Enhancing Energy Retrofit Strategies through an integrated comfort approach: Insights from a social housing in London

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Abstract. The climate crisis demands a shift in building use and adaptation, with the UK's energy retrofit strategy targeting an 80% carbon reduction by 2050. However, standard retrofit measures have led to issues like overheating, moisture related problems and the energy rebound effect. A well-integrated retrofit approach prioritising occupant health and comfort could help mitigate such problems, especially for social housing and historic houses. Thermal comfort and 'fuel poverty' are major reasons for retrofitting, and a 'people-first' approach that considers discomfort causes and passive comfort practices can develop effective strategies for both carbon savings and improved comfort.

This study focuses on a social housing Estate in South London, using surveys to understand residents' perceptions of their homes, conditions contributing to comfort or discomfort, and strategies to cope with cold and overheating. The study examines relationship between comfort perception and daily energy practices. Given the societal shift towards sustainable energy, there's an opportunity to rethink thermal comfort approaches. This research maps social and personal parameters influencing comfort within a broader framework, emphasizing the role of specific climate conditions and regional cultural practices.

The findings offer valuable insights for building practitioners involved in retrofitting historic buildings, providing guidance from a user-centred perspective. This research enhances the understanding of comfort perception's multi-faceted nature, leading to more informed and socially integrated energy retrofit designs.

Keywords – Social Housing; Thermal Comfort; Heritage buildings; Users; Retrofit. (5 keywords)

1. Introduction

Social housing estates are a crucial aspect of the UK's living heritage. In the past decade, many of these estates have been increasingly recognised as cultural heritage in the UK, leading to the 'listing' of many large welfare-state housing groups (Pendlebury et al., 2009). Such estates are primarily selected for their architectural historical value, but they also hold significant historical importance as part of the mid-20th century efforts to address working-class housing issues (Hopkins, 2017). Much of the existing social housing in the UK showcases modernist architecture, reflecting the heritage and legacy of the welfare state (Sanga, 2020). Social housing estates, beyond their architectural and historical value, represent a critical component of the contemporary UK's social fabric. These estates have historically provided affordable housing solutions, and their preservation and adaptation are essential for maintaining social equity and addressing contemporary environmental challenges.

Social housing is at the forefront of addressing the climate crisis within the building sector, leading the retrofit efforts for an estimated 4 million households across the country (Alabid et al., 2022). However, typical retrofit designs are not always suitable for the context of social housing. Research indicates that standard retrofit design assumptions do not directly apply to social housing, as the typical indoor thermal conditions used in building energy modelling do not accurately represent those in social housing (Teli et al., 2016). Social housing residents, who are more vulnerable to fuel poverty and thermal comfort stress (indoor cold strain) are a significant demographic (Healy at al. 2002). Social housing provides affordable homes to low-income families and older individuals in the UK. A major challenge in these projects is often addressing the rebound effect post-retrofit. There is a difference between the expected energy savings and the ones that are achieved by retrofits. This difference is documented bigger in households under fuel poverty, in response academics have acknowledged that an approach to measuring the benefits of retrofit, focusing solely on energy gains, can be insufficient. that simplistic criteria they started to include qualitative criteria for the effect of energy retrofits, such as improvement of thermal poverty (Coney et al., 2021).

As a response to these challenges, a well-integrated retrofit approach that prioritises occupant health and comfort could be contributing towards a solution. Thermal comfort and 'fuel poverty' are regularly cited as a major reason for undertaking retrofit projects. By adopting a 'people-first' approach that considers discomfort causes and potential gains from passive and adaptive comfort practices, we can help the development effective retrofit strategies that deliver carbon savings and improved building comfort, using the knowledge that already exists in communities (Monteiro et al, 2017).

Considering the societal shift over the past years towards a more sustainable approach to energy use, there is an opportunity to rethink thermal comfort approaches for the future. While numerous studies have explored the influence of different social and personal parameters on comfort, the aim of this paper is to contribute to a comprehensive mapping of all relevant factors in a broader comfort framework. Moreover, the concept of thermal comfort should be viewed as a decentralised question, where the specific climate conditions and regional cultural practices play a significant role in shaping individual comfort preferences and building requirements (Desvallées, 2022).

2. Methodology

An important objective of this investigation is to explore thermal comfort parameters through studying the thermal comfort practices of the occupants in a pre-retrofitted social housing estate. Therefore, a survey was designed and distributed online or in paper in person to the residents of a south London housing estate to help the participants' different accessibility needs and preferences. The survey was designed based on the results of semiconstructed interviews that were conducted in residents of 7 social housing dwellings in the Midlands, exploring thermal comfort parameters and occupant behaviour.

The survey was comprised of 5 parts and 32 questions and aimed to map a range of thermal comfort parameters and behaviours, ensuring that the diverse needs and affordances of the residents were accurately represented. The first section aimed to collect general information about the participants and their feelings about living in their homes and the area, and perception of their local climate. The second section was to draw insights into participants' comfort levels (thermal, visual, acoustic) and the condition of their home.

The third section focused on participants' comfort during winter, room usage, factors causing discomfort, expectations and preferences for each room based on occupancy hours, and ventilation practices during the colder months. The fourth part explored discomfort experiences during summer and the strategies individuals used to cope with such discomfort. Finally, the survey gathered participants' general opinions on energy efficiency and their expectations and feelings regarding the upcoming retrofit project.

The selection of the study case was based on several criteria. Firstly, the age of the building is representative of many social housing estates that will require retrofitting in the coming years. Secondly, the ethnic and cultural diversity of the estate's residents provides an opportunity to map cultural parameters that can influence thermal comfort, which could be important in a culturally diverse city like London. Lastly, the fact that the estate is scheduled for retrofitting after the study gives the researchers the opportunity to consider it as a potential case for conducting both pre- and post-retrofit thermal comfort surveys.

2.1 Study Case: Kingswood Estate, Southwark, South London

The survey was distributed among 39 residents of the Kingswood Estate between January and April 2023. Kingswood Estate is a social housing estate in Southwark, South London. The Kingswood Estate Social Housing consists of mid-level '50s yellow, brown-red brick modern buildings, as pictured in Fig1. The architectural style of the estate could be described as brick modernism, very prominent in '30s public architecture, and is quite often encountered in social housing estates in Britain in need for energy retrofit.

In 2022, a retrofit and refurbishment programme of 29.2 million pounds was commissioned. The programme included the following energy retrofit interventions: external wall insulation, internal wall insulation, window replacement, heating upgrades, installation of mechanical ventilation system, renewal of roofs and kitchen and bathroom replacements (Elkins Construction, 2024). The survey was distributed before the installation of the retrofit measures.

Fig1. The characteristic yellow and brown-red brick mid-rise blocks in Kingswood Estate.

Kingswood Estate, home for approximately 1.000 residents, can be considered more ethnically diverse than the UK average. As a whole, the UK population claims itself as approximately 82.2% white, with residents of this area being 42% white (Survey for Londoners, 2011 census data). Kingswood Estate is a diverse community with the majority of residents self-identified such as mixed racial background, Black-African, Black- Caribbean. The area around Kingswood Estate is one of the most affected by fuel poverty, with 11-12% of the households affected. Kingswood is amongst the 10% most deprived neighborhoods in the country for: Income, Income Affecting Children, Income Affecting older population.

The sample (with a response rate 19.5%) was ethnically diverse included both women (28) and men (11), aged between 20-68 years old. Households consisted mainly of 3 people (35.90%) and 2 people (30.77%). 58.97% of the participants lived in their homes for more than 5 years and 82.35% expressed satisfaction with their home. The homes were occupied during all hours of day by more than 50% of the participants.

3. Results and Discussion

3.1 Thermal Comfort and preference

Table 1 & 2 present the results for thermal sensation and thermal preference during winter and summer. Generally, 30.77% of participants reported a neutral thermal sensation. However, thermal comfort responses show a tendency towards colder sensations (cold, cool, and slightly cool) **(Table 1)**. This indicates a problem with thermal comfort and cold strain in this social housing estate, as confirmed more than 55% of participants who would prefer a warmer environment in their homes and (**Table 2)**.

As some participants stated in the comments: *“No heating is working, no warmer water”* which covers the basic needs of occupants. Another participants described that their appartment is *“always cold”*, and some other described the reasons behind feeling cold: not being able to keep their home warm: *“Large room difficult to get warm”*. Two of the participants also documented lack of sunlight and its effect on thermal comfort: *”We dont sleep there in the winter, the sun never comes there, it’s just too cold”*, *“Not enough sun in the winter, not heated often”*. One participant (with cold thermal sensation vote) stated the reason for their thermal discomfort is the more exposed position of their appartment: *“it’s too cold because is the last appartment on the floor”*.

Interestingly, as it is shown in Table 2, over 30% of participants expressed a preference for a cooler environment during summer. Therefore, summer thermal discomfort and overheating risks should be considered in the upcoming retrofit design.

Table 1. Residents’ thermal sensation results

Thermal sensation	**Cold**	**Cool**	**Slightly Cool**	**Neutral**	**Slightly Warm**	**Warm**	**Hot**
	12,82%	15.38%	20.51%	30.77%	5.13%	2.56%	0%

Table 2. Residents’ thermal preference results during winter and summer period

Thermal preference	**Colder**	**Cooler**	**Slightly Cooler**	**No change**	**Slightly Warmer**	**Warmer**	**Much warmer**
Winter	5.13%	2.56%	5.13%	17.95%	15.38%	30.77%	10.26%
Summer	7.69%	20.51%	7.69%	38.46%	7.69%	5.13%	0%

3.2 Heating practices and Passive Adaptive Strategies

Heating practices vary between households. While all participants heat their homes, the months of when they start and stop heating differs (with maximum variation of 3 months variation). Similar results were found for heating hours during the day. Additionally, participants reported irregular heating patterns (months they heat, hours they heat and which rooms they heat), often employing zoning and room isolation to keep their home warm while keeping the costs low. They tend to heat specific rooms, only when they need them (48.71%). Most commonly heated room is the bedrooms (25%). 94,87% of the participants worry about the heating costs the winter.

In winter, participants wear heavier clothing. 53.84% wear warmer clothes before turning the heating on or increasing the thermostat, 43.59% of the participants state that prefer to wear heavier clothing in the winter to make themselves warmer and 61.53% considering wearing heavier clothing necessary. Some of the strategies they use to manage thermal discomfort are carpets, heavier curtains, and warm drinks or showers. Similar adaptive strategies are employed in the summer. When homes have balconies, participants often use them as extra rooms during the day in the warmer months.

3.3 Windows, Ventilation behaviour & Indoor Air Quality Perception

Most residents reported practicing daily ventilation during winter and summer (as a habit). However, 64.10% of participants experienced issues with window operation, such as problems with handles, partial opening/closing, drafts, rainwater ingress, or safety concerns preventing them from opening the windows. Additionally, 41.02% of participants reported humidity problems and mould growth in bedrooms and bathrooms. Despite these issues, the majority of residents perceived the indoor air quality as neutral in terms of freshness and humidity. There seems to be no relation for the residents between the indoor air quality perceptions and humidity problems.

3.4 Local climate perception

An interesting finding from this study is the significant disparity in local climate perception among participants. For instance, 50% of participants perceive winter as cold, while 38% perceive it as mild. These differences can be attributed to individuals' thermal history and expectations, which directly influence their thermal comfort perception and behaviour.

The disparity is even bigger regarding summer climate perception. About 38.24% of participants experience the local summer climate as mild, 23.53% perceive it as warm, and 29.41% perceive it as hot. These findings could be valuable for further investigations into overheating, the changing climate in the UK and summer thermal comfort behaviour.

3.5 Thermal comfort expectations from energy efficiency retrofit

A significant finding of this study is that the vast majority of residents expect some improvement in their thermal comfort as a result of the energy retrofit: 25.64% anticipate a moderate change, 28.20% expect a considerable improvement, and 17.95% hope for a massive improvement. These expectations can show the importance of the retrofit project for the quality of life of the residents and the importance of thermal comfort improvement as a retrofit outcome by residents. However, such results could be a predictor for the presence of the rebound effect, which tends to be higher amongst users unsatisfied with their pre-retrofit thermal comfort, usually as an outcome of fuel poverty (Sorrell et al. 2009).

In addition to positive expectations, some participants expressed common concerns regarding the retrofit works mostly regarding safety and privacy. Noise and time also were among the complaints: "Noise dust from the works", "Noise and dirt", "takes longer than promised". Lack of trust in issues documented above has been found as one of the important barriers to energy retrofit from the residents' point of view (Xue et al., 2022). However, an interesting finding is that two of the residents expressed concerns/negative expectations about the financial viability of the project and the lack of maintenance: "Waste of money, they don't fix mould", "It's going to bankrupt, huge financial costs".

Even though there is a connection between thermal comfort improvement expectations and retrofit projects, the complaints could potentially arise because residents weren't included in the retrofit process. Among those surveyed, 50% reported not being involved in the process, while 35.89%

had a say in choosing the colour of their new kitchen. Including residents in decision-making, even for smaller decisions like colour choices, can be key to resident satisfaction and the overall retrofit process (Morgan et al., 2024). In this study, it was found that even after retrofit work had begun on the estate, 20.51% of residents still did not know if their homes would receive any energy efficiency measures. This high percentage highlights the need for more effective communication with residents.

4. Conclusions

This paper presents the results of a survey of residents in a modern pre-retrofitted social housing estate in south London about their thermal comfort perceptions and behaviour including heating practices, ventilation behaviour, and their expectations and concerns regarding an upcoming energy retrofit project. The findings of this study argue for the importance of understanding the complex relationship between comfort perception, heating, ventilation, and occupant behaviour in maintaining a comfortable and healthy indoor environment, as well the expectations of residents from such retrofit projects. It was found that winter comfort remains a priority, with cold strain still posing a significant risk in this estate. However, in parallel, considerations for overheating during summer should also be integrated into retrofit designs to ensure year-round comfort, as residents already express summer thermal discomfort.

Heating patterns among residents are irregular, with selective heating practices being common. Participants often employ zoning and different room use to manage thermal comfort, heating specific rooms only when needed. This behaviour indicates a need for potentially more tailored retrofit solutions that accommodate these practices and be fit for the context of social housing. Additionally, passive measures such as carpets and heavy curtains are widely used, though participants have limited awareness of their insulation properties, and they use them more as habits.

Ventilation practices are habits as well, though difficulties with window operation present significant barriers to effective ventilation. Addressing these issues is crucial for improving indoor air quality and preventing moisture problems and mould growth. The study also reveals a disparity in local climate perception among residents, which influences their thermal comfort behaviour and expectations, which also could be linked to the cultural and ethnic diversity on the estate. This finding suggests that thermal comfort expectations and practices may be influenced by the perception of the local climate.

The expectations for thermal comfort improvement post-retrofit are high, with many residents anticipating moderate to significant improvement. However, these expectations also raise the potential for the rebound effect, particularly among those previously experiencing fuel poverty. Effective communication and involvement of residents in the retrofit process are essential to manage these expectations and ensure satisfaction with the outcomes.

In conclusion, this study advocates for a holistic and people-centred approach to energy retrofits in social housing. It represents an initial investigation to understand deeper and respond to the diverse needs and behaviours of residents, and by promoting user engagement, retrofit projects can achieve both energy efficiency and improved quality of life for occupants.

This study adds to the arguments for the importance of a holistic approach to energy retrofits, one that prioritizes occupant comfort and well-being. Future research should continue to explore the intersection of social, cultural, and environmental factors in retrofit projects, ensuring that solutions are both inclusive and sustainable. By examining the diverse aspects of thermal comfort behaviour pre- retrofitting and assessing how retrofit measures affect the thermal comfort practices of various demographic groups, we aim to gain insights and develop retrofit strategies that are more equitable and effective.

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