

Introduction

This report aims to identify the social and environmental impacts associated with different methods of domestic heating used in some of the 13,000 social properties owned and managed by Bernicia Homes in the north-east of England. The homes in this study are located in Northumberland.

Research question: Can significant social and environmental impacts be identified and improved through changes to the method of heating homes?

The aims of this project are to identify the implications experienced by local residents with a range of heating methods including Trianco Aztec and Thermaflow electric boilers, electrical storage heaters and air source heat pumps. As such, can improvements to affordable heating systems be made to improve the thermal comfort of social housing residents across Northumberland and beyond?

Climate change was described by Levin et al (2009) as a 'super wicked problem' whereby climate change is a problem fundamentally rooted in science, with definite solutions hindered by societal actions and further complicated by the many involved stakeholders with competing interests. Additionally, it is often stated that before climate change can even be considered a problem, it must be agreed that it is a problem (Incropera, 2016). This has led to state-led, politically binding, promises such as the aim to reach 'net zero' emissions by 2050. The Climate Change Act of 2008, order 2019, introduces a target for at least 100% reduction of greenhouse gas emissions (compared to 1990 levels) in the UK by 2050. However, some emissions can remain if they are offset by removal from the atmosphere and or/trading of carbon units.

One of the many ways the UK government is attempting to reduce carbon emissions and combat climate change is by improving the UK's housing stock to be more energy efficient. Decarbonising homes will play a critical role in ensuring the country meets its legally binding emission targets by 2050. Measures currently in place focus on improving the energy performance of existing homes through insulation, triple glazing of windows, draught proofing and the installation of low-carbon heating such as air source heat pumps (Holmes et al., 2019).

Reeves et al (2010) identified two key external requirements to reducing domestic carbon emissions as a reduction in household demand for energy and a reduction in

the carbon intensity of grid electricity, or preferentially, a move to entirely net zero carbon sources to power grid electricity. As social housing makes up approximately a fifth of the UK's housing stock, social housing providers, such as Bernicia, are at the forefront of innovative efforts to achieve emission cuts in existing UK homes.

However, while reducing emissions is the key driver to this mission it is also essential that the social implications of change to potentially vulnerable householders are not overlooked. The cost of heating a home is on the rise and the vulnerable in society must not be cut off from the ability to achieve thermal comfort for the sake of decarbonisation. Fuel poverty is defined as the inability of an individual to adequately heat their home due to a lack of resources and inefficiency of the housing heating and insulation (Boardman 1991). This concept is highly dimensional and influenced by factors such as income, energy costs and the energy efficiency of the home. Living in a cold home comes with health implications for people of all ages, with the most vulnerable being senior citizens, young children and people with disabilities. The World Health Organisation (WHO) has set minimum standards for home temperatures at 21 degrees Celsius for living rooms and 18 degrees Celsius for bedrooms (Liddell., 2009). As such, one of the factors included within this report is the age and possible vulnerabilities of the householders interviewed.

This report hypothesises that providing efficient heating solutions will have both the environmental implications of lower emissions and the social implications of lower heating bills, and hence a higher quality of thermal comfort for the householders.

Methodology

The data included within this report was collected via questionnaire focused interviews. These structured interviews were based upon a fixed set of pre-defined questions shown in figure 1. The same interview script was used in each separate interview, following a semi-structured mode of interviewing. This methodology ensured that enough structure existed that comparisons could be drawn between separate interviews and data quality was maintained, while also ensuring flexibility to allow individual interviewees the ability to expand on specific areas of interest or enquiry (Young *et al* 2018). The interviewees were first contacted via telephone to first explain the procedure of the interview and set a time/date. The interviewees

were reminded multiple times that their participation was entirely voluntary and that they had the right to remain anonymous and to withdraw their given answers at any time. This helped to reassure the interviewees to ensure that un-biased answers were given to allow for correct and accurate data. The data was then analysed using basic coding and statistical methods such as mean, median and range calculations to allow conclusions to be drawn from the numerical data such as fuel prices and energy tariffs.

Results

The data gathered from the investigation is shown in table 2. The general patterns found include that the heating systems are not used in the summer, and in the winter heating systems are used for an average of 5 hours. This, however, depends on the type of heating used in the property. For example, air source heat pumps are designed to provide a constant, comfortable heat to the home and should always be switched on, whereas, systems like the Trianco Aztec boilers are often used for short sharp blasts of heating.

The interviews also uncovered that the residents using the Thermaflow heating systems were not using them as they are designed to be used. The system is designed to be switched on for longer periods of time to build up heat. However, the residents did not use them in this way and expressed concerns over the expense of these systems. Additionally, residents expressed concerns over the system not providing enough energy to heat up a bath. This is a basic level of comfort not afforded to users of the Thermaflow system, a comfort of particular importance to the elderly or people with medical conditions who can have their pain reduced by a warm bath.

Electric storage heaters were another heating option investigated, with these systems designed to be charged with heat during the night, when economy 2000 energy tariff is cheaper, with the heat then being 'stored' and slowly released during the day. The residents with these systems expressed further concerns over the cost of the system and, as such, only used 1 or 2 of the storage heaters at any time.

The average electricity cost for all homes was calculated to be approximately £110.80 a month, with the highest cost being seen in homes with electric storage heaters, and the lowest cost seen in homes with air source heat pumps. Nearly all of the tenants interviewed detailed inventive ways that aimed to reduce their energy

usage in order to save on bills. This included significantly modifying their lifestyles in ways such as only cooking in cheaper tariff periods, wearing many layers of clothes, shutting off colder rooms in the winter and using electric blankets in the colder months.

Even with all of these lifestyle modifications practiced, many tenants expressed concerns over the prices of their heating bills and significant anxiety over saving for the winter months.

The thermostat temperatures recorded in the interviews are on average lower than WHO recommendations for safe and comfortable living spaces at 16 degrees Celsius in the winter. This was an overall temperature given for the house that is 5 degrees Celsius below the recommended living room temperature and 2 degrees Celsius lower than the recommended bedroom temperature by the WHO (Liddell., 2009).

Discussion

Thermal comfort is defined as a “a state in which there are no driving impulses to correct the environment by the behaviour.” (Hensen., 1991). Therefore, thermal comfort is an individual preference influenced by factors such as culture, health, life experiences and age and is not a set condition, but rather a state of mind (Djongyang et al., 2010). However, the data gathered during the interview process seems to suggest that heating systems that provide a constant, maintained temperature, such as air source heat pumps, provide much more thermal comfort to the residents. This conclusion is supported by scientific studies such as the study conducted by Wang et al in 2018 where air source heat pumps were investigated for indoor thermal comfort control. This study concluded that, provided that homes are well insulated and draught proofed, air source heat pumps can provide a significant improvement to domestic thermal comfort. The air source heat pumps were also founded to be the cheapest and most efficient method of domestic heating investigated. Therefore, a switch to air source heat pumps has both social benefits of reducing anxieties around the financial cost of heating, improving thermal comfort and has also environmental benefits. They produce less CO₂ than traditional systems as the main component used for heating is based on a renewable resource. The system still needs electricity to run so is not free of carbon emissions, but with

electricity increasingly being provided by renewable sources such as wind and solar power, it is a more sustainable option than fossil fuels (Carroll et al., 2020).

One common comment on the alternative Thermaflow heating system included the inability for the residents to have a hot bath due to the tank not holding enough warm water to make bathing possible. While showers are commonly considered to be more environmentally friendly, taking baths, known as balneotherapy, can provide relief to patients suffering with arthritis and other painful conditions (Verhagen et al., 1997). Many of the tenants interviewed were adults over the age of 60 where this condition can be more common, and such the inability to have a warm bath should be considered a fundamental flaw of the system when aiming to provide comfort to residents.

Electric storage heaters were also investigated. These systems are often used in a manner where only 1 or 2 of the radiators are turned on to cut down on costs. This does not provide a warm overall temperature of the home, especially in larger, less well insulated homes. Complaints were also recorded on the cost of these systems with one resident paying over £200 a month despite taking all lifestyle precautions to reduce heating bills. Rising heating prices has implications for energy justice, an urgent ethical and political issue aiming to ensure that the move towards an environmentally sustainable energy future also coincides with sustainable social energy futures (Waite and Harada., 2019). Fundamentally, energy justice aims to ensure that the most vulnerable in society are not 'priced out' of heating their homes. Residents of colder homes and those experience fuel poverty are more likely to experience anxiety and depression than those living in warmer homes. However, thermal comfort is not a universal state, with some residents having higher 'thermal resistance' and such challenging orthodox definitions of comfort (Critchley et al 2007).

Whilst every effort was made to ensure the reliability of data collected, a limitation of the study exists in the sample size used. Nine Bernicia households were interviewed across Northumberland, this group is not large enough to provide a representative sample of the views of the entire social housing population in Northumberland. However, the investigation was limited by time and was voluntary in nature, so, unfortunately, many residents did not consent to an interview. This also introduced

voluntary response bias, whereby those who participated in the study likely did so because they felt strongly about the topic. Therefore, the results of the interviews will be skewed to reflect the opinions of those who consented to an interview.

Conclusions

Overall, satisfaction with the thermal environment within a home is a complex, subjective condition, with no absolute temperature standard for thermal comfort. While comfort is able to be modified by behavioural changes and actions, such as wearing many layers of clothes and altering activity levels, the heating system within a home can play a huge factor in modifying and dictating comfort. Air source heat pumps have been identified in this investigation to provide the most efficient heating system, reducing energy costs and providing a constant warm temperature flux. However, these systems are often expensive to install and only work efficiently in well insulated, draught proofed homes, and such, may not be suitable for use in older homes or homes with lower energy performance certificates. Therefore, while implementing more efficient systems, such as air source heat pumps, can improve the overall social and environmental impacts of heating houses, it is not a stand-alone solution to reducing domestic carbon emissions and will not be suitable in all homes. In order to reach net zero emission targets, homes must also reach high energy performance levels and all energy must come from carbon neutral sources.

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Figure 1

QUESTIONNAIRE

1. Questions

- 1.1. How many people live here?
Check occupants, whether children / adults <60 / adult >60 / vulnerabilities e.g. disability
- 1.2. Can you tell me what you understand about how your current heating system works?
Ask tenant to explain in their own words or accept "I don't know"
 - 1.2.1. Air source heat pump
 - 1.2.2. Thermaflow/Trianco Aztec boiler
 - 1.2.3. Night storage heaters
- 1.3. Did your housing officer or heating engineer explain how to use the system when you moved in?
Ask for any leaflets or instructions given out
- 1.4. Have you had other heating types before in this home or others? How does this compare?
Ask about technology, how long ago, house type, size and occupants if not the same as current
 - 1.4.1. For how easy it is to use?
 - 1.4.2. For how much it costs to use?
- 1.5. How much do you spend on your heating? How do you pay?
Ask for bills which are allowed to be photographed and redacted for report.
 - 1.5.1. Per week / month / quarter / year
 - 1.5.2. Pre-payment meter (with a key) / credit meter (direct debit or quarterly invoice) / through an app
- 1.6. What do you like about the system? What don't you like?
- 1.7. Do you have any questions you would like to ask us about this?

Table 2

Number of occupants	hours of heating in winter	hours of heating in summer	thermostat temperature	Is there always someone at home?	type of heating	prices	ways used to save money	opinions
2 (under 60) - disability	6 hours	0 hours	20	yes	aztec	50 a week - 1392 a year	using economy tariff, cooking in cheaper periods, LED bulbs	likes that system was too expensive
1 (over 60) - arthritis	7 hours	0 hours	15 max	yes	aztec	120 a month	using economy tariff, cooking in cheaper periods, thick clothes	likes that the system is good
1 (over 60)	few hours'	0 hours	10	no	aztec	20 a week	everything	likes that the system is good
1 (over 60)	3 hours	0 hours	no thermostat	yes	electric storage heaters	75-156 a month	uses a free-standing radiator and wheels it around	dislikes that preferred lots of power
1 (over 60)	storage heaters on at night	0 hours	no thermostat	yes	electric storage heaters	132-222 a month	electric blanket, loft insulation, wears layers	hates storage heaters
2 (under 60)	set via thermostat	0 hours	22 in winter, 16 in summer	yes	air source heat pump	50-80 a month	draught proofing, new house	underfloor heating system, nice ambient temperature, takes up a lot of space
2 (under 60)	only on when cold	0 hours	14	no	thermaflow	70 a month		lukewarm, not enough water for shower, not enough water for washing machine
2 (over 60)	n/a (just moved in)	n/a	15 max	no	thermaflow	58.90 a month		not enough water for shower, not enough water for washing machine (economy mode)
2 adults, 2 children	2-4 hours	0 hours	17	yes	thermaflow	unknown		not enough water for shower, not enough water for washing machine, has to use shower, not only lukewarm