Low-carbon retrofit of UK social housing and overheating risks: causes and mitigation strategies

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Abstract

Social and affordable rented housing is a significant housing sector across Europe. In the UK, the sector accounts for one in six homes, and houses some of the most vulnerable members of society in terms of health, income, and disability. Social housing is relatively advanced compared to other UK tenures in implementing low-carbon retrofit measures, such as solid wall insulation and draught proofing. However, such measures can increase the likelihood of summer overheating, which can lead to a range of negative health impacts, including increased mortality. Due to their vulnerability, many social housing tenants are less able to adapt to and manage overheating at home.

This paper uses the case study of social housing managed by a UK local authority in a city in the English Midlands to identify factors linked to low-carbon retrofit which may increase overheating risks, and mitigation strategies that could be adopted by social landlords to manage them.

Based on engagement with the local authority, the paper highlights a range of dwelling-specific overheating risk factors including aspect, built form, glazed area and available control measures within a home such as shutters and operable windows. Low-carbon retrofit is identified as frequently increasing overheating risks through reducing heat loss and increasing air tightness. The mitigation measures identified are predominantly behavioural, such as appropriate use of windows for ventilation and time-shifting heat-emitting appliance use. Low-cost technical measures, such as window tinting and solar shading, are also put forward. Through engagement with the case study local authority, potential practical steps for implementing these approaches are put forward which build upon existing processes for retrofit, housing management and tenant support. These include new communication resources using methods currently employed for addressing energy poverty, and overheating risk assessment procedures.

Introduction

The UK residential housing sector continues to be a major contributor to national CO_2 emissions. The sector contributed 69.1 $MtCO_{2e}$ to the national emissions total in 2018, or 15.3 % (Department for Business, Energy and Industrial Strategy, 2020). Energy efficiency retrofits for domestic properties are seen as a vital route to reducing domestic energy consumption going forward, particularly given the fact that 85 % of the existing housing stock in the UK is set to still be in use by 2050 (Committee on Climate Change, 2019; Killip, 2008). However, there is a growing body of evidence to suggest that energy efficiency retrofits may cause more incidences of overheating in domestic properties, where temperatures exceed comfortable limits for human habitation for long periods of time (Porritt et al., 2010; Tink et al., 2012; Ozarisoy & Elsharkawy 2019). Such incidents are likely to increase over future decades in the context of a warming climate, particularly during heatwave periods. Overheating brings with it a host of health and comfort risks, including reduced productivity, sleep deprivation and exacerbation of existing health conditions (Zero Carbon Hub, 2015; MHCLG 2019a). Vulnerable populations, for example the elderly or disabled, are more likely to suffer adverse effects from overheating than other populations. The overheating risk from warmth retrofits is therefore particularly relevant to social housing, where residents are more likely to belong to vulnerable groups than other tenancy types.

This paper investigates the overheating risks faced by social housing residents in an English Midlands city, where there is an ongoing program of energy efficiency retrofits for social housing properties. First, definitions of overheating will be discussed, based on current research and national standards. An examination of the risk factors faced by properties with regard to overheating will be conducted, and linkages identified between common warmth retrofits (such as insulation) and overheating risk factors. These risk factors will be used as a lens to investigate social housing properties managed by the local authority responsible for social housing. Following this, mitigation measures for reducing overheating risk will be identified, and issues relating to implementing these mitigations will be discussed, based upon feedback from the case study local authority. Finally, conclusions and recommendations for addressing this clear and present issue will be made.

Research Aims and Objectives

Our primary research question for this phase of the research is:

- "What are the future overheating risks for homes arising from low-carbon retrofit for social housing homes in an East Midlands City and how can they be managed?

This question leads to three objectives:

- Objective 1: Identify overheating risks for existing East Midlands social housing and linkages to low-carbon retrofits;
- Objective 2: Identify technical and behavioural measures that could be undertaken as part of the low-carbon retrofit process, and beyond the point of retrofit, to reduce risks of overheating; and
- Objective 3: Identify what factors will affect the viability of enacting the identified technical and behavioural measures.

Objectives 1 and 2 were investigated through a review of the available literature on overheating in social housing, UK homes more generally, and homes in the East Midlands specifically. Objective 3 was investigated through four meetings with the case study local authority, to co-develop and discuss outcomes of the literature review and other research. Overheating risk factors were identified through a survey of existing literature on overheating, focusing on papers and reports relating to the UK, as well as through semi-structured discussions with the sustainability and housing team from the case study local authority, and the overheating risks posed by built forms in their property portfolio.

Background: Overheating Risk and Warmth Retrofits

DEFINING OVERHEATING

First, a working definition of overheating needs to be understood. There are a number of differing definitions of overheating currently used to assess the overheating risk of a property, both at a new-build stage and a retrofitting stage. These are either defined through government building regulations, or by industry bodies, and are summarised in Table 1.

These definitions have been used, along with a public consultation process, to produce updates to both Part L (conservation of fuel and power) and Part F (ventilation) of the UK Building Regulations for new dwellings, to improve the "as-built" condition of new homes and reduce the likelihood of overheating in new properties in a future warming climate. The results of the consultation process and draft regulation changes were published in January 2021, as well as a draft document providing guidance on overheating and mitigating overheating risk.

The CIBSE TM59 modelling methodology has been used to assess overheating risks in a number of UK locations, and the Ministry of Housing, Communities and Local Government (2019a) report shows that through applying this methodology, it can be seen that a number of property types across the UK are already experiencing some degree of overheating according to the TM59 definitions. These incidences of overheating are likely to increase if warmth retrofits to increase SAP performance or energy efficiency are undertaken without also considering the increased risks of overheating in warmer periods.

Although this paper does not take a quantitative approach to analysing over-heating, these definitions highlight key issues to consider – namely a sense of an upper limit to indoor temperatures (in most cases, c. 25 degrees) which, if exceeded and if adaptation measures are not possible, pose a risk to the health of building occupants.

OVERHEATING RISK FACTORS

There are a number of key publications that have investigated overheating in domestic properties in a UK context in the last decade. From a national scale to a local scale, researchers from academic and public policy perspectives have identified an array of factors in how domestic properties are constructed and operated that can contribute to overheating risks, as defined by the standards used above. A number of organisations such as the Zero Carbon Hub have produced national-scale reports on risks of overheating in domestic properties, and the 2019 Overheating in Homes review from the Ministry of Housing, Communities and Local Government (MHCLG) demonstrates that overheating is a present and pertinent risk identified at a government level (DCLG, 2012, MHCLG 2019a; MHCLG 2019b; Zero Carbon Hub, 2015; Zero Carbon Hub, 2016).

The recent focus on overheating in domestic properties is linked to the rise in heatwave periods in the UK in the last 20 years. In particular, the August 2003 heatwave was identified by the Zero Carbon Hub as a turning point in research in the field, with overheating contributing to 2,000 excess deaths during the ten-day heatwave compared to the five-year weather and climate period preceding it (Zero Carbon Hub, 2015). In heating-dominated domestic energy use cultures, such as the UK, focusing on reducing the impacts of cold weather has been a policy priority for decades, but recent research into the effects of the changing climate and projections of warming through to 2050 has highlighted the need to consider the risks of domestic overheating alongside warmth retrofits to prevent cold-related impacts.

So, what are the risks of overheating in domestic properties, and how have these been identified to date? There are unfortunately a wide array of answers to that question, dependent

Table 1. Overheating Standards Comparison in the United Kingdom.

Standard	Summary	Definitions	Scope
SAP Appendix P	Assessment of internal temperature in summer and risk of high internal temperatures. Non-integral, does not affect overall SAP rating.	Assessment procedure for a Threshold Temperature: 20.5 °C–22.0 °C low risk, 22.0 °C–23.5 °C medium risk, <23.5 °C high risk.	Assessing and comparing energy performance of dwellings (both new and existing) (BRE, 2012).
ASHRAE Standard 55	Thermal environmental conditions for human occupancy, acceptable levels of thermal comfort.	Multiple definitions on acceptable temperature change and operative temperatures based on activity, clothing insulation level, ventilation and more. Operative temperatures between 20 °C and 24 °C considered optimal.	Defining acceptable levels of thermal comfort for human occupancy of buildings over a wide range of circumstances (Jenkins, 2020).
BS EN 16798-1:2019	Energy performance of buildings. Ventilation for buildings. Indoor environmental input parameters for design and assessment of energy performance of buildings.	Various depending on clothing level and metabolic rate (activity level). Operative temperature of 20.0 °C–25 °C recommended for category II residential settings.	Design and assessment of energy performance in buildings based on internal environmental conditions, and for indoor environmental comfort (British Standards Institute, 2019).
CIBSE TM52	Defining overheating in European buildings based on the recommendations of the CIBSE Overheating Task Force.	Static Criteria Living rooms: not exceeding 25 °C for more than 5 % of annual occupied hrs, 28 °C for 1 % of annual occupied hours (AOH). Bedrooms: not exceeding 24 °C for 5 % of AOH, 26 °C for 1 % of AOH. Adaptive Criteria: Difference between max permitted temperature (defined as $0.33 {}^{*} T_{rm}$ + 21.8 °C, where T_{rm} is mean outdoor temperature) and room should not exceed 1 K for more than 3 % of AOH.	Predicting overheating in buildings (new and existing), recommendations for static and adaptive criteria for thermal comfort assessment (Nicol, 2014).
CIBSE TM59	Design methodology for assessment of overheating risk in residential properties.	As CIBSE TM52.	Dynamic thermal modelling of new and existing residential buildings across a range of factors (CIBSE, 2017).

on a number of contextual factors. There is no "one-size-fits-all" solution to addressing the domestic overheating challenge (Deutsches Institut für Normung, 2014), and factors such as location, orientation, built form and occupant behaviour all contribute to the risk of a property overheating. These risks will be categorised into location-based risks, property-based risks, and occupancy-based risks (MHCLG 2019a, MHCLG, 2019b).

Location-Based Risks

The location of a property contributes to the risk of the property overheating. This applies at both a macro- (for example, national) scale, and a micro- (local/sub-local) scale. Sub-local in this instance will be used to refer to neighbourhood/street level location factors, rather than local referring to settlement-scale factors.

The urban heat island (UHI) effect has been well-documented in the literature (Parker, 2020; Carpio et al., 2020). This effect refers to the fact that cities tend to retain more heat from solar irradiation, and release more heat into the environment, than rural locations or smaller urban settlements. This is usually a factor of the population density of urban areas, as well as the built form of urban areas. Population density means that the production of heat from human activity, whether that be domestic, commercial or industrial, is concentrated in a smaller area, and thus has a higher proportional effect on the population than in non-urbanised locations. However, built form is the largest contributor to the urban heat island effect (Parker, 2020; Stewart, 2011), due to material used in the construction of cities. Materials such as concrete and asphalt have high thermal capacities and tend to release heat slowly, compared to organic materials such as soil, which has a comparatively lower specific heat capacity. This means that cities tend to heat up more slowly, but stay hot for much longer, contributing to overheating risks. In addition, the albedo, or reflectivity of materials used in cities tends to be quite low, and in particular materials such as asphalt, with very low reflectivity, absorb a much higher degree of solar radiation than higher-albedo materials (such as natural stone) (Carpio et al., 2020). This effect is particularly noticeable in the large cities of the UK, for example London, Manchester, Birmingham, Glasgow and others.

Property-Based Risks

There are a variety of overheating risks associated with the built form of properties, including their external fabric structure, internal room layout and built design. These factors can be used as a reliable indicator of overheating risks in a property, even distinct from the location and occupancy risks associated with the property.

The fabric structure of a property can contribute to the risks of overheating in the property. Newer homes with insulated cavity walls are often at a higher risk of overheating than older, solid-wall properties due to higher heat retention within the property, and slower rejection of heat through exterior walls. External insulation of solid-wall properties exhibits similar risk characteristics. In the drive for greater insulation and reduced heat losses in domestic properties, the additional risks of summer-time overheating have not traditionally been considered. This is particularly true in the United Kingdom: studies have shown that overheating risks, while part of the Standard Assessment Procedure for domestic properties (Appendix P), have not been given due attention by retrofit installers or management companies in the domestic housing sector, and as such warmth-focused retrofits have brought with them additional overheating risks (Zero Carbon Hub, 2015; MCHLG 2019b; Ozarisoy & Elsharkawy, 2019). This is particularly true when forecasting future overheating risks: in a future warming climate, overheating risks are likely to increase, and highly insulated properties are more likely to suffer from the effects of overheating (Morey, Beizaee & Wright 2020). In addition to the structure of the property, the materials the property is constructed from can contribute to overheating risks. High thermal-mass materials, such as bricks and concrete, tend to retain heat better than low thermal-mass materials such as timber.

One of the main sources of heat ingress into a property is through solar gains through glazed areas. Properties with a higher glazed-area to floor-area ratio are more likely to overheat than properties with lower proportions of glazed exterior surfaces. This is a particular problem in South-facing properties in the UK, as these properties will receive proportionally higher solar irradiance than properties with other facings. However, glazed area is also critical to passive ventilation in a property, and these conflicting needs must be balanced (Zero Carbon Hub, 2016). The draft guidance on overheating from the Ministry of Housing, Communities and Local Government also highlights the overheating risks that come from higher glazed areas, and provides standards on maximum glazed areas for properties to minimise solar gains.

The aspect, or facing of a property, can have both direct and indirect effects on the overheating risk of a property. The direct effects are similar to the issues with glazing, in that South-facing properties will experience more sunlight hours per-annum than properties with other facings. Single-aspect properties, such as back-to-back terraces or high-rise flats, are also at higher risks of overheating than dual-aspect properties (IE properties that have exposed walls facing in more than one direction), due to the lack of through-ventilation potential in the properties (Ministry of Housing, Communities and Local Government 2019a).

As well as the ability to reject heat through fabric components, the ventilation of a property is another contributing factor to the risk of the property overheating. Warmth retrofits commonly try to minimise air changes in a property as a heat-retention measure, which is effective. However, in minimising these air changes, this also minimises the ability of a property to reject heat into the environment. Ventilation can be achieved in a property via two main methods: passive ventilation, such as opening windows or air bricks, or active ventilation, such as mechanical ventilation systems or air conditioning systems. A lack of ventilation in a property, as well as contributing to poor indoor air quality, increases the risks of the property overheating. This is particularly important in single-aspect properties as mentioned above: through-ventilation (for example, by opening windows on opposite sides of a property) is an effective way of inducing air changes, but this is not possible in single-aspect properties. The draft MHCLG guidance on overheating also highlights this point: properties are divided into Group A and Group B properties based on the number of fabric elements in the property, and the façades of the property with openings in them. Group B properties (those with non-opposite façade openings) are recommended to have higher free areas in the property to promote excess heat rejection, due to the lack of ability to through-ventilate the properties.

Occupancy-Based Risks

Occupant behaviour is the final major factor that contributes to the risk of domestic properties overheating. Occupancy itself influences the overheating risk of a property: properties that have more occupied hours (for example, unemployed, elderly or disabled residents) also have higher overheating risks, due to the properties being "in use" for a greater number of hours. Occupants are also able to control their indoor environment to a greater extent than the built form can exert, and as such occupant behaviour can increase overheating risk, as well as decreasing it. Occupant risk factors include window-opening regimes, appliance usage, and room location within a property. Occupants that do not adequately ventilate properties are more likely to suffer from overheating when inside the property, as more heat is retained. High degrees of heat-rejecting appliance usage, for example cooking equipment and larger electronic items, are also a contributing factor to overheating risk. Occupants also bear the decision-making responsibility for room usage within the property, and siting bedrooms and living rooms in particular spaces within the property can contribute to the risk of these spaces overheating. For example, bedrooms have lower temperature thresholds for overheating than living rooms according to industry standards, and siting a bedroom in a particularly hot area of the house (such as a South-facing, highly-glazed room) means the room is more likely to overheat (Morey, Beizaee & Wright, 2020; Zahiri & Elsharkawy, 2018; Elsharkawy & Rutherford, 2018).

WARMTH RETROFITS AND OVERHEATING

There is a growing body of evidence from the literature that the pursuit of higher degrees of air-tightness and insulation in properties is contributing to overheating in these properties in warmer periods. Lee & Steemers (2016) examines scenarios for insulation and ventilation in theoretical timber- and masonry-framed properties under future climate scenarios, and finds that both insulation and ventilation contribute more to the mitigation or exacerbation of overheating risk than the fabric of the property itself. High levels of insulation and low levels of ventilation were found to violate the CIBSE TM52 overheating standards used in the paper much more often than the base case. Porritt et al. (2011) conducted an analysis of the effectiveness of mitigation interventions for overheating, and found that internal wall insulation increased the risk of properties overheating, while high-albedo external wall insulation or solar reflective wall coatings reduced the risk of overheating significantly.

Aragon, Teli & James (2018) provides an analysis of energy efficiency retrofits for social housing tower blocks in Portsmouth, UK, and finds that retrofitting the blocks to meet the 2010 UK building regulations would dramatically reduce energy consumption but result in overheating if no mitigations were taken to prevent this, such as the installation of solar shading. Psomas et al. (2016) also highlights the increased risk of overheating through warmth retrofits with a case study of four single-family houses in Northern and Central Europe (specifically Austria, the UK, Denmark and France). This paper identifies several measures that could contribute to overheating, but critical measures include increased floor insulation and improvements to home airtightness.

In light of these risk factors, there are a number of ways in which warmth retrofits and energy efficiency retrofits can affect the risk of a property overheating in warmer periods. Starting with fabric elements, any reductions in U-values of fabric elements through insulation or replacement, in isolation, will have an effect on the ability of the property to store and reject heat. Lower U-values have been pursued as an energy efficiency measure for winter heat, for example through wall insulation (be that internal, cavity or external), and are effective for this purpose, but need to be considered in the context of the whole home system, rather than in isolation. Simply reducing the emissivity or conductivity of wall elements to heat will cause more heat to be retained in the property, increasing overheating risk during warmer periods as the property cannot reject heat as effectively.

Similarly, retrofits for glazing in properties, such as replacing single-glazed windows with double-glazing, and other measures that affect openings in fabric elements of properties, can affect the solar gains a property experiences through glazing, as well as an effect on the ventilation ability of a property. Lower U-value glazing, such as double glazing, will mean more heat is retained in the property, while maintaining the level of solar gains from the existing glazed area. Ventilation can also be affected through window retrofits, if replacement windows have a smaller opening aperture than the existing windows.

Fabric retrofits and glazing retrofits are the most likely warmth retrofits to affect the overheating risk of a property, however it is important to consider the user in this context as well. The risk of overheating post-retrofit is not a solely technical phenomenon, and user behaviour in managing the home system is an important contributing factor. Users who are not informed about the potential for higher heat retention in a post-retrofit property may be unable to effectively manage the temperature in the property during warmer periods. This is also borne out in the literature: Baborska-Narożny, Stevenson & Grudzińska (2017) for example shows that occupant interventions during heatwave periods can dramatically reduce the incidences of overheating, but the scale of effect varies dramatically with the scale of occupant intervention and the ability of occupants to affect their indoor environment.

Mitigating Overheating Risk

There are a wide variety of measures that can be taken to mitigate the risk of social housing properties operating at above the regulated thresholds for heat. These mitigation measures can broadly be classified as technical measures, i.e. measures that make physical changes to the property or its systems, and behavioural measures, which relate to occupant behaviour and operation of the property. These can be related directly to risk factors, however technical risks may be solved most appropriately through behavioural solutions and vice versa.

BEHAVIOURAL MEASURES

Behavioural measures have a clear advantage over technical measures in that they can be implemented without additional capital cost to either landlords or tenants. Behavioural measures predominantly rely on changes in occupant behaviour towards the systems in a home in order to reduce internal gains, reduce solar gains, and improve passive heat rejection (Good Homes Alliance, 2019; Murtagh, Gatersleben & Fife-Schaw, 2017).

- Reducing Internal and External Heat Gains: There are a number of behavioural routes to reducing heat gains in a property. During sunny parts of the year and the day, internal or external blinds can be used to limit the solar gains through glazing. Closing windows and blinds in the daytime, and opening for ventilation at night, are also routes to reducing external gains in a property. Heat-rejecting appliances, such as cooking equipment, can have their use time-shifted to cooler parts of the day if possible, and ensuring that adequate ventilation is installed in cooking areas and utilised correctly reduces the risk of internal gains from such appliances. Ensuring that appliances that are not in use are switched off also limits internal gains. Finally, ensuring that heat-carrying pipes and boiler installations are sufficiently insulated reducing the risk of operation of these appliances causing additional internal gains.
- Improving passive heat rejection: Behavioural routes to passive heat rejection mostly comprise of ensuring that the currently-installed ventilation is used to good effect. Utilising ventilation in the most effective manner to reject heat is the main goal provided outdoor temperatures are cooler than indoor temperatures: this includes opening windows on opposite facades to promote through-ventilation, and opening windows during the cooler parts of the day (for example, night-time) to reject daytime heat from the property.

TECHNICAL MEASURES

A useful way of examining the potential technical interventions to reduce overheating risk can be found in overheating advice from the Zero Carbon Hub (Zero Carbon Hub, 2016). The ZCH propose a hierarchy of technical steps (see Figure 1) to address overheating risk, from a starting point of reducing heat gains in the property, to improving passive heat rejection, and finally considering mechanical measures to improve heat rejection and ventilation.

- Reducing Heat Gains: reducing internal gains for a property predominantly involves limiting solar gains, and limiting thermal gains from property occupation and use. Solar gains can be limited in a number of ways. These include using existing shading (for example, interior curtains or blinds) during sunny periods, installing new internal or external shading to limit solar gains through glazing, and minimising gains from appliances and occupancy by moving occupancy patterns to other rooms or time-shifting appliance use to cooler parts of the day.
- Improving Passive Heat Rejection: Passive heat rejection measures focus on improving the passive ventilation of a property, and the ability of fabric elements to reject excess heat where necessary. Improving passive ventilation involves ensuring that existing ventilation measures (such as windows and blinds) are able to be used for their intended purpose, and improving passive ventilation potential by converting non-opening windows to opening-windows, abiding by standards on window opening angles, and implementing through-ventilation strategies where possible by opening windows on opposite facades of a property.
- Mechanical Heat Rejection: Fitting a mechanical heat rejection system, such as a mechanical ventilation system, to a property will improve the ability of a property to reject heat, and lead to increased heat rejection and a lower risk of overheating. Mechanical measures are viable for properties where passive heat rejection and behavioural measures have not been successful in reducing overheating in the property, but will increase the energy consumption of the property, and as such are a less sustainable measure than passive and behavioural measures. Considerations also need to be made when fitting a mechanical heat rejection system around air flows in the property, and ensuring that the ventilation system meets relevant purge and sustained ventilation standards (such as Part F of the Building Regulations).
- Mechanical Cooling: Mechanical cooling systems, such as air-conditioning and HVAC systems more generally, are a last resort should other passive and active measures be insufficient for reducing overheating in a property. Increasing energy consumption of properties is not in line with the Council's energy consumption reduction goals, and as such mechanical cooling methods should be used sparingly in properties that are not responding to other mitigation measures. Air conditioning is effective at managing the internal temperature of a property, but attention should be paid to siting the air conditioning units within a property to effectively target problem rooms, or if a whole-property system is to be fitted, then effectively manage the air-flow of the system to cool the whole property efficiently.

While still subject to change, the draft Overheating Guidance, recently published as part of the Government's consultation on the Future Homes Standard, proposes some technical standards for mitigating overheating risk in properties. These standards cover maximum proportions of glazed area to floor area, and recommendations for shading in urban heat island areas (specifically Greater London), as well as "free area" (floor area) in a property and minimum ventilation standards.

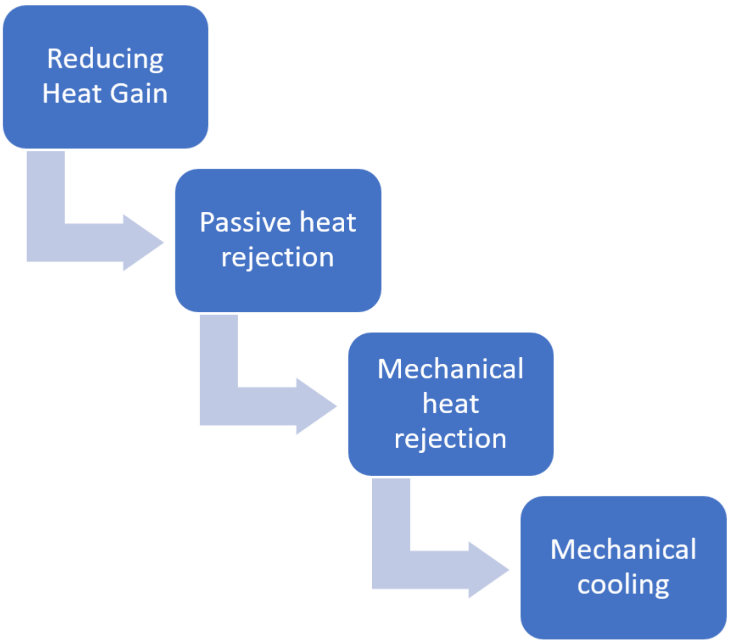

Figure 1. Hierarchy of Technical Overheating Risk Mitigation Measures. Adapted from Zero Carbon Hub (2016).

The draft Approved Document Part [X] for Overheating also provides guidance on technical standards for mitigating overheating risk and assessing overheating risk. Properties in the draft document are divided by region (Greater London, where the urban heat island effect is strongest, and the rest of England), and grouped by type. Group A properties have more than two fabric elements and openings on opposite facades to facilitate through-ventilation, while group B properties have two or fewer fabric elements, and openings on non-opposite facades. The report provides three technical standards for each property group to mitigate overheating risk: these are the maximum glazed area of the property, the use of external shading, and the minimum "free area" of the property, which is the unobstructed floor area. These standards also imply technical mitigations: external solar shading as a passive mitigation measure and increasing ventilation through ensuring a through-draft, are both measures that will assist in complying with these draft standards. Although put forward for new buildings, the guidelines highlight the types of measures which could also be relevant in a retrofit context.

Beat the heat: keep cool at home checklist

Homes can sometimes overheat during warmer weather, and occasionally in cooler months also. Even during a relatively cool summer 1 in 5 homes are likely to overheat. For many people, this makes life uncomfortable and sleeping difficult. Some people are particularly vulnerable to heat and for them a hot home can worsen existing health conditions or even kill.

The first part of this checklist helps you to identify if a home may be at risk of overheating and if occupants there may be at risk of ill health from overheating. The more factors that are present, the greater the risk is likely to be. The second part details how to reduce overheating and where to get help.

Types of homes that are more prone to overheating

Flats on the top floor	☐
Flats with opening windows on just one side	☐
Little shading (external or internal)	☐
Large unshaded east, west or south facing windows	☐
Located in a densely built-up urban area with little green space nearby	☐
Modern, very airtight, highly insulated or energy efficient ***Note*** Making homes energy efficient has lots of health and other benefits, but care also needs to be taken to avoid overheating in summer	☐
Poorly insulated heating or hot water system	☐
Restricted opening of windows (for example, safety catch installed or unable to open them due to noise, pollution or fear of crime)	☐

Is there anyone living here who may be at higher risk of ill health from overheating?

Older, especially over 75 years of age	☐
Children, especially under 4 years of age	☐
Live alone and/or socially isolated	☐
Long-term health condition (particularly heart and breathing problems)	☐
On multiple medications	☐
Reduced mobility and/or ability to look after themselves	☐
Difficulty adapting their behaviour in warmer weather (for example, due to dementia or alcohol/drug misuse issues)	☐
At home during the hottest part of the day (for example, small children or home workers)	☐

Figure 2. Checklist for assessing overheating risks (Public Health England, 2016).

Issues Affecting Implementation in Social Housing

The strategies set out above cover technical and behavioural routes to minimising the risk of overheating in social housing properties. However, in implementing these mitigation measures, there are a number of factors to consider. The discussion below is based upon factors highlighted by staff working in the housing and sustainability teams at the case study East Midlands local authority, where the viability of implementing a range of measures was explored. The factors put forward can be grouped into issues of cost and financing, installation, and operation/uptake. Finally, there are information-gathering issues to consider building a robust strategy for addressing potential overheating risks.

When considering retrofit measures to address the risk of overheating, the issue of cost and who bears the cost for retrofit work is a persistent one. Pursuing match funding from national Government schemes, such as the Green Homes Grant, is the current most-common route used by the case study local authority for accessing funding for warmth retrofits, and this is likely to be the most accessible route to funding for overheating retrofits where needed. Cost is widely highlighted as a barrier to energy efficiency retrofits (Psomas et al. 2016; Shao et al. 2012), and this is common to overheating retrofits as well (Shao et al. 2012). It is important to consider overheating at the point of retrofit with relation to costs as well: post-retrofit adaptations to mitigate overheating caused by the retrofit will incur additional costs to consumers and providers (DCLG, 2012).

Installation timings and methods are a common issue between warmth retrofits and overheating retrofits. Some retrofit measures, such as external wall insulation, are able to be completed with minimal disruption for tenants, but other measures, such as internal wall insulation or retrofit of glazing, are likely to cause significant disruption to tenants and their ability to use their home. This applies to overheating retrofits as well: external shading, for example, is able to be fitted with minimal disruption for tenants, but insulation of heating system components is likely to cause some disruption. An assessment needs to be done at the point of overheating retrofits, as with warmth retrofits, on the anticipated disruption for tenants, and agreement needs to be reached with the tenants as to the timing and scale of the retrofit. Options exist for avoiding this disruption, for example waiting until periods when the property is empty to conduct retrofit work.

Technical measures in and of themselves are often tied to usage in order to reach their maximum potential effectiveness. When considering overheating retrofits that are tied to operation of a technical retrofit, for example improved passive ventilation through window retrofits, it is important to consider the potential information requirements for tenants during and post-installation to ensure that the retrofit is used as intended and can deliver the expected benefits. Examples of information provision on overheating are limited, but a number of local authorities and government departments in the UK currently provide advice to residents on keeping cool in summer (NHS 2019; London Borough of Barnet 2021). Public Health England (2016) also provides a checklist for self-assessment of overheating risk (see Figure 2), and this format could be applied to more local-scale information provision on overheating.

Care also needs to be taken in delivery of overheating retrofits to ensure that residents are able to operate any equipment or fabric elements as required. An example of this would be in window opening regimes: elderly residents or those with limited mobility may be unable to open windows to the necessary recommended angles to enhance passive heat rejection. In this case, other behavioural measures or technical measures, such as room use changes or mechanical ventilation, could be considered, in order to ensure that these populations are not excluded from the potential for reduced overheating risk through retrofit.

This paper highlights the potential of behavioural measures, which suggests value in educational and support-based interventions to enable tenants to adapt to warm temperatures during heatwaves. There is an analogy here to the types of support mechanisms already in place for fuel poverty, such as providing written/online guidance, helplines or 1–1 advice (e.g. see Reeves, 2016). Local authorities, housing support services, health agencies and charities could look to enhance their tenant support with guidance on managing over-heating. This is already being done by national charities (e.g. see Age UK, 2021) and the case study local authority identified a number of opportunities for adoption, through tenant newsletters, web pages and pre-planned targeted communications during heatwaves.

Conclusion and Recommendations

This report has provided a summary of the current status of research into overheating in social housing in the UK, with a specific focus on an English Midlands city. Warmth retrofits for social housing stock and other energy efficiency are a vital component of the UK strategy for reducing domestic energy consumption, however the potential for warmth retrofits to increase the risk of overheating in a property during warmer periods is present. The negative effects of overheating in domestic properties, including risks to productivity, wellbeing and physical health, are more pertinent in social housing than other types of housing, given the higher degree of residents with health vulnerabilities (for example, age and reduced mobility) in social housing than other tenancy types.

There are three broad categories of risk factors that a social housing property can have in terms of its overheating risk profile: location-based risks, such as the urban heat island effect; property-based risks, such as construction morphology and fabric component, and occupancy-based risks, or operation-based risks, based on the users' interactions with the property. However, there are a number of mitigation strategies that can be applied to reduce the risk of these factors leading to overheating in warmer periods. Current guidance from NGOs such as the Zero Carbon Hub and the UK Government highlights four categories of measures: reducing heat gains in the property, passive heat rejection, mechanical heat rejection and mechanical cooling. Complex technical measures will have a significant capital cost associated with them, but much can be done to reduce overheating risk simply through low-cost technical interventions and behavioural change.

To reduce overheating in social housing post-retrofit, it is important to ensure that first, solar gains through glazing and internal gains through occupancy and appliance use are minimised. This can take the form of window films and tints to reduce solar gains, installing blinds or shutters (either internally or externally) in a property, and time-shifting the use of heat-rejecting appliances (such as cooking equipment) to cooler parts of the day. If these approaches are insufficient, increasing the passive ventilation of the property (such as opening windows on opposite facades) can be employed first, before considering mechanical ventilation measures to reject heat. Finally, in extreme cases, mechanical cooling may be needed to reduce the overall temperature in a property.

Information is a key component of strategies to reduce summer overheating. There are clear analogues with how winter warmth information is presented to tenants, and these same channels could be used to provide "keeping cool" advice for dealing with overheating risk. This could cover the risk factors identified above and provide advice to tenants on mitigation measures. Risk assessments are another route to providing more information on overheating to both tenants and the Council: while there are methodologies (particularly CIBSE TM59) that already exist to analyse the risk of a property overheating, these are often long-term assessments and require a high data component. A simplified procedure that takes into account the construction of the property, the fabric elements, glazing and orientation could provide a reasonable profile for a property for assessing overheating risk. This procedure could be conducted post-retrofit, or when the property is vacant, and this information used to inform tenants about mitigation strategies or considerations when using the property to reduce overheating risk.

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