Building Heat-Resilient Neighbourhoods

Drawing on the first-hand experiences of Islington residents, this project aims to develop a new overheating index for buildings.

November 2024

LOVE DES/GN STUD\O

SHADE THE UK

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Grantham Research Institute on Climate Change and the Environment

The summer of 2022 highlighted the urgent need for effective measures to address the impact of heatwaves on public health in the UK.

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Authors

Shade the UK & Love Design Studio

Shreya Kapur

Rafael Nemes

Tony Truepenny-Phillipson

Connor Rusby

William Scott

Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science (LSE)

Dr Candice Howarth

Anna Beswick

Andy Love
Founder of Shade the UK and Love Design Studio

Dr Candice Howarth
Head of Climate Adaptation and Resilience Grantham Research Institute, LSE

The project involves a collaboration between the following organisations.

Shade the UK

Shade the UK is a UK-based community interest company adapting the built environment and public spaces to protect the vulnerable against a changing climate.

Shade the UK's mission is to reduce the deaths caused by overheating in the UK to zero, safeguarding the health and wellbeing of vulnerable people during hot weather. We want the UK to become fully adaptable to increasing temperatures through the reimagination of how our cities, buildings and spaces are designed.

Love Design Studio

A London-based sustainability consultancy working with teams in the built environment to create sustainable buildings and promote ethical business practices.

Love Design Studio are a team of environmental consultants, designers, engineers and technicians to address various aspects of sustainability in our projects.

Love Design Studio aims to inspire businesses across all sectors to adopt a purpose-driven approach to building design and business practices. We aim for a world where economic success and environmental wellbeing coexist, generating a lasting and meaningful positive influence.

Grantham Research Institute on Climate Change and the Environment at LSE

The Grantham Institute was established by the London School of Economics and Political Science in 2008 to create a world-leading multidisciplinary centre for policy-relevant research and training on climate change and the environment, bringing together international expertise from across LSE and beyond, including on economics, finance, geography, the environment, science, law, international relations, development and political science.

The Institute's vision is a sustainable, inclusive and resilient world. Its purpose is to accelerate the transition, and remove obstacles, to a sustainable, inclusive and resilient world.

01 Introduction

The unprecedented temperatures in July 2022 led to more than 3,000 heat-related deaths (387 of which were in London), signaling the vulnerability of the country to extreme heat events[1]. Heatwaves are ‘silent killers’ and cost our economy billions of pounds every year[2].

More than half of UK homes currently suffer from overheating risk; this is projected to increase to 90% of homes under a 2°C scenario[2].

This project aimed to address the gap in user-friendly overheating metrics and empower a broader audience to make informed decisions regarding overheating risk in their buildings.

What is a metric?

A metric is a system or standard of measurement, commonly used for comparing and tracking performance. In the context of the built environment, metrics can help understand how well a building is performing across different issues of interest.

The impacts of increasing temperatures are multidimensional, affecting the health, wellbeing, economy and natural environment of the country in many ways that are only expected to worsen due to the effects of climate change.

Buildings in the UK have traditionally been constructed to defend against the cold rather than to minimise the effects of heat, and few domestic buildings are adequately suited to deal with a warmer climate in the UK.

This study looked into the possibility of creating an index for assessing the risk of overheating in existing structures that could be displayed in a property and potentially stored in an online database, akin to an Energy Performance Certificate (EPC).

This metric would serve as an effective tool for various stakeholders, such as homeowners, property managers, landlords and policymakers, to make informed decisions about heat resilience in properties. However, it is acknowledged that simply providing information about overheating via a metric will not be sufficient on its own to increase preparedness and responsiveness to extreme heat. Instead, this is encouraged to be part of a whole systems approach to adapt the UK.

The project involves a collaboration between:

(i) The Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science;

(ii) Shade the UK, a community interest company adapting the built environment and public spaces to protect the vulnerable against a changing climate; and

(iii) Love Design Studio, a UK-based sustainability consultancy.

This combined approach has ensured a practical, evidence-based approach to establishing a metric for assessing overheating risk in existing buildings in Islington.

The Problem

Unprepared building stock

01

Historically, buildings in the UK have been designed to maximise heat retention and energy conservation, overlooking issues of excess heat. Under current climate change scenarios, 90% of UK buildings are expected to suffer from overheating[1]. Adaptation measures are not being implemented rapidly enough.

Overheating risk in London

02

London is particularly at risk of overheating, consisting of highly built-up areas with limited green space. Inner London boroughs are at higher risk due to the Urban Heat Island (UHI) effect.

Complex metrics

03

Existing tools used to demonstrate overheating risk within buildings are highly complex and rely on complicated formulas with an impractical output for communicating issues effectively to the average person. This complexity represents a significant barrier to widespread comprehension and adoption of strategies to decrease risk.

Unheard voices

04

There is currently a reliance on statistics to convey the impacts of overheating, rather than the nuanced and unique telling of human experience.

Although the heatwaves experienced in 2022 led to more than 3,000 deaths, not enough has been done to proactively investigate how to translate this into urgent action and protect the most vulnerable populations from extreme heat.

Climate change is increasing the frequency and severity of extreme heat events in the UK. Yet, as seen from the aftermath of the 2022 heatwave, the country is not prepared for the impacts of these events.

What are the impacts?

Heat and wellbeing

Heat exposure represents serious health risks for vulnerable populations and people with underlying chronic health issues. Continuous exposure to heat can lead to heat cramps, heat exhaustion and heat stress, which can increase hospitalisations and prove fatal for some. It is estimated that in the UK, around 2,000 heat-related deaths are registered each year; predicted climate change expected to see this figure rise to 21,545 in the 2070s[3].

In addition to physical symptoms, heatwave events have also been associated with increased incidences of mental health issues. This is due to the heat-related inefficacy of medication on the body's ability to cool down and is linked to rates of violence, anxiety and depression[4].

Economy

The economic impacts of heat exposure are estimated to be £260-300 million per year, a figure that is expected to triple by 2050 due to losses in potential labour hours and risk of excessively high working temperatures, such as in the construction industry[5].

Built environment

UK buildings have historically favoured heat retention and energy conservation, overlooking issues related to excessive heat[6]. It is estimated that more than half of homes in the UK suffer from overheating risk, with the south-east and London at particularly high risk[1]. Low-income and neighbourhoods with a high proportion of ethnic minority groups are disproportionately burdened by this risk.

An estimated 90% of UK buildings require some form of intervention to reduce risk of overheating, representing retrofitting costs of at least £500 billion over two decades and potentially driving up energy consumption demand [1].

Infrastructure

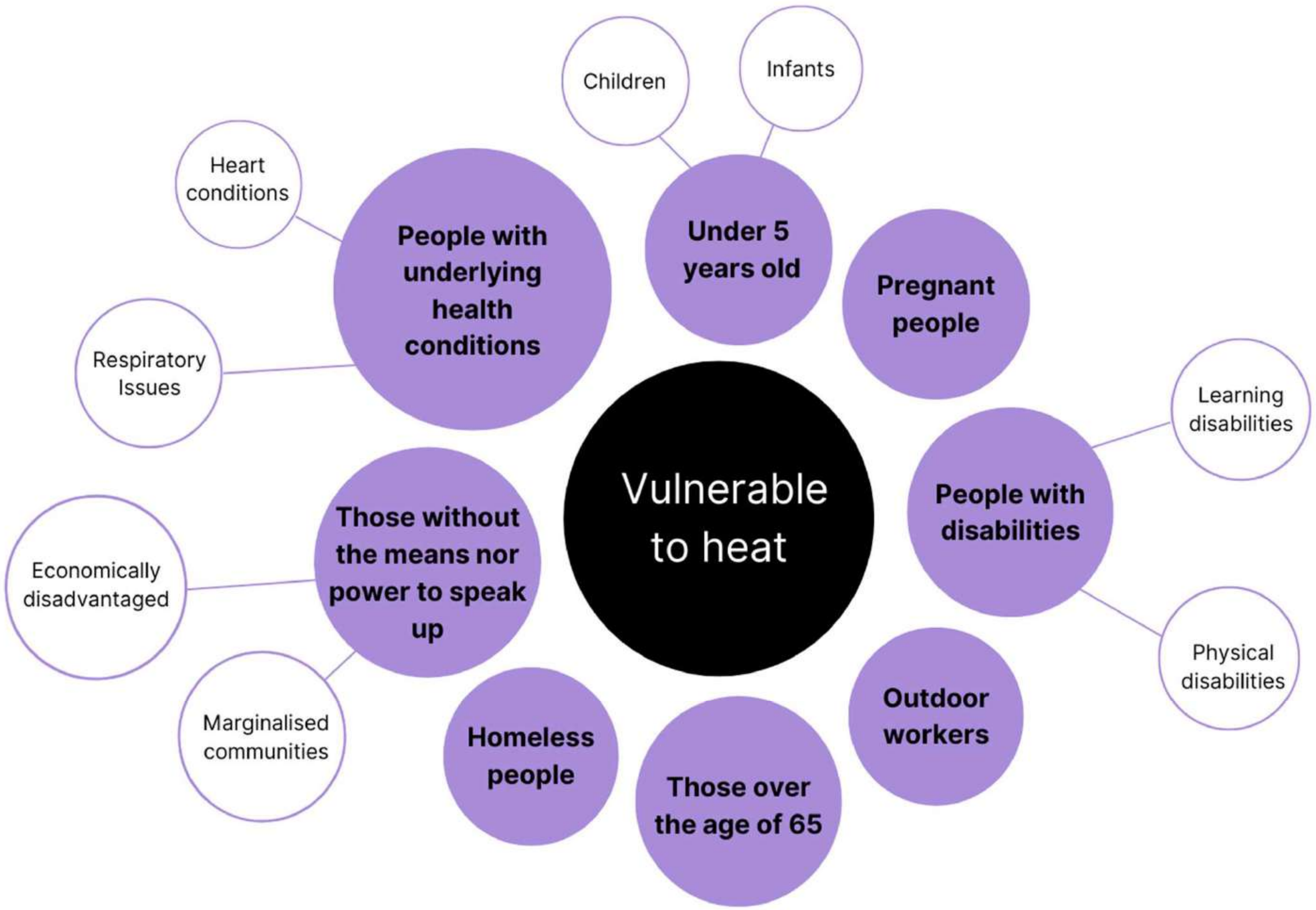
Extreme heat events cause shock disruptions to transport networks and place pressure on water, energy and telecommunication demand. Railway lines and road networks can be strained at very high temperatures as they buckle and melt, leading to significant disruptions and financial losses[7]. Furthermore, excess heat leads to surges in water and energy demand, with the risk of overwhelming existing networks.

Natural environment

Heat events impact our ecological system in multidimensional ways. For example, some mammals and birds present increased risks of dehydration and energy demand for travelling for resources. Urban trees are also increasingly negatively impacted by heatwaves as they age faster and are not able to cope with emerging pests and pathogens well[8].

Natural systems are also severely disrupted; ecosystem services, such as water provision, recover slowly in the heat. This can have subsequent impacts on food production and an increased risk of disasters, such as wildfires, with cascading impacts on the economy and society.

While the UK population faces heat risk, vulnerable communities are disproportionally harmed during heatwave events.



Those over the age of 65 face significant risk during hot weather. Many pre-existing health conditions can be exacerbated by extreme weather or taking medication that interact with heat and cause adverse effects[9]. It can be more difficult for those above 65 to escape the heat as they are often less mobile and therefore likely to spend extended periods of time indoors. Social isolation and increased risks of dehydration also increase the likelihood of harmful and sometimes fatal consequences.

Children are more susceptible to sunburn and heat exhaustion, especially if they spend a lot of time outdoors. Such exposure and physical activity in extreme weather without frequent access to water and shade can cause dehydration and affects a child's ability to concentrate and learn[10].

Low-income households may be more likely to experience overcrowding, which can exacerbate the impacts of heatwaves and make it harder to maintain a safe and comfortable indoor temperature. This is especially true for those in large social housing blocks that often suffer from poor ventilation[11].

Heatwaves have devastating consequences for the homeless due to a lack of shelter and access to water. This is exacerbated by environmental factors that increase the risk of heat-related illnesses, such as air pollution and limited access to healthcare.

Our approach

Overheating assessment
01

An overheating assessment was undertaken on a select number of building archetypes within Islington to demonstrate the current vulnerability of heat risk within Islington buildings and to refine and optimise a heat metric based on real-world scenarios.

Review of existing metrics
02

This report reviewed existing metrics and methodologies used for assessing overheating risk in new buildings to understand their strengths and limitations. Furthermore, the report investigated international best practices in assessing and mitigating overheating in buildings, emphasising how successful strategies could be applied in the UK.

Stakeholder engagement
03

The project team facilitated a roundtable event with various stakeholders, including Islington Council, community organisations, Islington businesses and residents. The interactive event aimed to understand the purpose, influence and design of a new heat risk classification system for buildings in Islington.

Collect narratives
04

We have collected anecdotal evidence via interviews with Islington residents who shared their experiences with overheating in buildings. The stories shared within this report provide non-technical insights of how buildings are performing under higher temperature scenarios and how vulnerability of individuals differs within these buildings.

02 The case for Islington

Building cities resilient to rising temperatures demands more than technical solutions. We must embed the real stories and struggles of communities affected by climate change into our strategies.

Inner boroughs of London that have rapidly built up over the last few decades, such as Islington, are particularly impacted by the Urban Heat Island effect, presenting challenges to different vulnerable groups[12].

Why Islington?

Alongside other major metropolitan cities, London is especially at risk of overheating given the Urban Heat Island (UHI) effect, whereby the grey infrastructure (i.e. roads, buildings, concrete) that dominates the urban environment retains more heat than green infrastructure (i.e. trees and shrubs). As a result, cities are significantly warmer than their rural counterparts.

Inner boroughs within London that have rapidly built up over the last few decades, such as Islington, are particularly impacted by the UHI. Consequently, Islington can reach 9°C higher than greenbelt areas sitting outside of London [12].

A recent study in 2024, published by the Greater London Authority, investigated the properties most vulnerable to heat risk in London[13]. The study established that schools, hospitals and care homes in Islington present one of the highest risks of overheating among all London boroughs.

High heat risk heavily interacts with the high socioeconomic vulnerability identified within Islington. Areas high in deprivation, young children and the elderly, and social isolation were found to be most at risk to increasing temperatures and will likely experience greater impacts [13].

The economic impacts of heat exposure are estimated to amount to millions of pounds per year due to losses in labour hours and disruptions to economic activity[5]. Islington's urban form and the UHI effect, economic impacts arising from heatwave episodes will become increasingly significant in a changing climate.

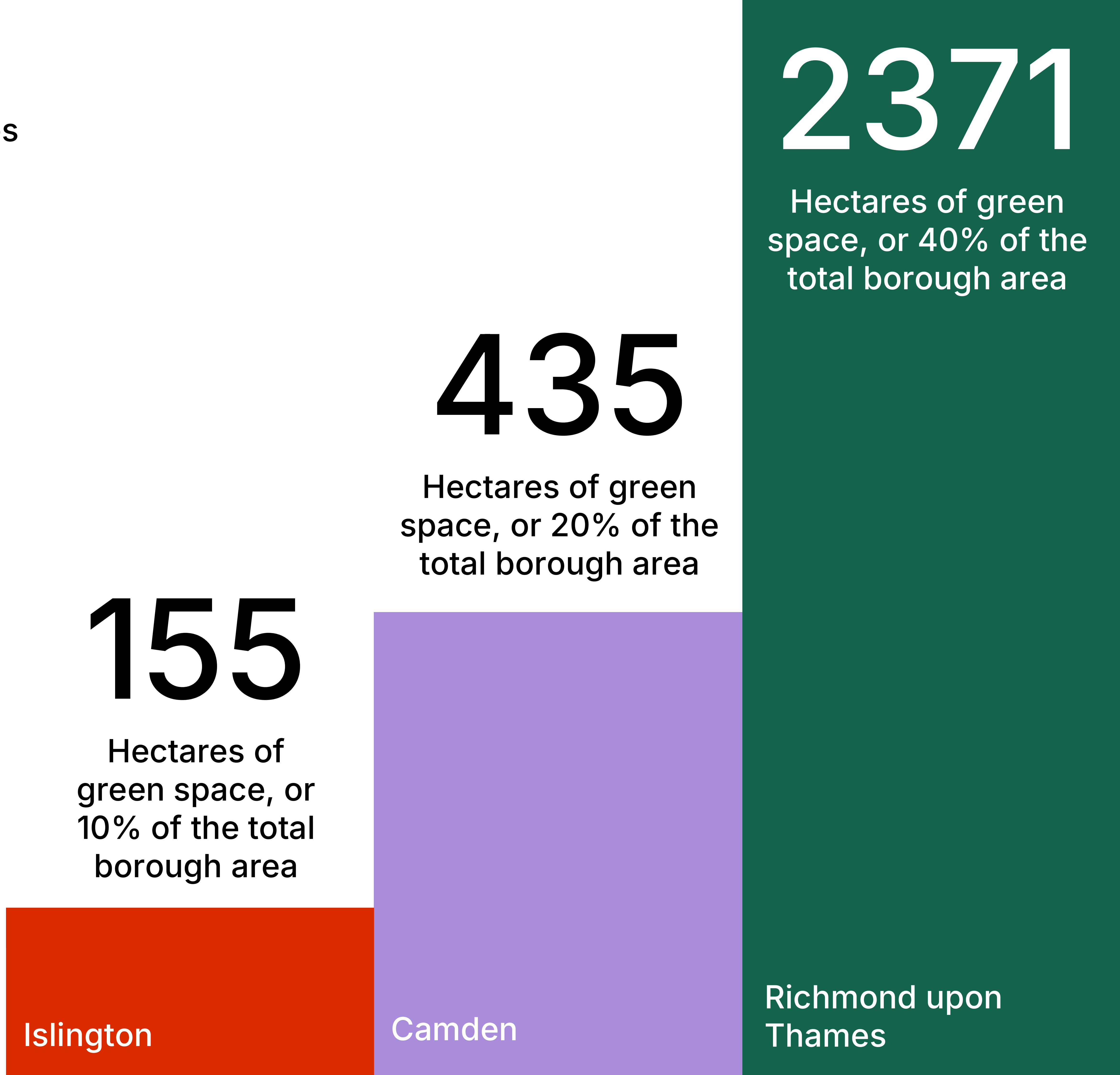
Therefore, due to the borough's vulnerability to extreme heat, Islington formed the basis of this research project.

Lack of green spaces in Islington

Green spaces offer multidimensional benefits, including significant temperature cooling effects in cities[14]. Green spaces can provide people with respite from extreme heat. Doubling green coverage within a city can reduce heat-related deaths by around 39.5%[15].

Only 10% of Islington has publicly accessible green spaces, spanning 155 hectares, ranking it the second lowest among all 32 boroughs in London[15].

17% of the borough is classed as being *"deficient in access to nature"*, which is categorised as being more than one kilometre away from publicly accessible green space[16].



Islington is a proudly diverse borough but has known issues associated with deprivation and inequality. These issues are often concentrated in specific regions of the borough.

Islington is home to some 24,800 people and has the highest population density in London. Islington has an ethnically, economically and socially diverse population but suffers from high levels of deprivation in certain regions: the borough is the sixth most deprived in London.

The risks associated with heat, and climate change more generally, are often felt most acutely by more deprived communities. This research project seeks to ensure impacts on the most deprived communities, regions and groups are considered in the first instance, given their increased sensitivity to health impacts associated with climate change.

The varied building stock in Islington includes many building types where occupants are at high risk of experiencing overheating and poor thermal comfort, further supporting the selection of Islington as a focus area for this work.

Several of these building archetypes have been modelled as part of this project; the archetypes are based on existing buildings across Islington, notably those within areas of known deprivation and equality.

Indices of Multiple Deprivation

To robustly select the most appropriate building archetypes, the English Indices of Multiple Deprivation (IMD) has been used to provide a breakdown of deprivation across England by Lower-layer Super Output Areas (LSOA).

The deprivation index is based on seven domains: income, employment, education, health, crime, barriers to housing and services, and living environment. The domains are considered in isolation, and in combination, and each LSOA is ranked across England for both the individual domains and for the index.

Each LSOA is then given an IMD Decile between 1 and 10, where 1 is the most deprived 10% of LSOAs and 10 is the 10% least deprived of LSOAs.

Overheating assessment

An overheating assessment was undertaken on the selected building archetypes within Islington to demonstrate the current vulnerability of heat risk within various Islington buildings.

A thermal dynamic simulation model (DSM) of each building archetype has been created for the overheating assessment, which incorporates the proposed solar control glazing, openable windows and doors, and building layout.

Each archetype was tested under weather files that are typically used to assess mild and extreme weather for new-build panning assessments in London (2020 and 2080 weather files) to understand both the current and future overheating risk. The peak temperature experienced within each building has been used to understand the relative overheating risk across each archetype.

Solar exposure analysis was also undertaken to illustrate the most exposed areas of the external building surfaces including the façade, windows and roof areas of each archetype on 21 June, where the sun is at its highest position in the sky and daylight hours in the UK are at their peak.

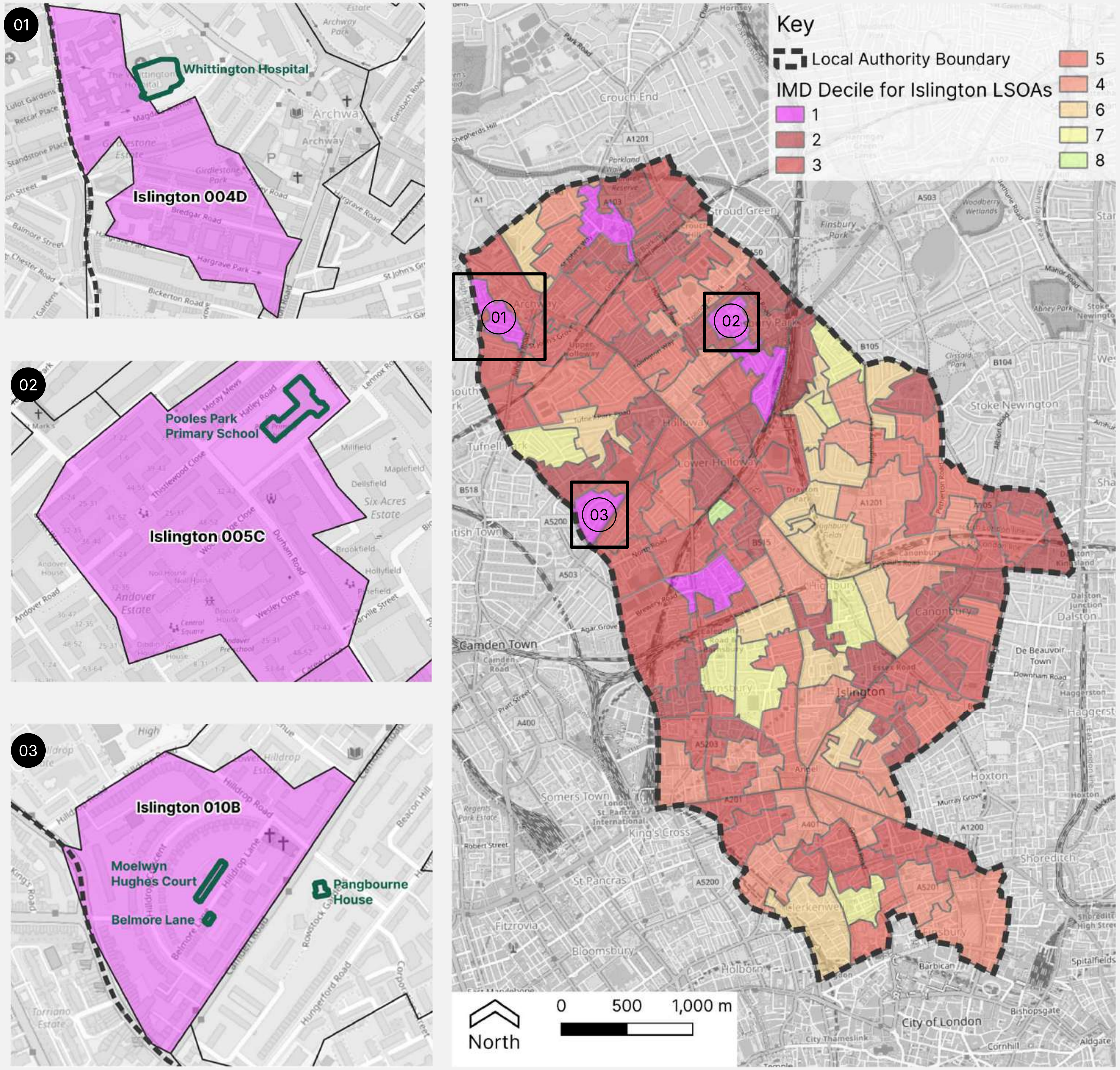
Building archetypes

The following building archetypes were chosen for assessment of overheating. The simulations are based on actual buildings in Islington:

- Residential developments
  - Mid-rise apartment block
  - High-rise apartment block
- Care home
- Hospital
- Prison
- School

Where possible, these have been identified in LSOAs in IMD Decile 1, with exceptions described overleaf.

Given the large number of residential properties within the borough, several residential buildings were assessed to demonstrate the performance from an overheating perspective across multiple forms of dwellings. The referenced residential buildings include social housing where there is often a higher proportion of vulnerable people than in private housing.

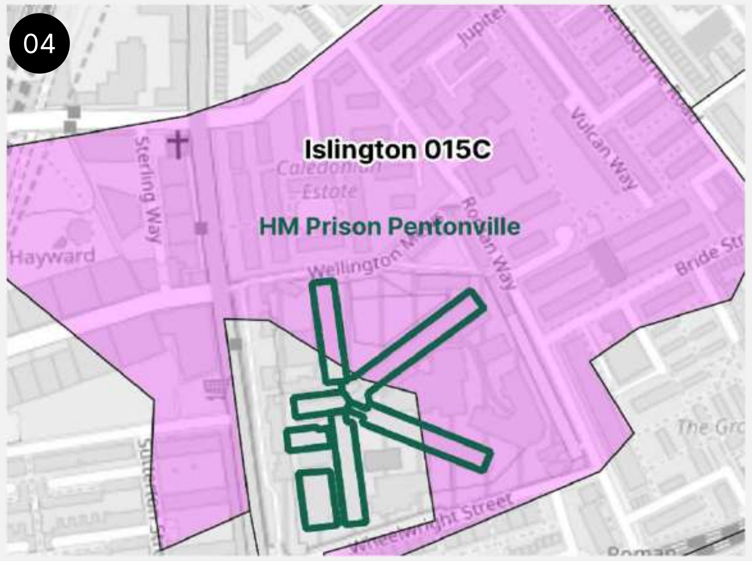


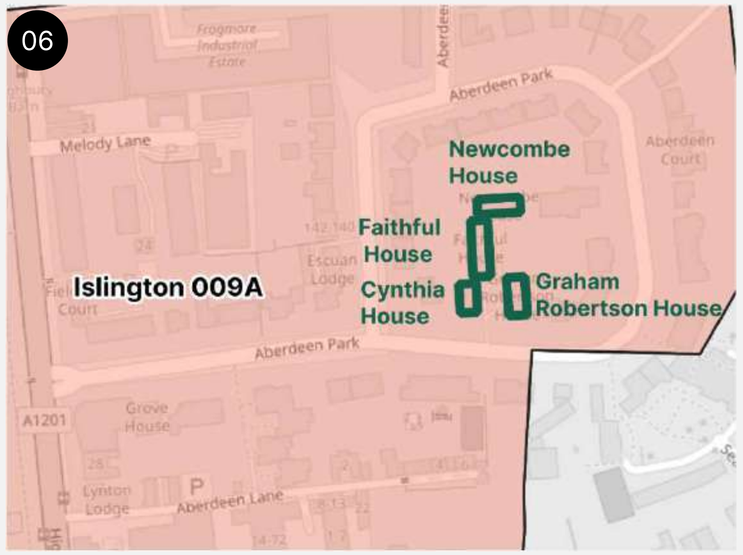
Indices of Multiple Deprivation across LSOAs within Islington

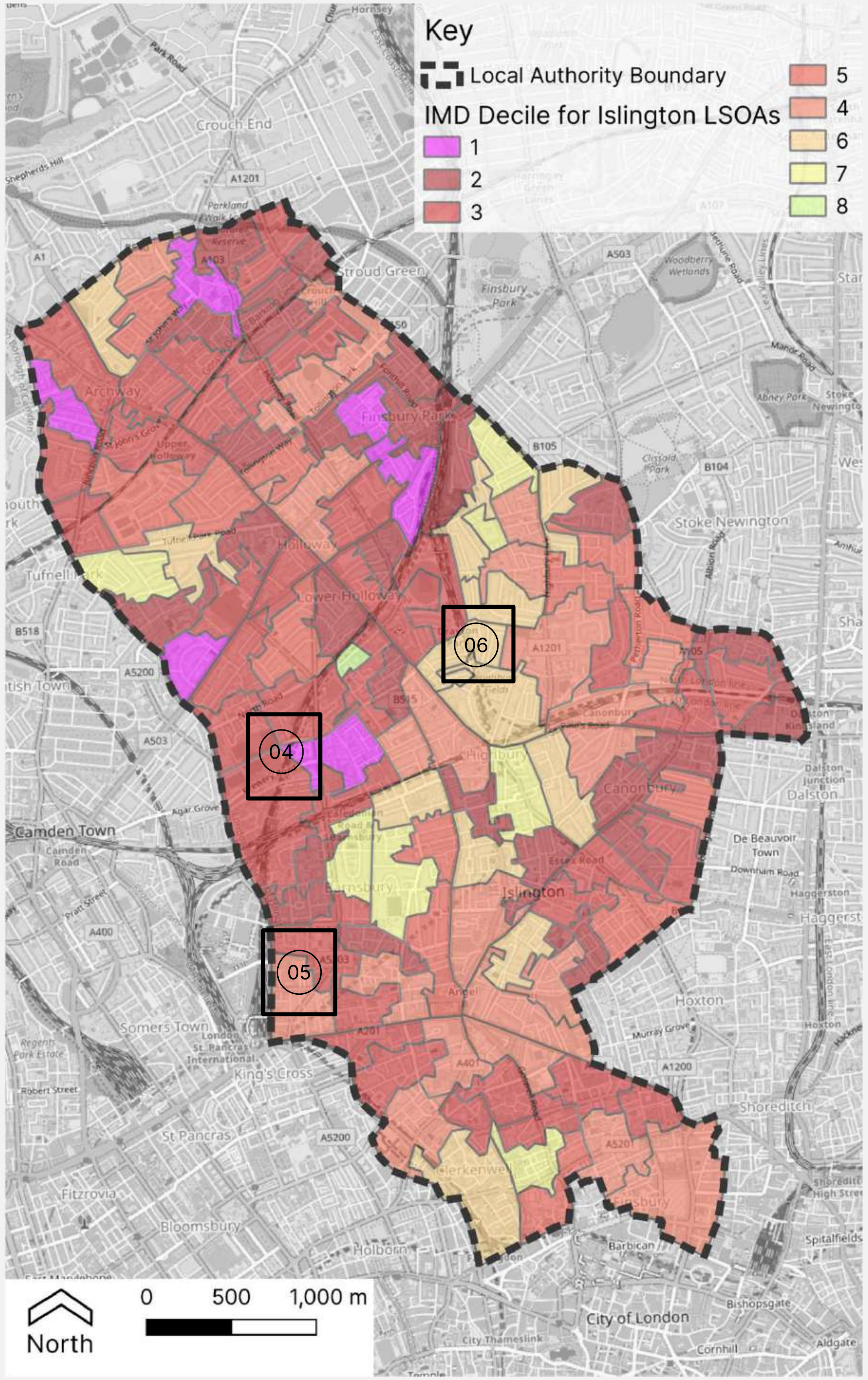
No care homes were located within the most deprived regions of Islington; therefore, a care home within an LSOA with a lower IMD Decile was selected to assess.

Additionally, a social housing project located within an LSOA with a lower IMD Decile was selected to assess for overheating. Newcome Estate was chosen in particular as it is currently undergoing energy efficient retrofit measures.

The dynamic thermal modelling will help understand if energy retrofit measures conflict with targets to minimise overheating risk within Islington.

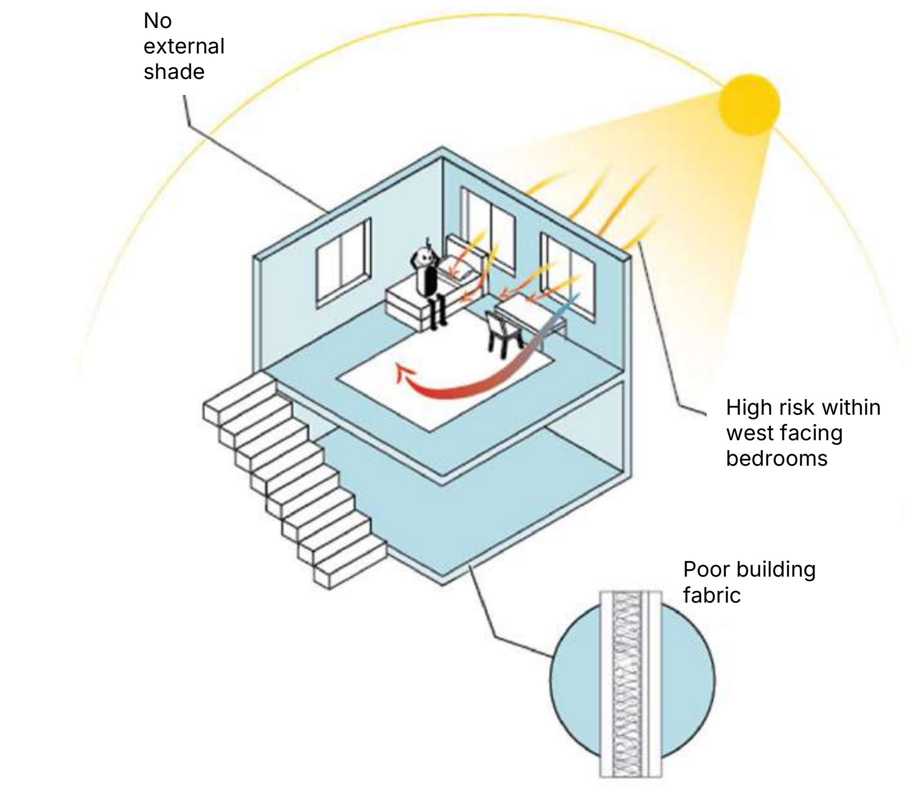






Indices of Multiple Deprivation across LSOAs within Islington

Low-rise residential



2020

34°C Peak temp

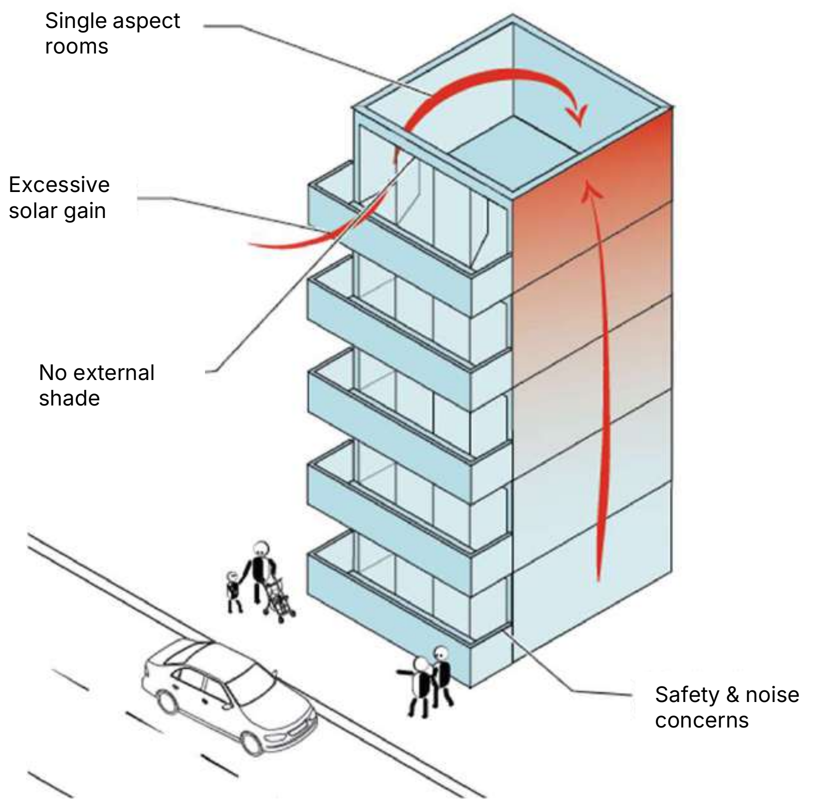
428 Total hours above 26°C

2080

44°C Peak temp

1800 Total hours above 26°C

High-rise residential



2020

36°C Peak temp

522 Total hours above 26°C

2080

48°C Peak temp

1820 Total hours above 26°C

Residential

Both low-rise and high-rise residential buildings are commonplace within the selected Islington LSAOs.

Indoor temperatures between 18-23 degrees is considered thermally comfortable. The Heatwave Plan for England states that indoor temperatures should ideally not exceed 26 degrees to maintain occupant comfort levels.

Low-rise residential buildings are more likely to provide larger, dual aspect spaces that allow for cross-ventilation. Amongst other factors, this subsequently makes low-rise housing experience lower temperatures than high-rise housing.

However, peak temperatures experienced were still high in both 2020 and 2080 weather files. When comparing the heat gains within a room on a hot day, which includes heat gains from the sun, lighting, equipment, and activity, solar gain is a significant contributor to the high internal temperatures.

West facing bedrooms in particular build up heat in the evening. This presents higher health and wellbeing risks for occupants as sleep can be severely disrupted under extreme indoor temperatures. Therefore, the buildings would benefit from incorporating external shade, especially ones that shade the sun later in the day.

Furthermore, iterations based on common energy retrofit measures were undertaken. External wall insulation and improved air tightness was not found to worsen the overheating risk within the buildings. The peak temperatures and the number of hours spent over 26°C experienced in the hottest rooms decreased after the retrofit measures, although the difference is marginal.

Regarding high-rise housing, west and south facing flats on the top floor are most at risk to overheating due to high solar exposure and lack of shading. High-rise buildings in Islington are typically characterised by high proportion of glazing and single-aspect rooms, signifying the importance of balconies, external shade, and adequate ventilation.

The thermal modelling was undertaken with the assumption that windows are openable. However, security was expressed as a worry amongst the interviewed Islington residents. Ground floor flats can experience significant overheating issues if open windows present security concerns, particularly at night.

Kirstie

Islington Resident

Kirstie shared her experience of how her daughter, Sophie, and family are impacted during the summer.

"That summer, my little daughter would've been just over a year old at the time. It was incredibly difficult; our mental health suffered enormously because she just could not sleep...she couldn't be awake either because it was incredibly uncomfortable."

"Little Sophie suffered terribly, which meant we suffered terribly, and no one slept in our household for weeks...there was no way to escape the heat."

Joseph

London Tenants Federation

Joseph works for the London Tenants Federation; he shared his experience talking to Tenants during the heatwave.

“[The heat] is a real worry for them [the tenants]. A lot of them are much older so they’re concerned about the impacts that such high heat can have on their health.”

“I’m really concerned about the buildings that people are living in, particularly blocks of flats.”

Joseph also shared his own experience living in a tall housing block.

“I live on the eighth floor of a block of flats; it means the heat is incredibly problematic...I couldn’t be in there during the day.”

Heather
Islington Resident

Heather shared her experience of working from home during the July 2022 heatwave.

“Myself and my husband have an air conditioning unit, but even we suffer with damp and mould in the winter and overheating in the summer in this flat we’re in.”

“Our bedroom is on the top floor in the attic, so it makes it even more unliveable...the portable AC unit is really loud and all of the electricity and gas prices were really high.”

"I live on the ground floor. I'm scared to leave the window open. So I've been thinking to put one of those gates so that I can leave it open so I don't get people coming in, but they [the council] say you're not allowed for health and safety and fire...So when I open the window at night, I need to be awake."

Alex

Islington Resident

Alex shared her experience living in a council flat during heatwave episodes.

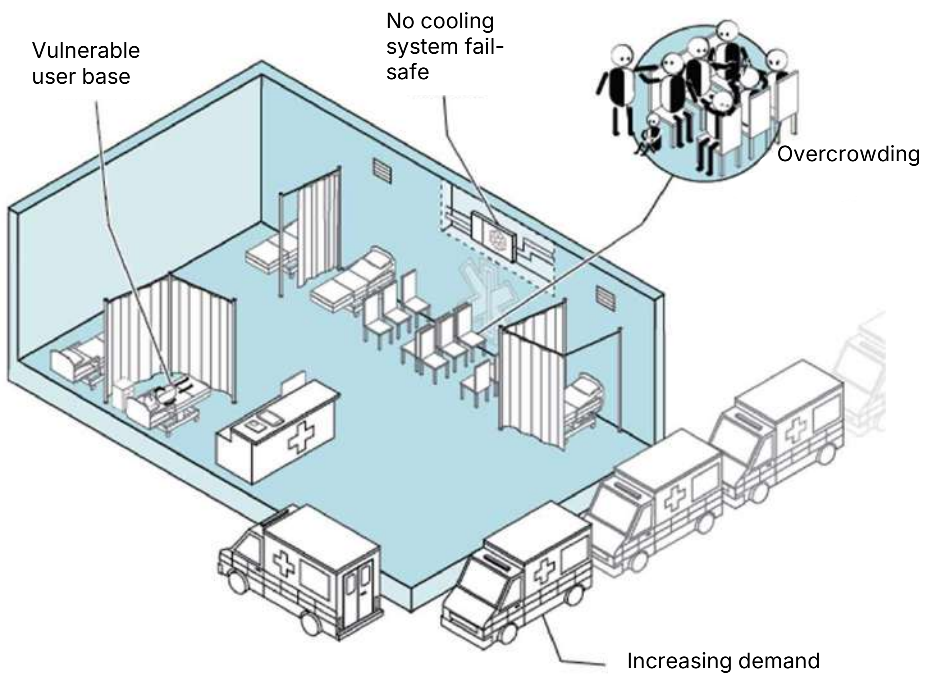
Camino

Islington Resident

Camino shared her experience as both an Islington resident and visitor of the Elizabeth House Community Centre.

"It was even hotter in the flat because it's the top floor...even with the windows open and everything at night time, it was bad."

"Well, I don't know how to deal with the heat either... maybe it's a cultural thing...because we don't have that much heat or that much sun, so people go out in the gardens when it's really, really hot."



A. Patient ward without air conditioning

2020

- 41°C — Peak temp
- 2200 — Total hours above 26°C

2080

- 50°C — Peak temp
- 3900 — Total hours above 26°C

B. Patient ward with air conditioning

2020

- 4.50 — Peak day cooling load kWh
- 13.50 — Annual cooling load mWh

2080

- 5.90 — Peak day cooling load kWh
- 19.70 — Annual cooling load mWh

Hospital

An overheating assessment was carried out for the portion of a hospital containing the main care wards, screening areas, canteen, and main reception area. Staff and patients will occupy these areas for prolonged periods and hence more likely to experience the impacts of overheating.

The hospital was assumed to provide active cooling to avoid the worst impacts from the heat; therefore, the overheating assessment was undertaken with and without air conditioning.

Reoccurring heatwave events could put both patients and staff at risk due to a strain on utilities and expected rise in emergency incidents. Additionally, in the event that the cooling system fails, peak temperatures in the patient wards have the potential to reach up to 41°C under current weather conditions and 50°C by 2080, both of which are extremely unsafe temperatures for patients and staff.

Patients are already in a vulnerable state of health. Subsequently, extreme heat cases can put further strain on the body to worsen their physical condition, and in some cases, be fatal.

For hospitals that are equipped with cooling, there is expected to be a 46% increase in annual cooling capacity by 2080 to keep the average patient ward at a comfortable temperature. Therefore, hospitals must be prepared for the significant increase in cooling demand with regards to financing, physical space, and installation.

Pamela

Islington Resident

Pamela shared her experience as a paediatric nurse in a children's ward.

"It didn't have to reach 40 degrees outside before it became unbearable inside the ward."

"All the drugs were melting... once they left the drug room, they became ineffective."

"It created a lot of stress in what was already a stressful environment...we were losing so much fluid yet didn't even have time to get water."

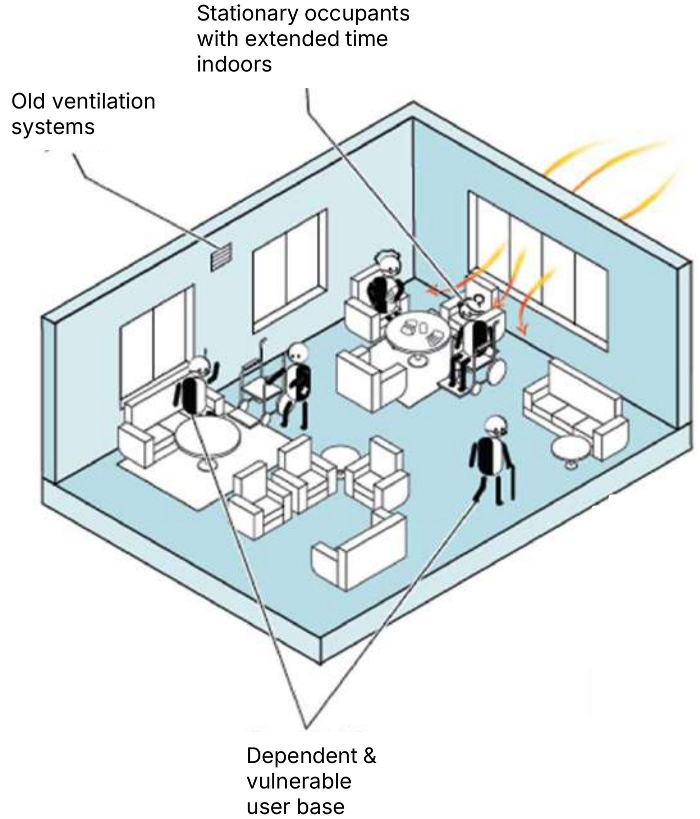
"It has a knock-on effect on the children who are already sick and have a temperature...they get irritable and less likely to eat."

Care Home

Considering the long-term stay and treatment of the most vulnerable, the high temperatures experienced within care homes illustrate the dangers arising from a lack of preparedness to rising temperatures.

The hottest rooms were found to be the lounge areas, where the patients are expected to spend the majority of their time.

Peak temperatures in the lounge have the potential to reach up to 34°C under current weather conditions and 45°C by 2080. Both temperatures are likely uncomfortable for staff and dangerous to the care home residents.



2020

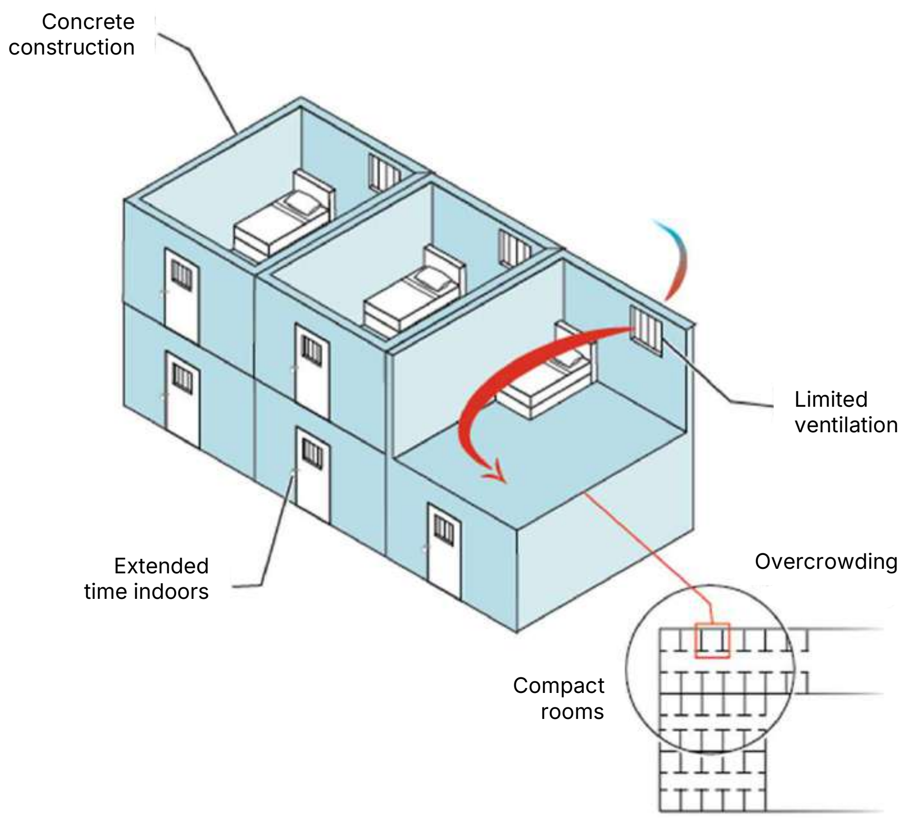
34°C
Peak temp

380
Total hours above 26°C

2080

45°C
Peak temp

1250
Total hours above 26°C



2020

34°C
Peak temp

340
Total hours above 26°C

2080

45°C
Peak temp

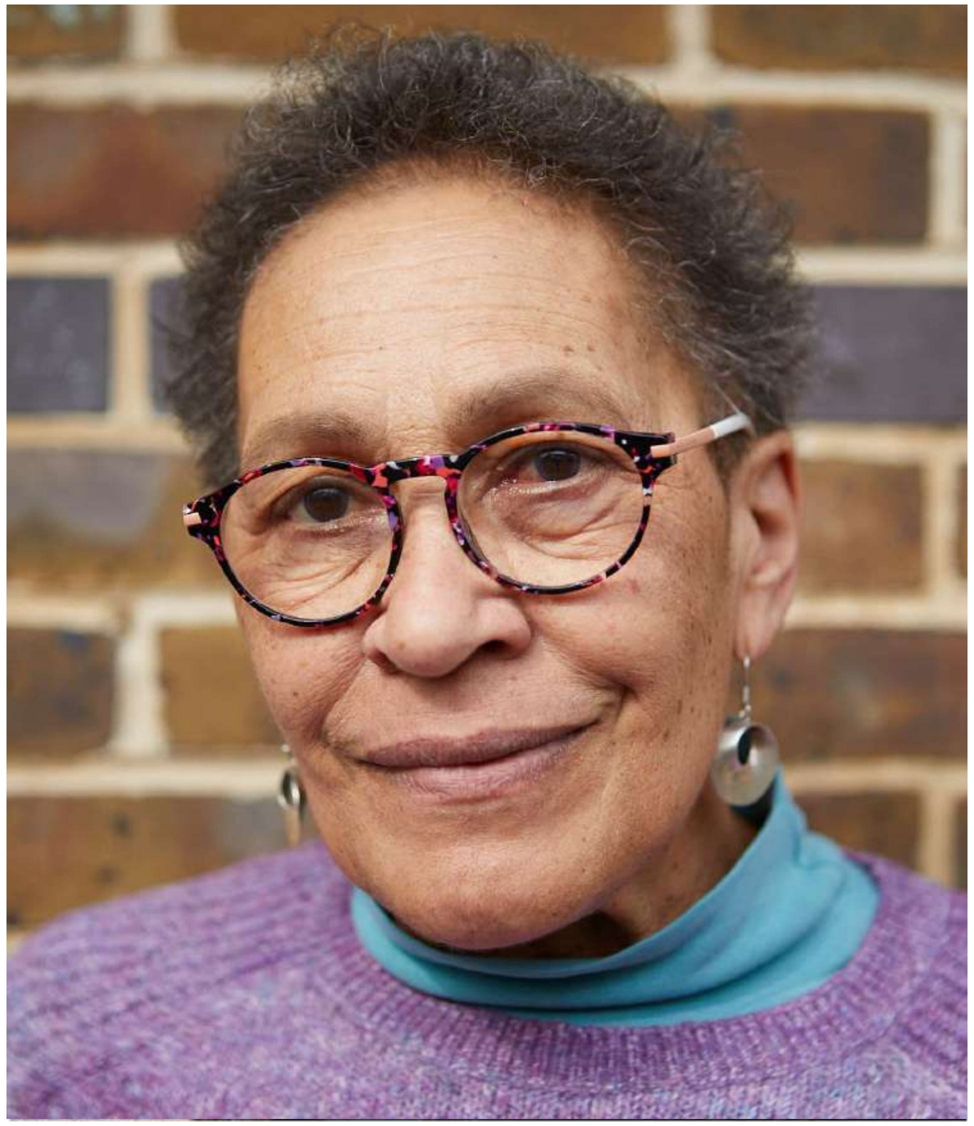
2020
Total hours above 26°C

Prison

Due to its use type, the prison complex is characterised by a large proportion of concrete surfaces, small cell rooms and limited window openings. By 2080, prison cells could reach temperatures greater than 26°C for 12 weeks of the year.

Similar to the other building archetypes assessed, west- and south-facing cells on the top floor present the highest overheating risk. Whilst glazing is not overprovided within prisons, the function of a prison heavily restricts occupants' choices to cool down, due to limited openings to windows, strict behavioural patterns and extended time indoors.

Furthermore, some prisons may be faced with overcrowding, which has not been factored into the overheating assessment. The excess of prisoners within confined spaces can lead to higher indoor thermal temperatures.



Lesley

Islington Resident

Lesley shared her experience of looking after her husband, who is diagnosed with Alzheimer's, during the heatwave.

"I'm always making sure my husband doesn't dehydrate...it was really hard to manage him then [in the summer] with his condition."

"He doesn't know if he's hot or not...you have to watch him all the time to make sure he's not wearing a jumper or overheating... it adds a lot of stress."

Elaine

Volunteer at the Hilldrop Community Centre
in Islington.

“We do gardening projects here, and we just felt that it was unsafe...we closed for those few weeks of the heatwave because we couldn’t risk [it]. People didn’t want to come; they wanted to stay at home.”

“Some of the people using the centre have a lot of mobility issues...there’s people using Zimmer frames or on walking sticks, and it can take them 20–30 minutes to come up here; that’s too long to be out in that heat!”

Elaine is the Community Manager at the Hilldrop Community Centre in Islington.
She shares her experience working during the summer months.

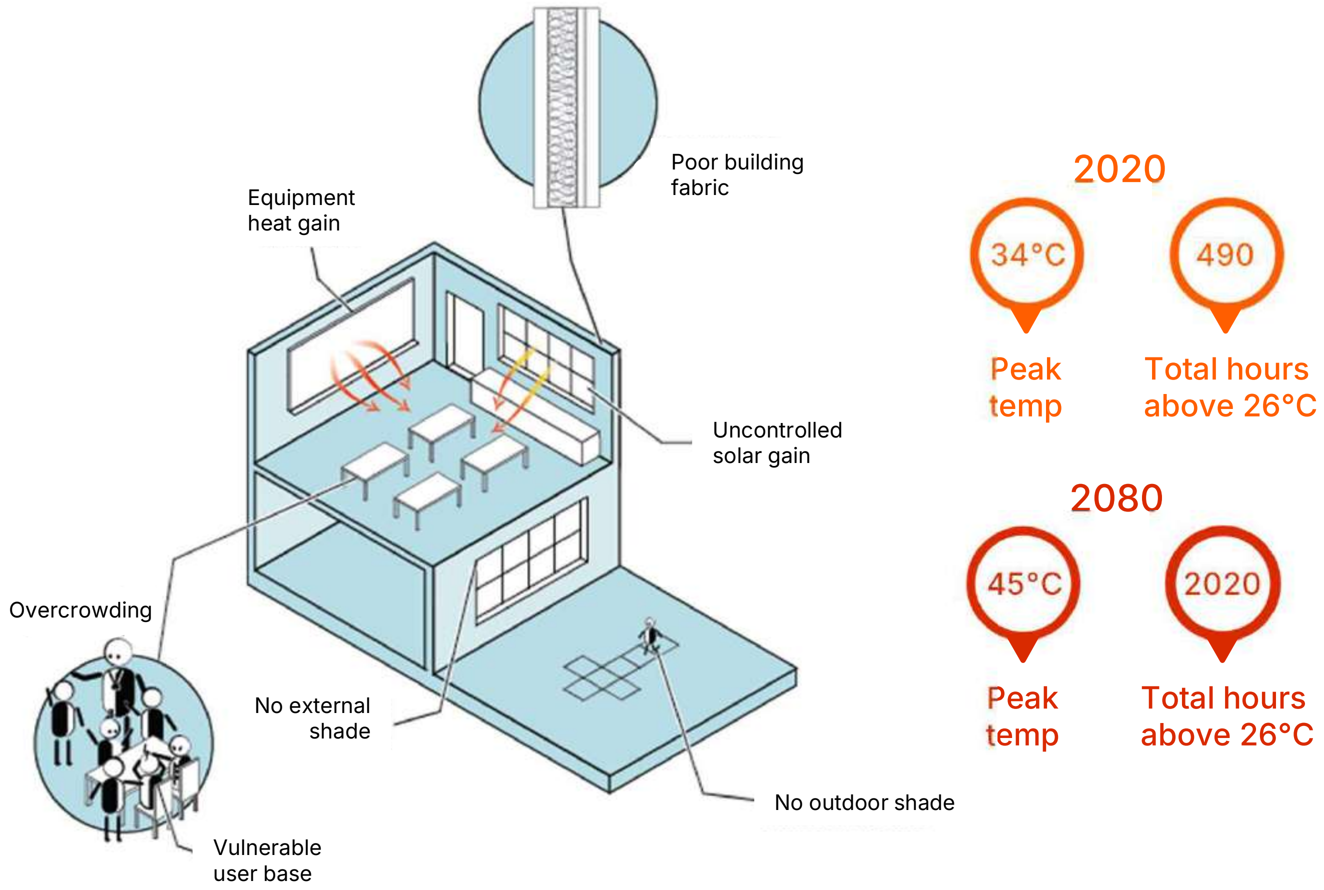
Primary School

School buildings in Islington are typically characterised by a high proportion of glazing to maximise daylight. The internal layout of the schools are based on a typical school's design, with classrooms positioned to have at least one external wall with multiple windows.

Poor building fabric associated with the age of the building, its south-west orientation and lack of localised shading presents key challenges for young children and members of staff occupying this space during the summer period.

Furthermore, school rooms, such as teaching spaces, have high occupancy levels and can experience large internal heat gains from people, lights and equipment, resulting in uncomfortable temperatures during warm weather periods. Through interviewing Islington residents, schools in Islington already experience overheating issues. With indoor peak temperatures in classrooms potentially increasing by more than 10°C by 2080 if we continue the current trajectory, there is an urgent need to manage heat risk within schools.

Children are particularly vulnerable to the impacts of climate change because of their limited capacity to respond to severe weather events. The potential health impacts of poorly ventilated spaces are drowsiness, headaches, sleepiness, poor concentration, loss of attention, increased heart rate and nausea.



"We couldn't teach...not much learning happened because they can't concentrate. They were very moody...some of them were even afraid."

Tabitha

Islington Resident

Tabitha shared her experience of working as a primary school teacher during the July 2022 heatwave.

Jonny

Pleasance Theatre Trust

Jonny shares his experience working at the Pleasance Theatre in Islington.

“With audiences just dropping off in this really hot period, that affects us as an unfunded venue...We’re a charity; we’re not a commercial entity so our ability to thrive and survive is based on our ticket income.“

“People just don’t want to come out to the theatre when it gets so hot... it’s a small room, it’s a stuffy room.”

Addressing the multifaceted impacts of heat risk must consider insights from diverse stakeholders; this will require multiple cross-scalar interventions.

The narratives provided in this report are just the tip of the iceberg, yet they underscore the lack of readiness of our current building stock in the face of climate change. These personal accounts of individuals in critical areas like homes, schools, hospitals, prisons and care homes stress the importance of taking proactive measures to tackle heat risk in Islington and beyond.

Results from the technical assessment of Islington archetypes further emphasise the extent of the issue across the borough. All different building types show concerning internal temperatures with increasing climate change, exacerbating the need for action.

Existing metrics and tools used to demonstrate overheating risk of buildings are complex and rely on complicated formulas with an impractical output for communicating issues effectively to the average person. This complexity represents a significant barrier to widespread comprehension and adoption of strategies to decrease risk, highlighting the need for an alternative, more user-friendly tool.

A metric that is both cost-effective in assessing risk of excess heat and which clearly communicates findings would serve as an effective tool for various stakeholders such as homeowners, property managers, landlords and policymakers to make informed decisions about heat resilience in properties. A greater focus is required in understanding the complexity of existing tools and their outputs, using diverse stakeholder perspectives to shape what this could or should look like.

Existing overheating metrics

03

Roundtable event

A roundtable event was held within Islington to share findings and understand the current view of overheating metrics from various stakeholders.

Key stakeholders involved included architects, local and regional authority members, engineers and property managers, residents, consultants and housing association representatives. Outputs and insights from the event have informed the methodology used to review existing metrics and tools currently used to assess overheating in buildings.

How do Islington stakeholders envision a successful heat metric?

The roundtable incorporated an 'idea generation' component where participants contributed ideas and to help shape what a successful heat metric could look like . Four key dimensions were explored: **solution, policy change, public engagement** and **impact.**

Solution

What does the product look and feel like? What information does it include? How do people access it?

- Legitimacy and trust are key components; the proposed solution demonstrates integrity and authenticity by being certified by a trusted institution or body.
- Clear and accessible for everyone as buildings are being accessed.
- Integrated within existing metrics (e.g. EPC) so there is a single place to go for climate risk information.

Public engagement

How do citizens, residents and organisations feel about the solution? How have they been engaged?

- Meet people where they are by listening, adapting approaches to different audiences, and by considering citizen assemblies.
- Signpost to solutions and actions, rather than just displaying the metric on its own.
- Prioritise the most vulnerable people and ensure their voices are heard.

Policy change

What local/national changes have taken place to implement the solution? Are there legal and regulatory requirements that have been considered?

- Amend or revise 'Part O' of the Building Regulations to include and mandate retrofit and non-residential buildings.
- Funding must also include public awareness and engagement campaigns alongside the solution itself, otherwise adoption will be sparse.
- Local authorities to incentivise adoption with tax breaks and favourable lending for implementing overheating mitigation measures.

Impact

How has the solution reduced harms from overheating? What positive social, environmental and economic impacts have been achieved?

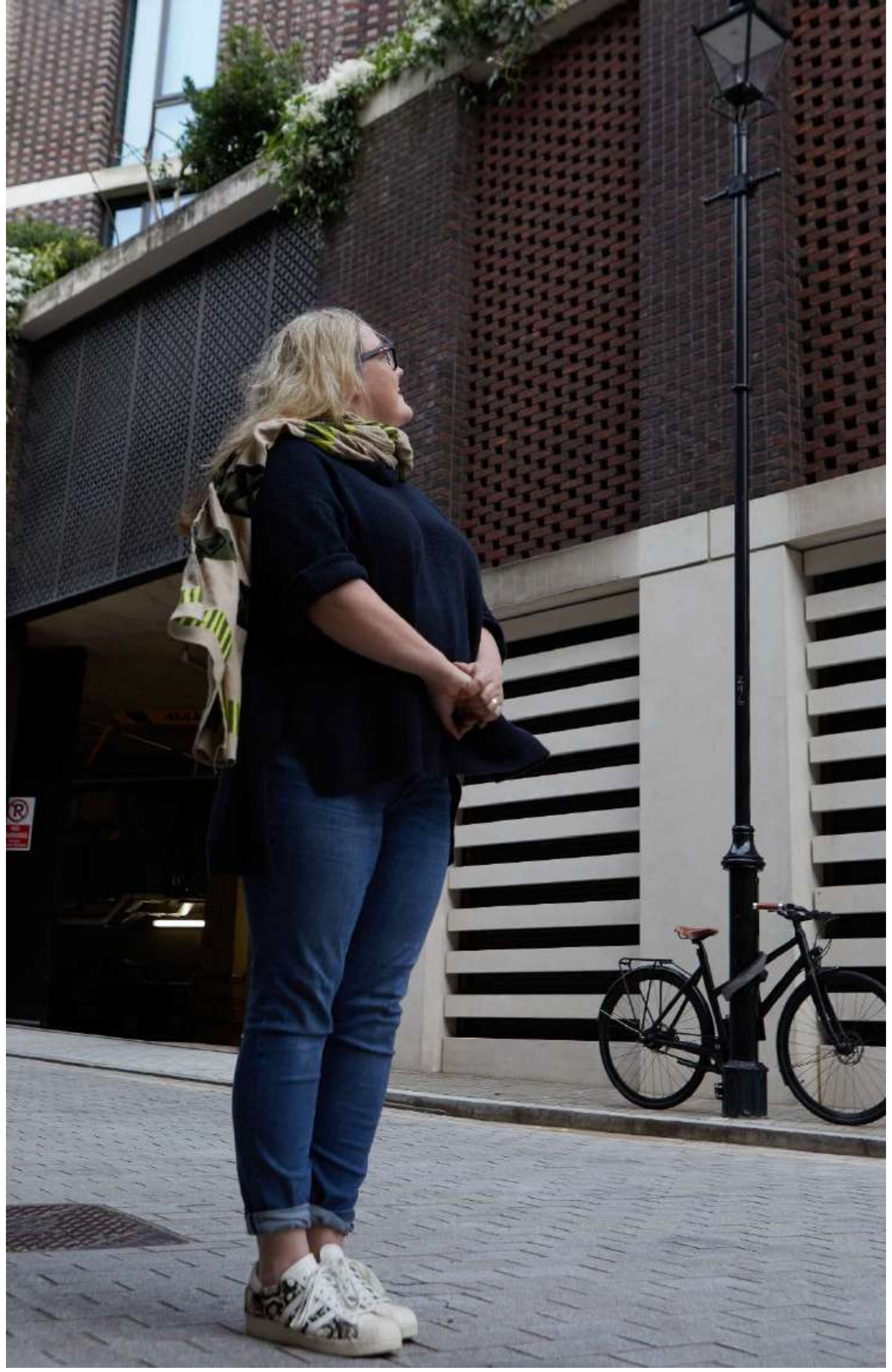
- Economic impacts are significant due to increased productivity and improved performance of the energy grid, away from forms of active cooling.
- Decreased number of excess deaths and improvements in mental health and wellness among the public.
- Increased understanding about overheating risks as a catalyst for wider climate action.

How would Islington residents respond to a heat metric?

Tabitha

"I think it would be helpful if it was easy to understand...it [a metric] would influence my decision to buy a place if the rating was bad as I might think how much would it cost to make it better and how much disruption is it going to cause."

"Although a lot of people are in denial that it is going to get hotter so they may not be influenced enough by the metric."



Kirstie

"Especially with a child, having gone through what we have gone through, [heat] would be at the forefront of our choice and the top of our criteria when moving into a new place...I can't believe it doesn't already exist."

Heather

"I would not have moved into this flat if I knew how boiling it was going to get."

"Being able to tell someone in the coldest of cold and the hottest of hot what they are going to be dealing with and what that's going to cost them in terms of their energy bills and their comfort levels. So yes, there should be a heat index but also one for health and wellbeing."

"So much of London is rented out by Landlords, and they have no incentive to improve their flats because they're not living in them. There needs to be crackdown on that to look after tenants"

A review was undertaken of the existing metrics and methods used for assessing overheating risk in buildings. Research was conducted to understand how overheating is understood from an international, European and UK context.

A metric is a system or standard of measurement, commonly used for comparing and tracking performance. In the context of the built environment, metrics can help understand how well a building is performing across different issues of interest.

A review of existing metrics has been undertaken by:

1. Assessing current overheating risk metrics that exist nationally, regionally and internationally.

2. Examining current and emerging technologies and software used to undertake overheating assessments.

3. Reviewing existing metrics that communicate complex issues.

The purpose of this review is to better understand how overheating is defined across the industry, and the challenges and opportunities arising from the different metrics currently employed globally.

By exploring these metrics and assessing ease of use and communicating outcomes, the report aims to develop the case for creating a user-friendly overheating metric that empowers a wider audience to make informed decisions on the overheating risk in their existing buildings.

Existing metrics that communicate complex issues

A review of existing metrics has been undertaken to evaluate the effectiveness of visual communication and comprehension (see Technical Annex A for the detailed review).

Six overarching typologies of existing metrics have been identified broadly encompassing the following key themes:

- Buildings and establishments e.g., BREEAM, LEED.
- Environment e.g., Air Quality Index, UV Index.
- Socioeconomic e.g., Human Development Index.
- Products and Services e.g., Audience Ratings, Eco-Impact Food Labels.
- Future projections e.g., Pollen Count.

The following key features were identified across the existing metrics.

1. Rating system

A scoring and rating systems provides a standardised way to rank items based on specific criteria. This approach serves to simplify complex information into a simplified output, allowing for comparison. Ratings can be numerical, such as the Food Hygiene rating, alphanumerical, such as the EPC, or tiered, such as BREEAM.

2. Colour gradients

Colour gradients are commonly used across existing metrics. The use of colour gradients creates a visually appealing and intuitive representation of the output from low to high without the need of supportive text.

The arrangement of the colours in a hierarchy enables quick comparison and is easily digestible to the layperson, aiding in decision-making processes among the target audience.

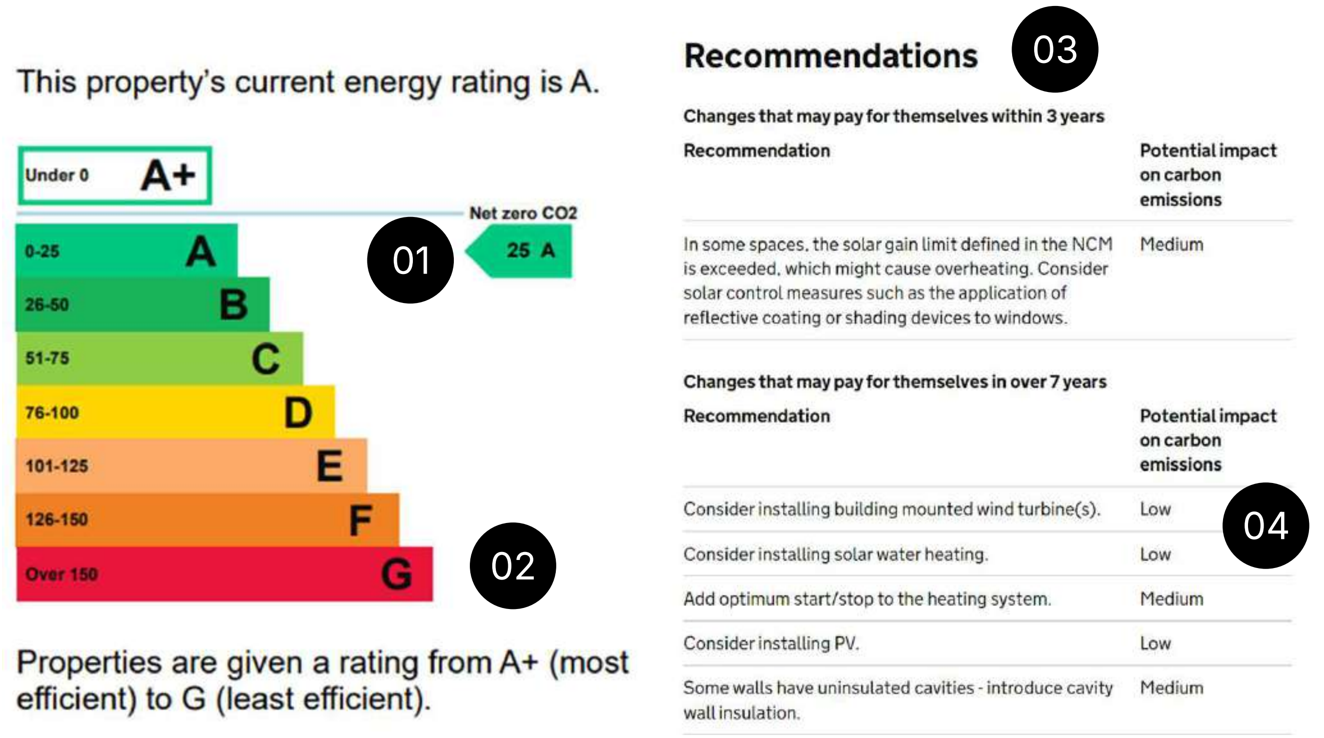
3. Disaggregation of data

The usage of layers to convey information is also particularly useful to break down complex information into smaller units. This approach provides more targeted information to the intended audience.

Complexity

The following questions were used to determine the complexity of the existing metrics: clarity, interpretation, accessibility, communication, interactivity, and detail.

Overall, the existing metrics present varying levels of effectiveness and accessibility, involving in many cases trade-offs between level of information incorporated, clarity, and ease of interpretation of the visual information.



Key features

- 01 Rating system from A–G
- 02 Colour gradient to visually communicate rating
- 03 Improvement recommendations classed by short- and long-term payback
- 04 Low–high scoring of recommendations by overall impact on energy

The EPC

Mostly notably amongst existing metrics for buildings is the Energy Performance Certificate (EPC); a document that assesses the energy efficiency of an existing building which provides information about how much energy a building uses. EPCs are mandatory when a building is constructed, sold or rented (with some exceptions). It is one of the most widely used building metrics in the UK.

An EPC provides a rating on a scale from A (most efficient) to G (least efficient), indicating to potential buyers or tenants the energy performance of the property and its likely running costs. This information can help them make informed decisions about where to live or work, potentially saving money on energy bills. A higher EPC rating can also enhance the value of a property. Buyers and tenants often prefer buildings that are more energy efficient due to the associated cost savings and carbon savings.

EPCs provide specific recommendations for improving the energy performance of a building, such as insulation or renewable energy. The recommendations are classed by short-term (3 years) and long-term (7 years) payback and have a low–high rating by its overall impact on energy.

Existing overheating metrics

11 existing overheating metrics were identified across an international, European, and UK context. The complexity of the existing metrics was evaluated by their methodology and how the overheating results are generated and communicated (see Technical Annex A for the detailed review).

Regarding the least complex overheating metrics, the **Good Homes Alliance** have established an **Overheating Tool** for initial assessments of thermal comfort. The tool provides guidance for identifying and mitigating early-stage overheating risks in new homes, which uses simple inputs, such as glazing areas and present shading, to determine risk levels.

The UK Building Regulations have also devised a tool for assessing risk of overheating in new dwellings in the UK. **Part O Approved Document** of the Building Regulations is a document encouraging the design and construction of buildings that limit unwanted solar gain during the summer months and provides occupants with adequate means to remove excess heat from indoor environments. The document provides the **Part O Simplified method** for early assessments of overheating risk, setting out maximum limits on glazed areas and minimum limits on window opening areas.

Well-established certifications, such as **Passivhaus,** The BRE Environmental Assessment Method (**BREEAM)**, and **WELL,** include overheating assessments with mid-level complexity. Overheating is not the sole purpose of these accreditations, instead they include an overheating assessment for new buildings to earn points towards a higher certification grade.

More complex standards, such as the North American **ANSI/ASHRAE 55,** the Eurasian **ISO 7730,** and the UK's **TM52** and **TM59** by the Institution of Building Services Engineers (CIBSE) provide guidance on how to predict overheating risk and degree of discomfort of people within buildings by establishing an 'acceptable' range of temperatures.

Although despite the high complexity of these standards, they fail to account for the magnitude and duration of extreme heat events. A noted example is the weather files applied within the CIBSE overheating assessments; the consecutive days of 40°C experienced during the 2022 heatwave is represented within a 2080s weather file rather than the 2020s weather files used to demonstrate current heat risk[17].

Overall, the metrics were determined to be overwhelmingly complex, largely due to the expertise requirements and generated outputs that are difficult to understand for the layperson. However, the less complex metrics identified are not comprehensive enough to tackle overheating risk and present the most suitable solutions for each building. Furthermore, the majority of metrics cater towards assessing new homes rather than existing buildings.

Existing overheating technologies

In this context, 'technology' refers to software used to assess overheating. 13 existing overheating technologies were identified across an International, European, and UK context. Examples include IESVE, Autodesk CFD, and Rhino.

Overall, the existing technologies are highly complex, and although more complex tools generate rigorous and accurate results, these are also associated with higher costs

Time

Time taken to complete the overheating assessments is high amongst most of the existing technologies, particularly when experts and/or specialised equipment are required. This therefore represents a key barrier to stakeholders such as landlords, housing associations, and tenants who may benefit from a better understanding of overheating risk in their buildings as time is associated with higher costs.

Access

Most of the assessed technologies are highly inaccessible to the layperson. For example, IESVE and SimScale, among others, require high levels of expertise within the industry to undertake these assessments. In many cases, the large number of expected inputs demands highly skilled users. The complexity of the methodology is reliant on the number of data inputs required, level of knowledge and/or expertise needed to perform the assessment, and number of steps involved in the process.

Communication

The technologies have a high level of jargon and quantitative technicality. Despite providing more comprehensive and concrete outputs, the results are limited in visuals and present very limited interactivity for users.

Cost

Costs represent a further barrier to accessing these tools in the first instance. In the rare cases where available tools are open access, such as the Ladybug ecosystem, these are also highly technical, requiring familiarity with coding to utilise their full potential.

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Overall, the metrics were determined to be overwhelmingly complex, largely due to the expertise requirements and generated outputs that are difficult to understand for the layperson. However, the less complex metrics identified are not able to determine overheating risk in existing buildings and present the most suitable solutions. Furthermore, the majority of metrics cater towards assessing new homes rather than existing buildings.

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04

Developing a new metric

Developing the heat metric

The goal is to create a robust and effective system that addresses the diverse needs and experiences of different buildings and communities. As discussed with stakeholders and residents, the following must be considered when designing the heat metric:.

Legitimacy and trust

The proposed heat metric solution must demonstrate integrity and authenticity to gain widespread acceptance. This can be achieved by having the metric certified by a trusted institution or body, which ensures that the information provided is credible and reliable.

Clarity and accessibility

The information should be clear and accessible to everyone. As buildings undergo assessment, the data should be easy to understand and readily available. Integrating the heat metric within existing frameworks, such as the Energy Performance Certificate (EPC), ensures a single, unified source of climate risk information. This approach could ensure the established credibility and recognition of the EPC, making the new metrics more acceptable and user-friendly.

Policy changes

To support the implementation of the heat metric, necessary amendments could be made to existing regulations i.e. revising 'Part O' of the Building Regulations to include and mandate retrofit and non-residential buildings. Additionally, funding could be allocated not only for the technical aspects of the solution but also for public awareness and engagement campaigns. Local authorities should incentivise adoption through tax breaks and favourable lending conditions, encouraging widespread implementation of overheating mitigation measures.

Public engagement

Effective public engagement is crucial for the success of the heat metric solution. Engaging with residents, and organisations through listening and adapting approaches to different audiences is necessary. Considering citizen assemblies can provide a platform for diverse inputs and ensure inclusivity. It is important to signpost solutions and actions rather than merely displaying the metric, ensuring that the public understands and acts upon the information. Prioritising the voices and needs of the most vulnerable populations ensures that the solution is equitable and comprehensive.

Impact and benefits

There are economic benefits of the heat metric by increasing the workload for those working in the built environment sector.

Whether it be from an increase in jobs for assessors or increasing the workload for builders there may be an injection into the economy from requiring a heat metric assessment; however, there are immediate costs to the homeowner/ landlord/building owner for preparing a heat metric assessment, so cost effectiveness needs to be considered at the next stage of the heat metric development. Increased productivity and improved performance of the energy grid, moving away from active cooling forms, are some of the advantages. Additionally, there will be a decrease in excess deaths and improvements in public mental health and wellness. By promoting a
better understanding of overheating risks, the heat metric can act as a catalyst for broader climate action.

Complexity and individual experiences

Conducting interviews to understand narratives and assess different building types highlights that overheating mitigation and resilience are complex issues. No two buildings or people's experiences are the same. This complexity underscores the importance of avoiding overconfidence in defining the heat metric at this pilot stage. A nuanced approach is required, and further analysis and a larger UK-wide scheme are necessary.

This broader perspective ensures that insights are gathered from multiple viewpoints and stakeholders, allowing for a more comprehensive and effective solution.

Ideas and examples

This section presents concepts and illustrative examples for communicating heat metrics and indices, aiming to aid understanding and practical application.

We have consulted with stakeholders in Islington to help curate some abstract ideas.

1. **The certificate approach**

One proposed method is the development of a Heat Metric Certificate, similar to the Energy Performance Certificate (EPC).

This certificate would provide a detailed assessment of a building's thermal performance, offering clear and concise information that stakeholders can use to make informed decisions about energy efficiency improvements against thermal improvements.

2. The data approach

Another approach could involve incorporating raw data curated in a way that provides detailed information about the performance of each room in a building.

This method would ensure that thermal performance data is included in the standard energy efficiency evaluation, making it more comprehensive and informative.

Developing a centralised, online database accessible to the public could offer a comprehensive repository of heat metrics. This platform would enable stakeholders to access, compare and analyse thermal performance data across various buildings, promoting transparency and informed decision-making.

An online database would serve as a valuable resource for researchers, policymakers and the public, facilitating widespread engagement with the data.

3. The simple approach

To enhance visibility and public awareness, a sticker type system, similar to the Food Hygiene Rating or UV Index, could be introduced. Buildings would display a heat rating sticker at prominent locations, providing immediate visual cues to occupants and visitors about the building's thermal efficiency. This approach would make the information more accessible and easily understandable for a broader audience.

4. The design approach

A heat metric could take the form of a set of plan drawings of the building with an overlay describing the overheating risk. This visual representation would make the data more intuitive and relatable for users, enabling them to see which areas of the building are most susceptible to overheating.

This approach would enable occupants, owners and stakeholders to better understand and address the thermal performance of their buildings.

These suggestions are preliminary concepts intended to initiate discussion and innovation.

They highlight the need for a cohesive, UK-wide strategy to ensure comprehensive insight and collaboration among diverse viewpoints and stakeholders.

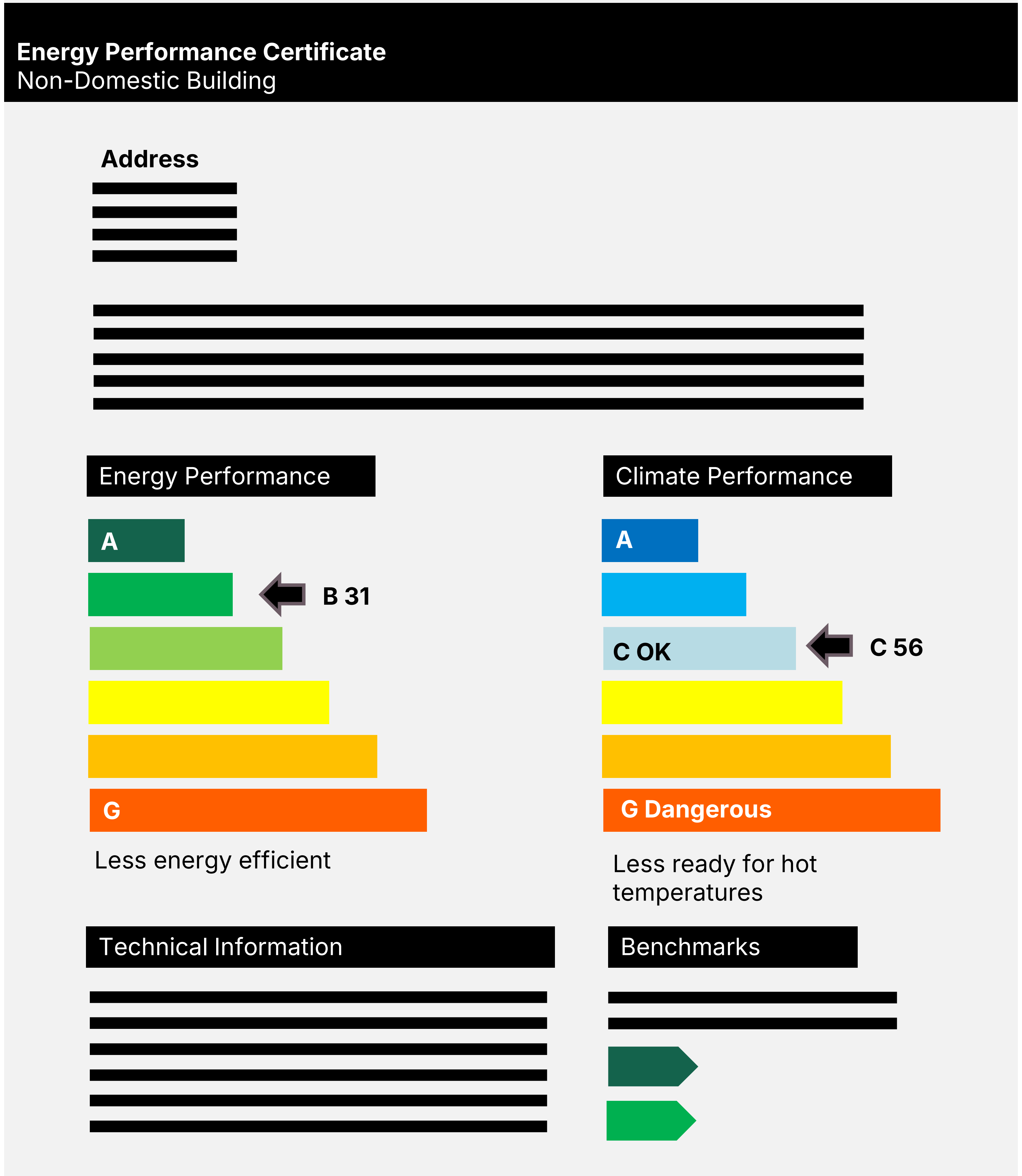
1. The certificate approach

One approach is to combine the current EPC methodology and certification output with a thermal/climate performance index based on overheating risk.

This would mean that one assessment would be carried out for dual purposes, effectively halving the workload.

A database already exists for EPCs so information could be found online for those who wish to find it.

However, the nuances of the building and occupier may not be picked up within the calculation method.



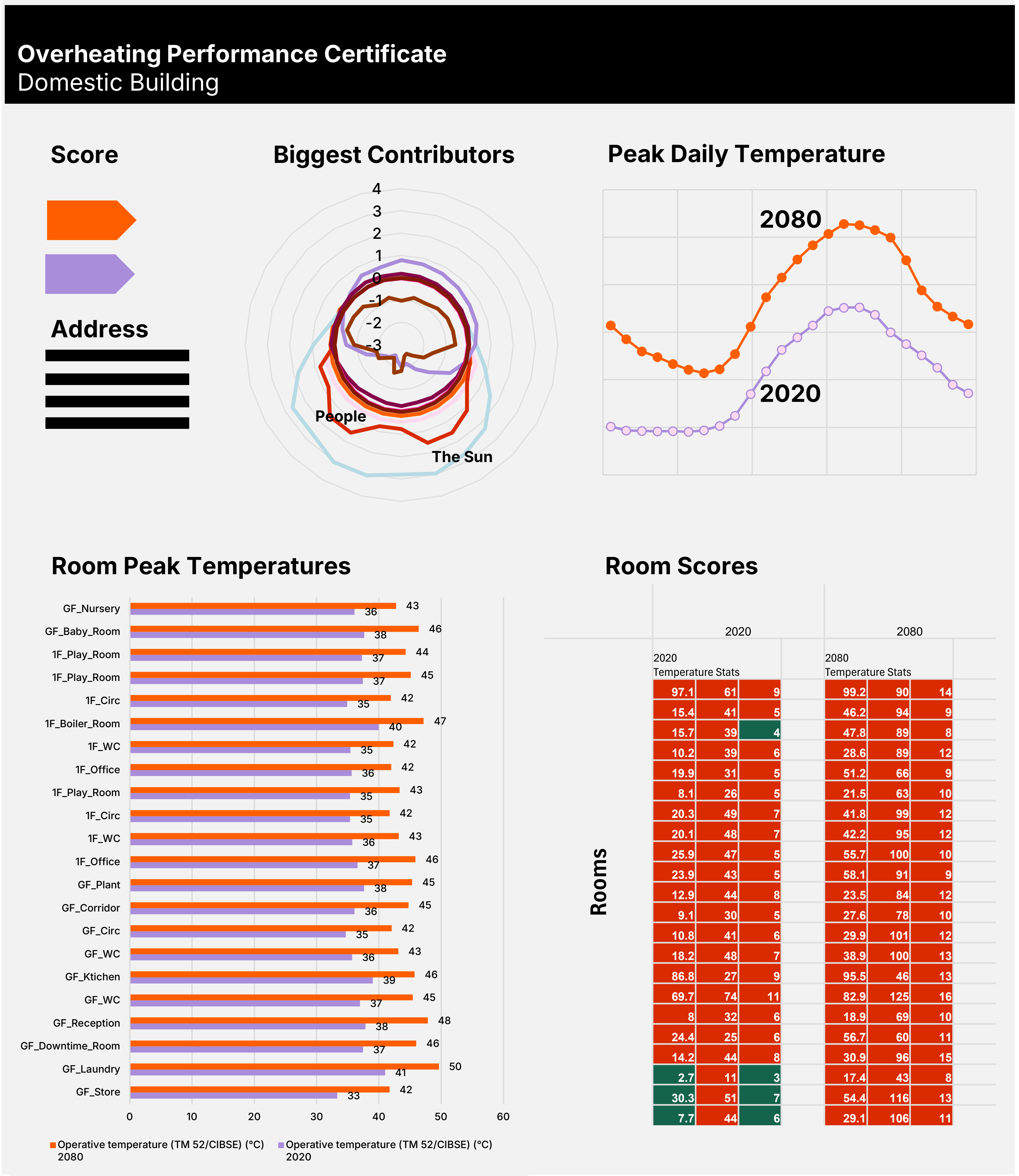
2. The data approach

Another approach is to provide the building owner with more of the raw data to inform them of the particular issues in each room and expected peak temperatures.

However, doing this runs the risk of being overcomplicated and turning building owners off as it may be difficult to interpret the figures.

Alternatively, this information could be stored in a database, but not necessarily form part of the certificate.

This approach is more reliant on more complex modelling methods than simple checklists.

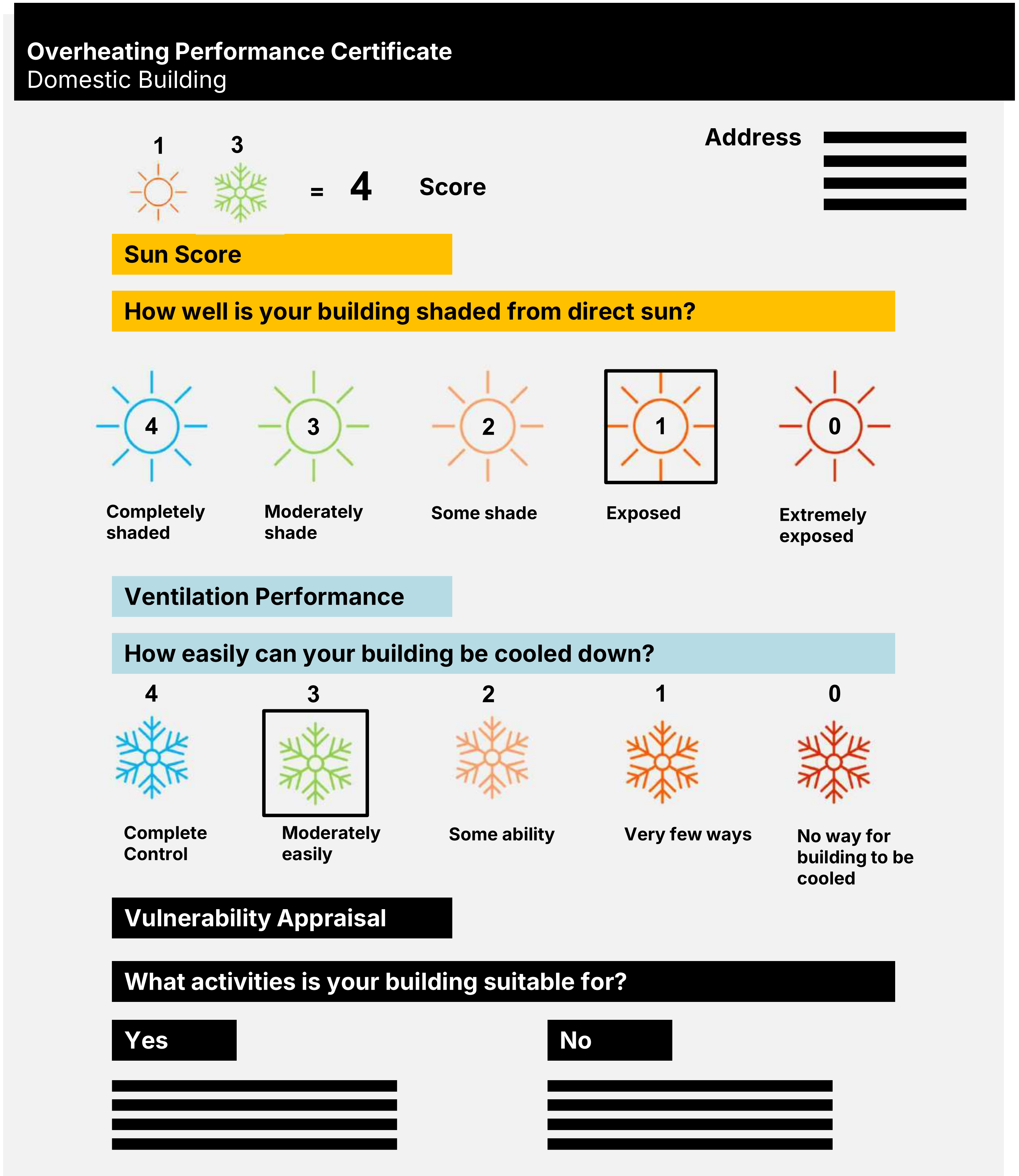


3. The simple approach

Based on studying the various examples in Section 3, a simple way of communicating risk could be provided.

This example could utilise illustrations, focusing on the two core principles of overheating mitigation in building design:
a. solar gains/exposure;
b. the ability to get rid of heat from a space.

This could then drive an output of recommendations describing who the space is suitable for, i.e. if a room in a building is found to be dangerously hot, then the building would not be considered suitable for vulnerable groups.



4. The design approach

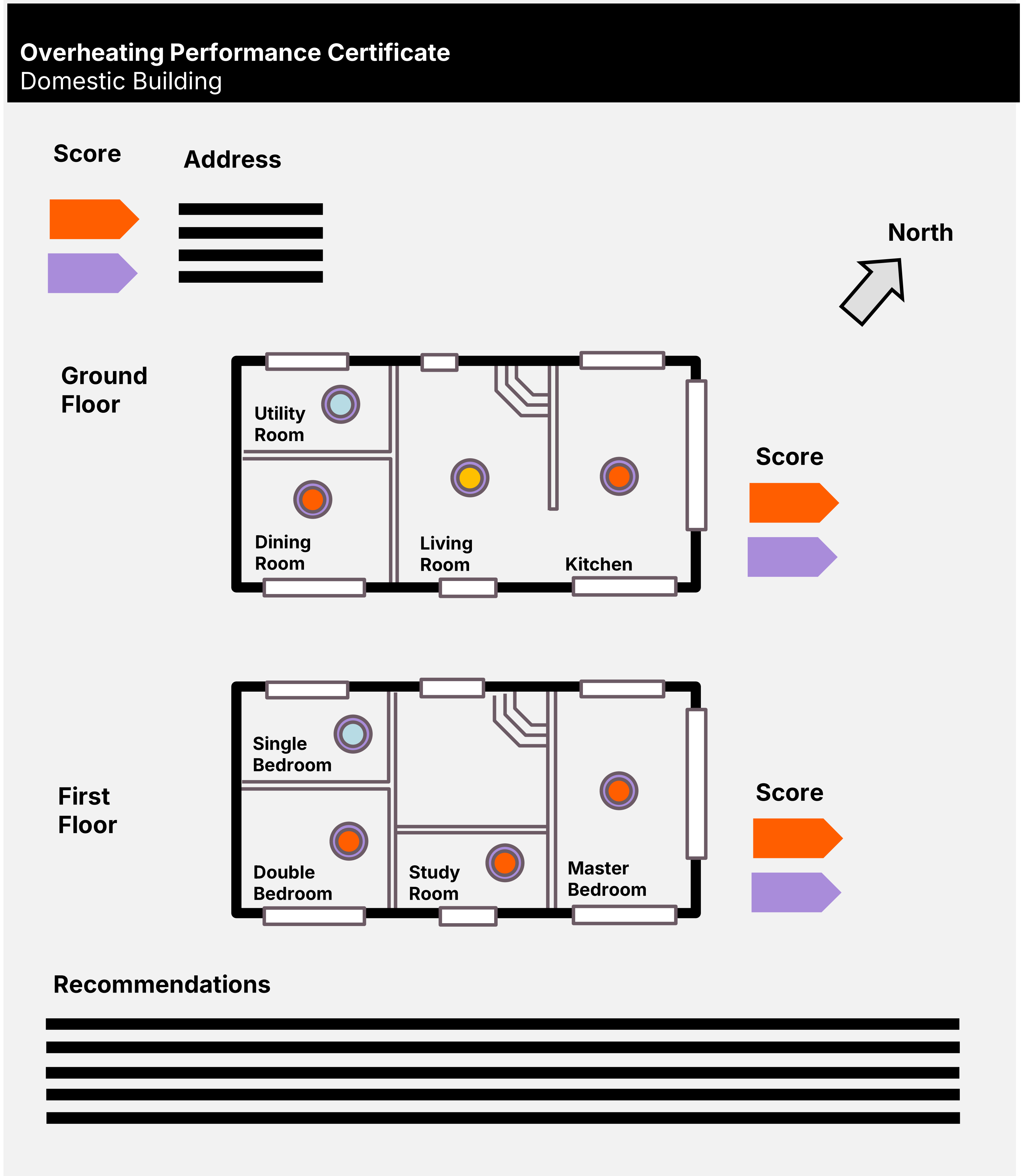
In a similar fashion to a fire escape plan drawing, the floorplate could be used to illustrate overheating risk per room.

In this example, we could coloured symbols to explain the peak temperature and vulnerability risk per room.

A separate entry could provide recommendations per room.

The software could be combined with existing geometry building simple software tools and artificial intelligence/3D camera tools.

This will become more challenging for more complex buildings.



05

Next steps

Overheating assessment summary

An overheating assessment was undertaken on a select number of building archetypes within Islington to demonstrate the current vulnerability of heat risk within Islington buildings and to refine and optimise the metric based on real-world scenarios.

The outcomes from the pilot assessment overwhelmingly demonstrate that Islington's building stock is not ready to withstand the increasing risk of excessive heat. This presents serious implications for buildings providing key public services in the borough, such as care homes, educational institutions and hospitals, given the high risk for occupants particularly during peak heatwave events.

Residential buildings assessed further demonstrate the lack of preparedness in the borough: council homes, flats and housing estates, particularly those south-facing or with a high proportion of glazing, place dwellers at high risk of overheating.

Islington is not prepared for increasing temperatures.

Narratives

Although the heatwaves in 2022 led to more than 3,000 excess deaths, this has not been translated into urgent action to adapt our buildings and spaces to prevent this from happening again. There is currently a reliance on statistics to convey the impacts of overheating, rather than the nuanced and unique telling of human experience.

Anecdotal evidence from interviews of Islington residents helped contextualise how buildings in the borough perform under high temperatures. Emerging themes from the narratives highlight how locals perceive the increasing heat as 'inescapable', impacting those must vulnerable, in flats and social housing, the most. Their stories emphasise the need to consider vulnerabilities in future climate change adaptation strategies within the built environment.

Existing metrics

Metrics available in the market for demonstrating overheating risks of buildings tend to be overly complex with an impractical output for communicating the issues effectively to the average person. This complexity presents a significant barrier for homeowners and tenants in understanding the risk of overheating within their building.

Next steps and further considerations

Explore additional software options and incorporate mapping

This pilot study used one type of dynamic software tool, and the 'overheating' criteria set out in CIBSE TM59 and TM52 guidance references. This was used due to being a well-established tool for predicting overheating risk within buildings in the UK. Further research should build on this and explore overheating outputs utilising a wider range of software tools as described in Section 2 and 3 of the report.

Incorporating mapping techniques into follow-on research would be beneficial for visualising and better understanding the impacts of the UHI effect on the urban fabric. This approach would also enable overheating to be considered holistically at the neighbourhood level, complementing a focus on building archetypes.

Economic feasibility study

Following the exploration and refinement of potential new metrics for overheating, further market research is needed across the UK to understand stakeholder perceptions of these options. This research should consider complexity of metric options, aesthetics, and ease of use and communication. Such an approach would maximise the co-production of their design, ensure alignment with user needs, and enhance adoption.

From local to national

Given the project budget's constraints, this pilot study has focused on the local level of Islington, specifically targeting the most deprived areas of the borough (in selected LSOAs). Further research should build a wider picture of the risk of overheating across all local authorities in the UK to increase understanding of heat risk at a neighbourhood level. The research should incorporate a broader range of archetypes and representative building stock across the UK to better reflect the vulnerability of a wider range of building occupants.

Next steps and further considerations

Further development of the metric

A national approach to developing, piloting and testing the heat metric ideas would promote consistency, reliability and widespread adoption, ensuring that the benefits of these heat metrics are realised on a broad scale. Further development and refinement of these ideas are essential to address practical implementation challenges and optimise their effectiveness, as uptake of the metric will also be dependent on the local context.

Combining the quantitative data-rich nature of this pilot study with enhanced qualitative research techniques would enable a deeper understanding of the requirements required to design and expand a heat metric and ensure its usability to inform behaviours and practices. An expanded, well-structured and rigorous research study, covering the whole UK, can ensure that these heat metrics provide valuable insights and drive meaningful improvements in the energy efficiency of buildings.

Conducting interviews, focus groups and in-lab testing to understand how narratives can be effective in assessing experiences of overheating in different building types highlights that overheating mitigation and resilience are complex issues. No two buildings or people's experiences are the same. This complexity underscores the importance of avoiding overconfidence in defining the heat metric at this pilot stage. A nuanced approach is required, and further analysis and a larger UK-wide scheme are necessary. This broader perspective ensures that insights are gathered from multiple viewpoints and stakeholders, enabling a more comprehensive and effective solution.

Going beyond information provision

A carefully designed and tested metric would provide an effective way to convey complex information about overheating in buildings, and enable residents, tenants and building owners to better understand the overheating status of their buildings. However, it is essential that this metric is part of a suite of measures adopted simultaneously to enhance awareness, preparedness and responses to extreme heat.

Other measures could include broader yet targeted communication campaigns, behavioural guidance, nature-based cooling solutions, resilient infrastructure, regulation, policy, practice and governance. This would ensure that a whole systems approach is adopted to better prepare people for the impacts of overheating in buildings. Further research is needed to identify the optimal combination of different measures and tools to ensure the information conveyed via the metric is understood and taken up by different building occupants and stakeholders. This includes developing robust indicators to measure the effectiveness and impact of the metric uptake.

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Glossary

ANSI/ASHRAE 55	Standard establishing the ranges of indoor environmental conditions to achieve acceptable thermal comfort for occupants of buildings.
Ansys	Engineering simulation and 3D design software utilised to perform thermal analysis among other capabilities.
Autodesk CFD	Software tool relying on computational fluid dynamics simulations utilised to predict behaviour of liquids and gases.
BREEAM: Hea 04	The BRE Environmental Assessment Method (BREEAM) is an assessment method which sets standards for best practice in sustainable design through established criteria and a scoring system allocated to different categories. The aim of Hea 04 (thermal comfort) is to ensure that appropriate thermal comfort levels are achieved through design, and controls are selected to maintain a thermally comfortable environment for occupants within the building.
Cen 13790	Standard specifying calculation methods for the assessment of energy need and cooling, heating and cooling load and internal temperature of new buildings among other variables.
CIBSE TM52 and TM59	Design-stage methodologies created by the Chartered institution of Building Services Engineers (CIBSE) to use to assess the predicted level of thermal comfort within a building. The method being employed (TM52 for all building types or TM59 typical for flats and houses) depends on the building type being assessed.
DesignBuilder	Simulation software which provides advanced building performance simulation to undertake building energy and thermal comfort analysis.
EnergyPlus	Whole building energy simulation programme used to both model energy consumption and water usage in buildings. The tool can be further used to provide heat balance-based solutions following surface temperatures thermal comfort calculations.

Glossary

Good Homes Alliance	A non-profit sustainability organisation undertaking collaborations with relevant stakeholders towards the achievement of energy efficient and comfortable residences. The alliance has created a tool and guidance for identifying and mitigating early stage overheating risks in new dwellings, and was formally launched in 2019.
IESVE	Software tool which enables the simulation of internal temperature conditions allowing users to establish whether threshold conditions of thermal discomfort will be reached. This dynamic thermal modelling approach offers greater accuracy and flexibility when performing overheating assessments, and it is recommended by the CIBSE as a tool.
ISO 74	The Dutch adaptive thermal comfort guideline introduced to assess overheating risks in new buildings. The 2014 revision (ISO 74) introduces requirements which combine traditional non-adaptive comfort standards with elements of adaptive standards.
ISO 7730	Method for predicting the general thermal sensation and degree of discomfort of people exposed to moderate thermal environments. It enables determination and interpretation of thermal comfort, giving the environmental conditions considered acceptable for general thermal comfort as well as those representing local discomfort.
Part O Simplified	Document within the Building Regulations encouraging the design and construction of buildings that limit unwanted solar gain during the summer months, and provide occupants with adequate means of removing excess heat from indoor environments. The simplified method sets maximum limits on glazed areas and minimum limits on free areas for ventilation through openings.
Passivhaus	International energy performance standard which focuses on reducing requirement for space heating and cooling while enabling excellent indoor comfort levels, including risk of overheating.
PHPP	Detailed overheating guidance and tool plugin developed by the Passivhaus Trust covering design strategies to reduce risks, limitations and constraints that may have an impact, key indicators of likelihood of risk, and a series of stress tests to demonstrate robustness of assessment.

Glossary

prEN 16798-1	Document specifying requirements for indoor environmental parameters for thermal environment, indoor air quality, lighting and acoustics. Provides guidance on how to establish these parameters for building system design and energy performance calculations.
Rhinoceros and Ladybug	Open access tools and suite of free resources compiled in an ecosystem utilised to undertake 3D modelling and thermal comfort analysis through the incorporation of plugins.
SAP 2012	The Standard Assessment Procedure (SAP) 2012 was used until recently for building regulation compliance of new dwelling in England and Wales, and incorporated a high-level overview of overheating risk within the energy study.
Simscale	Engineering simulation tool capable of undertaking complex analysis such as thermal comfort parameters.
TAS	Engineering simulation and 3D modelling tool used to perform daylight and climate based daylight modelling analysis and thermal comfort and natural ventilation studies within buildings.
Thermal Monitoring Equipment	Equipment used to monitor temperature and assess comfort levels in real-time within a sensitive environment. Some examples of equipment include temperature sensors and thermal imaging instruments.