energy improvement' is adopted to avoid decontextualizing energy retrofit activity. It is used to refer to literature/scholarship which have investigated changes or upgrades to the building envelope (windows, insulation), heating or hot water systems, and microgeneration technologies with the deliberate intention to reduce, or decarbonise, energy demand (Wilson *et al.,* 2015).

2. Energy retrofit is part of home improvement

How to encourage and increase homeowners' investment in energy efficiency and microgeneration technologies has generated a considerable body of academic work across several disciplines and approaches. Generally, policy towards the owner-occupied housing stock in the UK, and in high-income countries, has been underpinned by an implicit assumption of a rational approach to investment, which relies on grant mechanisms to counter market failures. Evidence of this approach comes from Munro and Leather (2000) in the UK and more recently by Tjorring and Gausset (2018) in the Danish context. A long-established body of work on applied behavioural research underpins this perspective and is critiqued by Wilson *et al.* (2015) in relation to home energy improvements. A contrasting perspective comes from the sociology of sustainable consumption (see for example two special issues by Gram-Hanssen, 2014b; Gram-Hanssen & Georg, 2017)[2] to demonstrate that homeowners' decisions to invest in energy efficiency (Karvonen, 2013) and microgeneration technologies (Tweed, 2013) are not narrowly financial. For instance, numerous studies (Hand *et al.,* 2007; Haines & Mitchell, 2014; Judson & Maller, 2014; Maller & Horne, 2011; Maller *et al.,* 2012; Tweed, 2013; Wilson *et al.,* 2013, 2015, 2018) have pointed out that homeowners make changes to the materiality of their home in response to everyday concerns (e.g. having enough bathrooms so that conflicts don't arise in the morning when everyone wants a shower at the same time) and that energy retrofitting most often occurs alongside other home improvements (e.g. re-doing or adding bathrooms or kitchens). Accordingly, home energy improvements are not a distinct type of renovation and instead are more commonly part of a broader improvement in amenities. Indeed, in a study surveying 1028 UK households, thinking about, planning or finalising a renovation, 54 percent combined energy efficiency and amenity improvements, 35 percent were making only amenity upgrades, and *only* 11 percent chose to undertake energy improvements on their own (Wilson *et al.*, 2013). Together, these studies suggest that policy makers, practitioners and researchers should understand that most often, energy retrofits and microgeneration installations are indistinct from broader home improvements, and adjust incentives and marketing activities to target the underlying reasons why homeowners renovate in the first place.

This perspective that energy retrofitting is about more-than-energy suggests that homeowners' motivations for such investments are complex. Improving aesthetics, modernisation, space and property value have repeatedly been reported as the primary reasons for home improvement by UK homeowners (Earl and Peng, 2011; EST, 2010). Moreover, Gram-Hanssen (2014a) report other drivers for renovation to be improving comfort, increasing indoor temperatures, and wanting a room or home that is more

[2] Special issues of *Building Research and Information* include: 'Retrofitting owner-occupied housing: remember the people' (2014) and 'Energy performance gaps: promises, people, and practices' (2017).

fashionable. A common feature of accounts pointing to the complexity of home energy improvements (Gram-Hanssen, 2014a; Haines & Mitchell, 2014; Kerr *et al.,* 2018; Munro & Leather, 2000; Wilson *et al.,* 2018) mention lifestyle pursuits, aspirations and expectations of home comfort as driving investment and activity. Interesting solutions have emerged from these studies, for instance offering financial assistance for redecoration alongside home energy improvements (Munro & Leather, 2000) or that 'marketing, sales channels and existing points of contact between homeowners and the amenity supply chain [could] be used to target efficiency measures at would-be amenity renovators' (Wilson *et al.,* 2018, p. 1342). Connecting scholarship on home comfort and home energy improvement thus forms the starting point for this paper.

Home comfort is clearly multidimensional (e.g. warmth, aesthetics, emotional support); however, in much investigation, it is primarily assumed to be purely physical and to mean thermal comfort. Subsequently, the paper draws on Ellsworth-Krebs *et al.'s* (2018) framework of home comfort which brings together home, homemaking and housing scholarship to conceptualize the findings of a qualitative study of Scottish households[3]. Ellsworth-Krebs *et al.* (2018, p. 14) present a broader range of aspirations and aspects of desirable home life, identifying 12 co-existing meanings of home comfort (e.g. thermal comfort, relaxation, companionship, control, tactile comfort, visual comfort, mental wellbeing, auditory comfort, familiarity, contributory comfort, physiological comfort, odour and fresh air) and defining it as 'relaxation and wellbeing that results from companionship and control to manage the home as desired'. Thus, Ellsworth-Krebs *et al.* (2018) argue for moving beyond commonly imagined aspects of housing quality such as temperature, air quality, noise levels, and lighting to broader emotional, social and cultural meanings of home life that influence householders' activities. This empirically and conceptually informed framework suggests that changing expectations of privacy, personal space and the relationship between householders have been key driving forces in (re)shaping visions of desirable home life and ultimately the layout of homes.

3. Methodology: researching the comfort context of energy retrofitting

This section outlines the recruitment strategy, sample characteristics, methods and analysis of the study. This paper responds to calls for more in-depth, interpretivist studies that offer alternative ways of thinking in energy policy (Schweber & Leiringer, 2012; Summerfield & Lowe, 2012) in order to overcome 'the relatively narrow understanding of the "social" in research on energy and buildings' (Schweber & Leiringer, 2012, p.490). Using a qualitative approach, the study explored the energy saving activities of homeowners whilst simultaneously investigating what 'home comfort' meant to them. It involved whole-household discussions, based around open-ended questions, during which activities such as the drawing of 'ideal rooms' and house tours were undertaken. This work was undertaken in Scotland with 45 householders from across 21 households between February and June 2014 (Table 1).

Table 1. Sample: household characteristics, house type and age, home and microgeneration technologies

	Household Type	Household income	House Age and Type*	Age	Home amenity improvement. Energy improvement **
1	Couple	£40,000-60,000	1964-2004, detached	60s	Extension: kitchen, living room. Photovoltaic (solar electricity), solar thermal (hot water)
2	Couple	£40,000-60,000	before 1964, semi-detached	40s and 50s	Remodel. Solar thermal (hot water), stove
3	Single	Less than £20,000	2004-2014, semi-detached	80s	New build. Eco-build

[3] Ellsworth-Krebs *et al.*'s (2018) framework on home comfort was developed from the same data set, analysing responses to 'What does comfort mean to you?' and 'What do you do to be comfortable?' as well as common features in drawings and discussion of the ideal room drawings. The results and discussion that follow thus builds on that paper's analysis of the meaning of home comfort in terms of making this relevant to energy research and policy.

4	Couple, 2 children	£40,000-60,000	before 1964, semi-detached	40s and under 10	Extension: kitchen, guest bedroom. Photovoltaic (solar electricity), stove
5	Couple, 1 child and 1 parent	£40,000-60,000	1964-2004, detached	50s, 10s and 80s	Remodel, extension: attic into 2 bedrooms, Granny flat. Photovoltaic (solar electricity), solar thermal (hot water), stove, biomass boiler, Eco-build extension
6	Single	Less than £20,000	1964-2004, semi-detached	60s	Remodel. Air-source heat pump, solar thermal (hot water)
7	Single, 1 lodger	Less than £20,000	before 1964, detached	60s	Extension: B&B with 2 bedrooms. Photovoltaic panels, solar thermal (hot water), Eco-build extension
8	Single, 1 child	Less than £20,000	before 1964, terraced	50s and 20s	New build. New storage heaters
9	Couple,	Prefer not to answer	before 1964, detached	60s	Remodel. Photovoltaic (solar electricity)
10	Couple	Prefer not to answer	before 1964, detached	50s	Remodel. Photovoltaic panels, solar thermal (hot water), wind turbine, stove
11	Couple	£20,000-£40,000	before 1964, detached	50s	Remodel, extension: B&B with 1 bedroom. Photovoltaic (solar electricity), stove (with all wood harvested from their land)
12	Couple	£20,000-£40,000	1964-2004, detached	80s	New build. Photovoltaic (solar electricity)
13	Couple, 1 lodger	£40,000-60,000	before 1964, detached	50s and 20s	Remodel. Stove
14	Couple, 2 children	£40,000-60,000	before 1964, detached	40s, 60s, and under 10	Remodel, extension: conservatory and study. Biomass boiler
15	Couple, 2 lodgers	£20,000-£40,000	before 1964, terraced	70s and 20s	Remodel. Thermodynamic panels (hot water)
16	Couple, 2 children	£40,000-60,000	before 1964, terraced	40s, 10s and under 10	Stove
17	Single	£20,000-£40,000	2004-2014, detached	80s	New build. Photovoltaics (solar electricity)
18	Couple, 2 children	£20,000-£40,000	2004-2014, detached	30s and under 10	New build. Passive house, solar thermal panels, stove, mechanical heat recovery ventilation
19	Couple	Prefer not to answer	1964-2004, detached	70s	Remodel, extension: en-suite bedroom and study. Photovoltaics (solar electricity), wind turbine, ground-source heat pump, mechanical heat recovery ventilation, stove,
20	Couple	£20,000-£40,000	before 1964, detached	70s	Remodel. Photovoltaics (solar electricity), stove
21	Couple	Prefer not to answer	2004-2014, detached	60s	New build. Photovoltaic (solar electricity), solar thermal (hot water), stove, air-source heat pump, Eco-build

* The house age ranges are related to key changes in building regulations that give a broad indication of standards when homes were built – 1965 was the introduction of the first national UK building standards and 2006 amendments made provision for microgeneration technologies and incorporation of European Directives on measuring energy in all existing and new builds.
** Building fabric improvements (e.g. insulation, upgraded windows, A-rated appliances) are not included due to space constrains and the ubiquity of these among the sample.

The recruitment strategy was to enlist participants who lived in 'zero-carbon' homes, that is homeowners who had made efforts to save energy by improving the efficiency of their house (e.g. improving the building fabric, buying new boilers and A-rated appliances) and installing microgeneration technologies (e.g. solar thermal panels, photovoltaic panels, biomass boiler, heat pumps, wood stoves and wind turbines). Two local energy saving organisations in Fife, Scotland, were initially used to identify and contact participants, with a snowball approach toward recruitment used thereafter. All participating households had improved the building fabric of their home through insulation, whilst three-quarters had upgraded windows, half had bought A-rated appliances and nearly a third had installed new boilers. All but two were owner-occupiers, this is a key group to understand considering that owner-occupiers account for over half of the housing stock in the UK and are a group which are more difficult to regulate in the context of energy improvement.

This study is not meant to be representative of the UK population, however to give the reader a sense of the average household and housing in the UK some comparison to national statistics is provided. Participants in this study were predominantly white British; only one household was from the United States of America and had been living in Scotland for less than five years. Approximately half of the households were occupied by retirees and this is likely due to the sampling strategy being targeted at 'zero-carbon' homes. For instance, several participants mentioned investing their pension in microgeneration technologies in order to keep energy costs down when they were on a fixed income in the future. Furthermore, being able to afford your own home is more common for older age groups (in the UK 76% of those aged 65-74 owned their own homes, compared to 40% of those aged 24-34; ONS, 2013). As a result of this recruitment, participants were predominantly white professional couples who were relatively advantaged in terms of income and health (national median disposable household income was £27,200 overall and £20,700 for retired households at the time of the study (figures for 2013-14, ONS, 2015))

Whole-household interviews, including the drawing activity and house tours were generally 45 to 120 minutes in duration and were all recorded and transcribed. The coding was validated continuously by cross-coding random parts of the material and correcting for inconsistencies and the researchers met regularly to discuss and review the development of open and axial coding (Charmaz, 2014). The link between investment in energy improvements and other home improvements emerged from analysis of responses to questions on energy saving activities and descriptions of other home improvements that emerged as a result of discussing home comfort.

To protect confidentiality, all participants are identified by pseudonyms (age and household number). Ethical approval was sought and awarded by the University of St Andrews Ethics Committee.

4. Energy retrofit occurs alongside moving, adding on and building new homes

This section considers the way in which homemaking aspirations can reduce overall energy consumption. While others writing on home energy improvements have highlighted that these occur alongside amenity improvements (BPIE, 2018; EST, 2010; Palm & Reindl, 2016; Tjorring & Gausset, 2018; Wilk & Wilhite*.,* 1985; Wilson *et al.,* 2015), the householders in this study did not make the connection that their energy improvements to the building fabric occurred alongside key homemaking moments (moving home, adding onto the home, and building a new home). This finding is important because physical energy improvements may occur in relation to other home improvements (Wilson *et al.,* 2013). However, these key homemaking moments generally have very little to do with saving energy (at least initially) and are more related to broader life events (e.g. relocating for work, expecting children and wanting a family home, downsizing as unable to manage a bigger home) and householders' expectations of what a home should be or have (e.g. style of kitchen, number of bathrooms and bedrooms 'needed'). Consideration of these moments emphasised that broader social expectations of the home impact and structure attempts to improve energy efficiency or install microgeneration technologies. Drawing more explicit attention to this contradiction importantly highlights the utility of putting home energy improvements in the wider context of people's homemaking activities and aspirations, which present opportunities that energy advice and policy arguably have insufficiently attended to.

4.1 Moving home

Moving into a new home was a key moment identified in homeowners' discussion of energy saving. Improving insulation and windows was generally stressed as the priority and was commonly the 'first thing' and done 'straight away' after moving in:

> *We put in loft insulation as soon as we could after our first winte*r (Sean, 55, H10)
> *Cavity wall was the year after we moved in, yes straight away, that was the first thing we did* (Steve, 61, H1)
> *We had double-glazing done before our first winter in here* (Sue, 55, H13)

That is not to say that energy-related improvements did not, or do not, occur at other times, but moving in was the most discussed period for making changes and the above quotes illustrated that there is a sense of urgency during this time from homeowners. Similarly, in one of the first and most comprehensive investigations of home energy improvements, Munro and Leatherman (2000) linked household lifecycle stages with home improvement or repair activity. In their study, qualitative interviews with 211 owner-occupiers highlighted young households and recent movers as the most likely to make improvements, whilst older households engage in very little aspirational work and have diminishing capacity for DIY (Munro & Leatherman, 2000). These findings have been corroborated elsewhere, in particular, moving house and retirement have been identified as key times when homeowners are already disturbed or are more willing to make material changes (BPIE, 2018; EST, 2010; Palm & Reindl, 2016; Tjorring & Gausset, 2018; Wilk & Wilhite*.,* 1985). The importance of moving home being a key time in which energy improvements are undertaken is likely unsurprising, but it highlights that this may be a key period for energy policy, advisers or efficiency marketing to target. However, even in countries where real estate agents are required to display energy labels such as France, priorities of having a 'big enough' house, location (e.g. proximity to work, mass transit, green space, affordability), and resale were found to generally trump homebuyers' concerns about a house's efficiency or heating system (Meissonnier, 2014). This again points to the potential for more energy efficiency funding schemes, marketing of improvements or regulation to target new homeowners because even though energy ratings may not be the priority when house hunting, the initial period of after moving in is a key time when householders are more open and inclined to make improvements (Wilk & Wilhite, 1985).

4.2 Adding onto the home

Seven of the fifteen households that moved into existing homes added extensions, in order to create additional bedrooms and living space. For participants, the building of these extensions were a prime opportunity to upgrade boilers, especially if a household's heating system did not have the capacity to heat the additional space. However, while new boilers were mentioned by homeowners as part of what they had done to save energy, the impetus for upgrading boilers was not always on saving energy *per se* but as a necessary part of coping with additional space:

> *I knew that I was going to build this extension eventually and I needed a much bigger system to power it so I was either going to replace - and also we were remodelling bathrooms so where the gas boiler was had to be moved - so I was either going to put in a huge gas boiler or go for this biomass boiler* (Harold, 53, H5)

Therefore, understanding the meanings and timings of extensions may be useful in explaining and intervening in domestic energy demand (returned to below). It is an important reminder that while adding onto the home may be a time when householders upgrade their boilers or make other energy efficiency improvements, these are not done in isolation and in fact increasing space runs counter to the intention to save energy due to more space needing to be heated. Indeed, this is common considering numerous studies have found that households undertaking energy retrofitting at the same time also increased floor size and the number of rooms in the home (Judson & Maller, 2014; Maller & Horne, 2011; Maller *et al.,* 2012). This misses opportunities to target advice and link energy efficiency marketing at homeowners making extensions or to tighten building regulations on extensions.

Expectations of house size and space per person were inherent in discussion of home extensions. For example, Andrew and Emma explained that their extension was meant to be very energy efficient but the architect maintained that they could not afford it, even though she was able to build an extension that was bigger than they had requested.

> *Andrew: We were trying to specify it as a very eco-build, very warm, you know, minimal heating for that space. But I don't think the architect really..*
>
> *Emma: Yes I don't know really, I mean I think she maintained that we couldn't afford it, but she did give us in the end something bigger than we imagined having*
>
> *Interviewer: Do you want it that big?*
>
> *Emma: Well we do like it, but it's not what we imagined. She gave us a two story, which is great, our families live away and when they come to visit we don't have a spare room. And you know*

our parents are retired and they will come and stay for a couple of weeks and it is quite disruptive and the kids get moved. So the two story will be great because we will have an extra bedroom space which will be nice (41 and 40, H4)

Andrew and Emma's experience emphasises that even households trying to be energy aware can be distracted by other expectations of home. In this case, energy saving was outweighed by the desire to connect with family (e.g. spare bedroom ensuring privacy for guests and children, large open-plan kitchen). This demand for more space per person affects wider trends in domestic energy demand. For instance, efficiency improvements globally have been calculated to reduce the energy use per unit of floor area at average annual rate of 1.3%, however due to floor area increasing 3% annually globally, this results in rising energy demand overall (IEA, 2017).

Adding onto the home can be an important trigger for energy efficiency improvements (e.g. new boiler, insulation, or windows); nonetheless extensions will likely increase demand for space heating (e.g. bigger kitchen, adding on a spare room or conservatory).

4.3 Building a new home

In this study there were six households living in newly built homes: four households were involved in designing their own homes and three of the newly built homes were intentionally designed to be eco-builds. What is interesting about the four households that designed their new homes was the importance placed on the size, even if energy demand and environmental impact were significant for three of them:

Well I think our architect was amazing […] He said to us, 'you tell me how much money that you've got and I will tell you how many square feet'. And all the things that we wanted, three bedrooms, one each for the children, one for my mother and a double bedroom for us and I said 'he [my husband] needs a study to retreat to and with all these people in the house we need another shower downstairs' (Stacy, 81, H12)

We wanted to build a really cheap house to live in […] So we did a lot of research about the cheapest way to run a large house and it turned out that it was the Passivhaus system […] So that was the main thing that we did to save energy was to make the house as efficient as possible (Bill, 34, H18)

We worked out actually what we wanted for the next half of our lives […] and that is when we came up with no oil, no gas, regular power-cuts, warm and wetter climate and two people who want to live together and separately […] The other thing is that it is 450 m^2, which is a big family house, with four bathrooms (Jack, 62, H21)

What I have done is move out of that place into this place, which is smaller […] I told him [the architect] that 'I want the minimum area […] I do not want any more than I have drawn unless you can produce a good reason'. And his reason was that I could have it, and I said 'I don't want it, it is extra heat'. Architects are used to thinking people want as much room as they can possibly get (Michael, 85, H3)

The first three excerpts stress the desire for large family homes. At the time of building, Stacy and Darren were designing a home that could accommodate a family of six and ensuring everyone had their own personal space 'to retreat to' was a primary aim (H12). Similarly, Shona and Bill have two young children and their home is meant to adapt to the 'needs' of a growing family and children having their own bedrooms when they are older (H18). Jack and Nancy were at a different stage in their life when designing and building their home; even though they built a big 450m^2 house it is only for the two of them and the occasional guest (H21). Jack stressed this space was 'needed' for them 'to live together and separately' and they each have a study and en-suite bedroom. What this evidence suggests is that although saving energy may be connected to a key moment in homemaking (e.g. designing a home), it is not necessarily the reason for moving or building a new home. Indeed, the importance of house size appeared a great deal in participant's discussions of home comfort and privacy as will be explored further below (Section 5). These considerations around space ultimately shaped demand more than householders' intentions to save energy. In this study it was particularly revealing that all of the intentional new eco-builds were relatively large houses, except for Michael (H3) who had downsized to save energy (Figure 1). Yet there was little acknowledgement by participants that a larger sized house would negatively impact on the intention to save energy.

Figure 1. New eco-build homes (left to right H3 and H18, H21)

Overall, this section explored energy saving activities and their relationship to key moments in homemaking, which often contextualised energy improvements that otherwise were explained in isolation. These results further support calls to make home energy saving advice more practical (Christensen *et al*., 2014), as it is insufficient to provide information to householders about financial costs of, and savings from, instalments (e.g. new boiler, insulation, microgeneration technologies) when mundane concerns like having 'enough' water pressure for a family with teenagers (Reid & Ellsworth-Krebs, 2017) or preserving beautiful cornicing (Sunikka-Blank & Galvin, 2016) are important considerations in undertaking home improvements. Indeed, considering that energy retrofitting was generally tied to the timing of other home improvement (or moving house), it is essential that home energy advice, regulation or incentive schemes explore how to link into home improvement advice and marketing. There is clearly opportunity to engage with other middle actors (e.g. building professionals, real estate agents, architects) that influence householders' housing and home improvement decisions, especially considering that multiple participants mentioned architects encouraging them to add more space despite their emphasis on reducing energy consumption. Home improvement scholarship highlights the increasing speed that fashions and investment in home improvements are occurring (Williams, 2008; Rosenburg, 2011) as a result of globalisation (Mackey and Perkins, 2017a,b), lifestyle television and Big Box retail (i.e. B&Q, IKEA, Home Depot) (Powell, 2009). Furthermore, this hints at the power of architects and designers, shows like Grand Designs (Lewis, 2008), and the writers of home magazines to market energy retrofit, space-optimisation, or smart homes. These sorts of strategies may be seen as tangential to energy policy and reducing energy demand, but nonetheless significantly impact on householders' investment in their homes and images of ideal home life which significantly shape an individual's activities and consumption (Royston *et al.,* 2018).

5. Home comfort and increasingly energy demanding expectations

Whilst the above analysis presented home energy improvement as an outcome of homemaking, expectations of home comfort can also result in home life becoming increasingly energy demanding. With this in mind the paper turns to consider how desirable visions of home life may explain changes that increase consumption, despite the study participants' intentions to save energy.

5.1 Personal space: the 'need' for somewhere to 'retreat to' when co-habiting

This section begins to demonstrate why Ellsworth-Krebs *et al*.'s (2018) emphasis on companionship and control as key expectations of home comfort are important to domestic energy demand. In their study, companionship was a key part of participants' initial answer to 'what does comfort mean to you?' (Ellsworth-Krebs *et al.,* 2018, p. 10):

> *Having my children around me, my family […] when all four of us are in the house it just feels totally right, it doesn't matter what is going on* (Sue, 55, H13)

Yet, the desire for companionship created tensions over sharing spaces within the home and much of participants' discussion around home comfort were related to ensuring individuals have sufficient personal space and a sense of privacy because of the frustrations of sharing the home (e.g. wanting quiet when others are being noisy) as well as household management of material features of the home (e.g. decorating, lighting). Being able to decorate and having familiar objects was essential to a sense of comfort and homeliness (Ellsworth-Krebs *et al.,* 2018), as long as there was somewhere in the home each householder felt they could 'do what they want' then disagreements over decor or lighting in communal areas were more tolerated. Indeed, children and teenagers spoke most about comfort in relation to having their own room. Hence, Ellsworth-Krebs *et al.* (2018) argue that control (i.e. in relation to intra-household dynamics) should be more prominent in studies of home comfort and this is significant to domestic energy research because ensuring this sense of privacy was often a justification for 'needing' more space in the home to facilitate co-habiting:

> *Harold: I think the other thing which we probably haven't touched upon but would end up being important but we have just got it by default is the sheer size because it is a really large house, it may not feel it, but when you have been in smaller houses or flats then yes it is. So we can effectively all live in our individual zones without massively treading on each other. I'm not sure how we would cope if we all had to live in a more confined area*
> *Interviewer: Do you all agree with that?*
> *Sarah: Yes!*
> *Elizabeth: Yes (Elizabeth and Sarah laughed)*
> *Sarah: It is nice to have your own sense of space and times that you can be on your own*
> *Ailsa: It just feels more comfortable, just go up to my room and watch something* (53, 54, 85, 16, H5)

There was a commonly held perception of a 'need' for personal space which led householders to suggest a preference for larger homes. For example, a family with two young children commented on a large family home being desirable because there is enough space that "there can be somebody being very noisy and it's not bothering anyone else" (Shona, 36, H18). This is an important explanation as it relates to these often undiscussed tensions between intentions to save energy and the reality that moving home, adding on or building a new home were, often in part, about (increasing) space per person (Section 4).

Space per person is an issue that has been largely neglected in home heating/cooling research and energy policy, yet is critical to energy demand per person. The trend towards smaller households, which DECC (2013) and Wilson and Boehland (2005), Viggers *et al.* (2017) all suggest is a driver of a rise in domestic energy demand in the UK, US, Australia and New Zealand, is an issue that cannot be addressed by making products and buildings more energy efficient. Simply improving the energy efficiency of the house perpetuates and encourages these sorts of trends because it sends the message that these are reasonable standards of living to expect. In fact, a small house built to moderate energy performance standards generally requires less energy than a large house built to very high standards (Wilson & Boehland, 2005) and targeting these social norms cannot be overlooked in strategies to reduce demand (Lorek and Spargenberger, 2019).

5.2 A house on standby: accommodating the 'peak household'

This section further explores the notion of the 'peak household' because the desire for companionship and privacy and increasing space per capita is also impacted by intentions to accommodate past and future peaks in household size. In energy research, peaks are important because they drive the capacity of energy supply systems and Wilhite and Lutzenhiser (1999) introduce the notion of 'social peak loads' as a call to energy researchers to consider valuative questions about right and wrong ways to live. They argue that 'social peak loads', and the planning and building for them, leads to constant energy drains due to maintenance of unused capacity and the fact that putting infrastructure in place to meet these peaks allows base loads to escalate and 'basic' standards of living to be renegotiated (Wilhite & Lutzenhiser, 1999). For instance, SUVs become the minimum expected car, with extra seats on 'standby,' to accommodate hoped-for guests. Wilhite and Lutzenhiser (1999) also draw attention to increasingly individualised spaces (i.e. decline of sleeping together in the 'living space' in Japan to having individual bedrooms) creating social peaks and we build on this with the notion of meeting these space 'needs' for the 'peak household'. For example, 'needing' extra bedrooms for when young children grow up (e.g. planning for the household to grow and ensuring the house is big enough to accommodate this future household size) or making use of extra space when children have grown up and moved out of the family home (e.g. the household is smaller but house size stays the same):

> *Eventually the kids won't share a room, but just now they are more than happy to share. I like it when they are little to have each other* (Shona, 36, H18)
>
> *It was our daughter's bedroom and I use it for sewing and if I have got a lot to do on the computer, I can come through here and be away from everything you know just get on with it and spread myself out* (Mary, 69, H19)

These quotes highlight homeowners renegotiating the use of space in response to changes in the household size. Shona mentions having two guest bedrooms at the moment because when their two children get older they will 'need' their own rooms. Introducing the idea of the 'peak household' presents a different angle from which to approach reducing domestic energy demand. Rather than focusing on design and efficiency, understanding householders' expectations of the house size and layout presents opportunities to engage with social conventions and norms that significantly impact overall energy demand.

Several households noted how well their home adapted after their children moved out because it created extra space for their individual activities (e.g. painting, playing piano, sewing, having a study). This repurposing of children's bedrooms and play areas may be part of householders' justification for staying in larger family homes. Homeowners also justified staying in their larger family homes due to the need to store their children's things, even when their children were grown up and had their own homes and families at the time of data collection. In fact, in this study only three out of eleven households that had adult children who no longer lived at home had downsized. These were three older and single individuals (H3 and H17, 80s; H6 60s), two of whom were widows, who no longer felt they could manage larger homes on their own. Four households (H7, H11, H13 and H15) had taken on lodgers, with two remodelling to set up more formal B&Bs which filled spare bedrooms after their children had moved out. While it is widely recognised that larger household size decreases energy demand per capita in energy research and advice (DECC, 2017), this was not recognised by participants in explaining their energy saving activities. This may be an important life phase that energy advisors or researchers could focus more on (although moving home is a complex decision) because these family homes may not suit the needs of ageing occupants. Indeed, these older homeowners, who made up roughly half the sample in this study, are an important group to engage considering the meanings of comfort discussed by older homeowners and participants in this study is likely to go beyond 'necessary energy uses' (Walker *et al.,* 2016), a concept explored to a greater extent in the context of fuel poverty, and instead represents more 'ideal' notions of home comfort which have implications for (excessive) energy consumption.

Furthermore, guest bedrooms are part of this demand for space linked to the 'peak household' because these are often rooms in the home that are underused for the majority of the year, but 'needed' to accommodate peak demands in space. Certainly, being able to accommodate guests was a key part of the vision of home and was mentioned in the majority of interviews and only two households in this study did not have a guest bedroom. Having space to accommodate guests may seem entirely 'normal' and beyond the scope of energy saving advice (Owen *et al.*, 2014; Palm, 2010) or policy, however it connects back to explaining householders' investment in energy saving improvements. For example, Andrew and Emma intended to re-do their kitchen so that it was a 'very eco-build' and they ended up with a two-story extension which included a spare bedroom for their parents to visit. This is not surprising in many ways, yet these everyday concerns are largely overlooked in domestic energy scholarship. There is limited literature linking domestic energy demand to companionship and the family (Aro, 2017; Head *et al.,* 2013; Dowling & Power, 2012; Klocker *et al.,* 2012; Walker *et al.,* 2015; Madsen, 2017) or a desire for privacy and personal space (Huebner & Shipworth, 2017; Judson & Maller, 2014; Kuijer & Watson, 2017; Lorek and Spargenberger, 2019; Maller & Horne, 2011). Nonetheless these writings, combined with scholarship on the benefits of smaller homes and cultural variations in managing privacy in the home (Ozaki, 2002; Richmond, 2012; Susanka, 2001), reveal some potential strategies to reduce energy demand: begin to challenge social perceptions that bigger homes are always 'better'; question the 'need' for guest bedrooms and how the 'peak household' is accommodated; and support initiatives and policies that encourage and enable householders to downsize.

Intervening in the trend towards smaller households and under-occupation of homes is arguably a more significant way to reduce demand per person than upgrading a boiler or loft insulation (Huebner & Shipworth, 2017). Governments could play a role in supporting householders to downsize and this is one of the most effective recommendations energy advisers can offer (Palm, 2010), especially to older people who require higher indoor temperatures and are less likely to invest in thermal retrofitting (EHS, 2016; Munro & Leather, 2000; Wilk & Wilhite, 1985). Huebner and Shipworth (2017) systematically review motivations for and barriers to downsizing in the UK, highlighting three main challenges alongside insightful recommendations to make downsizing an attractive and possible option: (1) structural challenge, lack of alternative and attractive accommodation to move to; (2) psychological challenge, not wanting to give up space; (3) financial challenge, concern about loss of ownership, 'stamp and duty tax' when buying a new home, and potential rent increases. Understanding expectations of personal space and innovative ways to meet space needs for co-habiting, such as communal storage and guest bedrooms for visitors in communal housing, is an essential part of designing and marketing 'downsizer homes' for the ageing population. Furthermore, Huebner and Shipworth (2017) emphasise the potential of lodgers as an alternative way to reduce under-occupation and allow homeowners to stay in their homes. This recommendation connects back to more fluid definitions of the household in the past, in which renting a room in a home was more common (Flanders, 2015), and again points to the utility of domestic energy research engaging with changing expectations of home life that are not solely explained by financial considerations or thermal comfort requirements.

Energy policy and research should not miss opportunities to align with downsizing initiatives, increasing housing density and creating attractive housing for an ageing population, thereby 'mainstreaming' energy into 'invisible energy policies' (Royston *et al.,* 2018). Furthermore, there is little research in general that explores the perception that bigger homes are more desirable beyond its relation to status (Bourdieu, 1984; Goffman, 1951; Veblen, 1899; Wilhite & Lutzenhiser, 1999) and investment (Anderson, 2011; Wiesel *et al.,* 2013), and we recommend that comparing experiences and expectations of house size temporally or spatially is a topic that warrants future research. That is not to say that energy researchers should simply focus on restricting increasing house sizes but should also join debates on how to ensure that housing provides adequate occupant satisfaction in terms of privacy and personal space. Improving standards of visual and acoustic privacy in high-density housing present opportunities for energy researchers to engage with architects, urban planners, and designers on key factors that could improve satisfaction with smaller, communal and high-density forms of housing necessary to reduce absolute energy consumption.

6. Conclusion

In their efforts to influence homeowners' activities to save energy, policy makers need to consider the broader emotional, social and cultural meanings of home that influence householders' decisions and everyday life. This study has revealed that householders invest in home energy improvements at key homemaking moments (e.g. moving house, adding on, or building a new home) and that expectations of increasing personal space undermine energy savings. This is unsurprising considering that extensions are the most commonly carried out alteration in homes (e.g. 29% of the UK housing stock (DCLG, 2012)), yet much energy policy and research remains stubbornly in a silo focused on 'motivating' householders to invest in energy improvements on their own. Indeed, the home is an ongoing project, constantly under improvement in response to external changes in technology and ideas of modernity as well as internal shifts related to life course, emotional and financial capacity to make material changes, or negotiate a shared vision with other household members. Home improvements are made in response to aspirations to provide the 'good life' for their family – en-suite bedrooms and enough bathrooms so there are no conflicts with teenagers in the morning, a home office and big open plan kitchen - not simply to save energy or improve thermal comfort. Thus, this study hints at a much wider range of people and interventions that could be pursued to steer everyday home life to be less energy-demanding rather than the narrow mainstream focus on pro-environmental campaigns and financial rationalisation. The exploration of home comfort (Ellsworth-Krebs *et al.,* 2018) and understanding processes of homemaking presents new avenues for engaging with changing energy demands that are the result of shrinking household sizes and increasing space per person. Energy policy cannot stay adrift from governments' pursuit of higher density housing, nor can it ignore key social changes, such as increasingly educated populations delaying partnering and parenting, increases in one-person households (e.g. roughly 40% of Scandinavian households and 30% of UK and US households are one-person households (UNECE, 2015), or the demands of an ageing population on the housing supply (Winston, 2017). It is time to explore how changing expectations of personal privacy and more of the home being left on standby impact energy demand per capita.

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