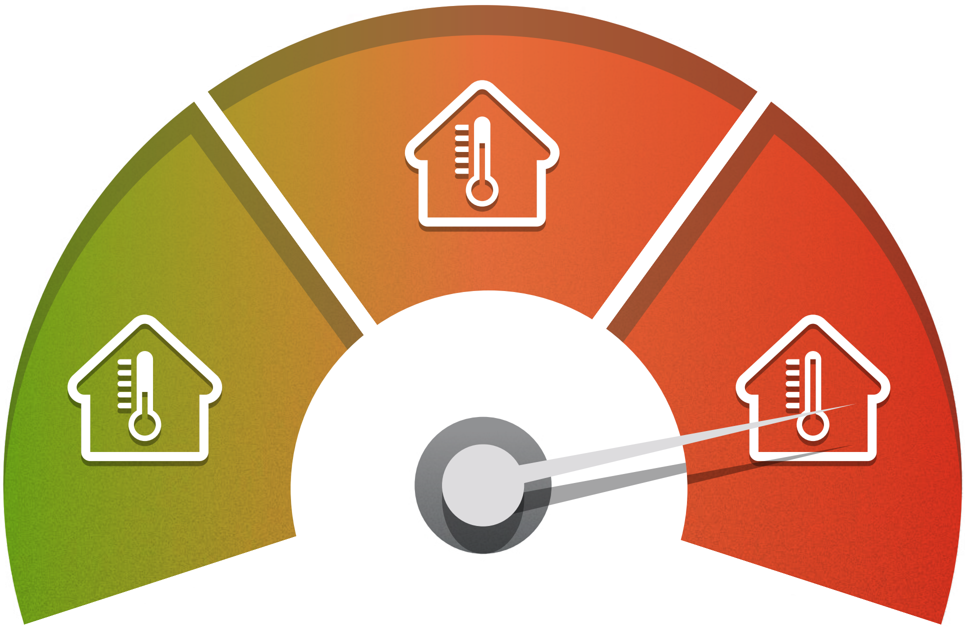

OVERHEATING IN HOMES

THE BIG PICTURE

FULL REPORT

The Zero Carbon Hub was established in 2008, as a non-profit organisation, to take day-to-day operational responsibility for achieving the government's target of delivering zero carbon homes in England from 2016. The Hub reports directly to the 2016 Taskforce.

To find out more, or if you would like to contribute to the work of the Zero Carbon Hub, please contact: info@zerocarbonhub.org.

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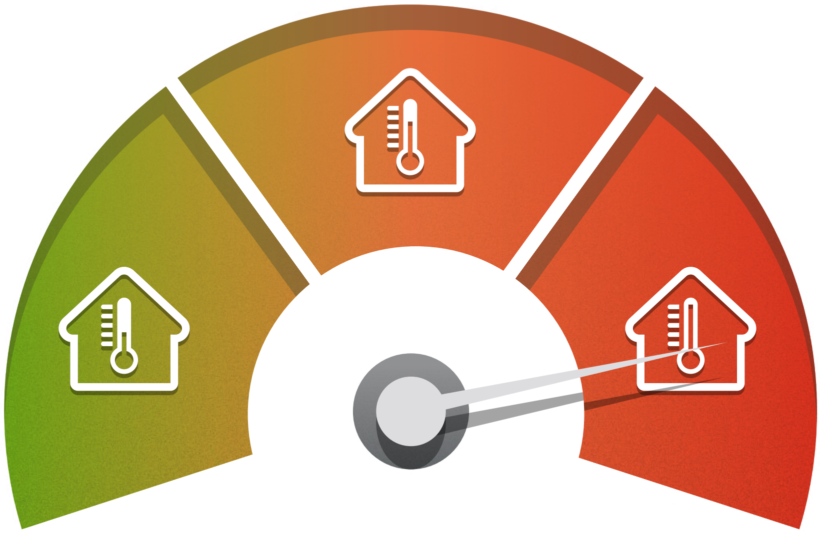

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FOREWORD

In recent decades the construction and energy efficiency sectors have made substantial progress in rising to the challenge of delivering highly energy efficient homes.

All new homes are now required to meet strict energy efficiency standards and millions of existing homes in England and Wales are better insulated, have energy efficient glazing and efficient heating systems. A growing proportion of the housing stock is also benefiting from low carbon energy production through decentralised systems and technologies such as photovoltaic (PV) panels.

Properties are becoming more cost-effective to run and the built environment is playing its part in the transition to the low carbon economy. As a result of this effort, the sector is making progress in tackling the problem of cold homes and fuel poverty, although there is still much work to be done.

However, as we get better at building and retrofitting homes to prevent heat losses in the winter, we may inadvertently increase the risk of overheating in warmer months.

Throw into the mix likely increases in the number of unusually hot summers as the climate changes, more frequent and intense heatwaves, and continuing construction in dense cities, then more people could find they are living in homes which reach uncomfortable or excessive temperatures. Temperatures beyond, for example, those referenced in the Government's Housing Health and Safety Rating System (HHSRS), or beyond the thermal comfort limits recommended by professional bodies such as the Chartered Institution of Building Services Engineers (CIBSE).

It is hard to imagine anybody wanting to live in a home which they find uncomfortably hot or which could lead to them falling ill. Similarly, it is hard to imagine building professionals setting out to construct or retrofit homes which are likely to overheat. Unfortunately, however, it is clear that overheating is happening – potentially in up to 20% of the housing stock in England.[1] The expectation that the issue will worsen in the future is further cause for concern.

Why does overheating happen? How can the construction and energy efficiency sector prevent the issue getting worse? What can local and national governments do to support the housing sector? And why does it matter?

These questions prompted the Zero Carbon Hub (ZCH), with the backing of government departments and industry partners,[2] to create a two-year project to take stock, investigate the extent to which the housing sector is gearing up to address overheating risk, and assess what changes to business processes and government frameworks could increase the resilience of the housing stock to extreme heat.

1. See Chapter 4 for the research behind this figure and for discussion on the position in Wales.

2. See Annex A of the full report for a list of partners and stakeholders.

This report presents preliminary findings from the project so far, with a particular focus on reflecting what the housing sector has told us about their concerns and level of preparedness to tackle overheating. It is the 'big picture' on overheating. It is evident from the feedback the ZCH has received that many organisations are at the beginning of the journey. For others, processes intended to minimise overheating risk are being embedded in their businesses.

Going forward our national strategies must be geared towards minimising and preventing overheating as far as possible. To have simple checks and processes in place during construction and retrofit projects to identify potentially high-risk properties, and promote the use of designs and measures which can limit or remove unwanted heat. Such checks are more important than ever as buildings become more airtight.

A second phase of the project will begin this year, aiming to make detailed recommendations about the types of policies and frameworks that could help the sector take a significant step forward in keeping people comfortable and healthy in their homes.

Rob Pannell
Managing Director, Zero Carbon Hub

We are enormously grateful to our partners and stakeholders, many of whom have contributed time and expertise to this project for free. See Annex A of the full report for a list of contributors.

ACRONYMS

ASC
Adaptation Sub-Committee of the Committee on Climate Change

ARCC
Adaptation and Resilience to a Changing Climate

BRE
Building Research Establishment

CCRA
Climate Change Risk Assessment

CIBSE
Chartered Institution of Building Services Engineers

DCLG
Department for Communities and Local Government

DECC
Department of Energy and Climate Change

DEFRA
Department for Environment, Food and Rural Affairs

GHA
Good Homes Alliance

GLA
Greater London Authority

HHSRS
Housing Health and Safety Rating System

LAAP
Local Adaptation Advisory Panel

LCCP
London Climate Change Partnership

NAP
National Adaptation Programme

NPPF
National Planning Policy Framework

PHE
Public Health England

PPW
Planning Policy Wales

SAP
Standard Assessment Procedure

ZCH
Zero Carbon Hub

Box 1. The term 'Housing Provider'

The term 'Housing Provider' is used throughout this report to refer to organisations who build, manage, rent or retrofit domestic properties. The term covers:

- Housebuilders and developers
- Private landlords
- Registered social landlords/housing associations
- Local authority housing providers
- Companies providing energy efficiency retrofit services

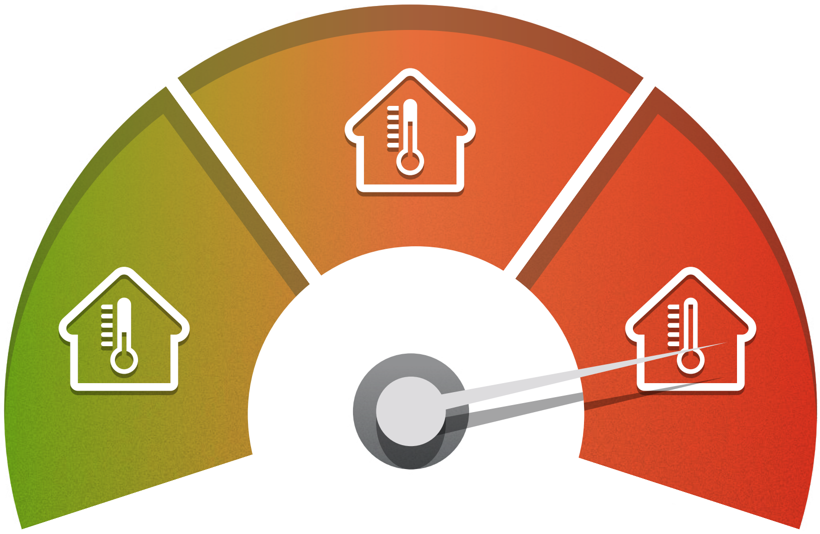
The project team also engaged with technical and other experts who directly influence the types of homes being built and how retrofit projects are carried out. These include:

- Architects
- Building services engineers
- Building physicists
- Manufacturers
- Specialist contractors
- Academics
- Building control
- Warranty providers
- Trade associations
- Planners
- Local authorities
- Environmental Health Officers
- Public health representatives
- Health and Well-being Boards
- Central government departments

The term 'housing sector' means Housing Providers plus this wider group of organisations.

The geographical scope of the project is England and Wales. The findings relate to new and existing dwellings.

EXECUTIVE SUMMARY



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CONTEXT

What is the concern about overheating in homes?

During the summer heatwave in Northern France in August 2003, unprecedentedly high temperatures for a period of three weeks resulted in 15,000 excess deaths. The vast majority of these were among older people. Research after the heatwave event revealed that at least 50% of these deaths could have occurred due to exposure to heat in people's homes.[1]

Across England and Wales that same year, there were over 2,000 excess deaths during the ten-day heatwave in August, compared to the previous five years over the same period. Again, the worst affected were people over the age of 75 years.[2]

It is widely predicted that climate change will lead to more frequent and intense heatwaves, as well as increases in average temperatures across the country. Combined with increased urbanisation and an ageing population, thousands more people are expected to be affected by heat-related ill health by 2050.

Historically, heat has been lost in uncontrolled ways from buildings due to lower levels of thermal insulation and infiltration through gaps in the building fabric. This has contributed to keeping levels of overheating in dwellings low. More recently, the drive for energy efficient, airtight buildings, which is integral to the fuel poverty agenda and objectives to reduce cold-related deaths, means greater care must now be taken to consider and reduce the potential for overheating when homes are being built or refurbished.

In short, the concern is that more people will become exposed to excess heat in their homes with consequences for their health and well-being. Overheating is therefore an important issue which needs to be dealt with.

1. *Includes deaths in care homes. Fouillet et al (2006).*

2. *Johnson et al (2005).*

"As temperatures rise due to climate change there is an increased risk of overheating in buildings."

ENVIRONMENTAL AUDIT COMMITTEE

'At the request of Government, the Zero Carbon Hub is currently developing a project to assess the case for action on dealing with overheating in homes...'

Committee on Climate Change, Adaptation Sub-Committee, 'Managing climate risks to well-being and the economy' (2014)

What has been done by the Government to tackle the issue already?

The Governments in England and Wales have taken steps to lessen the impacts of future heatwaves and overheating in homes more generally. Amongst these measures:

- The Heatwave Plan for England was introduced to 'protect the population from heat-related harm to health';[1]
- The National Planning Policy Framework (NPPF) and related guidance in England plays a key role in minimising vulnerability and increasing resilience to the impacts of climate change, and Local Plans must also take account of climate change. The Planning Policy Wales (PPW) has similar overall objectives, and specifically references increased thermal discomfort as an impact of climate change;
- The Housing Health and Safety Rating System (HHSRS) provides an approach to evaluate the potential health and safety risks from specified deficiencies in dwellings, including from 'excess heat';
- An overheating 'check' for new dwellings in the Standard Assessment Procedure (SAP) was created, underpinned by Criterion 3 in Approved Document Part L1A of Building Regulations;[2]
- Overheating was flagged as key risk in the 2012 UK Climate Change Risk Assessment (CCRA) and in Cabinet Office contingency planning;
- The National Adaptation Programme (NAP) 2013 was created, which sets out actions geared towards tackling overheating and names organisations with the responsibility for delivery; and
- Progress against these actions is now monitored by the independent Adaptation Sub-Committee of the Committee on Climate Change (ASC) and their first statutory progress report to Parliament is due this summer.

It is, however, far from clear that these frameworks alone will be sufficient to drive significant reductions in the incidence of overheating in homes at a national level over the longer term. This issue is discussed in greater detail in Chapter 7.

Questions about the effectiveness of existing frameworks have also been raised recently by Parliament's Environmental Audit Committee and by the London Assembly's Environment Committee.[3]

1. *The Heatwave Plan for England (2015); See also the historical Heatwave Plan for Wales (2012).*

2. *Which can be found at Appendix P. There are no corresponding provisions for existing dwellings.*

3. *'Environmental Audit Committee – Tenth Report, Climate Change Adaptation' (4 March 2015); London Assembly Environment Committee, 'Come Rain or come shine' (26 March 2015).*

What has been done by the housing sector to tackle the issue already?

Many organisations representing or advising Housing Providers including the ZCH, the NHBC Foundation, CIBSE, the Good Homes Alliance (GHA), BRE, Arup and Aecom, have published evidence reviews and practical guidance on building design and adaptation measures. A list of relevant publications can be found at www.zerocarbonhub.org.

Major programmes of research funded by Innovate UK, including the Design for Future Climate competition (D4FC) and the Building Performance Evaluation (BPE) Programme, have also contributed significantly to the sector's knowledge and understanding of building thermal performance.

Similarly, a large body of evidence has been produced by the academic community. The Adaptation and Resilience to a Changing Climate (ARCC) network, for example, has brought together research projects looking at adaptation and resilience in buildings, and drawn out key messages for policymakers.

A range of organisations have created networks to raise awareness on overheating, share research and expertise and help to drive action, including the Environment Agency's Climate Ready network, Climate UK (and the related partnerships), Climate Local and the Local Adaptation Advisory Panel (LAAP).

It is also apparent that a growing number of Housing Providers are carrying out their own research. For example, they are monitoring temperatures in their residential stock or surveying occupants to check how thermally comfortable their homes are. See, for example, the ZCH's Rowner Research Project Overheating Report (2015).

There is therefore a substantial body of advice and guidance available. The concern is, that for a number of reasons, this best practice is not being fully embedded within the organisations that have responsibility for shaping the performance of future homes. See Chapter 7.

CHAPTER 2 SUMMARY

DEFINITIONS

"The definition is very difficult...there isn't one single definition that will fit all circumstances."

HOUSING ASSOCIATION

Chapter 2 describes the range of definitions, criteria and thresholds used by the sector to understand whether a dwelling is overheating, or might overheat in the future.

Professional bodies, such as CIBSE, have produced guidance on temperature thresholds, which if exceeded for certain periods of time, would result in most occupants in the building feeling uncomfortably warm. In such circumstances the building is considered to have overheated. See CIBSE Guide A Environmental Design (2015) and the Defining Overheating Evidence Review for more detail.

Key findings:

- In common with other studies, the most pressing issue identified is that there is no accepted or agreed definition of overheating which can be applied by the domestic sector as a whole.
- As a result, the ZCH's stakeholder interviews and the Overheating Survey confirm that Housing Providers understand and are using many different ways of defining overheating.
- Where specific criteria are adopted, these relate to thermal comfort,[1] as expected, and most often to CIBSE's Guide A (2006), not newer guidance published in 2013 which incorporates the 'Adaptive Comfort Model'.[2]
- Health-related guidance usually sets different temperature standards or thresholds, since the people most at risk from the health effects of excess heat may experience those effects at temperatures below the upper thresholds for thermal comfort. Prolonged heat exposure, which can cause serious health problems for vulnerable groups, is also not well accounted for by simple temperature thresholds.
- Health-related standards are also usually based on external temperatures, making them more difficult to apply as design standards for buildings.[3]
- Housing Providers reported that the range of different standards and lack of clarity is creating issues for them. For example, if Environmental Health Officers seek to enforce health and safety standards which the dwelling was not designed to deliver, protracted disputes can arise.

In general terms, by overheating, the ZCH means the phenomenon of excessive or prolonged high temperatures in the home, resulting from internal or external heat gains, which may have adverse effects on the comfort, health or productivity of the occupants.

1. *Thermal comfort has been defined as "that condition of mind which expresses satisfaction with the thermal environment". ISO 7330.*

2. *The Adaptive Comfort Model seeks to take account the ability of occupants to acclimatise to recent external temperatures and adapt themselves or the building they are in.*

3. *Although the HHSRS references 25ºC, which is presumed to be an internal temperature.*

"Indoor thresholds for health are needed as a protective measure against preventable morbidity and mortality."

OVERHEATING IN NEW HOMES. A REVIEW OF THE EVIDENCE (2012), NHBC FOUNDATION (NF46)

For a summary of the range of temperature thresholds related to heat and the built environment see the ZCH's Defining Overheating Evidence Review (2015), and the London Climate Change Partnership (LCCP) and Environment Agency's Heat Thresholds Project Final Report (2012).

- Lastly, new guidance on adaptive thermal comfort published by CIBSE was developed primarily from evidence from the non-domestic sector. The approach needs to be fully road-tested in the domestic sector and further field studies are needed to confirm its applicability to bedroom comfort temperatures during the night.

There are a number of limitations and issues associated with the range of current methods of defining overheating which are explained more fully in Chapter 2.

What could this mean for future frameworks?

Without a sector-wide accepted definition:

- Dwelling designs which have the same characteristics as existing dwellings where high temperatures are known to have caused harm to health could inadvertently be approved by Building Control Officers;
- Overheating risk assessments of dwellings will continue to be judged against different criteria, limiting comparison between them;
- Housing Providers will continue to experience a lack of clarity about what reasonable steps they are required to take to safeguard current and future occupants, and be subject to very different types of planning requirements, for example, depending on which part of the country they operate in; and
- Without a level playing field, those who invest in taking reasonable steps to safeguard the comfort and health of occupants may find they are commercially disadvantaged.

Agreeing a definition is unlikely to be an easy task. Many practical issues need to be considered, including how any definition would account for:

- Climatic variation across the country, including future climate projections and the ability of people to acclimatise and adapt;
- Neighbourhood effects and local microclimates in urban environments which can compound the effect of the urban heat island;
- The importance of night-time temperatures in dwellings (compared to non-domestic buildings);[1]
- The different overheating risk profiles of the housing stock;
- The subjective nature of the experiences of occupants; and
- Vulnerable occupants.

What form the definition would need to take in order to be universally applicable, what status it would have (e.g. in guidance or regulation), what unintended consequences having a very precise definition could create, and what alternative ways of driving action exist, will all need careful exploration.

Action

ZCH to form a working group of experts to make recommendations to Government on what form an overheating definition or standard could take, and how it would be implemented in practice (by March 2016).

1. High night-time temperatures can impair a persons ability to recover from heat stress during the day and lead to disrupted sleep.

CHAPTER 3 SUMMARY

CAUSES AND RISK FACTORS

Chapter 3 sets out the main causes and risk factors associated with overheating in homes.

In summary, overheating occurs when too much heat builds up inside a dwelling – from external sources such as the sun, or from internal sources such as appliances or hot water pipes – which cannot quickly or easily be rejected or removed.

All buildings should act as a physical buffer between the outside and inside to protect their inhabitants from the extremes of the external environment. Where a building is located, how it is orientated, how it is constructed, how it is ventilated, how it is heated, and how it is used, all contribute to how well a dwelling fulfils this role. Recent research by Mavrogianni et al (2012) explored the links between external and internal temperatures in dwellings in London, and the extent to which the building can amplify external temperatures.

Figure 1. Illustration adapted with permission from 'Understanding Overheating – Where to start' (NHBC Foundation NF44, 2012) showing some of the causes and cumulative effects of overheating in homes

1. Site context

External pollution, noise and excessive noise may prevent occupants from opening their windows. Surrounding hard surfaces will absorb heat and release this during the night.

2. External temperature

On a warm, still day when external temperatures are high, fresh air may not provide enough of a cooling effect to address overheating.

3. Solar gains

Double-glazed windows with a low-e coating prevent heat from escaping. Houses with unshaded west-facing glass will suffer from higher levels of solar gain in the warmer part of the day.

4. Internal gains

Electrical appliances, occupant activities such as cooking, and building services, e.g. boiler and hot water storage, all have the potential to radiate heat that may contribute significantly to the increasing internal temperatures.

5. Building design

Modern homes have increased levels of insulation and airtightness, resulting in more heat being retained within the homes. This means any built-up heat in the homes will have to be actively removed.

Box 2. Examples of risk factors

The following summary has been adapted with kind permission from guidance produced by the ARCC network in 2013.

Location
Summer temperatures are generally higher in the South and South East England. Built up neighbourhoods will be at higher risk of overheating as a result of the Urban Heat Island effect (UHI).

Type of properties
Many factors affect the risk of overheating, including built form and orientation. Flats, especially on the top floor, are often identified as being at highest risk.

Fabric characteristics
The position of insulation, how lightweight the construction is, the colour of the facade, and the type, area, and position of the glazing can all affect the likelihood of buildings overheating.

Orientation and exposure
West-facing (and potentially east-facing) windows are especially problematic. Although south-facing rooms also experience overheating, they are easier to shade from the high angle summer sun.

Occupancy/behaviour
Occupants staying at home all day could experience more overheating than an occupant who does not.

Ventilation
Where noise and security issues discourage the use of window opening for cooling.

Key findings:

- Not all types of dwelling overheat. The risk of overheating varies from building to building. Those which have a higher propensity to overheat usually have recognisable risk factors, which means the sector can be cautiously optimistic about being able to identify and treat them;
- The generic causes of heat gains and overheating risk factors are well understood. Nearly all Housing Providers the ZCH interviewed had a good sense of the types of developments within their stock which would be more prone to overheating,
- However, it was clear that problems can arise when trying to identify the precise causes of a particular overheating problem once it is happening, Interviewees considered that detailed knowledge across the sector as whole is lacking.
- It was also common for Housing Providers to report issues with internal overheating risk assessment processes which could result in inherently risky designs and projects not being flagged early enough in the construction or refurbishment process. Once designs or specifications are fixed, it becomes more difficult to make changes to address any concerns about overheating.
- Conversely, a number of interviewees described how their technical teams are using their experience and knowledge of overheating risk factors to identify sub-sets of properties or designs which have characteristics that make them more likely to overheat, before carrying out any formal modelling exercises. A form of 'first pass'.
- These 'higher risk' properties were then subjected to detailed 'dynamic' thermal modelling, and if found to fall short of the chosen overheating criteria, measures would be installed or design changes made to reduce the potential for overheating. The sub-set of units singled out for special attention was often very small – less than 5% of their total stock.
- The Housing Providers carrying out this form of triaging process continued to use the SAP overheating check on their other properties (except one, who used their own more detailed methodology).
- By performing this 'first pass' the teams concerned felt better able to factor in their practical knowledge of the site, such as whether the property in question is located next to a busy main road, meaning windows are not opened in practice. Such factors can be difficult to account for in standardised calculations and models.

What could this mean for future frameworks?

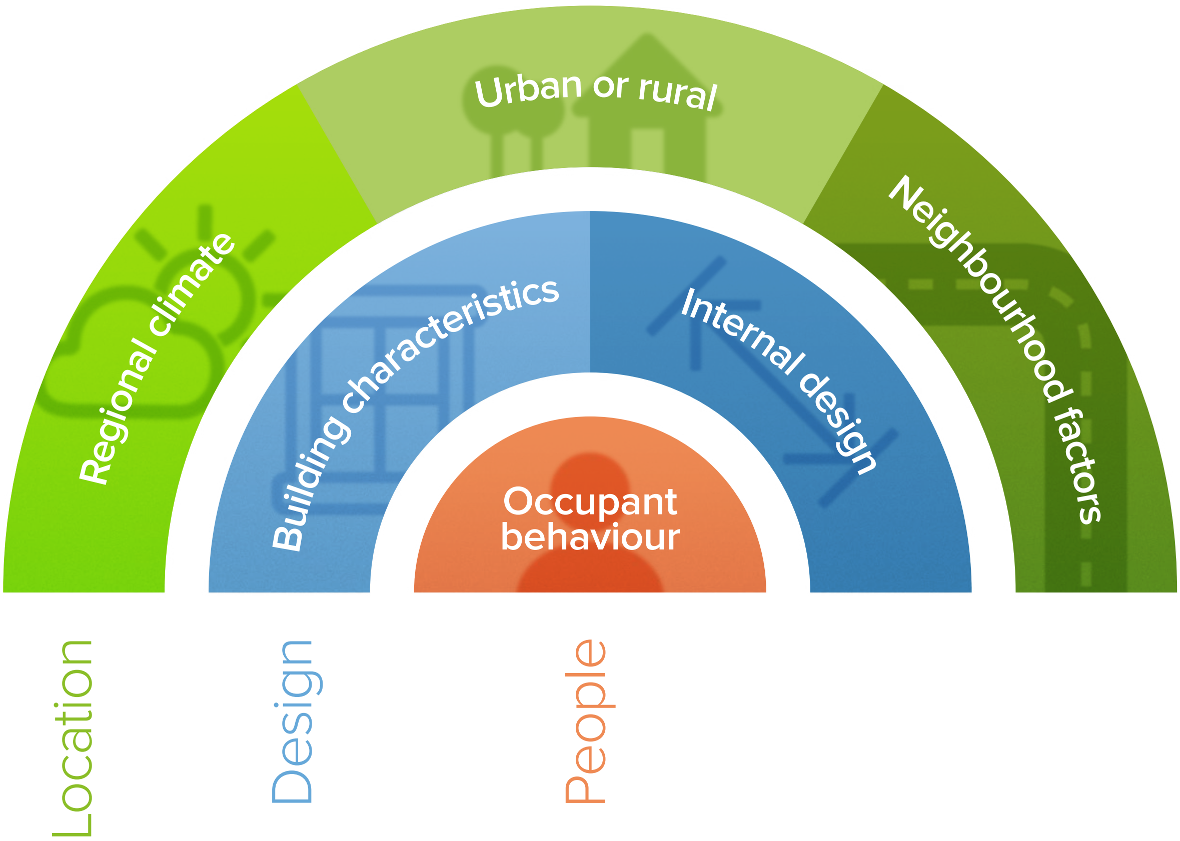
The analysis of overheating risk must start at the concept stage of projects. Future policies and frameworks which support Housing Providers in identifying potentially high risk dwellings within their stock for special attention, from an early stage, should help to ensure that investment in solutions is targeted at the homes and people which need it most. It also appears that such an approach could prove to be cost-effective and relatively simple to weave into current business practices as certain Housing Providers are doing it already.

The feasibility of this type of approach will be explored in greater detail in Phase Two, including consideration of how to avoid potentially problematic homes being missed accidentally.

Action

ZCH to coordinate work to develop proposals on how to improve overheating risk assessment processes and commission guidance on which combinations of location, properties and occupants in England and Wales are more prone to overheating by March 2016.

Figure 2. A conceptual diagram of the types of factors which, if they can be accounted for, should improve the reliability of overheating risk assessment processes for dwellings



CHAPTERS 4-5 SUMMARY

EXTENT

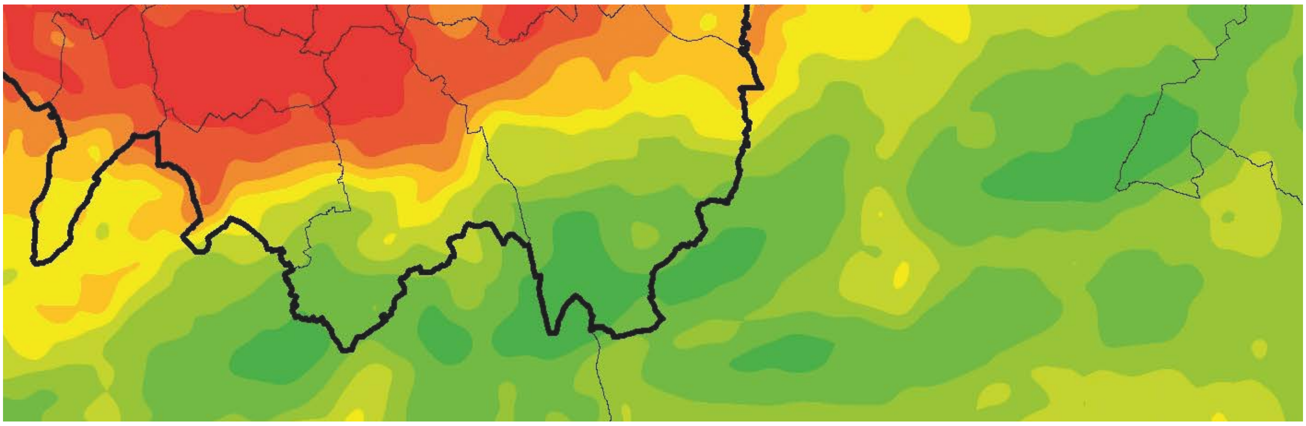
One of the barriers to taking concerted action on overheating has been a lack of evidence about the scale of the problem.

Chapters 4 and 5 summarise information and evidence about the current and possible future extent of overheating, the severity of observed cases and the perceptions and experiences of Housing Providers. The ZCH has also published a leaflet describing how certain drivers of change could affect the incidence of over-heating in the future.

Key findings:

- Much of the available evidence on overheating comes from small-scale monitoring studies carried out by individual organisations or is anecdotal in nature e.g. in the form of case studies or logs of reported cases.
- A number of recent larger studies, summarised in Box 3, provide insight into the scale of the issue for properties in England. The first, Beizaee et al (2013), was the basis for the ASC's observation in their 2014 report that up to 20% of homes may already exceed defined thresholds for overheating, even in cooler summers.[1]
- Recent industry surveys and interviews also suggest that Housing Providers are finding cases of overheating in their stock. This type of information should, however, be used with caution due to the potential for self-selection.
- The ZCH's Overheating Survey aimed at Housing Providers, for example, found that 53 (70%) out of a possible total of 75 organisations reported experiencing at least one instance of overheating in their housing stock in the last 5 years (i.e. in dwellings they had built or now manage). 7% reported no overheating problems, and the remainder did not answer the question.

1. *Managing climate risks to well-being and the economy, ASC progress report (2014).*



Box 3. Summary of larger-scale studies which investigated the extent of overheating in homes in England

Beizaee et al (2013)

Nearly 200 unheated homes throughout England of mixed dwelling type and age were monitored during the summer of 2007. Despite this being a relatively cool summer (the majority of England had its coldest August since 1993) the team found that 21% of bedrooms exceed 26°C for more than 1% of night-time hours. 47% of bedrooms exceeded temperatures of 24°C for more than 5% of occupied hours – the temperature at which sleep is thought to become impaired.

Lomas and Kane (2013)

A monitoring study of over 200 unheated homes in Leicester in 2009 found that almost 27% of living rooms exceed the threshold of 28°C for 1% of occupied hours. Nearly 20% of bedrooms had temperatures over 24°C for 30% of the two-month summer monitoring period. Again, average external temperatures during monitoring were cooler than normal for the time of year, although there was a short hot spell.

The Energy Follow-up Survey (2013)

A study carried out by BRE for DECC found that 20% of the 2616 households interviewed in 2010/11 in England had difficulty keeping one or more rooms cool during the summer months. Monitoring of a sub-sample of 823 homes confirmed that temperatures in the homes reporting overheating were 0.5°C to 1.5°C higher than in households who did not report any issues. The average mean temperature for those households who reported a problem equates to a 'medium' overheating risk in the SAP Appendix P scale.

The Risk to Housing from Overheating, BRE (2014)

Interestingly, using English Housing Survey (EHS) data, just 0.5% of the housing stock was assessed to be at risk of overheating against HHSRS (health-related) criteria. The BRE, however, noted that this research was exploratory and that these figures are likely to be an underestimate due to the small sample size, the fact that the building assessments used were not restricted to summer months, and because the data used was not as detailed as would be collected by environmental health practitioners conducting a full HHSRS assessment.

- As would be expected, most instances of overheating reported in the Overheating Survey were from companies operating in London, the South East and the South West of England. However, companies operating in Wales, the Midlands and Northern England also reported cases too.
- The detailed findings of the larger scale studies referenced in Box 4 suggest that only a small proportion of homes are reaching very high temperatures or have high temperatures for prolonged periods of time.
- For example, in Beizaee et al (2013), it was noted that 'whilst the average maximum temperatures were not unduly high, 25.7°C in the living rooms and 25.4°C in the bedrooms, individual dwellings had living room and bedrooms temperatures up to 30.3°C.' It should be noted that vulnerable occupants, in particular, can start to suffer health effects from heat exposure at much lower temperatures than these.
- Looking forward, whilst predicting the future incidence of overheating is not possible, an examination of drivers of change, climate change studies and modelling exercises all point towards the conclusion that overheating will become more common in the housing stock in England and Wales.
- Should temperatures in homes more frequently exceed recognised thermal comfort or health-based thresholds for longer periods of time and by larger margins in the future, then the consequences for the occupants of those dwellings could also become much more severe.

Box 4. Heatwaves

By the 2040s a summer as hot as 2003, when over 2,000 excess heat-related deaths occurred, is expected to be very common in the UK – potentially every other year (Christidis et al 2014).

What could this mean for future frameworks?

Although information on the current extent of overheating in homes at a national level is still patchy, when pieced together the picture is cause for concern. It is also apparent from the range of studies referenced throughout the report that overheating is being observed in summers with normal or below average temperatures – and is not limited to hot spells and heatwaves.

However, as stressed in Chapter 3, dwellings which overheat tend to have recognised risk profiles. There is no suggestion that any home could overheat at any time. Similarly, cases of overheating are not distributed evenly across England and Wales. London and the South East of England are usually affected most, but as average temperatures rise across all areas of the UK in the next century, more locations could see overheating issues.

Unfortunately, the larger-scale studies carried out to date do not cover dwellings in Wales, making it very difficult to make a reliable statement on the extent of overheating in the Welsh housing stock. Anecdotal evidence from the Overheating Survey and from stakeholder interviews with Welsh organisations suggest, as might be expected, that the incidence of overheating in Wales is currently low.

Further large-scale monitoring studies in England, and particularly in Wales, would deepen our understanding of the incidence, causes and regional patterns of overheating – but it is unlikely that gaining an exact number of the homes at risk is ever possible. Lack of certainty should not delay the sector in making careful progress towards addressing the issue.[1]

One of the challenges Housing Providers and governments face is to decide how to plan on the basis of evidence of current overheating, whilst also acknowledging the complexity and uncertainty around future levels.

Action

ZCH to work with the research community to determine whether it is possible to develop a methodology to model the potential future incidence of overheating at the national and local level and what this could tell us (by December 2015).

1. These drivers of change are discussed in more detail in Chapter 5 and in the ZCH's Drivers of Change – Overheating in Homes leaflet.

CHAPTER 6 SUMMARY

IMPACTS

"The cost is that I've had to spend time and the worry of having to deal with [overheating] after it's happened. That's a cost in itself."

HOUSING ASSOCIATION

Chapter 6 explores the consequences for occupants, Housing Providers, and for the health sector and the economy when homes overheat.

A more detailed summary of the impacts of overheating can also be found in the Impacts of Overheating Evidence Review.

Key findings;

- Housing Providers report that overheating problems can damage customer relations, and lead to reputational harm and costly remedial works.

  One housebuilder shared their experience of carrying out extensive remedial works on a recently completed apartment building in order to gain Building Control sign off and to satisfy the local Environmental Health Officer, operating under the Housing Act. Without the apartments being heated, winter temperatures exceeded 27°C. During this time, the housebuilder experienced negative media coverage and customer dissatisfaction. Remedial works, which costed approximately £100,000, were required to bring the worst affected apartments within acceptable humidity and temperature ranges.

- Heat-related morbidity (incidence of ill health) and mortality (incidence of death) is sometimes used a proxy for overheating. There are currently approximately 2,000 heat-related deaths per year in England and Wales, and this figure is projected to rise to over 7,000 by the 2050s as a result of climate change and a growing and ageing population.[1] A tripling of current levels.

  Excess heat can have significant health implications, particularly for vulnerable groups, including the elderly, infants, those who are obese or have chronic illnesses, people who are socially isolated and those who live in urban environments. These groups are often less physically able to acclimatise or adapt to keep cool at home when external temperatures rise.

- The evidence base on potential healthcare costs resulting from overheating is limited. The CCRA did, however, estimate that by 2050, annual heat-related mortality and morbidity costs could increase from 2012 levels by a further £84m and £183m (respectively).[2] These figures represent a four-fold increase in mortality-related costs and a doubling of morbidity-related costs.

1. Hajat et al (2013).. See Chapter 6 for the methodology used. Cold-related deaths are projected to decline by 2% from a baseline of 41,000.

2. 2012 levels are £23m and £73m. At 2010 prices. See Chapter 6 for the methodology used.

"Overheating can damage residents' health and well-being, increase social care costs, reduce economic activity, increase NHS costs and lower quality of life."

YOUR SOCIAL HOUSING IN A CHANGING CLIMATE

- Economic losses are also expected as a result of work-days lost, accidents and reduced productivity resulting from overheating in homes as a result of sleep deprivation (or when working at home).
- Overheating in the workplace and the resulting economic losses to businesses was also investigated in the 2012 CCRA. It estimated that the number of staff days lost once internal temperatures exceed 26°C would to financial losses of £1.1bn to £5.3bn by the 2050s, compared to the current estimate of £0.77bn.[1] The same kind of analysis is needed to relate the cost of productivity losses in the workplace due to ill health and sleep deprivation caused by overheating in homes.
- Lastly, the energy efficiency and fuel poverty agendas could suffer set-backs if the sector begins to use more energy to cool homes as standard practice.[2] In the absence of policies and frameworks which clearly drive action on building design, form and fabric first, the use of mechanical cooling could become more common.
- It is estimated that approximately 3% of the housing stock in England currently has air-conditioning.[3] The potential impact of any increased uptake in mechanical cooling on the electricity grid needs further exploration.
- Nearly all stakeholders interviewed by the ZCH support approaches which encourage good building design and the use of passive measures first, with mechanical cooling being used if such approaches are not able to deliver the temperature reductions needed. A good example of this type of approach being used is the 'Cooling Hierarchy' adopted by the GLA in their planning policy guidance.[4]

What could this mean for future frameworks?

By proactively supporting and working with Housing Providers to help them reduce the number of cases of overheating in their stock, local authorities and national governments could also see benefits in terms of reduced healthcare burdens, reduced productivity losses and better integration of policies with the energy efficiency agenda. Even small reductions in internal temperatures can result in a lowering of heat-related mortality.[5]

These benefits will need to be weighed against the costs associated with implementing policies to drive reductions in overheating as the costs of designing-in or installing measures in homes will often fall to Housing Providers, while the direct benefits will accrue to the occupants. However, Housing Providers should also benefit from avoided costs over the longer-term, including from unexpected remedial works.

Action

In Phase Two, the ZCH will commission economic analysis to assess the high-level costs and benefits of a range of policy options intended to tackle overheating at the national level. These could range from light-touch options such as increasing awareness of overheating, to regulatory options including tightening up provisions in Building Regulations or creating new legal standards (by March 2016).

1. *See Chapter 6 for the methodology used.*
2. *Gupta et al (2015).*
3. *Frontier Economics, Irbaris, Ecofys (2013).*
4. *London Plan Policy 5.9.*
5. *Jenkins et al (2014).*

CHAPTER 7 SUMMARY

PREPAREDNESS

A theme running through this report is the value and importance of being prepared.

Chapter 7 summarises information gathered by the ZCH on the extent to which Housing Providers are making preparations to prevent future cases of overheating and are able to respond effectively when cases occur.

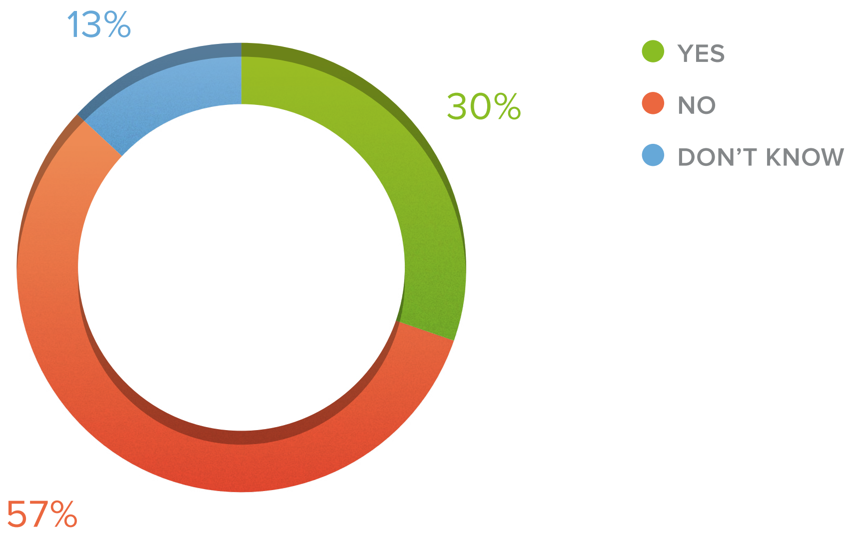
Key findings:

- Addressing overheating risk has not, historically, been a high priority for many of the Housing Providers interviewed by the ZCH, but this is beginning to change.
- Those who reported that consideration of overheating has been a low priority for them also said they had not experienced many problems with elevated temperatures in their stock, which they also viewed as inherently low risk.
- However, it is clear that the risk profiles of buildings can change when projecting out to future decades.

> A new piece of economic analysis for a housing association operating in Southern England found "a 13% increase in heat-related health costs as a result of stock expansion, and a doubling of costs as a result of climate change in 2040, is judged to be possible", and that 'targeted investment in flooding and overheating measures now would make significant financial savings for them in the future'. This analysis is being used to highlight the importance of investment in overheating measures. Further examples of housing associations going through similar long-term business planning exercises are included in the full report.
>
> See Building the Business Case for Targeted Investment in Resilience Planning by the Global Climate Adaptation Partnership, Daniel Black & Associates, the University of Bath and the University of Manchester.

- Interestingly, 59% of the 74 Housing Providers answering the relevant question in our Overheating Survey reported having a form of assessment process in place intended to identify properties at risk of overheating. However, 36% did not, and the remainder did not know. The level of robustness of the methods used is highly variable.
- A variety of methods are being used to assess risk, ranging from informal approaches, SAP Appendix P, detailed dynamic simulation modelling (DSM) and the Passive House Planning Package (PHPP).
- Housing Providers and experts raised many concerns with Appendix P. The view, summarised by the quote 'no one fails Appendix P', suggests the process is not separating out properties which are genuinely at risk of overheating as effectively as it could. DECC plans to consult on proposed amendments to Appendix P.

Figure 3.
Does your organisation currently specify overheating related requirements in your contracts with architects / designers?



> "We have never been asked to get to the level of quantifying overheating in a housing scheme in a discussion with a client or a housing association. There is just a general anxiety about it."
>
> **ARCHITECT**

- In addition, risk assessments carried out on residential units do not usually give a picture of the future likelihood of properties to overheat or take into account wider contextual factors which make the property more prone to overheating. Factors such as future weather, unusual occupancy patterns, and location effects such as the UHI and the building's microclimate, are not factored in as standard.
- Another indicator of preparedness relates to the extent to which supply chain contracts cover overheating and how well defined the requirements are. By way of example, 57% (of the 23 Housing Providers who answered the specific question on new-build properties) said they do not specify requirements on overheating in contracts with architects or designers. As shown in figure 3.
- Regarding technical solutions, information gathered during our stakeholder interviews suggests, similar to the causes of overheating, there is a reasonable level of general knowledge within the sector on the types of technical solutions available to address overheating at the property or development level.
- However, stakeholders felt more guidance is needed on how effective different combinations of measures are at reducing temperatures and keeping buildings cool for different house-types and locations, particularly on the use of thermal mass to moderate heat flows. A number of interviewees wanted to see more advice on what types of measures to deploy if their tenants were experiencing severe overheating during a heatwave or hot spell.

> Links to technical guidance documents and case studies produced by a range of experts can be found at **www.zerocarbonhub.org**. The ZCH will also publish a summary of technical and behavioural solutions, commissioned from the BRE, in July 2015.

- Although concerns were raised during the stakeholder interviews about overheating measures being 'value engineered' out during projects, two thirds of 72 Housing Providers in the Overheating Survey said they have a process in place to check that designs and measures are delivered in practice. Only 22 (30%) said they have no process.

> The ZCH's 'Design versus As-Built' project highlighted the impact on the performance of buildings when designs are not delivered as intended, and the same is true for overheating. Product substitution and value engineering can mean that even when dwellings are designed to stay comfortable, in practice they do not.

- Lastly, a significant proportion – 41% (out of 51 organisations answering the relevant question in the Overheating Survey) – reported finding out about overheating problems only after receiving unsolicited feedback or complaints by occupants. This approach risks overheating becoming severe before being addressed, or masking a larger problem as there is evidence that, culturally, people can be reluctant to complain about being too hot.

What does this mean for future frameworks?

Balancing requirements on heat gains and heat losses in very airtight homes will become even more important as the climate changes. As summers become warmer and heatwaves occur more frequently, Housing Providers will need to 'worry' more about summer thermal comfort and how people will keep cool. It is equally important that the policy and regulatory frameworks guiding action support them in this process.

This question of what detailed amendments may be needed to national and local frameworks will be considered in detail in Phase Two of the project, focusing in on the differences between the English and Welsh regimes. However, evidence gathering so far provides some early insights. The following issues were consistently raised by stakeholders:

- Modelling of overheating risk is being done too late in the process to influence the design of projects;
- Unrealistic assumptions are being used in models resulting in properties being incorrectly assessed as 'low risk' or passing overheating criteria;
- Use of modelling and/or checklist can create false expectations that the risk of overheating has been effectively mitigated, without follow-up;
- Many models do not incorporate factors that are known to exacerbate overheating, such as a property being located in an Urban Heat Island, corridors overheating due to heat gains from hot water pipes, or cumulative heat gains through the building fabric over a whole summer;
- National planning guidance does not explicitly cover overheating in England, and where Local Plans include provisions, there is a question mark over whether these are fully implemented or enforced;
- Building Regulations contain only very general provisions relating to the reduction of heat gains in Part L1A, there are no specific provisions on overheating in Part F on ventilation either, and low priority is being given to the issue by Building Control Officers;
- Initiatives designed to drive energy efficiency retrofitting of existing buildings, such as the Green Deal and Energy Companies Obligation, do not explicitly give advice to guard against overheating;
- Most voluntary building codes and standards do not include specific provisions on the summer thermal performance of buildings, although this also appears to be changing.

> "There is nothing that forces you to think about [overheating] at the concept stage. When you get to the detailed design stage, it's hard to then add external shutters like those seen in Europe, for example. You can't do that without planning permission."
>
> **HOUSEBUILDER**

CONCLUSIONS

CHAPTER 8 SUMMARY

Over the last year the ZCH has worked with over 100 organisations to gain an insight into the strategic and practical issues which need to be addressed to enable overheating in homes to be tackled more effectively.

The level of concern about future overheating in the sector appears to be mounting. Most organisations the ZCH engaged with are in the very early stages of figuring out whether their stock might be at risk of overheating in the future, and what to do about this. Others, and particularly those who have experienced difficult to treat overheating cases in the past, are determined to minimise or prevent future cases and are looking closely at their businesses processes, or have already made changes to them. A small number are in the strong position of having not had any significant overheating issues to date, but have invested in overheating prevention measures in any event because it made sense for their business.

Experts and practitioners raised issues about the policy frameworks and regulations which guide the sector. The most challenging being the lack of an agreed sector-wide definition, but also issues with risk assessment processes and enforcement. The current regime does not actively encourage Housing Providers to give serious consideration to whether any of their stock might overheat in the future.

Our conclusion is that overheating cannot yet be considered to be a managed risk for much of the sector. There are gaps and uncertainties in current frameworks which mean inherently risky designs and buildings can be approved. Secondly, despite evidence gaps, there is enough information and evidence about the causes, extent of, and solutions to overheating in homes to warrant taking careful yet concerted action to tackle the issue.

Despite this, the ZCH also found impressive examples of Housing Providers working hard to future proof their stock by making changes to internal processes to fully embed strategies intended to minimise and design-out overheating as far as possible. This focus on prevention is important as the range of options available to tackle overheating become more limited once a building's form and orientation is fixed.

Anecdotal evidence from stakeholder interviews suggests that those with strong overheating risk assessment processes felt confident that their stock will not overheat further down the line, compared to those who did not.

Early indications are that future policies and frameworks which support the sector in minimising and preventing overheating, as far as possible, by identifying and giving particular attention to high risk homes, could prove feasible, effective and relatively low cost compared to other blanket approaches. During Phase Two the ZCH will explore the practicalities of this approach, amongst others, and aim to quantify the costs and benefits.

Finally, we have highlighted the effects of the 2003 heatwave and the expectation that similar heatwaves will become much more frequent in the future. With this in mind, we must ensure that the new homes being built, as well as the existing stock, can cope with such events – even when built to high standards of energy efficiency. This will be even more important with the introduction of the Zero Carbon Standard for new homes in 2016. It is clear that overheating can happen in cooler summers too. Increasing our overall level of preparedness must therefore be an ongoing process – a core part of the frameworks that guide building design and retrofit activity.

"My general view of the overheating issue is that this, together with indoor air quality, will be the two predominant issues over the next 5 to 10 years [for the sector]. We have learnt how to keep buildings warm successfully and our Building Regulations deliver a high quality level of heating performance."

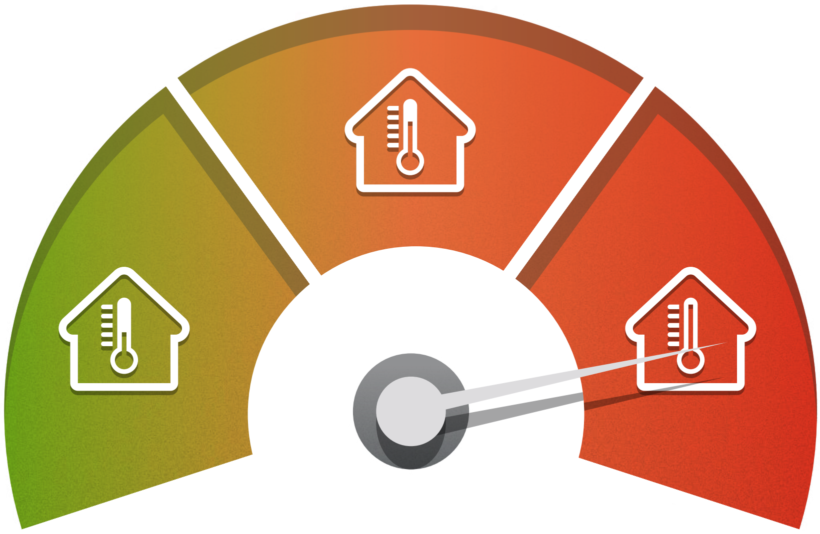
TRADE BODY

NEXT STEPS

The objective of Phase Two is to make recommendations to government and industry decision-makers on the types of frameworks which could cost-effectively incentivise the construction and energy efficiency sector to take action to tackle overheating in homes. To support this core analysis, the ZCH will work in full consultation with partners and stakeholders to:

1. Raise awareness on overheating by publishing a series of short, targeted documents, including: (by July 2015)
   - A publication written by the BRE describing the types of technical and behavioural solutions available to Housing Providers to mitigate or manage overheating;
   - Case studies of temperature monitoring projects carried out by housing associations setting out what prompted the research, what the results were and how this information informed future strategies to address overheating; and
   - A leaflet aimed at local authorities showcasing examples of the work being carried out by certain Local Planning Authorities and others to map heat risk, reduce the incidence of overheating at the neighbourhood or city level, and to plan for future heat-related health and social care provision.
2. Identify potential (short-term) updates to the overheating check in SAP Appendix P and analyse how the role of Appendix P could evolve over time as the sector's approach to tackling overheating changes and new modelling protocols are developed. (by October 2015).
3. Commission work to draw together guidance to link advice on technical solutions to known causes of overheating, and describe the possible impacts of solutions in a range of potential scenarios. (by October 2015).
4. ZCH to work with the research community to determine whether it is possible to develop a methodology to model the potential future incidence of overheating at the national and local level and what this could tell us. (by December 2015).
5. Make recommendations to Government on what form an overheating definition or standard could take, and how it would be implemented. (by March 2016).
6. Provide a preliminary assessment of the costs and benefits of a range of potential policies and frameworks designed to tackle overheating and describe how they would be implemented in practice. For example, would regulatory changes be needed? Particular attention will be given to testing the feasibility and effectiveness of policies which better support Housing Providers in identifying and treating high-risk homes. (by March 2016).
7. Work with partners and legal experts to develop example clauses and templates on overheating for inclusion in design and procurement contracts. (by March 2016).
8. Take advice on whether to commission economic analysis and what a robust methodology would be to:
   - Quantify the cost of productivity losses resulting from overheating in homes, especially at night; and
   - Quantify what reductions in future healthcare costs may be possible at the local level in a range of hypothetical scenarios with low, medium and high levels of future overheating.

FULL REPORT



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METHODOLOGY

CHAPTER 1

What is the purpose of this report?

At the request of Government, the ZCH formed the project 'Tackling Overheating in Homes' in 2014. Supported by our partners and over 100 stakeholders the team has gathered evidence and information on:

1. The current extent and impact of overheating in homes;
2. The possible future extent of overheating;
3. The degree to which the housing sector is already gearing up to tackle the issue; and
4. What further action could be required to adequately manage the risk of current and future overheating.

The project is divided into two phases:

Phase One

Evidence gathering phase (March 2014 to June 2015) – Phase One has drawn on existing research and the experiences of Housing Providers and other technical experts to provide a synthesis of the scale, patterns and impacts of overheating in new and existing homes and how these could change over time.

Phase Two

Options appraisal and associated projects (July 2015 – April 2016) – During Phase Two the ZCH intends to analyse in detail a range of strategic responses which could be adopted by the Government and/or the housing sector to tackle overheating in homes in a systematic way and assess as far as possible the costs, benefits and feasibility of each. The options appraisal will cover the new-build and existing homes sectors in England and Wales separately. A series of related projects, set out in the 'Next Steps' section will also be taken forward to support this work.

Dissemination

The ZCH will also work with partners to continue to raise awareness and disseminate information on overheating in homes. Tailored leaflets and factsheets intended for use by local authorities, housing associations and housebuilders will be published over the course of 2015.

This report presents our preliminary findings for Phase One of the project – the 'big picture' on overheating. Our focus on the internal processes Housing Providers have to manage overheating risk has allowed us to draw early conclusions on what appear to be appropriate next steps for decision-makers, and these will inform the second phase of the project.

The report is intended for Government and industry audiences with an interest in future policies and frameworks on overheating in England and Wales. It is not guidance.

'At the request of Government, the Zero Carbon Hub is currently developing a project to assess the case for action on dealing with overheating in homes...'

Committee on Climate Change, Adaptation Sub-Committee, 'Managing climate risks to well-being and the economy' (2014)

What information has informed this report?

400+

RESEARCH PAPERS AND REPORTS

6

THEMATIC EVIDENCE REVIEWS

75

HOUSING PROVIDER SURVEY REPRESENTING 207, 728 HOMES, IN PARTNERSHIP WITH SUSTAINABLE HOMES (SEE PAGE 30)

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CONFIDENTIAL IN-DEPTH INTERVIEWS WITH HOUSING PROVIDERS AND OTHER INDUSTRY EXPERTS

WORKSHOPS AND ONE-TO-ONE MEETINGS

Evidence Reviews

The ZCH commissioned a series of Evidence Reviews from experts on key themes. These were published in March 2015 and can be found at www.zerocarbonhub.org.

Defining Overheating
by the Chartered Institution of Building Services Engineers (CIBSE), ARCC Network, University College London (UCL), and the London School of Hygiene and Tropical Medicine (LSHTM)

Assessing Overheating Risk
by Inkling LLP, CIBSE, UCL and ARCC Network

Impacts of Overheating
by AECOM

Overheating Risk Mapping
by AECOM

Drivers Of Change – Overheating In Homes (Leaflet)
by ZCH and AECOM

A sixth Evidence Review by BRE will set out the range of technical and behavioural solutions available to address overheating in new and existing homes. This is due to be published in July 2015.

THE OVERHEATING SURVEY

A short survey of Housing Providers was carried out by the ZCH, in partnership with Sustainable Homes, in November 2014.

The survey aimed to gain a picture of how organisations who build new homes, and those who manage or retrofit existing homes, assess the risk of those properties potentially overheating and what other processes they have in place to manage the risk. 75 valid responses were received representing 207,728 dwellings. The answers to the survey were confidential to allow respondents to be candid in their response but aggregated information has been included in this report.

Figure 4.
Breakdown of Overheating Survey respondents by type

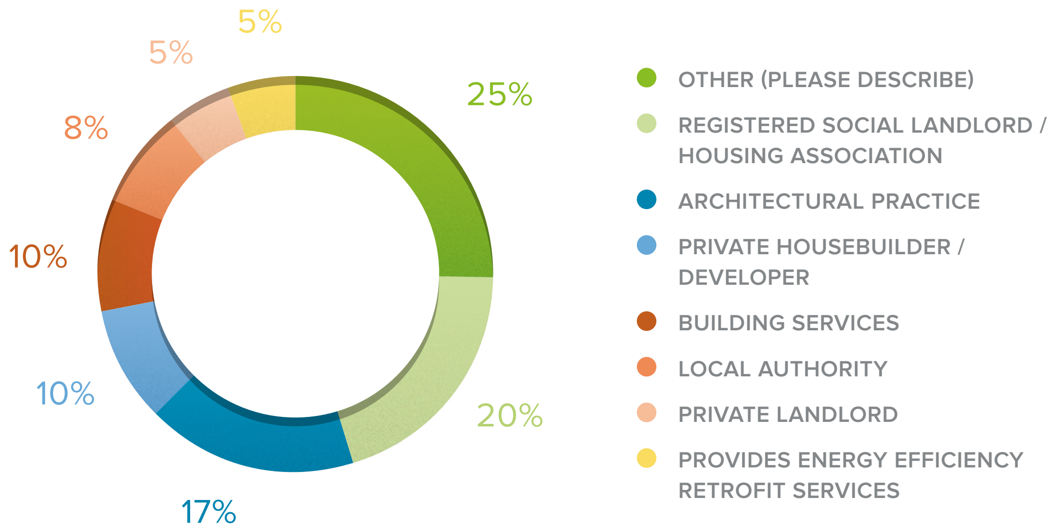
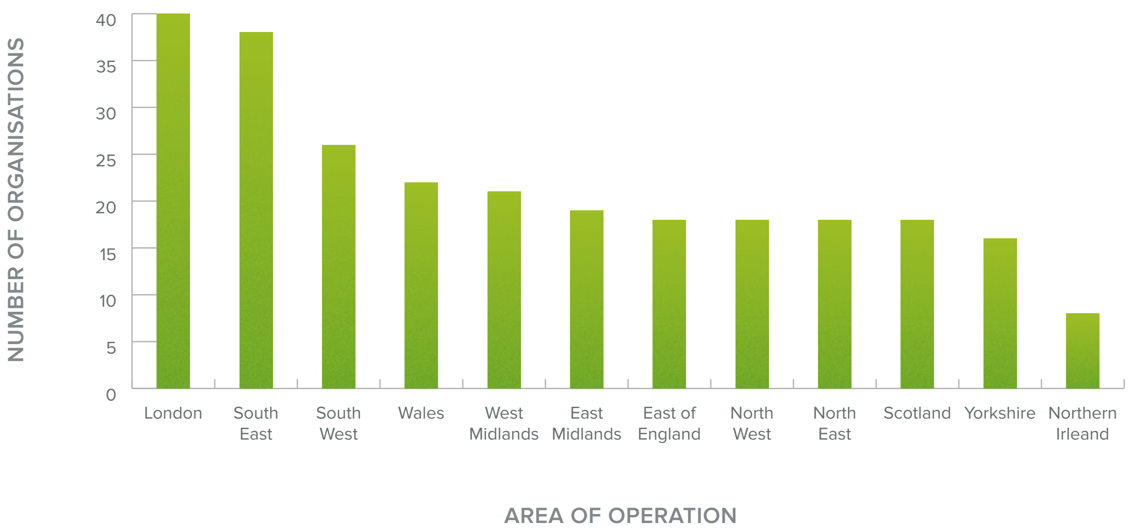


Figure 5.
Breakdown of respondents to Overheating Survey by the locations they operate in



DEFINITIONS

CHAPTER 2

Chapter 2 describes the range of definitions, criteria and thresholds used by the sector to understand whether a dwelling is overheating, or might overheat in the future.[1]

The housing sector tends to understand and encourage the design and refurbishment of dwellings with the aim of allowing the occupants to be thermally comfortable – the concept of 'thermal comfort'.[2]

Thermal comfort has been defined as:

'that condition of mind which expresses satisfaction with the thermal environment'

Professional bodies, such as CIBSE, have produced guidance on the temperature thresholds, which if exceeded for certain periods of time, would result in most occupants in buildings feeling uncomfortably warm. In such circumstances the building is considered to have overheated.

For instance, CIBSE's previous edition of Guide A Environmental Design (published in 2006) suggests 28°C as the maximum threshold above which the majority of people in a building will start to feel uncomfortable. The guidance also highlights that high night-time temperatures can lead to disrupted sleep and impair a person's ability to recover from heat stress during the day. Experts have stressed that this effect is likely to be most pronounced in locations with strong heat island effects, such as in deep urban areas. Such locations can have significantly higher night time temperatures compared to their rural surroundings. Control of night-time temperatures is therefore particularly important for the domestic sector and, as a result, a lower peak threshold temperature of 26°C is recommended for bedrooms. See Table 1 below.[3]

Table 1. **Peak operative temperatures for the design of buildings – adapted with permission from CIBSE's Environmental Design Guide A (2006), recently superseded by the 2015 edition**

Building type	Peak operative temperature (°C)	Overheating criterion
Offices	28°C	1% annual occupied hours over peak temperature
Schools	28°C	1% annual occupied hours over peak temperature
Homes – living areas	28°C	1% annual occupied hours over peak temperature
Homes – bedrooms	26°C	1% annual occupied hours over peak temperature

1. For more detail see the Defining Overheating Evidence Review.

2. BSI (BS EN) ISO 7730 (2005).

3. The indoor comfort temperatures recommended by CIBSE's Guide A (2006) for free running buildings are slightly lower: 25°C for living rooms and 23°C for bedrooms.

The "operative temperature" combines the air temperature and the mean radiant temperature in a weighted average.

Overheating criteria are commonly used by researchers, building designers and modellers to assess the likely summertime thermal performance of buildings. If the building is assessed to 'fail' against these criteria, changes to the building's design or other measures would be needed to bring it within the thermal comfort thresholds. See Chapter 3.

Absolute thresholds, like those in table 1, are relatively simple to use with most modelling tools, but do not take into consideration that the comfort levels of occupants vary with outdoor temperature and other factors. An alternative approach – the 'adaptive thermal comfort model' – has been incorporated into the 2015 edition of CIBSE's Guide A.[1] This approach aims to account for the fact that the occupants of buildings tend to make simple adjustments to try to keep themselves cool, and also that healthy people acclimatise to some extent, and tolerate changes in temperatures.

The adaptive thermal comfort model therefore:

- Relates external temperatures to upper and lower internal temperature thresholds for 'free running' buildings (i.e. those which are not being heated or mechanically cooled). For any outdoor temperature there will be a range of possible indoor temperatures which are comfortable; and
- Assumes people make adjustments and modify their environments, for example, by wearing different clothing, opening windows more often, using cooler rooms or closing their curtains during the hottest periods of the day.

The British Standard (BS EN) 15251:2007 introduced the concept of acceptable indoor comfort temperatures for four categories of buildings described in Table 2. The classifications relate to the ability of the occupants to modify and adapt to their environments and are represented by the range of comfort bands in Figure 6.

A building with vulnerable occupants would be classed as Category I. The upper temperature thresholds are lower for this category than for Category II and III buildings, where it is assumed that occupants will have much more ability to adapt themselves and their internal environment.

CIBSE's recommendation in Technical Memorandum 52 (2013) is that new buildings, major refurbishments and adaptation strategies should conform to Category II.[1]

1. Guide A (2015) references detailed guidance: CIBSE's Technical Memorandum 52 (TM 52). The Limits of Thermal Comfort, Avoiding Overheating in European Buildings (2013).

Figure 6.
Indoor comfort temperatures for free running buildings as a function of the running mean outdoor temperature, for the three building types. (Used with kind permission from the British Standards Institute).

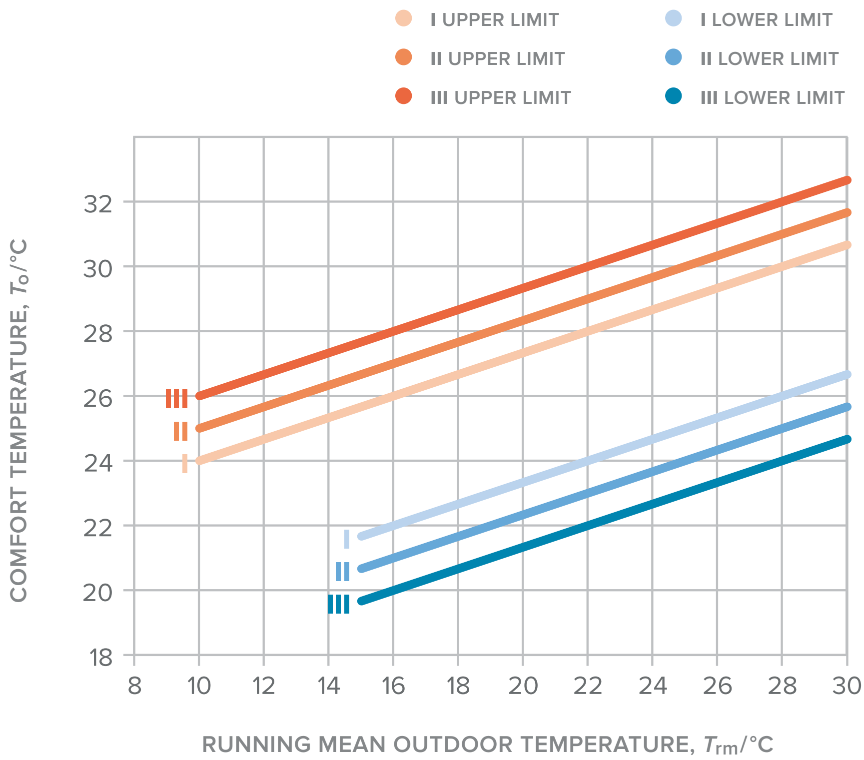


Table 2.
Description of building types recreated from BS EN 15251:2007 (Used with kind permission from the British Standards Institute)

Category of occupant	Description
Category 1	High level of expectation (only used for spaces occupied by very sensitive and fragile persons) ± 2K
Category 2	Normal expectation (for new buildings and renovations) ± 3K
Category 3	A moderate expectation (used for existing buildings) ± 4K
Category 4	Values outside the criteria for the above categories (only acceptable for a limited periods) >4K

Notwithstanding the movement towards adaptive comfort-based temperature bands, Guide A (2015) continues to advise that sleep quality may be compromised when the indoor operative temperature rises above 24°C and recommends that peak bedroom temperatures should not exceed an absolute threshold of 26°C.

The adaptive thermal comfort model is based on extensive field studies, but these were carried out primarily in the non-domestic sector. The approach therefore needs to be fully road-tested in the domestic sector and further field studies are needed to confirm its applicability to bedroom comfort temperatures during the night. More investigation is also needed into its application to dwellings intended to house vulnerable occupants with varied health conditions.

“[People’s] ability to [adapt the environment] will depend on the opportunities which the building they inhabit gives them to do so.”

FERGUS NICOL

Excess heat can have significant health implications, particularly for vulnerable groups, including the elderly, infants, those who are obese or have chronic illnesses, people who socially isolated and those who live in urban environments. These groups are often less physically able to acclimatise or adapt to keep cool at home when external temperatures rise. See Chapter 6.

The Government's Standard Assessment Procedure (SAP) provides a basic methodology at Appendix P for understanding whether a new dwelling might overheat.

SAP is used to assess compliance with Building Regulations Approved Document Part L1A 2013: Conservation of fuel and power in new dwellings. Criterion 3 of Part L1A, 'Limiting the effects of heat gains in summer' relates to overheating risk. SAP Appendix P provides a method for demonstrating 'reasonable provision" has been made to limit heat gains. However, Appendix P is not integral to SAP in that it does not affect the overall SAP rating. Building Control Officers do however check the overheating assessment as part of the report.

Energy assessors performing SAP assessments input information related to the propensity of buildings to overheat, such as values for thermal mass and solar gains. Using this information and average external temperatures, the average internal temperature for the property in June, July and August is calculated. This temperature is then compared to threshold temperatures set out in Appendix P (see Table 3 below). If the average temperature of the property exceeds 23.5°C, then it is considered to have a high chance of overheating and this information would be recorded as a 'fail' on the SAP report. See Chapter 7 for further discussion on Appendix P.

Table 3.
Threshold temperatures corresponding to the likelihood of high internal temperature during hot weather (Adapted with kind permission from SAP Appendix P).

SAP threshold temperature	Likelihood of high internal temperatures during June, July and August
< 20.5°C	Not significant
≥ 20.5°C and < 22.0°C	Slight
≥ 22.0°C and < 23.5°C	Medium
≥ 23.5°C	High

Health thresholds

There is a difference between defining the conditions that should be met for acceptable thermal comfort and the limits above which there could be significant health impacts for occupants. Where health-related guidance on internal temperatures exists, it sets different standards or thresholds, since the people most at risk from the health effects of excess heat may experience those effects at temperatures below the upper thresholds for thermal comfort. Prolonged heat exposure, which can cause serious health problems for vulnerable groups, is also not well accounted for by simple temperature thresholds.

"High temperatures can increase cardiovascular strain and trauma, and where temperatures exceed 25°C, mortality increases and there is an increase in strokes."

GOVERNMENT'S HOUSING HEALTH AND SAFETY RATING SYSTEM

The Government's Housing Health and Safety Rating System (HHSRS) includes requirements related to the health and safety risks of "excess heat". The guidance considers threats to health from excessively high indoor air temperatures as a 'hazard' and, although not strictly speaking a standard, the guidance references 25°C as an important threshold for residential dwellings. This question and other questions about the property are used by local authorities operating under the Housing Act 2004 to assess whether there are deficiencies in the dwelling.

World Health Organisation guidance from 1987 states that heat-related health effects for sedentary people, such as the elderly, are minimised at air temperatures below 24°C.

"Where do you draw the line between temperatures affecting health versus thermal comfort. Some of us are very comfortable in heat, others aren't. Some groups of people may have their health put at risk by excessive heat."

TRADE BODY

The Heatwave Plan for England (2015) also contains advice related to internal temperatures in dwellings:

- That cool rooms, maintained at temperatures below 26°C, should be provided in hospitals, care/nursing homes and other residential environments occupied by vulnerable' individuals; and
- Fans should not be used if indoor air temperatures are greater than 35°C.[1]

However, most health-related research and standards are based on external temperatures, making these inappropriate to apply as design standards for buildings. Using outdoor thresholds to predict the possible health impacts of elevated internal temperatures has limited value as there are many variables that affect how warm the building really is inside, for example, heat gains from appliances, the materials the building is constructed from and the level of solar gains. All affect how external temperatures relate to internal conditions. See Chapter 3.

Maximum daytime outdoor temperatures are a predictor of heat-related mortality. Threshold temperatures vary across the country depending on how acclimatised the population is to warm weather.

Research shows that in London mortality starts to rise when the maximum daily external air temperature goes above 24.7°C, and has been estimated to rise by approximately 3% for every further 1°C increase in external temperature. In other regions, the thresholds at which mortality starts to rise are lower. For example, the threshold for the North East of England is 20.9°C.[2]

Heat-related health impacts also vary considerably depending on an individual's characteristics and levels of heat exposure, which adds another layer of complexity to the specification of health-related indoor temperature thresholds. Occupants have different degrees of vulnerability to heat depending on, for example, their age, health and social contacts.

At present, there are currently no officially established, universally accepted upper internal temperature thresholds for health. A review led by the UK's Health Protection Agency[3] outlined the urgent need for collection of evidence on the subject of internal health-related temperature thresholds and suggested that the determination of such thresholds and the development of an appropriate indoor heat vulnerability index is a public health issue.

1. The Heatwave Plan states that at temperatures above 35°C fans may not prevent heat related illness. Additionally fans can cause excess dehydration. The advice is to place the fan at a certain distance from people, not aiming it directly on the body and to have regular drinks. This is especially important in the case of sick people confined to bed.

2. Armstrong et al (2011).

3. Now Public Health England (PHE).HPA (2011), Anderson et al. (2013).

"Indoor thresholds for health are needed as a protective measure against preventable morbidity and mortality."

OVERHEATING IN NEW HOMES. A REVIEW OF THE EVIDENCE (2012), NHBC FOUNDATION (NF46)

What definitions are Housing Providers using?

The ZCH's stakeholder interviews and Overheating Survey confirm that Housing Providers understand and are using many different ways of defining overheating.

Organisations responding to the survey were asked "How does your organisation define 'overheating' in residential properties?" Approximately two thirds of the 70 organisations who provided information about the definition they use defined overheating in general terms, and these definitions related to the thermal comfort of occupants (rather than health considerations). 8 organisations referenced SAP Appendix P as their definition. The remainder said they defined overheating using quantified criteria including CIBSE's Guide A (2006), or criteria developed specifically for Passivhaus designs. It is unclear to what extent these definitions are officially adopted within the organisations answering the survey.

"We're like a lot of the sector, we do struggle to define [overheating] within any set parameters...We struggle to think of it in terms of a single temperature, and of course it's so subjective to occupants and their age..."

HOUSING ASSOCIATION

"The only time we've looked at [overheating] we've used CIBSE's Guide A 2006 as the only thing out there that comes close to a definition. There have been a couple of times where the HCA [Homes and Communities Agency] has requested analysis in accordance with CIBSE Guide A – which we've done for them in a sample of house types."

HOUSEBUILDER

Housing Providers also reported that the range of different definitions is creating issues. For example, if Environmental Health Officers seek to enforce health and safety standards which the dwelling was not designed to deliver, protracted disputes can arise. The lack of clarity created by the absence of a standard for domestic properties is leading to uncertainty over whether organisations have 'done enough' to meet legal requirements.

"We're finding increasingly that the local environmental health officers have a view and they're potentially at odds with their building control colleagues."

HOUSING ASSOCIATION

A number of interviewees also raised questions about the extent to which occupants can adapt their homes or themselves to warmer weather in practice, especially vulnerable people, and how overheating criteria deals with this.

"We've been discussing an overheating issue in a development recently where people in the business are trying to argue with the purchaser that there isn't an overheating problem because SAP tells you there is not a significant overheating risk. And if that were right – i.e. that's the regulation to do with overheating, then that would be the end of it...To be in a situation where we can't demonstrate that we comply is a bit scary."

HOUSEBUILDER

What could this mean for future frameworks?

In common with other studies, the most pressing issue identified is that there is no accepted or agreed definition of overheating which can be applied by the domestic sector as a whole.

Box 5. Don't Building Regulations already set a standard?

Approved Document Part L1A is designed to drive the conservation of fuel and power, rather than set thermal comfort standards. It requires housebuilders to make "reasonable provision to limit heat gains" in dwellings in order to reduce the need for mechanical cooling. Specific criteria or thresholds are not specified. The overheating 'check' in SAP Appendix P provides a means of demonstrating that reasonable provision has been made, but the calculation is not integral to the SAP rating and it is unclear what happens if a development fails the test. See Chapter 7.

"The dwelling should have appropriate passive control measures to limit the effect of heat gains on indoor temperatures in summer, irrespective of whether the dwelling has mechanical cooling. The guidance given in paragraphs 2.38 to 2.42 of this approved document provides a way of demonstrating reasonable provision."

CRITERION 3, APPROVED DOCUMENT PART L1A

Without a sector-wide accepted definition:

- Dwelling designs which have the same characteristics as existing dwellings where high temperatures are known to harm health could inadvertently be approved;
- Overheating risk assessments of dwellings will continue to be judged against different criteria, limiting comparison between them;
- Housing Providers will continue to experience a lack of clarity about what reasonable steps they are required to take to safeguard current and future occupants, and be subject to very different types of planning requirements, for example, depending on which part of the country they operate in; and
- Without a level playing field, those who invest in taking reasonable steps to safeguard the comfort and health of occupants may find they are commercially disadvantaged.

"If you put a absolute [temperature threshold] in [Building Regulations] you might get a situation like in the US, where air conditioning units work to that absolute."

MANUFACTURER

Agreeing a precise form of definition is unlikely to be an easy task. In particular, defining a single temperature threshold which would apply in all circumstances may be inappropriate for the reasons set out below. However, research done to date provides a solid foundation for agreeing a way forward and means that progress can continue to be made towards addressing overheating risk even as the sector moves towards a clearer standard. A number of practical issues need consideration, including how any definition or standard would account for:

- Climatic variation across the country, including future climate projections and the ability of people to acclimatise and adapt;
- Neighbourhood effects and local microclimates in urban environments which can compound the effect of the urban heat island;
- The importance of night-time temperatures in dwellings (compared to non-domestic buildings);
- The different overheating risk profiles of the housing stock;
- The subjective nature of the experiences of occupants; and
- Vulnerable occupants.

What form the definition would need to take in order to be universally applicable, what status it would have (e.g. in guidance or regulation), what unintended consequences having a very precise definition could create, and what alternative ways of driving action exist, will all need careful exploration in Phase Two of the project.

Action

ZCH to form a working group of experts to make recommendations to Government on what form an overheating definition or standard could take, and how it would be implemented in practice (by March 2016).

CAUSES AND RISK FACTORS

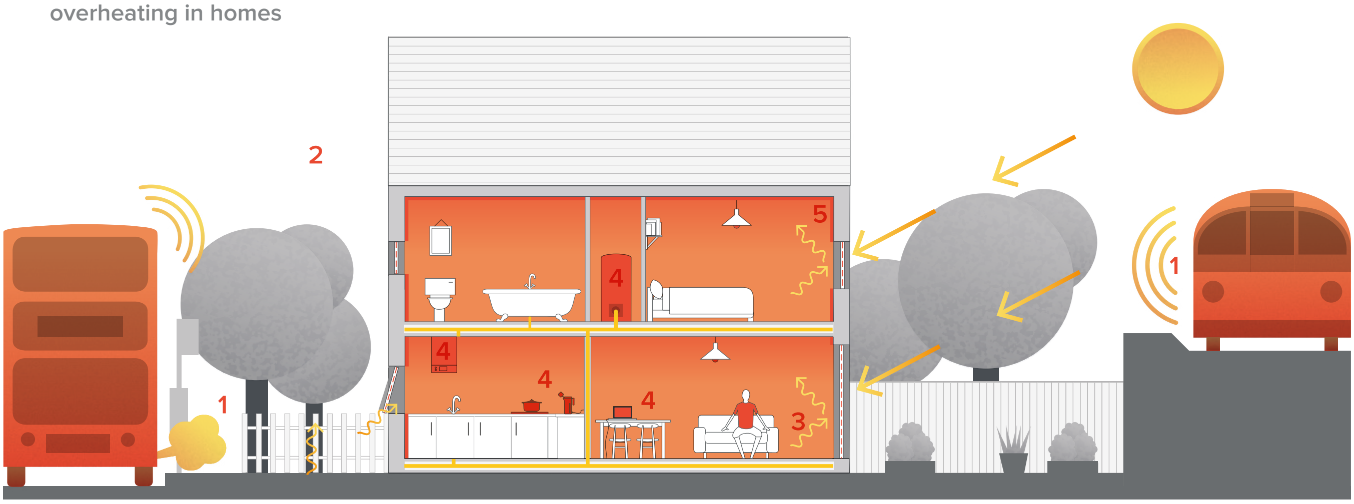
CHAPTER 3

Chapter 3 sets out the main causes and risk factors associated with overheating in homes.

In summary, overheating occurs when too much heat builds up inside a dwelling – from external sources such as the sun, or from internal sources such as heat from people, appliances and hot water pipes – which cannot quickly or easily be rejected or removed.

All buildings should act as a physical buffer between the outside and inside to protect their occupants from the extremes of the external environment. As described, where a building is located, how it is orientated, how it is constructed, how it is venti-lated, how it is heated, and how it is used, all contribute to how well a dwelling fulfils this role.

Figure 7. Illustration adapted with kind permission from 'Understanding Overheating – Where to start' (NHBC Foundation NF44, 2012) showing some of the causes and cumulative effects of overheating in homes



1. Site context

External pollution, noise and excessive noise may prevent occupants from opening their windows. Surrounding hard surfaces will absorb heat and release this during the night.

2. External temperature

On a warm, still day when external temperatures are high, fresh air may not provide enough of a cooling effect to address overheating.

3. Solar gains

Double-glazed windows with a low-e coating prevent heat from escaping. Houses with unshaded west-facing glass will suffer from higher levels of solar gain in the warmer part of the day.

4. Internal gains

Electrical appliances, occupant activities such as cooking, and building services, e.g. boiler and hot water storage, all have the potential to radiate heat that may contribute significantly to the increasing internal temperatures.

5. Building design

Modern homes have increased levels of insulation and airtightness, resulting in more heat being retained within the homes. This means any built-up heat in the homes will have to be actively removed.

External air temperature and location

As would be expected, high external air temperatures affect conditions inside a dwelling. If external temperatures are high, the fresh air deliberately brought into buildings – either through windows and other natural ventilation openings, or provided by mechanical ventilation – will be warm.

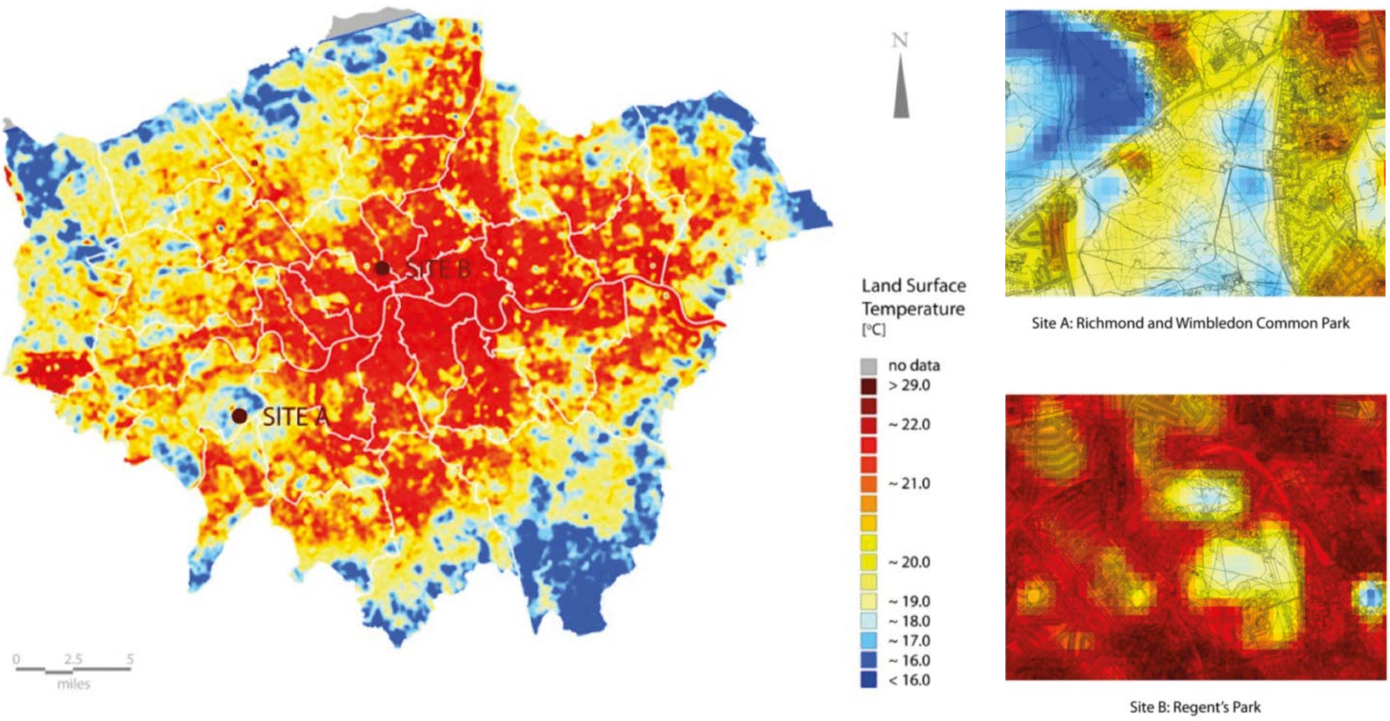
The external temperature of course varies in different regions of the UK. The temperature in London and the South of England is usually hotter than in say Edinburgh. However, the external temperature can also be influenced by more local factors, such as the Urban Heat Island and the microclimate around the building.

The Urban Heat Island

The Urban Heat Island (UHI) is a phenomenon where the temperature at the centre of large cities has been found to be significantly higher than in the surrounding rural areas.

The effect has been studied in several UK cities. Maximum summer intensities (urban to rural temperature differences) of 9°C have been recorded in London and 8°C in Manchester. Figure 8 shows satellite land surface temperatures measurements taken over London just after 9pm on 12 July 2006 (during a heatwave), and demonstrates the variation in temperatures from the centre to the outskirts of the city.

Figure 8. **Land Surface Temperature in London at 21:00 on 12 July 2006 (LUCID project)**



A number of factors contribute to the development of the UHI. During the day the urban fabric, in the form of hard surfaces such as tarmac, brick and concrete, absorbs and stores heat from the sun. This heat is then re-emitted at night, keeping built-up areas warm as the temperature outside cities drops. The effect is therefore most pronounced at night as the heat stored in the 'thermal mass' of buildings and streets is slowly released. The amount of heat absorbed depends on the material.

The effect of the UHI is that the air brought into dwellings for ventilation will be warmer than it might otherwise be in a comparable rural location. This is of particular relevance to homes, compared to non-domestic buildings, where people are trying to sleep at night.

Local hot spots and the microclimate

Variations in external air temperature can also occur on much smaller scales, from street to street or building to building. For example, supermarkets and convenience stores have refrigerators and chillers, which are continuously exhausting heat into the atmosphere. If these heat outlets are sited immediately below residential flats, occupants will be less able to cool their dwellings by opening the windows. Again, the air coming in will warmer.

Depending upon the materials used, large areas of hard-surfaces, such as pavements, car parks or even the building façade itself, can absorb large amounts of heat from the sun. This will significantly warm the layer of air immediately adjacent to these surfaces compared to the ambient external temperature. If the windows or ventilation system inlets draw air from this warm surface layer, it will warm rather than cool the building.

Solar radiation, windows and building orientation

Energy from the sun is transmitted immediately through windows, if not shaded, and will warm up the inside of a building. In winter this heat can be useful, but in summer too much sun coming through the windows can contribute to a room or dwelling overheating. South-west and west-facing rooms are considered to be at greatest risk as they will receive direct sunlight in the late afternoon when the ambient external temperature is also at its highest. Although south-facing windows are generally easier to shade due to the high angle summer sun.

Ideally, the size and position of windows should be optimized for each orientation. It is common practice, however, for larger developments to use the same standard flat or house types regardless of orientation. As a consequence, the indoor temperature and risk of overheating may differ substantially in otherwise identical homes.

Importantly, heat from the sun also warms the external surfaces of a building. This heat will gradually conduct through the walls and roof into the building.

"We recognise that as we decrease the amount of solar gain in the summer period [through the use of certain types of glazing solutions] we may then increase the heating costs for the owner in the winter. It decreases the winter gain at the same time."

HOUSEBUILDER

Building structure and fabric

How effectively buildings protect their inhabitants from the worst extremes of weather depends, in part, upon how they are constructed and from which materials. When considering overheating, one consideration is whether the structure is light or heavyweight and how much insulation is used.

Insulation slows down the transmission of heat through the building fabric. In winter this keeps heat in so that the inside of building stays warm. In summer, insulation can also prevent extreme heat entering through the fabric of building, slowing down the transmission. However, once heat is inside it can become trapped and so it needs to be deliberately rejected or purged.

Heavyweight building materials, such as brick, stone or concrete have the capacity to soak up and store large amounts of heat – or cold – due to their high specific heat capacity. So-called 'thermal mass' can be used to maintain more uniform temperatures inside a building.

To be most effective thermal mass must be 'exposed' to the inside of the dwelling, rather than covered up by carpet or ceiling tiles, and the heat absorbed by thermal mass during the day must be released and removed or purged on a regular basis – usually by ventilating at night when air temperatures are lower. If this is not done, the heat will build up in the thermal mass, warming up the whole building. In a non-domestic building, large volumes of cooler external fresh air can be brought in at night when the building in unoccupied to cool down the thermal mass. In dwellings, it can be much harder to achieve this.

Internal heat gains

As well as heat from outside, there are sources of heat inside every dwelling. People living in the dwelling generate heat. The amount generated depends both on the number of occupants and their level of physical activity.

The average household also uses over 3,000 kWh of electricity every year on cooking, lighting and electrical and electronic appliances (excluding electric heating). These all contribute to the build-up of heat within a dwelling. Although the energy efficiency of some devices, e.g. LED lighting, is improving, overall electricity consumption is rising. See Figure 9.

Like solar radiation through the windows, internal heat gains make a significant contribution to the build up of heat within a dwelling, but they are much harder to predict accurately at the design stage. They are heavily dependent upon the lifestyle of the occupants, Post-occupancy surveys have revealed considerable variation in energy use between otherwise comparable properties.

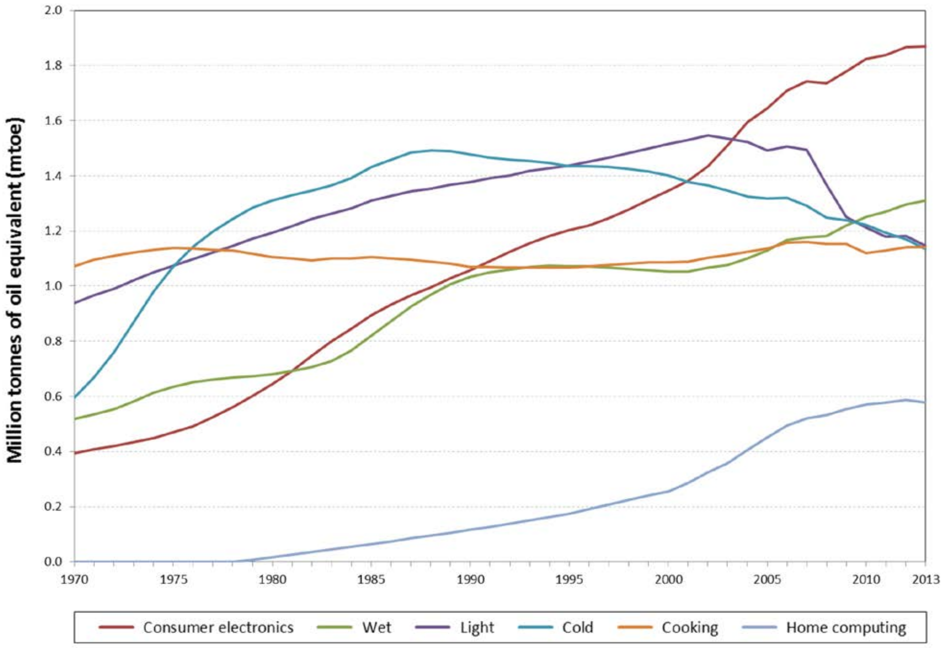


Figure 9. **Electricity consumption by household domestic appliances, by broad type, (UK 1970 to 2013) DECC (2014) Market Transformation Programme**

Building services and hot water distribution pipes

Another cause of internal heat gains are poorly insulated domestic hot water system pipes and tanks which liberate heat into the property.

Communal heating systems are now frequently installed in large residential developments. There is one central heat generating plant from which hot water is continuously piped throughout the building, usually above or below the corridors, ready to provide heat and hot water to individual dwellings on demand. This can be an energy efficient way of generating and supplying heat and also makes it easy to use low carbon fuel options, such as gas Combined Heat and Power or biomass.

> "Reasonable provision should be made to limit heat losses from pipes as set out in the Domestic Building Services Compliance Guide. This includes insulating primary circulation pipes for domestic hot water services throughout their length. NOTE: in the case of apartment blocks, insulating primary circulation pipes for space heating as well as for domestic hot water services within communal spaces can help to limit potentially unwanted heat gains and overheating of the space." Approved Document Part L1A, Criterion 3

The hot water in the pipes is typically maintained at a temperature of 60°C to 80°C.[1] At such high temperatures, even if the pipes are well insulated, heat from them will be lost to the corridors or individual dwellings. Unless the systems are run at lower temperatures, or corridors or flats are well ventilated so that occupants can get rid of this heat in summer (which then becomes wasted heat), eventually the structural fabric of the building will heat up. This effect is leading to high temperatures in apartment blocks, particularly in corridors.

1. *NHBC Foundation (2012). Overheating in new homes (NF46).*

"This year, the [overheating] cases I've been involved in do have communal heating systems that are dumping a lot of heat into corridors. Residents still need their hot water at that time of year, so it's still pumping around the building."

HOUSING ASSOCIATION

Box 6. **Heat Networks Code of Practice**

CIBSE together with the Association for Decentralised Energy has produced a Code of Practice for Heat Networks (or District Heating) to be published in 2015. Under the code, designers are to consider ways to reduce the heat losses from communal heating systems in order to reduce carbon emissions, operating costs and overheating risk. This work is supported by DECC and the need for a new Code of Practice is underlined by the fact that the draft code has already been adopted by some Local Authorities in their tendering process.

"Distribution pipes should of course be insulated. There is a question of how they are insulated, but also there is the point about variable flows and variable temperatures. So even if the pipes are super insulated, if you have water going round at 110 degrees centigrade, then you are going to end up with high [heat] losses in summer...very often the heat interface unit is not insulated either, so the heat interface unit becomes a radiator."

TRADE BODY

Ventilation

Approved Document Part F of the Building Regulations requires sufficient fresh air to be brought into dwellings to maintain optimal levels of indoor air quality. It must also be possible to rapidly remove or purge pollutants when required.

Ventilation is the main means of removing excess heat from buildings in the UK and reducing the risk of overheating, although this aspect is not specifically covered by Part F.

"Purge ventilation provisions may also be used to improve thermal comfort, although this is not controlled under the Building Regulations."

APPROVED DOCUMENT PART F

Providing the air outside is cooler than that inside, ventilating a dwelling with fresh air exchanges hot internal air with cooler external air. The sensation of moving air on the skin also has a cooling effect Traditionally, dwellings in the UK have rejected heat in summer through opening windows and purge ventilating. The majority of newer-build constructions also rely solely upon natural ventilation.

"The architect did not want opening lights as it "would have spoiled the aesthetics of the building lines."

"PREVENTING OVERHEATING. GHA (2014)

However, in practice, studies have found that occupants are sometimes either unable or unwilling to open windows, and leave them open for sufficient time to achieve meaningful levels of heat rejection, for a variety of reasons.[1] These include concerns about security, pollution and noise, especially at night. Many energy efficient, airtight homes provide a very effective acoustic barrier to the outside world, heightening the noise contrast experienced by the occupant when they open the window in a busy location.

A number of cases have been documented where the window opening area was too small to provide adequate ventilation or the windows could not be opened at all.[2] In other cases, windows cannot be secured in an open or part-open position.

"Some residents also have the expectation that the ventilation system functions as a cooling system."

A CASE STUDY: ONE BRIGHTON (2011)

Single aspect apartments

Where windows are open on more than one side of a dwelling, wind pressure will draw external air into the building on one side and pull it out on the other side, creating a through draft. In single-sided apartments, which only have windows on one side, much less air movement will be generated by opening the windows – especially on hot still days.

Mechanical ventilation

A growing proportion of new homes use mechanical ventilation systems such as Mechanical Extract Ventilation (MEV) or Mechanical Ventilation with Heat Recovery (MVHR).

These systems are normally designed and installed to fulfil requirements in Part F of the Building Regulations, which sets ventilation rates intended to deliver good indoor air quality. The minimum background ventilation rate (normal rate) shown in Table 4 is to ensure a continuous supply of fresh air to the whole dwelling – approximately equivalent to 0.5 air changes per hour. Whereas the minimum high rate (boost rate) is intended to extract moist and/or polluted air from kitchens, bathrooms and other utility and sanitary rooms.

Part F also requires "purge" ventilation at a rate of 4 air changes per hour in all habitable rooms. This ventilation rate is orders of magnitude greater than the minimum background ventilation rate. Purging is a short-term immediate response to remove moisture and pollutants in exceptional circumstances, for example when accidental spillages occur or while painting and decorating.

Ventilation for thermal comfort is also called "purge ventilation", but as discussed, this is not covered by Part F. Current guidance from the NHBC Foundation[3] suggests that similar air flow rates of 4 to 5 air changes per hour are needed for thermal comfort ventilation.

1. For example, Kolm-Murray (2013). Individual and community resilience to extreme weather events amongst older people in south Islington: attitudes, barriers and adaptive capacity.

2. For example, Preventing Overheating: Investigating and reporting on the scale of overheating in England. Good Homes Alliance (2014).

3. Designing homes for the 21st century Lessons for low energy design. NHBC Foundation (2013).

The flow rates required to achieve 4 air changes per hour are also shown in Table 4 for a range of typical dwellings. These are between 6 and 9 times higher than the recommended minimum boost rate for a mechanical ventilation system. The result is that natural ventilation through window opening is also normally relied on by designers alongside mechanical systems.

Another issue raised by stakeholders with MVHR systems is that they use heat from the exhausted stale air to warm the incoming fresh air – which can provide energy savings in winter. Most systems are fitted with a 'summer bypass mode' so that this function is significantly reduced in summer. If the bypass mode is not used, the result is that pre-heated air is delivered in summer. There is evidence to suggest that occupants do not always understand that they may need to switch over to summer bypass manually.[1]

Table 4. **Minimum Part F air flow rates for background and boost ventilation supplied by a mechanical ventilation or MVHR system and air flow rates required to achieve Part F "purge" ventilation at 4 air changes per hour for a range of typical dwellings. Calculation assumes a room height of 2.5m**

	Single aspect apartment	Dual aspect apartment	Mid-terrace house	Detached house	Large detached house
Floor area	55 m^2	58 m^2	76 m^2	118 m^2	212 m^2
Minimum high rate (boost rate)	21 l/s	21 l/s	35 l/s	43 l/s	64 l/s
Minimum background ventilation rate (normal rate)	17 l/s	17 l/s	23 l/s	35 l/s	51 l/s
Purge flow rate to achieve 4 air changes per hour	153 l/s	161 l/s	211 l/s	328 l/s	589 l/s

1. For example, BUS surveys carried out as part of BPE programmes, e.g. Bainbridge, (2011). Do buildings that are built according to sustainability principles and to a high environmental standard deliver a sustainable living solution to their occupants? A Case Study: One Brighton (MSC thesis).

Box 8. **Examples of risk factors**

The following summary has been adapted with kind permission from guidance produced by the ARCC Network in 2013.

Location

Summer temperatures are generally higher in the South and South East England. Built up neighbourhoods will be at higher risk of overheating as a result of the Urban Heat Island effect (UHI).

Type of properties

Many factors affect the risk of overheating, including built form and orientation. Flats, especially on the top floor, are often identified as being at highest risk.

Fabric characteristics

The position of insulation, how lightweight the construction is, the colour of the facade, and the type, area, and position of the glazing can all affect the likelihood of buildings overheating.

Orientation and exposure

West-facing (and potentially east-facing) windows are especially problematic. Although south-facing rooms also experience overheating, they are easier to shade from the high angle summer sun.

Occupancy/behaviour

Occupants staying at home all day could experience more overheating than an occupant who does not.

Ventilation

Where noise and security issues discourage the use of window opening for cooling.

Are Housing Providers embedding knowledge of causes and risk factors in their organisations?

The risk of overheating will vary from building to building depending on whether the causes outlined in the previous section are evident. Dwellings which have a higher propensity to overheat would usually have these recognisable risk factor. This means the sector can be cautiously optimistic about being able to identify and treat them.

> A detailed review of the literature on the combinations of causes and risk factors that can result in dwellings overheating will be carried out in Phase Two of the project to inform the workstream on methods for identifying particularly high-risk properties.

The generic causes of heat gains and overheating risk factors are well understood, and nearly all Housing Providers the ZCH interviewed considered that they have a good sense of the types of developments within their stock which would be more prone to overheating.

However, it was clear that problems can arise when trying to identify the precise causes of a particular overheating problem once it is happening. A number of interviewees also commented that detailed technical knowledge across the sector as a whole is lacking.

It was common during the interview process for Housing Providers to report issues with internal overheating risk assessment processes which could result in inherently risky designs and projects not being flagged early enough in the construction or refurbishment process. For example, reliance on modelling at a point in the construction process when it is too late to influence designs. Once designs or specifications are fixed, it becomes more difficult to make changes to address any concerns about overheating.

Conversely, a number of interviewees described how their technical teams are using their experience and knowledge of overheating risk factors to identify sub-sets of properties or designs which have characteristics that make them more likely to overheat, before carrying out any formal modelling exercises. A form of ‘first pass’.

For new-build properties, these ‘higher risk’ units were then subjected to detailed 'dynamic' thermal modelling, and if found to fall short of the chosen overheating criteria, measures would be installed or design changes made to reduce the potential for overheating. The sub-set of units singled out for special attention was often very small – less than 5% of their total stock.

Most Housing Providers carrying out this form of triaging process continued to use the SAP overheating check on their other properties, or their own methodology.

By performing this 'first pass' the teams concerned felt better able to factor in their practical knowledge of the site, such as whether the property in question is located next to a busy main road, meaning windows are not opened in practice. Such factors can be difficult to account for in standardised calculations and models.

"Where we have single aspect apartments or elements with large areas of glazing...I have then insisted we do dynamic modelling to look at the overheating risk. The judgement on whether dynamic modelling is needed is also based on...the layout, orientation, what's around the building, how much glazing it has, is it dual aspect, what's the ventilation system... all of these things influence whether we are going to get an overheating problem."

HOUSEBUILDER

Box 7. Doesn't SAP Appendix P already flag high risk properties?

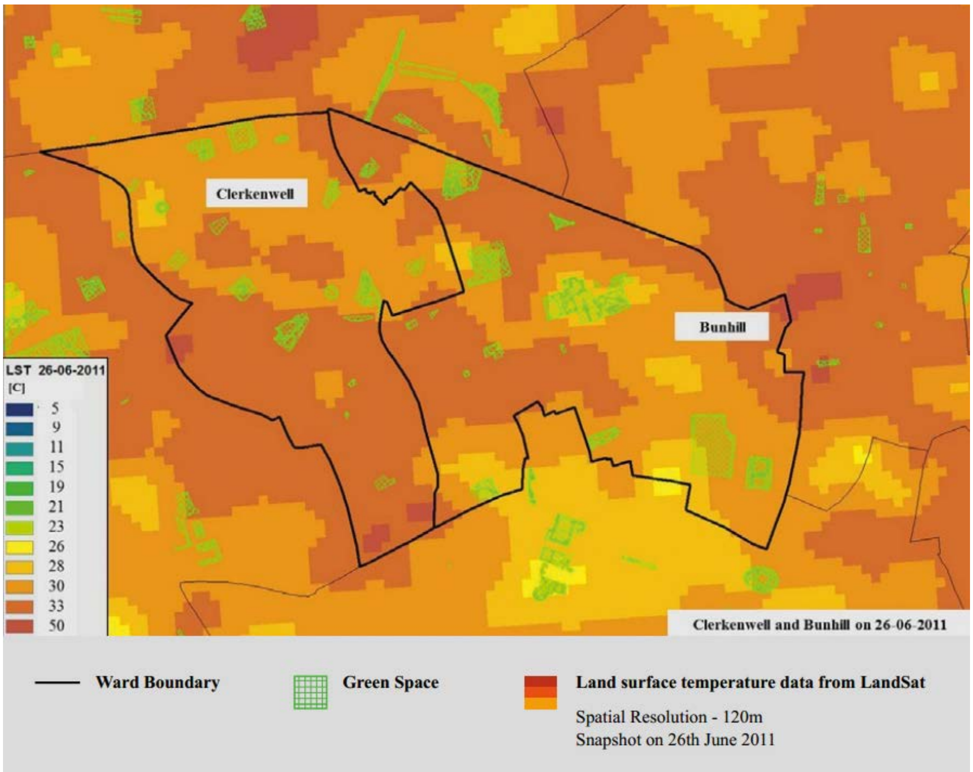
Appendix P and other overheating assessment tools and methodologies have certain limitations which are discussed in greater detail in Chapter 7 and in the Assessing Overheating Risk Evidence Review. Overall, there is concern that the Appendix P process is not identifying high risk properties as intended.

Stakeholders are keen to explore two proposals to further assist planners, Building Control Officers, designers, developers and retrofitters with the process of overheating risk assessment:

- The development of simple 'rules of thumb' or yes/no questions which would ensure that any first pass on a planned development or retrofit project is carried out in a sufficiently systematic way. Its purpose would be to help Housing Providers flag up at an early stage which units 'to worry about'.
- Whether new protocols and resources could be developed to enable property or scheme level risk assessments to take better account of the location and people-related factors which can significantly influence whether a building overheats in practice. For example, whether the property is located in an Urban Heat Island, or the amount of green space nearby known to have a cooling effect. Housing Providers are unlikely to have control of some of these factors, so the challenge is to find a way to make existing (or newly created) data available in a way that does not create unnecessary burdens on businesses.

There are some excellent examples of local authorities carrying out work to identify overheating 'hotspots', for example in Birmingham and London, which Housing Providers could draw on. These are summarised in the Overheating Risk Mapping Evidence Review. One example, produced by Arup for the Greater London Authority (GLA), is shown in Figure 10. ARUP considered two pilot areas within the London Borough of Islington: Bunhill and Clerkenwell. Both locations are in central London and have low green space density and high Land Surface Temperatures (LST). This co-occurrence of factors indicates greater heat risk. Overlaying them shows that larger green spaces appear to influence the LST, whereas smaller spaces have a more limited effect.

Figure 10. Clerkenwell and Bunhill measured Land Surface Temperatures – day time 26th June 2011 and green spaces map overlay (ARUP 2014, 24)



What could this mean for future frameworks?

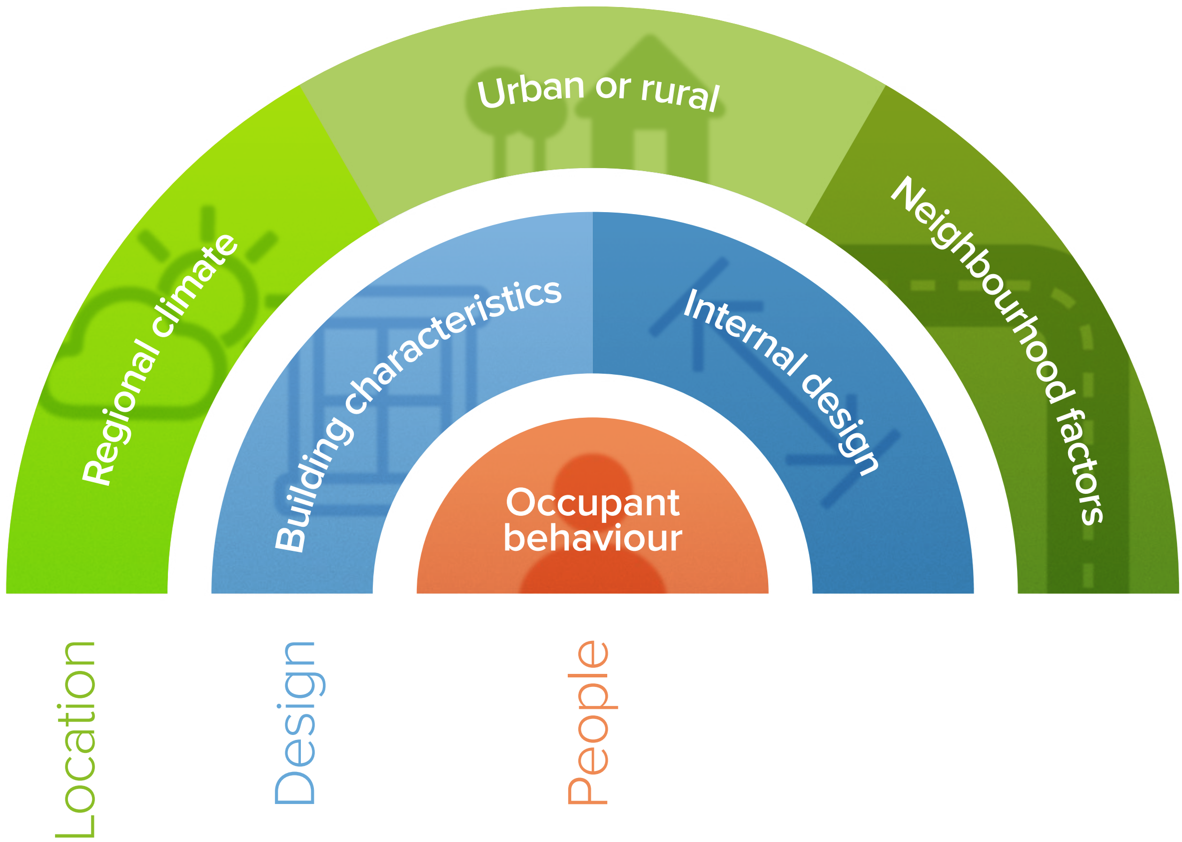
The analysis of overheating risk must start at the concept stage of projects. Future policies and frameworks which support Housing Providers in identifying potentially high risk dwellings within their stock for special attention, from an early stage, should help to ensure that investment in solutions is targeted at the homes and people which need it most. It also appears that such an approach could prove to be cost-effective and relatively simple to weave into current business practices as certain Housing Providers are doing it already.

The feasibility of this type of approach will be explored in greater detail in Phase Two, including consideration of how to avoid potentially problematic homes being missed accidentally.

Action

ZCH to coordinate work to develop proposals on how to improve overheating risk assessment processes and commission guidance on which combinations of location, properties and occupants in England and Wales are more prone to overheating (by March 2016).

Figure 11. A conceptual diagram of the types of factors which, if they can be accounted for, should improve the reliability of overheating risk assessment processes for dwellings



EXTENT

CHAPTER 4

One of the barriers to taking concerted action on overheating has been a lack of evidence about the scale of the problem.

Chapter 4 summarises information and evidence about the current extent of overheating, the severity of observed cases and the perceptions and experiences of Housing Providers.

Evidence about the extent and severity of overheating comes from a variety of sources, including:

- Post-occupancy monitoring studies (small and large-scale);
- Modelling the number of homes likely to be 'at risk' of overheating against specified criteria; and
- Reports of overheating from occupants themselves.

Most monitoring studies measure the indoor temperatures (and sometimes humidity levels) of living rooms and bedrooms in test homes over one or more summers. These provide a record of the actual temperatures within properties which can then be used to assess whether the property is overheating in terms of, for example, CIBSE criteria or other more qualitative assessments. Determinations of 'overheating' are therefore dependent on the criteria used. Studies of this type are often accompanied by Building User Surveys designed to help researchers understand the factors that could influence the results, such as the time of day the occupants are usually at home.

> It is clear from the studies summarised in this Chapter that different criteria have been used in each to determine whether overheating is occurring. This means they cannot be directly compared, but together, provide an indication of the incidence of overheating within the housing stock. Future research which uses the original data from these studies but analyses them in a consistent way would provide further insights.

Much of the available evidence on overheating comes from small-scale monitoring studies or Building User Surveys carried out by individual organisations. However, a number of recent larger studies, summarised from page 52, provide information relevant to the scale of the issue in properties nationally (in England). The first, Beizaee et al. (2013),[1] was the basis for the ASC's observation in their 2014 report[2] that up to 20% of homes may already exceed defined thresholds for overheating, even in cooler summers.

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1. *Beizaee et al. (2013). National survey of summertime temperatures and overheating risk in English homes*

2. *Adaptation Sub-Committee (2014). Managing Climate Risks to Well-being and the Economy.*

Beizaee et al. (2013)

Nearly 200 unheated homes throughout England of mixed dwelling type and age were monitored during the summer of 2007. Despite this being a relatively cool summer (the majority of England had its coldest August since 1993) the team found that 21% of bedrooms exceeded 26°C for more than 1% of night-time hours. 47% of bedrooms exceeded temperatures of 24°C for more than 5% of night-time hours – the temperature at which sleep is thought to become disrupted.

Living room temperatures were examined for the period 08:00 to 22:00 and bedroom temperatures from 23:00 to 07:00. The researchers noted that the rooms may not necessarily have been occupied during these times of the day for the whole monitoring period. In addition, overheating criteria were applied to measurements made over a period of just 41 days, and not to a whole year. The thresholds were therefore used to identify rooms that were "uncomfortably warm" – rather than being used as pass/fail criteria.

Lomas and Kane (2013)[1]

A monitoring study of over 200 unheated homes in Leicester in 2009 found that almost 27% of living rooms exceed the threshold of 28°C for 1% of daytime and evening hours. In the study, criteria of 25°C for 5% of occupied hours, and 28°C for 1% of occupied hours were used, respectively, as indicators of mild and severe summertime overheating risk in living rooms.

Nearly 20% of bedrooms had temperatures over 24°C at night for 30% of the summer monitoring period. Again, average external temperatures during monitoring were cooler than normal for the time of year, although there was a short hot spell.

The Energy Follow-up Survey (2013)[2]

The Energy Follow-up Survey carried out by BRE for DECC found that 20% of the 2616 households interviewed in 2010/11 in England had "difficulty keeping one or more rooms cool during the summer months". Monitoring of a sub-sample of 823 homes confirmed that temperatures in the homes that reported overheating were 0.5°C to 1.5°C higher than in households who did not report any issues. The average mean temperature for those households who reported a problem equates to a 'medium' overheating risk in the SAP Appendix P scale.

The study consisted of a follow-up interview of a sub-set of households first visited as part of the 2010/2011 English Housing Survey (EHS). A sub-sample of these households were selected to have temperature loggers and electricity consumption monitors installed. Analysis was based on the interview sample, weighted to the national population. The results presented in the report were therefore considered to be representative of the English housing stock with an assumed 21.9m households.

1. Lomas and Kane (2013). Summertime temperatures and thermal comfort in UK homes.

2. Energy Follow-up Survey 2011 (2013). Report 7. Overheating and thermal comfort.

The Risks to Housing from Overheating (2014)[1]

This study, which used EHS data, found that just 0.5% of the housing stock (around 112,000 homes) was assessed to be at risk of overheating against HHSRS (health-related) criteria. The BRE, however, noted that the research was exploratory and that these figures are likely to be an underestimate due to the small sample size, the fact that the building assessments used were not restricted to summer months, and because the data used was not as detailed as would be collected by environmental health practitioners conducting a full HHSRS assessment. This finding does, however, indicate the difference using health-related criteria compared to thermal comfort criteria makes in understanding the scale of overheating.

The EHS comprises an interview survey with all the householders in the sample, and a physical survey and inspection by qualified surveyors of a sub-sample of properties. Currently 6,200 dwellings receive an inspection each year. The survey gathers a small amount of information on the likelihood of overheating which is collected as part of the HHSRS assessment of the dwelling. Three years worth of data were combined for this study to make a sample size of 23,000 dwellings. The data was weighted to be representative of the English housing stock in 2010.

Is observed overheating severe?

The detailed findings of the four studies referenced above suggest that only a small proportion of homes have very high peak temperatures or have high temperatures for prolonged periods of time.

For example, in Beizaee et al, it was noted that 'whilst the average maximum temperatures [across the sample] were not unduly high, 25.7°C in the living rooms and 25.4°C in the bedrooms, individual dwellings had peak living room and bedroom temperatures up to 30.3°C.' It should be noted that vulnerable occupants, in particular, can start to suffer health effects from heat exposure at much lower temperatures than these.

The Energy Follow-up Survey also considered the length of time overheating was occurring as an important indicator of severity. 22% of the households reporting overheating problems said that at least one room in their home was difficult to keep cool 'every day' during the summer months monitored.

The Risks to Housing from Overheating study referenced above, concluded that just 1,000 of the 22.6 million properties in England could be at extreme risk of overheating. 'Extreme' was defined as a Category 1 Excess Heat Hazard under the HHSRS. However, as noted above, the findings are likely to be an underestimate.

Should temperatures in homes more frequently exceed recognised thermal comfort or health-based thresholds for longer periods of time and by larger margins in the future, then the consequences for the occupants of those dwellings could also become much more severe, and potentially life threatening.

1. The risks to housing from overheating (2014). By BRE for the Committee on Climate Change.

Are Housing Providers and others also finding cases of overheating?

Recent industry surveys and interviews also suggest that Housing Providers are finding cases of overheating in their stock. See Box 9.

Box 9. Industry surveys

The ZCH and Sustainable Homes's Overheating Survey aimed at Housing Providers found that 53 (70%) out of a total of 75 organisations reported experiencing at least one instance of overheating in their housing stock in the last 5 years (i.e. in dwellings they had built or now manage). 7% reported no overheating problems, and the remainder did not answer the question. As would be expected, most instances of overheating reported were from organisations operating in London, the South East and the South West of England. However, organisations operating in Wales, the Midlands and Northern England also reported cases.

The year before, the GHA conducted an online survey of Environmental Health Officers, local authorities, Housing Providers and GHA members to investigate the "extent of the overheating problem nationally." 185 "instances of overheating" were identified from 126 responses to the survey. 66 (73%) of the 90 overheating instances for which additional information was provided, were in urban locations and 19 (20%) in suburban locations. The authors noted that the results cannot be considered representative for the country as a whole. However, from the instances presented they concluded "that overheating can be a serious problem for people living in specific types of housing...with summer temperatures in the UK predicted to rise in coming years due to climate change, instances of these problems are likely to increase."

Note that survey information should be used with caution due to the potential for selection bias.

Lastly, small-scale overheating monitoring projects provide further insight into the extent of overheating in individual developments. A summary of monitoring studies will be published by the ZCH in July 2015. This will cover information shared by 3 to 4 developers on how monitoring data they have collected is being used within their organisations to help mitigate future overheating risk. One case study will be the ZCH's Rowner Research Project. See Box 10.

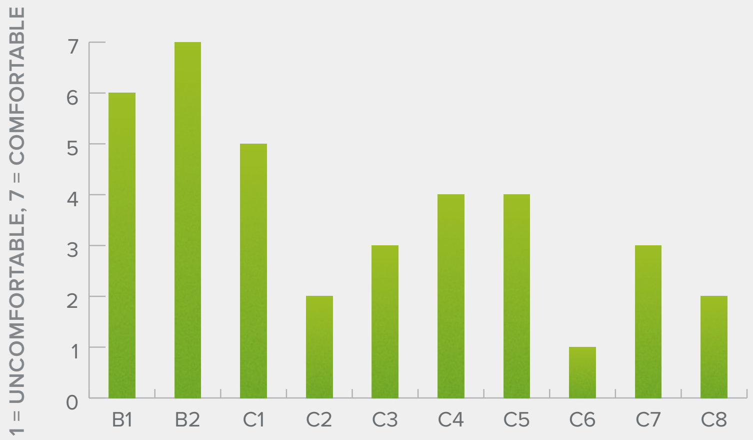
"Increased awareness of the [overheating] issue throughout the housing sector is echoed by resident and partner responses...As a result we have decided to revisit the topic of overheating and a number of the key design quality areas which accompany it... within this year's design workshop series"

QUALITY COUNTS: RESULTS OF THE AFFORDABLE HOMES PROGRAMME QUALITY AUDITS (2013/14), HOMES AND COMMUNITIES AGENCY

Box 10. Rowner Research Project

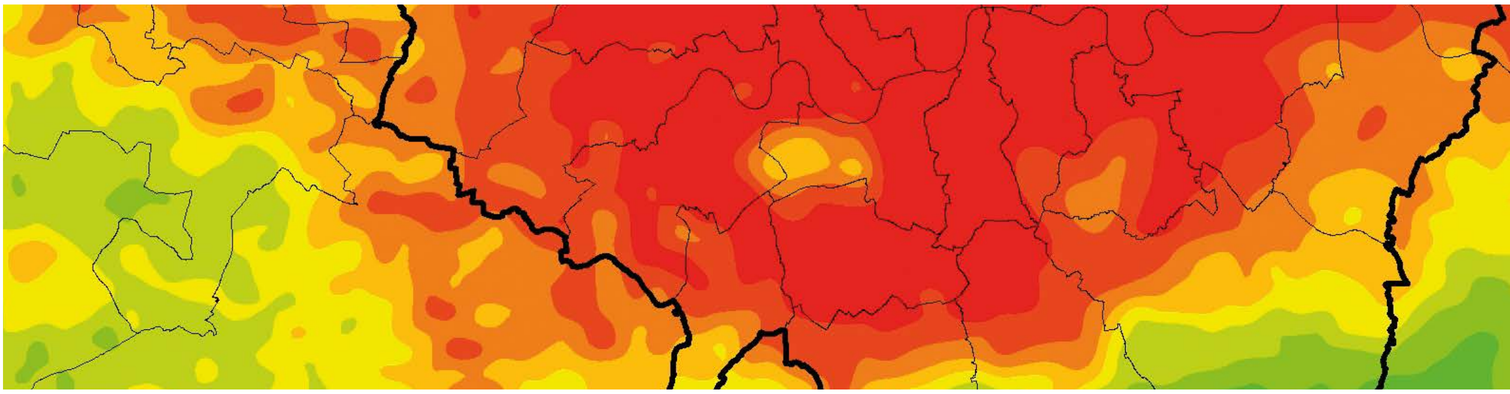
The research project at Rowner investigated the design and delivery of 24 flats, split equally over two blocks.

The first block, Block B was built to comply with the Code for Sustainable Homes level 3 energy requirements, while the second block, Block C, was built to achieve the Fabric Energy Efficiency Standard. In order to evaluate overheating a number of temperature, humidity and window opening sensors were installed in four properties in Block B and seven properties in Block C over 2012 and 2013. The monitored temperatures were assessed against CIBSE thermal comfort criteria. Building User Surveys were also carried out with over half of the residents reporting that it was "hot" in the summer. The results can be viewed at www.zerocarbonhub.org.



Overall thermal comfort

In terms of overall thermal comfort the blocks were perceived to perform considerably better during winter than in summer. During winter the majority of people felt comfortable and pleased with the conditions, while during summer the results were more varied with 45% of residents reporting that they felt uncomfortable, and 55% stating that it was hot.



"That's life isn't it? You have got a few days of the year when it's going to be extremely hot, enjoy them while you can because the rest of the time it's going to be cold."

SNACC FINAL REPORT [1]

"We've put together a record of all the [overheating] complaints... but I think we are only dealing with the tip of the iceberg. Only those who have got to the point where they can't cope with it complain. We might hear from 1 resident, but maybe we've 20 with a problem."

HOUSING ASSOCIATION

Reporting routes

A number of recent reports have raised the possibility that overheating in homes could be more widespread than our current best estimates suggest.

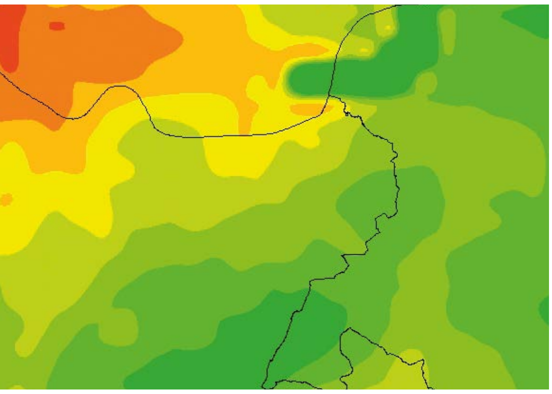
There are a number of reasons why thermal discomfort or excess heat could be greater than we think. Firstly, consumers appear to be more likely to accept being too hot in their homes for short periods, than being too cold. A well-known study conducted by Islington Council in 2012/3 found that residents considered that being too warm was not something people in the UK complained about and that warm weather was something to look forward to.[2] The danger is that people wait too long to report a problem or seek medical attention if they become ill. If people are unaware that they are vulnerable to heat and instead welcome it, then the overheating issue can become much more dangerous. Similarly, if occupants do not report difficulties, Housing Providers may be unaware there is a problem.

Related to this, the GHA also highlighted that occupants may not be reporting overheating problems because they have no route to do so. This concern was echoed by stakeholders the ZCH engaged with, but a number of Housing Providers interviewed also commented that their customers were generally "not shy about making complaints" and that customer services teams were available to answer any concerns. Annual surveys of occupants to check satisfaction levels appear to be a normal part of operations. One Housing Provider said that, in their experience, people were much more likely to complain if there was a problem with a new home because expectations were higher. See more discussion in Chapter 7.

It is therefore worth investigating consumer perceptions on the availability of reporting routes in more detail to determine whether adequate provision is being made to report overheating issues.

1. *Williams et al (2012). Suburban Neighbourhood Adaptation for a Changing Climate (SNACC) Final Report.*

2. *Kolm-Murray (2013). Individual and community resilience to extreme weather events amongst older people in south Islington: attitudes, barriers and adaptive capacity. Islington Council, London.*



"We have only had one case of overheating. In that instance the client had removed shading devices from the designs, against our advice."

ARCHITECT – WALES

What could this mean for future frameworks?

Although information on the current extent of overheating in homes at a national level is still patchy, when pieced together the picture is cause for concern. It is also apparent from the range of studies referenced throughout the report that overheating is being observed in summers with normal or below average temperatures and is not limited to hot spells and heatwaves.

However, as stressed in Chapter 3, dwellings which overheat tend to have recognised risk profiles. These will be explored in greater detail in Phase Two of the project. Secondly, cases of overheating are not distributed evenly across England and Wales. London and the South East of England are usually most affected, but as average temperatures rise across all areas of the UK in the next century, more locations could experience overheating issues.

Unfortunately, the larger-scale studies carried out to date do not cover dwellings in Wales, making it very difficult to make a reliable statement on the extent of overheating in the Welsh housing stock. Anecdotal evidence from the Overheating Survey and from stakeholder interviews with Welsh organisations suggest, as might be expected, that the incidence of overheating in Wales is currently low.

Further large-scale monitoring studies in England, and particularly in Wales, would deepen our understanding of the incidence, causes and regional patterns of overheating – but it is unlikely that gaining an exact number of the homes at risk is ever possible. However, lack of certainty should not delay the sector in making careful progress towards addressing the issue.

FUTURE EXTENT

CHAPTER 5

Chapter 5 summarises evidence and information relevant to the possible future incidence of overheating in homes in England and Wales.

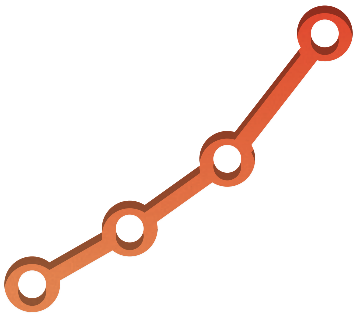
Accurately predicting the future extent of overheating is, of course, not possible, but by considering drivers of change, climate change studies and modelling exercises we can build up a picture of the expected patterns. This provides a useful starting point for business and policy planning exercises.

All projections carry a level of uncertainty and are sensitive to their underlying assumptions. As a result, any conclusions about future overheating based on these will also be uncertain.

Drivers of change

Note that some of the projections set out in this section relate to the UK as a whole, and are not broken down for England and Wales only.

The combined effect of a range of drivers of change can be expected to influence the future extent and severity of overheating. These include:



Increasing average temperatures and hotter summers

As the climate changes, more extreme weather events are predicted in the UK, as well as average summers becoming hotter and generally drier. We can also expect longer and more frequent heat waves and higher average peak temperatures.

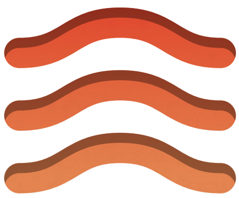
- Although average temperatures at a national level can vary significantly from year to year, average annual temperatures have increased across all regions of the UK over the past hundred years.
- Eight of the UK's top-ten warmest years have happened since 2002, and 2014 was the warmest year since records began in the UK.[1]
- The UK Climate Projections 2009 (UKCP09) estimate that both seasonal mean and daily mean temperatures in summer and winter are likely to increase by 2050 under all emissions scenarios.

1. *Met Office (2015).*

"If you are talking to people dealing with adaptation they think of climate change as a risk management issue. Which is 'how much risk are you prepared to accept? What are the things coming that you can plan for?, and what are the things that you can't plan for?"

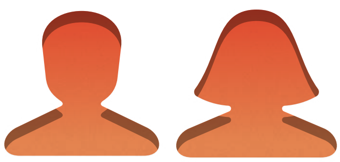
LOCAL AUTHORITY

- During the period 1961 to 1990, the summer mean daily maximum temperature in London was 21.3°C. By the middle of the 21st century, it is projected to be between 22.5°C and 28.1°C.[1]
- Temperature increases are expected throughout the UK. In Cardiff, for example, the summer mean daily maximum temperature for the period 1961 to 1990 was 19.8°C. By the 2050s, this value is projected to increase by between 1.1°C and 6.8°C.
- Between 1961 and 2006, the average number of Cooling Degree Days, a measure of how much energy is required for cooling, has increased throughout the UK and more than doubled in London.[2]



Heatwaves

- In Europe, the most severe heat-related impacts in living memory occurred during the heat wave of August 2003. Temperatures reached 38.5°C in Kent on 10 August.
- The latest research suggests that by the 2040s a summer as hot as 2003, when summer temperatures exceeded the 1961–90 mean by 2.3°C, is expected to be very common in the UK; potentially every other year.[3]



Demographic changes

Although people living in hot countries are generally more accustomed to higher temperatures, it is not clear how quickly people in England and Wales will acclimatise. Particularly those who are most vulnerable to the effects of excess heat. The elderly population are at increased risk of heat related illness, especially if their health is already declining. They are usually less able to adapt to higher temperatures. They may also live alone and be socially isolated, and so don't seek help quickly enough. The proportion of the population who are overweight or suffer from cardiovascular diseases is also increasing, and these groups too, are more at risk of heat-related illness. See Chapter 6.

- The population of the UK is growing and is projected to increase to over 73 million people by 2037, an increase of over 9 million people from 2012 levels.[4]
- People are also living longer. For example, life expectancy at birth in the UK has increased from around 71 years for males born in 1980-1982, to 79 for those born in 2011-2012. The population over 75 is projected to nearly double in the next 30 years, to around 13% of the UK population in 2037.

1. *The climate projections in this section are taken from CIBSE's Probabilistic Climate Profiles (ProCLIPS). The ranges used are from the low emissions 10-percentile to the high emissions 90-percentile.*

2. *UKCP09.*

3. *Christidis et al (2014).*

4. *Office of National Statistics (2013).*

Working patterns

Direct heat exposure during the day time for home workers is increasingly likely to have an impact on the work capacity for those segments of the population, and mean the management of day, as well as night time temperatures in homes, becomes important.

- People may increasingly work from home in the future. According to recent estimates, around 14% people at work in the UK are home workers, a percentage that has increased by 2.8% since records began in 1998.[1]

Urbanisation

A greater proportion of the population are expected to live in urban areas where building densities are generally high and the UHI is more pronounced.

- In 2011, nearly 82% of the population in England and Wales lived in urban areas. Around 21% of the urban population were aged 60 or over.[2]
- Many cities in the UK experience the UHI effect where temperatures in the city-centre can be much higher than in surrounding rural areas, particularly at night. Differences of as much as 9°C have been recorded in London and 8°C in Manchester compared with local rural areas.[3]

Construction practices

Many high-density new developments have a central corridor with single-aspect apartments on either side. This practice has advantages in maximising the number of dwellings which can be built per unit area. However, recent research suggests such flats have a higher risk of overheating than other house types. One reason, discussed in Chapter 3, is that it can be harder to achieve adequate ventilation in a single-aspect apartment than in an apartment or house with opening windows on two or more sides.

- In 2014, approximately 30% of the newly completed residential units in England were flats, compared to 20% in 2000 and approximately 50% in 2008.[4]
- In London the proportion of apartments is much higher than the rest of England, at 83% in 2012. Fewer new flats are being built in Wales (as a proportion of the stock) compared to England; less than 15% of the total new housing stock in 2014.[5]

As the population ages, more care homes and retirement properties are also being constructed. The occupants of these types of accommodation are particularly vulnerable, and good building design will be critical to avoid increasing the chances of overheating occurring.

"We have tended to get complaints where we have had single elevation apartments that don't have a good ability to create drafts and air circulation through the building."

HOUSING ASSOCIATION

1. *Office of National Statistics (2014).*
2. *Defra (2013).*
3. *Greater London Authority (2006); Levermore et al (2011).*
4. *Department of Communities and Local Government (2015).*
5. *Welsh Government (2014).*

Energy efficiency and air-tightness

In recent decades there has been a strong drive towards reducing heat loss and winter heating costs in homes by incorporating energy efficiency measures. As a result many dwellings have benefited from being insulated and increased levels of airtightness, and lose much less heat through the building fabric. Such measures are, of course, extremely beneficial in winter – helping to keep homes warm and to save energy – but the need for designers and contractors to actively consider summer thermal performance will become even more important as the climate changes.

Future incidence of overheating

There are very few projections relating directly to the potential future incidence of overheating in dwellings in England or Wales. Although researchers and modellers can simulate the possible effects of future climate for individual projects and schemes, these are not normally intended to be scaled-up.

> The CCRA 2012 considered overheating of buildings as a key risk for the future of the built environment sector, but found, for example, that insufficient data was available to break this risk down in detail by construction age and type.

The two studies set out in Box 11 do, however, provide information about the types of methods that can be used to make projections on the possible future extent of overheating for specific locations. They also give a sense of the potential future change in levels of overheating for those locations, compared to current levels.

Box 11. **Modelling Studies**

Jenkins et al. (2014)

This study relating to London and the surrounding area investigated the links between future climate and thermal discomfort in homes. The modelling suggested that by the 2030s, around 60% to 75% of residents living in flats in the Greater London area could be affected by "thermal discomfort" under a high emission scenario (median result) compared to around 45% to 65% currently. Estimates were also made for other dwellings types.

The study drew on research by Mavrogianni et al. (2012) which had assessed the potential effect of different building stock characteristics and thermal properties on internal living room temperatures in London, with results highlighting a potential amplification effect of daily maximum external temperatures. Based on an internal temperature threshold of 28°C above which most people will feel discomfort in living spaces, the amplification values were used as proxies to estimate a range of external temperature thresholds above which residential discomfort could occur. These values were then combined with climate and other projections to estimate future levels of thermal discomfort.

Suburban Neighbourhood Adaptation for a Changing Climate (2012)

One of the aims of the SNACC project was to answer "how can existing suburban neighbourhoods in England be 'best' adapted to reduce further impacts of climate change and withstand ongoing changes?"

The team examined six suburban neighbourhoods in three English cities: Oxford, Bristol and Stockport. Before adaptation options were modelled for the individual neighbourhoods, the "overheating potential" of each neighbourhood was assessed and visualised using the DECoRuM-Adapt simulation model.

The report describes the characteristics of the neighbourhoods and the dwellings that led to conclusions about the risk of future overheating. Across all case studies the overheating potential was assessed for the current climate, and for the 2030s and 2050s using medium and high emissions scenarios (50% and 90% probabilities). The level of overheating potential varied for each case study, but in all the neighbourhoods, a very large proportion of properties had a "high likelihood" of being overheated in the 2030s and 2050s high emissions scenarios.

The risk of overheating in Botley (Oxford in general) was the highest of all SNACC case study neighbourhoods. This was particularly attributed to the existing warmer climate the southeast experiences. The risk in Cheadle (Stockport in general) was the lowest.

Overall, the modelling demonstrated that the adaptation packages suggested were successful in mitigating the potential for overheating.

Future heat-related mortality

Research which considers the potential effect of climate change on health impacts, and specifically excess deaths caused by rising temperatures, also provides an indication of potential future overheating. However, it should be stressed that such studies are not intended to produce findings on the changing incidence of overheating directly, and not all the projected fatalities will be due to heat exposure within the home, as discussed in Chapter 4.

There are now estimated to be approximately 2,000 heat-related deaths per year in England and Wales (Hajat et at. (2014)). In the absence of adaptation of the population, researchers estimate that this figure could rise to over 7,000 heat-related deaths per year by the 2050s as a result of climate change and a growing and ageing population – a tripling of current levels. London and the East Midlands are the regions that have been most affected by heat.

See Chapter 6 for information on methodology used to produce this estimate.

Again, the geographical distribution of mortality effects is not expected to fall uniformly. A recent study looking at the regional variation of the relationship between cardiorespiratory deaths and temperature found that a 2°C rise in external summer temperatures could lead to approximately 1,500 additional deaths in England and Wales, about one half of which would occur in 95 districts. Figure 12 maps the distribution of these deaths over 376 local authority regions.[1] It is important to note that this study only covers cardiorespiratory deaths due to heat and not other causes.

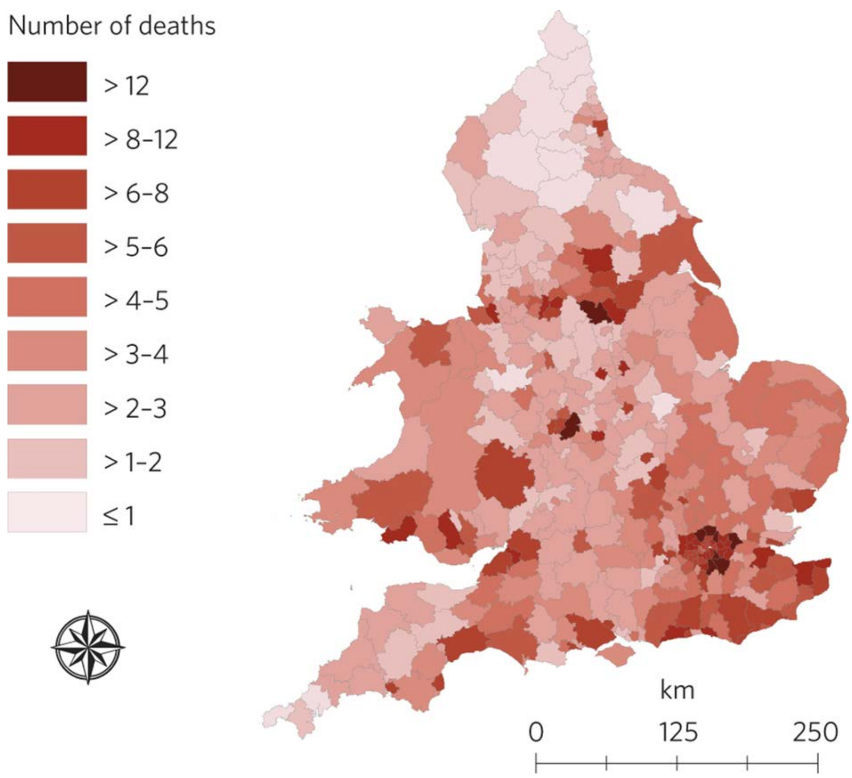


Figure 12. **The number of additional cardiorespiratory deaths in the districts of England and Wales that would be expected during five summer months if temperatures were warmer by 2°C.**

1. Bennett et al. (2014). *Vulnerability to the mortality effects of warm temperatures in the districts of England and Wales.*

What could this mean for future frameworks?

It is extremely difficult to quantify the possible levels of overheating in homes over the long term, but if current trends continue and are realised as expected, it is highly likely that overheating will become more commonplace. The impacts of overheating cases may also worsen as the proportion of the population who are vulnerable to the effects of heat exposure grows. See Chapter 6.

One of the challenges Housing Providers and governments face is to decide how to plan on the basis of evidence of current overheating, whilst also acknowledging the complexity and uncertainty around future levels.

Action

ZCH to work with the research community to determine whether it is possible to develop a methodology to model the potential future incidence of overheating at the national and local level and what this could tell us (by December 2015).

IMPACTS

CHAPTER 6

Chapter 6 explores some of the consequences for Housing Providers, and for the health sector and the economy when homes overheat.

A more detailed summary of the impacts of overheating can also be found in the Impacts of Overheating Evidence Review.

When overheating occurs in homes it can have an impact on the comfort, well-being and health of the people living there. The focus of this chapter is on knock-on effects for businesses and the sector as whole.

"Overheating can damage residents' health and well-being, increase social care costs, reduce economic activity, increase NHS costs and lower quality of life."

YOUR SOCIAL HOUSING IN A CHANGING CLIMATE (2013)

Business impacts

Housing Providers report that overheating problems in their stock can damage customer relations, and lead to reputational harm and costly remedial works.

Where the characteristics or design of an existing dwelling makes is difficult to keep the temperature at comfortable or healthy levels, then remedial works may become necessary. The project Your Social Housing in a Changing Climate (2013) published by the London Climate Change Partnership (LCCP) is a good example of how a large-scale retrofit project can increase the summer comfort levels of occupants.

Box 12. **Your Social Housing in a Changing Climate (2013)**

Two residential tower blocks in Barking and Dagenham comprising 200 flats were refurbished during 2010-2012, bringing the blocks in line with Decent Homes requirements and installing climate change adaptation measures.

To reduce overheating risk, the windows were replaced with triple glazed units which had blinds built in between the inner double glazed unit and the outer pane of glass. These are common in other European countries and were considered more suitable than other, external shading options that would be difficult to install and maintain in a high-rise tower. Insulated external cladding was also installed. The installation of the overheating prevention measures were deemed sufficient to ensure comfortable temperatures in the homes, without having to install ceiling fans. The measures not only helped to reduce the risk of overheating but also made the properties warmer in winter.

"The cost is that I've had to spend time and the worry of having to deal with [overheating] after it's happened. That's a cost in itself."

HOUSING ASSOCIATION

Generally, during interviews, stakeholders pointed out that the range of options available to address overheating after the event are often more limited than if measures had been designed-in to begin with. Replacing windows or installing new ventilation systems, for example, can be more disruptive or expensive if not combined with other works. Lower cost choices, such as solar film on windows, may not always be acceptable to residents either.

The GHA, in the their 'Preventing Overheating' report (2014) also noted that there can be difficulties in addressing the root causes of overheating in existing buildings and highlighted the value of including measures in existing maintenance contracts. The LCCP also highlighted in the Your Social Housing in the Changing Climate report that combining adaptation with Decent Homes refurbishments reduced the residual cost of adaptation measures by £920,000 – a 39% saving against carrying out adaptation works in isolation.

If options for dealing with an overheating problems in a given property or scheme become very limited, then providing comfort cooling may be the only solution remaining, with energy cost implications for the occupants. See more on this in Chapter 7. Getting initial designs right is therefore crucial.[1]

For Housing Providers, carrying out unexpected remedial works can also be costly and challenging.

"Instead of being the homes most people want to live in, they become the homes people don't want to live in..."

HOUSING ASSOCIATION

One housebuilder shared their experience of carrying out extensive remedial works on a recently completed apartment building in order to gain Building Control sign off and to satisfy the local Environmental Health Officer, operating under the Housing Act. Without the apartments being heated, winter temperatures exceeded 27°C. During this time, the housebuilder experienced negative media coverage and customer dissatisfaction. Remedial works, which costed approximately £100,000, were required to bring the worst affected apartments within acceptable humidity and temperature ranges.

The examples above help to demonstrate the benefits of designing-in measures to prevent or mitigate out overheating risk as far as possible in new builds, and the value of avoiding the introduction of overheating problems to existing homes when refurbishing them. For existing homes, linking adaptation projects to planned refurbishments can make projects more cost-effective.

1. Further discussion on the types of designs and measures that can be used to reduce the risk of new and existing dwellings overheating will be set out the Solutions Evidence Review due to be published in July 2015.

Productivity impacts

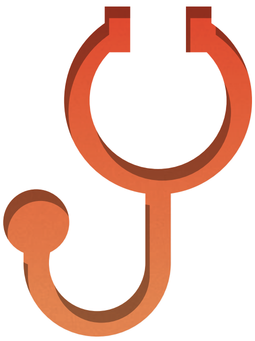
Economic losses are also expected as a result of work-days lost, accidents and reduced productivity due to heat-related sleep deprivation and other heat-related health issues causing work absences.

High temperatures have been shown to affect the quality and continuity of sleep. The time taken to get to sleep is longer, sleep is more interrupted and total sleep time is reduced.

Sleep disturbance has been linked to reduced productivity at work, as well as poor physical and mental health. However, in order to be able to quantify the potential productivity losses to business, new research is needed to analyse the relationship between overheating in homes, interrupted sleep and health issues, and productivity. Estimating productivity losses over time as the climate changes, and in urban areas in particular where it can be more difficult to cool down dwellings at night, would also be of value.

> "Healthy individuals have efficient heat regulation mechanisms to help cope with increasing temperatures, yet there are limits to the amount of heat exposure an individual can tolerate."
>
> **JENKINS ET AL. (2014)**

Overheating in the workplace and the resulting economic losses to businesses was investigated in the 2012 CCRA. The team estimated that the number of staff days lost once internal temperatures exceed 26°C could lead to financial losses of £1.1bn to £5.3bn by the 2050s, compared to the current estimate of £0.77bn. The same kind of analysis is needed for the domestic sector.



Health impacts

A range of health effects from mild to severe can result from exposure to high temperatures in homes. Especially when temperatures remain high for prolonged periods.

Excess heat can have significant health implications, particularly for vulnerable groups, including the elderly, infants, those who are obese or have chronic illnesses, people who are socially isolated and those who live in urban environments. These groups are often less physically able to acclimatise or adapt to keep cool at home when external temperatures rise.

Box 13. Why can excess heat lead to ill health and fatalities?

The human body needs to maintain its core body temperature between 36.1°C and 37.8°C, although it can cope with temporary increases of up to 38°C or 39°C without causing damage to health.

The body loses and gains heat by a number of mechanisms, for example sweating. Failure of these thermoregulation mechanisms to cope with high temperatures can lead to heat stress, illness and death. Mild effects of exposure to high temperatures include dehydration, prickly heat, heat cramps, heat oedema (fluid retention often in ankles and feet), heat syncope (dizziness and fainting) and heat rash, as well as reduced productivity and concentration.

Certain vulnerable groups, such as those over 65, are generally less able to regulate their body temperature. Sweating, blood flow to the skin and extremities, plasma volume and cardiac output are all reduced. Such groups may also be less able to detect temperature changes and have a diminished sensation of thirst. Social isolation and pre-existing medical conditions are additional risk factors for this age group.

Other people at higher risk of heat-related health impacts are those with serious chronic health conditions (particularly heart or breathing problems), mobility issues, and serious mental health problems. Obesity is also a risk factor. Individuals who are obese generate more heat when active and need less heat to be produced before their core temperature rises.

Young children and babies are also less able to regulate their own body temperature and are at greater risk of dehydration than adults, as well as being more dependent on others.

A number of research projects have attempted to quantify the health impacts of excess heat, including in terms of hospital admission costs, patient-days and heat-related excess deaths. Although there are a limited number of studies and the projections carry significant uncertainty, they do provide a sense of scale.

- During the summer heatwave in Northern France in August 2003, unprecedentedly high temperatures for a period of three weeks resulted in 15,000 excess deaths. The vast majority of these were among older people. Research after the heatwave event revealed that at least 50% of these deaths could have occurred due to exposure to heat in people's homes.[1]
- Across England and Wales that same year, there were over 2,000 excess deaths during the ten-day heatwave in August, compared to the previous five years over the same period. Again, the worst affected were people over the age of 75 years.[2]
- The Committee on Climate Change recently highlighted research from 2006 on the economic impact of the 2003 heatwave in the UK. Health-related costs were estimated to range between £14m and £2.6bn. The lower end of the range uses the Value of a Life Year (VOLY) measure, while the upper uses the Value of a Prevented Fatality (VPF).[3]

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1. *Fouillet et al (2006) Excess mortality related to the August 2003 heat wave in France.*

2. *Johnson et al (2005).*

3. *Metroeconomica (2006). Defra Climate Change Impacts and Adaptation Cross-Regional Research Programme: Project E – Quantify the cost of impacts and adaptation.*

- There are now estimated to be approximately 2,000 heat-related deaths per year in England and Wales. In the absence of adaptation of the population researchers estimate that this figure could rise to over 7,000 heat-related deaths per year by the 2050s as a result of climate change and a growing and ageing population. [1]

  > Hajat et al's research had two stages: (1) epidemiological analysis of historical weather and mortality data to characterise the associations with current climate patterns; and (2) risk assessment, where the temperature-mortality relationships from stage (1) were applied to projections of future climate, taking into account future population trends. The estimate above equates to the mean (257%) increase in heat-related mortality by the 2050s and is based on "an ensemble of nine climate models".

- In 2012 analysis for the CCRA suggested that by 2050, annual heat-related mortality and morbidity costs in the UK could increase from 2012 levels by a further £84m and £183m (respectively). These figures represent a four-fold increase in mortality-related costs and a doubling of morbidity-related costs.[2]

Analysis of past heat events shows that health impacts often occur rapidly, on the same or following day of exposure.[3] This highlights the importance of policies such as the Heatwave Plan for England which "aims to prepare for, alert people to, and prevent, the major avoidable effects on health during periods of severe heat".

Energy policy impacts

During the ZCH stakeholder interviews and workshops, concern was frequently expressed that the energy efficiency and fuel poverty agendas could suffer set-backs should the domestic sector begin to use more energy to cool homes in the future.

Research shows that once occupants become uncomfortably warm in their homes, they take action to alleviate the situation – and these actions may have energy implications. For example, sudden spikes in fan use and the purchase of portable cooling units are not uncommon.

> It should be noted that fans do not cool the air like air conditioning units, but enhance people's ability to lose heat and also alter our perceptions of temperature. Guidance advises against the use of fans at temperatures above 35°C.

Although the impact of cooling measures on energy use is expected to be modest in the short-term, if the use of air conditioning, for example, were to become the norm, the energy implications could be significant.

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1. *Hajat et al, (2014). Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s.*

2. *Based on 2010 prices. Costs in 2012 were estimated to be £23m and £73m. The analysis used a Value of a Life Year figure of £60,000 and assumes that each death resulted in a loss of four months of life. A cost of £625 per hospital admission patient-day was used.*

3. *Armstrong (2011).*

"To deal with cases of overheating] we tend to use mechanical solutions – buy lots of fans – creating a spike of energy use and that's where we're really concerned...people will be spending all year round on heating and cooling, which could create financial problems for the fuel poor who don't have the level of income.'

LOCAL AUTHORITY

Air-conditioning for comfort cooling is not widespread within the residential sector – estimated at less than 3% of the housing stock in England.[1] There is, however, anecdotal evidence to suggest a growing expectation that it will be included in newer urban apartments and penthouses at the higher end of the market.[2]

Health concerns are often a motivation for installing air conditioning, especially where other means of adaptation are either unavailable or difficult to adopt. Portable cooling units were also used as a temporary solution by some of the vulnerable residents in case studies reported by the GHA in their 2014 report.

There is, however, considerable uncertainty around the future uptake of air conditioning in homes in the UK and the corresponding implications for energy demand. One projection, which makes an estimate based on how people responded to changing temperatures in the United States, is that 18% of homes in the South of England could install domestic air conditioning systems by 2030. However, uptake patterns can alter rapidly and are very difficult to estimate. The response in England may be very different to the United States.[3]

As effective as air conditioning can be in providing a thermally comfortable environment, particularly for vulnerable occupants, there are also several disadvantages to be considered from a wider public policy perspective. Increased uptake of air conditioning is expected to lead to increased energy use by householders in the summer, and potentially to socioeconomic inequalities related to paying for that energy.

Space cooling demand from air conditioning is part of the SAP calculation and is included in the assessment of overall energy use. Dwellings with air conditioning would usually have worse SAP ratings than comparable homes without such cooling systems.

Air conditioning affects external temperatures in the microclimate surrounding homes. Heat from the system is ejected into the air, intensifying the urban heat island, potentially creating a negative feedback loop by further increasing the need for cooling within the home.

A third consideration is that increased demand for mechanical cooling could put additional strain on the electricity grid, particularly during hot spells and heatwaves. During the August 2003 European heatwave, for example, electricity demand in France rose significantly due to the intense use of electrically driven cooling systems. This issue was exacerbated by energy supply problems related to the hot weather.[4]

Lastly, reliance on energy-using mechanical cooling could result in fuel poor households needing to pay for energy to cool homes in the summer, as well as well as the energy needed to heat homes in the winter. Should poorer households struggle to pay, they may decide not to use their systems at all.

For the reasons set out above, stakeholders interviewed by the ZCH tended to support approaches which encourage good building design and the use of passive measures. Mechanical cooling was viewed as appropriate if passive measures are, for any reason, unable to deliver the temperature reductions necessary to protect the health of occupants. Current policies aim to encourage a "passive first" approach.

1. Compared to Greece, for example, where market penetration is 45% to 50%.

2. Young (2014). Home is where the heat is. CIBSE Journal.

3. Peacock et al. (2010). Investigating the potential of overheating in UK dwellings as a consequence of extant climate change.

4. Salagnac (2007). Lessons from the 2003 heat wave: a French perspective.

"Air conditioning is likely to be a waste of time for the elderly if they do not turn it on because it uses power. Solutions have to be low cost, or no cost. Better design."

HOUSEBUILDER

A good example is the 'Cooling Hierarchy' adopted by the Greater London Authority (GLA) in their planning guidance.

Box 14. **The Cooling Hierarchy**

The GLA encourages the use of design and building form first to prevent overheating, using active cooling as a last resort. This is called the 'Cooling Hierarchy'.

Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

1. Minimise internal heat generation through energy efficient design
2. Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
4. Passive ventilation
5. Mechanical ventilation
6. Active cooling systems (ensuring they are the lowest carbon options).

The GLA also advises that London Boroughs should develop detailed policies and proposals to support the avoidance of overheating and to support the cooling hierarchy.

What could this mean for future frameworks?

If future policies and frameworks can fully support Housing Providers in achieving temperature reductions in homes through good design and the use of adaptation measures, then benefits for those businesses should follow. Potentially significant In-direct benefits for the health sector, and the economy more generally, could also be realised. Research aiming to quantify these in-direct benefits more clearly at the national level is needed.

Jenkins et al. (2014) used projections of urban temperatures along with assumptions on demographic changes to produce an assessment of heat impacts on urban society. The study, which focused on Greater London and the surrounding area, assessed mortality risk, thermal discomfort in residential buildings and adaptation options.

The team highlighted that climate change is projected to increase future heat-related mortality and "residential discomfort". However, by adjusting the 'temperature response function' by 1–2°C, to simulate adaptation measures and acclimatisation, annual heat related mortality could be reduced by around 30% to 70% (depending on the scenario used), relative to the 'no adaptation' scenario.

PREPAREDNESS

CHAPTER 7

"[Overheating has] come onto our radar recently. Summer overheating is not something we've looked at any in great depth up until now, and that's partly down to a lack of clarity about a definition... we've now got it listed on our risk register as something we need to start thinking about."

HOUSING ASSOCIATION – WALES

Chapter 7 summarises information gathered by the ZCH on the extent to which Housing Providers and the wider sector are making preparations to tackle overheating in homes.

A strong theme running through this report is the value and importance of organisations being prepared. Preparations are needed both to aid the prevention of cases of overheating and to allow Housing Providers to respond effectively if instances do occur.

Information from the ZCH's stakeholder interviews, the Overheating Survey and two workshops in 2014, provide insight on the theme of preparedness.

Prioritising overheating

Addressing overheating risk has not, historically, been a high priority for many of the Housing Providers interviewed by the ZCH. However, it was also apparent that certain organisations have already raised the profile of the issue within their organisation. For example, Peabody has included objectives related to "reducing the impact of climate change on our communities...[by] evaluating the present and future risk of summer overheating..." in its Environmental Sustainability Strategy 2012-2015.

Those who reported that consideration of overheating has been a low priority for them also said they had not experienced many problems with elevated temperatures in their stock, which they also viewed as inherently low risk. However, it is clear that the risk profiles of buildings can change when projecting out to future decades.

Another reported barrier was a lack of data on the potential current and future cost of overheating issues for businesses. Cost information was deemed by most stakeholders to be essential to securing investment commitments from Board members. See the box below for an example of how commissioning such economic analysis allowed one housing association to value the potential benefits of avoiding overheating.

A new piece of economic analysis for a housing association operating in Southern England found that "a 13% increase in heat-related health costs as a result of stock expansion, and a doubling of costs as a result of climate change in 2040, is judged to be possible", and that 'targeted investment in flooding and overheating measures now would make significant financial savings for them in the future'. This analysis is being used to highlight the importance of investment in overheating measures.

See Building the Business Case for Targeted Investment in Resilience Planning by the Global Climate Adaptation Partnership, Daniel Black & Associates, the University of Bath and the University of Manchester.

"In many cases, the risk of overheating may be low and no action will be necessary for a Housing Provider. However, unless they assess their potential current and future levels of risk methodically, there is potential to be 'caught out' by changing external circumstances such as the climate."

TECHNICAL EXPERT

Assessing risk

74 organisations answered the question 'Does your organisation have a method or process to assess the risk of your residential properties overheating?' in our Overheating Survey. We did not define the term 'process' deliberately.

Interestingly, 59% reported having a risk assessment process. However, 36% did not, and the remainder did not know. See figure 13.

Some of the 44 organisations who said they have a risk assessment process also gave information on their reasons:

- The most important reason for introducing a process was 'To ensure customers are happy'.
- The second favoured reason was to have 'A general policy to ensure properties are suitable for a changing climate'.
- The least important reason given was 'Competitors/others assess overheating risk, so we do too.'

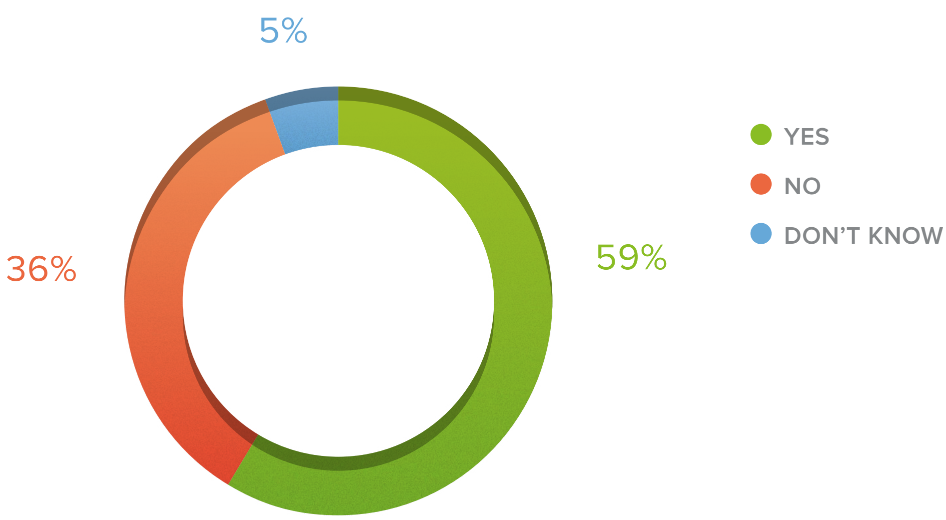
When combining this finding with information from the stakeholder interviews, it is apparent that the types of methods and risk assessment processes used are variable, and all have limitations.

There are a number of methodologies and tools available to model and predict overheating risk in domestic schemes and properties, as well as methods to help planners and local authorities to map risk spatially (as discussed in Chapter 3).

In terms of understanding the level of preparedness, the key questions are:

- Are the methodologies and tools being used as intended?;
- Do the results of modelling and mapping exercises correlate well with observations in real properties?: and
- Are there sufficient skills and resources in the sector to perform reliable risk assessments?

Figure 13.
Does your organisation have a method or process to assess the risk of your residential properties overheating?
(Number of respondents out of 74 responses)



The Assessing Overheating Risk Evidence Review describes the range of overheating risk assessment methods and tools in detail, and sets out some of the steps that are needed to ensure the outputs better reflect how homes are really lived in. Chapter 3, also summarised the main elements of SAP Appendix P overheating calculation. Box 15 provides a generic summary of how dynamic simulation tools work.

Box 15. Dynamic Thermal Simulation Models

Dynamic thermal simulation models are software packages which model the energy interactions and internal environmental conditions in a building on an hour-by-hour basis.

They are powerful tools which were primarily developed for use in designing commercial buildings. They have many applications including sizing heating and air-conditioning plants, evaluating energy performance and checking Building Regulations compliance, as well as predicting overheating risk. They have the capacity to model more of the complex features of buildings including different technologies for heating, ventilation and cooling, external shading devices, different building materials, and newer technologies such as Phase Change Materials (PCM).

Dynamic thermal simulation therefore plays a key role in the design of non-domestic, commercial buildings, but it is less frequently used in the domestic sector, which generally takes a different approach to design.

A significant amount of data is inputted into the models:

- Building geometry, location and orientation;
- Detailed construction information about how the fabric is built up and the thermal properties of each of the materials used;
- Internal heat gains from people, lighting and equipment, and the daily patterns that these will follow;
- Ventilation information; and
- Hourly weather data.

The model outputs include energy consumed for heating (and ventilation and cooling where installed) and the internal temperature in each zone modelled. Most commercial tools have built-in functionality to calculate overheating risk using standard methodologies and criteria, such as those defined in CIBSE Guide A. If the initial model fails to pass the chosen criteria, changes are made to the design until it succeeds.

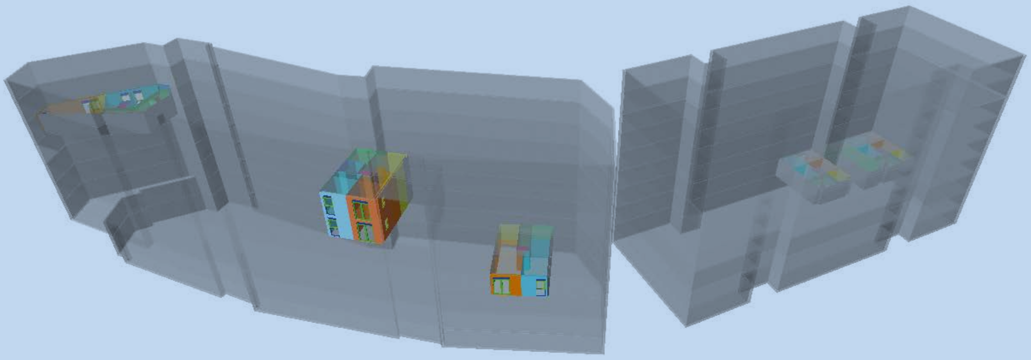


Figure 14. **Example model of units in an apartment block**

Many modelling related issues were raised by stakeholders during the interviews:

1. Modelling is often done too late in the process to influence the design of the scheme.

   "The serious problem with the design tools is that you tend to apply them when the design is fixed. So for instance, the overheating check in SAP is extremely limited because you are running the SAP calculation to demonstrate compliance with Building Regulations – which you are doing long after you've got planning consent...to be told late in the process that you've got an overheating risk is not very helpful."

   ARCHITECT

2. Housing Providers and experts raised many concerns with Appendix P. The view, summarised by the quote 'no one fails Appendix P' suggests the process is not separating out properties which are genuinely at risk of overheating as effectively as it could. Stakeholders considered that the assessment is too easy to pass and, as currently structured, allows assumptions to be included that are unrealistic. For example, that windows are constantly open. The result is that a 'low risk' assessment may be given inappropriately. DECC plans to consult on proposed amendments to Appendix P.

   "...It is too easy to twist the response in SAP to make sure you always get a pass."

   HOUSEBUILDER

3. After modelling is carried out, individual occupants may still find temperatures uncomfortable. Risk assessments therefore do not dispense with the need for organisations to have processes in place to deal with isolated overheating issues should they arise.

   "We use a definition of overheating – what percentage of the year does the temperature exceed 25 degrees centigrade... We are reviewing this with our projects to see if it fits with real complaints."

   CONSULTANT

4. One Housing Provider stressed that the use of dynamic modelling on all their sites was not an option due to the resource intensity of the exercise, and that its use was also ad hoc at present. Using detailed modelling when significant changes to design specifications were being made was something they would consider.

   "Modelling sample sites is not part of standard practice. It is not part of the process for each house type to have an overheating review. It has been more on an ad hoc basis when we've needed to. I personally would like it to be more part of the process – maybe not every house type – but perhaps if we make significant specification changes...'

   HOUSEBUILDER

5. Concerns were also raised that modelling and checklists can create a false expectation that the risk of overheating has been effectively mitigated and that no further action is needed. Modelling can give an indication of the likelihood of a property or scheme overheating against the criteria chosen, but should be used alongside broader experience and awareness of the risk factors to look out for.

   "Models can take you so far, then you have to rely on experience."

   ARCHITECT

6. Modelling overheating in isolation is not a cost-effective approach.

   "We are still doing [modelling] in isolation – overheating, daylight, FEES, energy carbon. All in silos. It's not fluid, consistent or quick. Invariably the modelling all happens after [a design is on the table] and puts pressure on the business model."

   ENVIRONMENTAL CONSULTANT

7. As discussed in Chapter 3, it can be difficult to factor in some of the real-world causes of overheating. Factors such as future weather, varied occupancy patterns, and location effects such as the UHI and the building's microclimate, are not included in most models as standard.

   "...we nearly always found a problem where for one reason or another people weren't able to open windows properly and ventilate in the way that designers had imagined. It's the external context – whether it's noise, pollution, proximity to busy roads, anxiety about security. It's all of those things that don't show up when you are modelling a building with the conventional tools, but actually have a huge impact when the building is being operated."

   ARCHITECT

8. There are no standard protocols to guide modellers on which inputs to use, such as occupancy patterns. The result is that two modelling exercises could be carried out on the same development and produce different results.

   "Domestic occupancy patterns are not well reflected in the overheating risk models at the moment, and that's largely because they vary significantly and unpredictably. We need to decide as an industry on some 'upper reasonable' limits for how people occupy their homes and design for them. These will need to be considered for different sizes of dwelling as heat gains tend to be more concentrated inside smaller units. Agreeing these profiles will empower more accurate and consistent overheating risk predictions to be made."

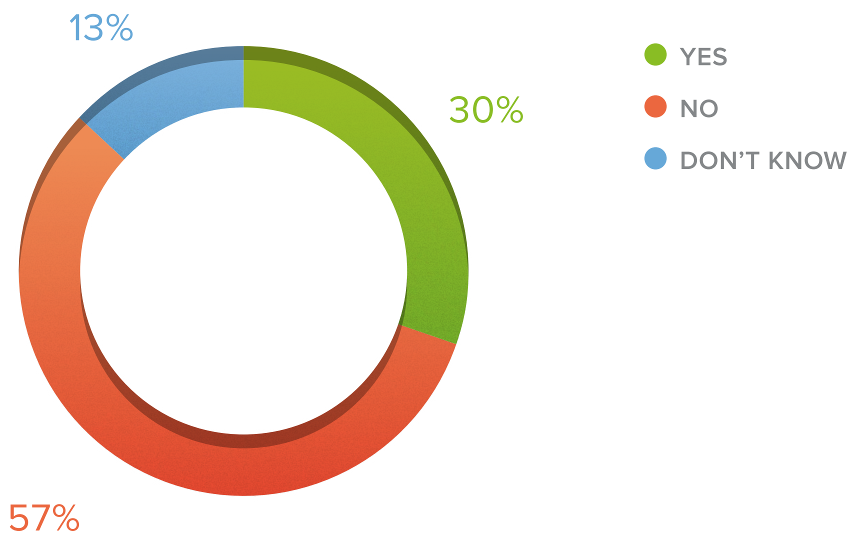
   TECHNICAL EXPERT

9. Risk assessments currently focus on 'occupied areas'. However, unless communal corridors and stairwells are explicitly modelled, heat generated in these areas, for example, from hot water pipes, is not accounted for.

Designs and specifications

Another indicator of preparedness relates to the extent to which supply chain contracts cover overheating and how well defined the requirements are. By way of example, 57% (of the 23 Housing Providers who answered the specific question on new-build properties in the Overheating Survey) said they do not specify requirements on overheating in contracts with architects or designers. The results were similar for existing properties.

Figure 15.
Does your organisation currently specify overheating related requirements in your contracts with architects / designers?



Survey respondents also gave examples of the types of requirements they do include. These included:

- Requiring contractors to advise on and address overheating through Employers Requirements;
- Ensuring PHPP targets are included;
- Requiring contractors to assess shading measures; and
- Requiring contractors to carry out dynamic thermal modelling.

In terms of what is driving organisations to specify requirements, a number of interviewees stated that the practice was common for demonstrator projects such as when trialling buildings being constructed to the proposed Zero Carbon Standard, or similar. A number of local authorities in London were also widely referenced as requiring developers and architects to address overheating in their housing schemes.

For an example, see Islington Council's Local Plan: Development Management Policies (20130 where overheating modelling is required for major new developments.

"Applications for major developments are required to include details of internal temperature modelling under projected increased future summer temperatures to demonstrate that the risk of overheating has been addressed."

"We have never been asked to get to the level of quantifying overheating in a housing scheme in a discussion with a client or a housing association. There is just a general anxiety about it."

ARCHITECT

"Our clients don't really ask us [to consider overheating at the concept stage]. Just the issue with hot corridors in communal areas."

ARCHITECT

"The pre-contract for architects has generalisations in there. We need to tighten this up."

HOUSING ASSOCIATION

"From a retrofit perspective, on our projects, no, we haven't specifically said that the people involved have to look at the overheating. But we do make sure that the insulation systems we use have specified how they work in terms of regulating heat flows – the tried and tested systems."

HOUSING ASSOCIATION – WALES

Technical solutions

Regarding technical solutions to overheating, information gathered during the stakeholder interviews suggests, similar to the position on the causes of overheating, there is a reasonable level of general knowledge within the sector on the types of technical solutions available to address overheating at the property or development level.

However, stakeholders felt more guidance is needed on how effective different combinations of measures are at reducing temperatures and keeping buildings cool for different house-types and locations. Particularly on the use of thermal mass to moderate heat flows. A number of interviewees also wanted to see more advice on what types of measures to deploy if their tenants are experiencing severe overheating during a heatwave or hot spell.

"With new build we don't fully understand the effect of the positioning of the insulation. We may not be allowing the thermal mass to store up some of the heat and let it go. Only professionals seem to understand this problem very well."

HOUSING ASSOCIATION

Links to technical guidance documents and case studies produced by a range of experts can be found at **www.zerocarbonhub.org**. The ZCH will also publish a summary of technical and behavioural solutions, commissioned from the BRE, in July 2015.

Technical experts also felt that published advice and knowledge is sometimes underutilised. Technical experts said they would benefit from having simple briefing documents available to explain the value of, for example, modelling and/or monitoring as a way of reducing future risk and liability to their clients.

"...There is always a break down in understanding between the people running the modelling, the service engineers, and the architects designing the building. So if the model assumes 50% of the glazing to be opening, we often misunderstand what is intended by that. Usually it means 50% of the glazing area to be completely open to the outside, not that half the windows can open! There is so little understanding (in our profession)."

ARCHITECT

Delivering on the design intention

A third indicator of the level of preparedness in the sector is the extent to which the designs and measures intended to reduce the likelihood of overheating in dwellings are implemented in practice.

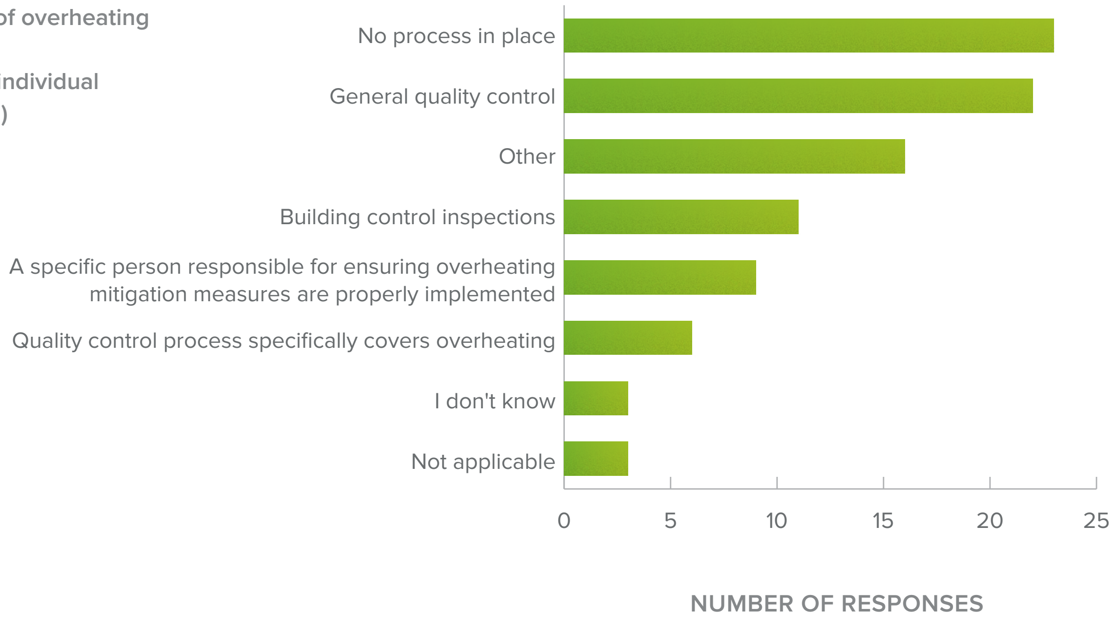
Respondents to the Overheating Survey were asked *'How do you ensure that any building or system designs and technical measures intended to mitigate the risk of overheating in your properties are implemented as specified? (Select all that apply)'*

Although concerns were raised during the stakeholder interviews about over-heating measures being 'value engineered' during projects, two thirds of 72 Housing Providers answering the Overheating Survey said they have a process in place to check that designs and measures are delivered in practice. 22 (30%) said they have no process. See Figure 16.

The ZCH's 'Design versus As-Built' project highlighted the impact on the performance of buildings when designs are not delivered as intended, and the same is true for overheating. Product substitution and value engineering can mean that even when dwellings are designed to stay comfortable, in practice they do not.

It may be the case that general quality control processes are adequate for most properties, but those deemed to be higher-risk may require greater attention to ensure the solutions identified by technical experts are implemented through to completion.

Figure 16.
Types of process used to ensure that measures to mitigate the risk of overheating are implemented (Total number of individual respondents = 72)



Feedback on overheating

Lastly, a significant proportion, 41% (out of 51 organisations answering the relevant question in the Overheating Survey), reported finding out about overheating problems only after receiving unsolicited feedback or complaints by occupants.

As discussed in Chapter 4, reliance on feedback alone risks overheating becoming severe before being addressed or masking a larger problem should occupants fail to report overheating issues.

The stakeholder interview exercise also highlighted examples of good practice:

Box 16. Checking for overheating

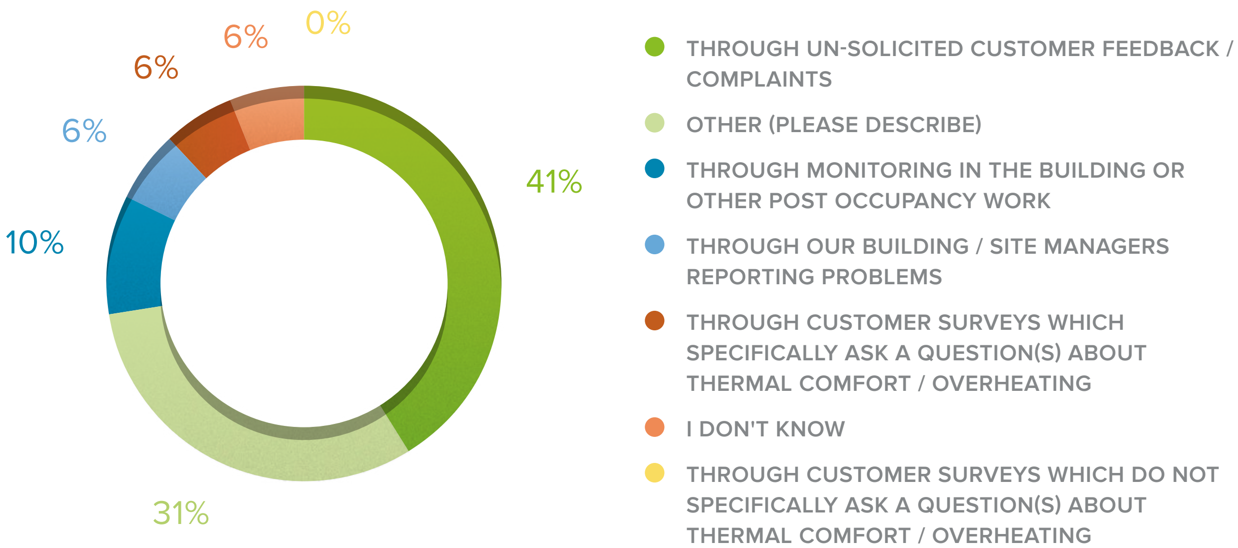
The use of up-front checks by Building Managers

'The process [that triggered an investigation into a case of overheating] was the housing managers reporting back to me that the corridors were hot."

The use of Post-occupancy Evaluation

'We interviewed residents [after they moved in] to see if there were any problems."

Figure 17.
For those who reported experiencing overheating problems in their stock, how did they find out there was a problem?



Motivation

The primary reasons cited by Housing Providers in the Overheating Survey for taking action to manage overheating risk were:

- Customer (occupant) satisfaction;
- Avoidance of reputational damage; and
- Recognition of the general need to adapt buildings to climate change.

The main reasons cited for not taking action or giving overheating lower priority during stakeholder interviews were:

- Not having experienced an overheating problem or never having received any complaints to date;
- The view that the organisation in question only builds or manages low-risk dwellings;
- The assumption that architects, designers and those specifying works will solve the issue; and
- The view that where there are clear legal requirements relating to other aspects of building performance, these take priority.

As would be expected, local authorities and policymakers gave different types of barriers:

- Other policy issues taking urgent priority;
- Lack of resources and funding;
- Lack of quantification of the level of overheating risk (current and future) for the local area.

Summary – Examples of actions Housing Providers are taking to be prepared

The table below summarises the types of actions Housing Providers reported taking to be more prepared to tackle overheating in their stock.

> It should be noted that some of these actions are more likely to be carried out by landlords and housing associations who have long term management responsibility for their stock. However, certain housebuilders also reported taking similar steps and saw maintaining strong long-term relationships with their customers as important to their business model.

Table 5. Actions being taken by Housing Providers to prevent and manage overheating risk

	Actions being taken by Housing Providers
Risk profiling	• Internally investigating how many of the homes the organisation has built or is responsible may fall into a 'high-risk' category for overheating based on current and future exposure. • Ensuring risk assessments include identification of homes with occupants who are more susceptible to the effects of high temperatures (if this is known), as well as the physical characteristics of the development/scheme. • Assessing the potential impact on occupant satisfaction, finances and the reputation of the organisation if units or schemes identified overheat.
Getting prepared	• Formally including overheating issues in business planning and risk registers at Board level. • Focusing resources on any high-risk units/schemes identified first. • Preparing advice for occupants on how they can help to keep their homes cool, including advice on the use of any mechanical ventilation or cooling systems. • Up-skilling delivery teams and supply chains on overheating and the importance of implementing prevention measures.
Prioritising prevention	• Empowering technical teams, designers, architects, installers and contractor to 'design out' and prevent overheating using design briefs, Employers Requirements and contracts. • Encouraging the use of passive measures that last the lifetime of the building. • Carefully selecting the ventilation strategy and making sure it works in practice. • Having processes in place to see the delivery of designs and measures through to completion.
Knowing the response	• Recognising that even with good plans, isolated cases of overheating still occur. • Identifying routes for occupants to feedback and report overheating issues. • Preparing in advance what steps to take if an overheating problem occurs, and what types of solutions to offer occupants. • Proactively monitoring or surveying a proportion of homes or occupants to check the strategies being used are working.

Even if an organisation considers the risk of their stock overheating to be very low because they have not experienced problems to date, it is still appropriate to check that assumptions hold true when thinking about the lifetime of the building, how climate change could alter the risk profile, and who might live there in the future.

"There is nothing that forces you to think about [overheating] at the concept stage. When you get to the detailed design stage, it's hard to then add external shutters like those seen in Europe, for example. You can't do that without planning permission."

HOUSEBUILDER

What does this mean for future frameworks?

Despite the evidence gathering uncovering examples of good practice, it appears that the types of actions described in table 5 are not being carried out by the sector as whole, or on a routine basis. It is also evident that organisations with impressive technical knowledge and experience on overheating are sometimes finding it difficult to embed this into internal business processes and practices. In many cases, the Housing Providers interviewed said overheating was not considered at Board level in any formal way.

Balancing requirements on heat gains and heat losses in very airtight homes will become even more important as the climate changes. As summers become warmer and heatwaves occur more frequently, Housing Providers will need to 'worry' more about summer thermal comfort and how the occupants of dwellings will keep cool. It is equally important that the policy and regulatory frameworks guiding action support them in this process.

The question of what detailed amendments may be needed to national and local frameworks to support Housing Providers in this journey will be considered in detail in Phase Two of the project. However, the evidence gathered so far provides early insights. The following issues were consistently raised by stakeholders:

1. Modelling of overheating risk is being done too late in the process to influence the design of projects. For new homes, consideration of overheating risk should happen at the concept stage before plans are submitted to local planning authorities. For existing homes, consideration of whether planned retrofit activities could lead to overheating, should heat flows be significantly affected, should also be considered at an early stage in the project.
2. Unrealistic assumptions are being used in models, potentially resulting in properties being incorrectly assessed as 'low risk' or passing overheating criteria. At present there are no official protocols to guide modellers when assessing overheating risk, for example, relating to which weather files to use or assumptions to make on internal heat gains. Developing best practice protocols and testing these against monitoring data could help to ensure consistency of results and strong correlations will real-world observations.
3. Use of modelling and/or checklists can create false expectations that the risk of overheating has been effectively mitigated, without follow-up. Experts strongly advise that organisations should still plan for dealing with potential isolated overheating problems further down the line.
4. Many models do not incorporate factors that are known to exacerbate overheating, such as a property being located in an urban heat island, corridors overheating due to heat gains from hot water pipes, or cumulative heat gains through the building fabric over a whole summer. In Chapter 3 we proposed exploring how to better link knowledge and evidence on the broader location and people-related causes of overheating, to property-level assessments.
5. National planning guidance in England does not explicitly cover overheating (but the equivalent policy in Wales does), and where Local Plans include provisions, there is a question mark over whether these are fully implemented or enforced.

"A standard or other requirement that takes climate change into account is likely to be needed to prevent overheating in new homes."

ADAPTATION SUB-COMMITTEE, COMMITTEE ON CLIMATE CHANGE

Box 17. The National Planning Policy Framework

The National Planning Policy Framework (NPPF) in England constitutes guidance for local planning authorities and decision-takers both in drawing up plans and as a material consideration in determining planning applications. A section of the framework is devoted the meeting the challenges of climate change, flooding and coastal change.

A key role played by planning is minimising vulnerability and providing resilience to the impacts of climate change is identified. Risks from overheating are not explicitly included in the main body of the NPPF, although climate change adaptation is defined in the glossary as including responses to rising temperatures.

"The planners we worked with were not sufficiently aware of overheating. We're driven by design, and when planners won't approve the plans we can't follow through on them..."

HOUSEBUILDER

6. Building Regulations contain only very general provisions relating to the reduction of heat gains in Part L1A, there are no specific provisions on overheating in Part F on ventilation either, and it appears that low priority is being given to the issue by Building Control Officers.

"If SAP comes back and says there is no danger of overheating – at the design stage – that addresses the current regulatory requirement."

REGULATOR

In 2016 a further tightening of energy efficiency standards is expected to implement the zero carbon policy for new homes. Balancing requirements on heat gains and heat losses in very airtight homes will become even more important. As summers get warmer, the policy frameworks in general, including those driving the retrofit agenda will also need to 'worry' more about the summer cooling.

"We've been discussing an overheating issue in a development recently where people in the business are trying to argue with the purchaser that there isn't an overheating problem because SAP tells you there is not a significant overheating risk. And if that were right – i.e. that's the regulation to do with overheating, then that would be the end of it...To be in a situation where we can't demonstrate that we comply is a bit scary."

HOUSEBUILDER

7. There can be an inherent tension between delivering buildings that are both energy efficient and resistant to overheating. Some measures which may reduce the chance of a building overheating may be disincentivised by current frameworks such as the Building Regulations. For example, the use of solar protective glazing can result in a lower SAP rating being awarded than if standard glazing solutions are used.

8. Initiatives designed to drive energy efficiency retrofitting of existing buildings, such as the Green Deal and Energy Companies Obligation, do not explicitly give advice to guard against overheating.

"Home refurbishment should provide a safe and comfortable environment throughout the year, which will include measures to minimise overheating, as well as reducing demand for heating."

ARCC, MESSAGES FOR POLICYMAKERS (2012)

9. Most voluntary building codes and standards do not include specific provisions on the summer thermal performance of buildings, although this also appears to be changing. See Box 18. However, organisations, including the Committee on Climate Change (Adaptation Sub-Committe) have argued that reliance on voluntary codes may not be sufficient to drive the level of action needed on overheating.

"We have recognised that this [overheating] is an issue that needs attention, but we believe that it would be best dealt with through Building Regulations, rather than through our own technical standards. What is needed first is agreement on what overheating is and then we need to develop some simple rules that can be applied through the Building Control process."

WARRANTY PROVIDER

Box 18. Examples of industry codes and standards

The GHA requires Leader and Developer members to comply with a minimum set of standards on their residential development projects. These include a Health and Well-being Standard under which members should address indoor air quality, thermal comfort and moisture levels within the design process and also consider broader issues such as daylighting, green space and adaptability. Once built, homes should be monitored, both at the point of completion and during occupation, and post-occupancy feedback gathered to prove that they are performing to acceptable standards, including in terms of thermal comfort.

The BRE's Home Quality Mark was launched in March 2015 as part of the BREEAM family of quality and sustainability standards. It is currently being trialled with a number of developers with the aim of becoming an operational standard in Autumn 2015. The My Home section sets specific performance outcomes for new homes, including for comfort and overheating. At the time of writing the technical methodology is under development, but the intention is to make use of existing commonly used assessment methodologies to avoid additional costs. The BRE's website states, "To avoid overheating and ensure affordability, any new home needs to offer a stable and warm environment that is easier to heat at a lower cost in winter but is capable of providing 'cool air' and ventilation in summer."

10. Questions were raised about the extent to which health and social care planning and budget-setting exercises are anticipating a potential increase in the incidence of overheating in homes at a national and local level. Specifically, it is unclear whether the knock-on impacts of overheating for the NHS and other organisations providing healthcare are being routinely accounted for.

> The Health and Social Care Act 2012 established Health and Wellbeing Boards (HWB) as a forum where leaders from the health and care system work together to improve the health and wellbeing of their local population and reduce health inequalities. Local HWBs have responsibility for producing Joint Strategic Needs Assessments (JSNAs) and joint health and wellbeing strategies which are used to determine local health and social care priorities.

"...I think it [overheating] is not [considered in the JSNA]...they've put climate change and adaptation in there, but the needs assessment doesn't include anything on that."

LOCAL AUTHORITY

"Our adult social care teams do [link health care provision and overheating]... However, I don't know whether overheating is in every JSNA. That's going to drive priorities for health. Likewise, does every core strategy recognise overheating? I suspect not..."

LOCAL AUTHORITY

CONCLUSIONS

CHAPTER 8

Over the last year the ZCH has worked with over 100 organisations to gain an insight into the strategic and practical issues which need to be addressed to enable overheating in homes to be tackled more effectively.

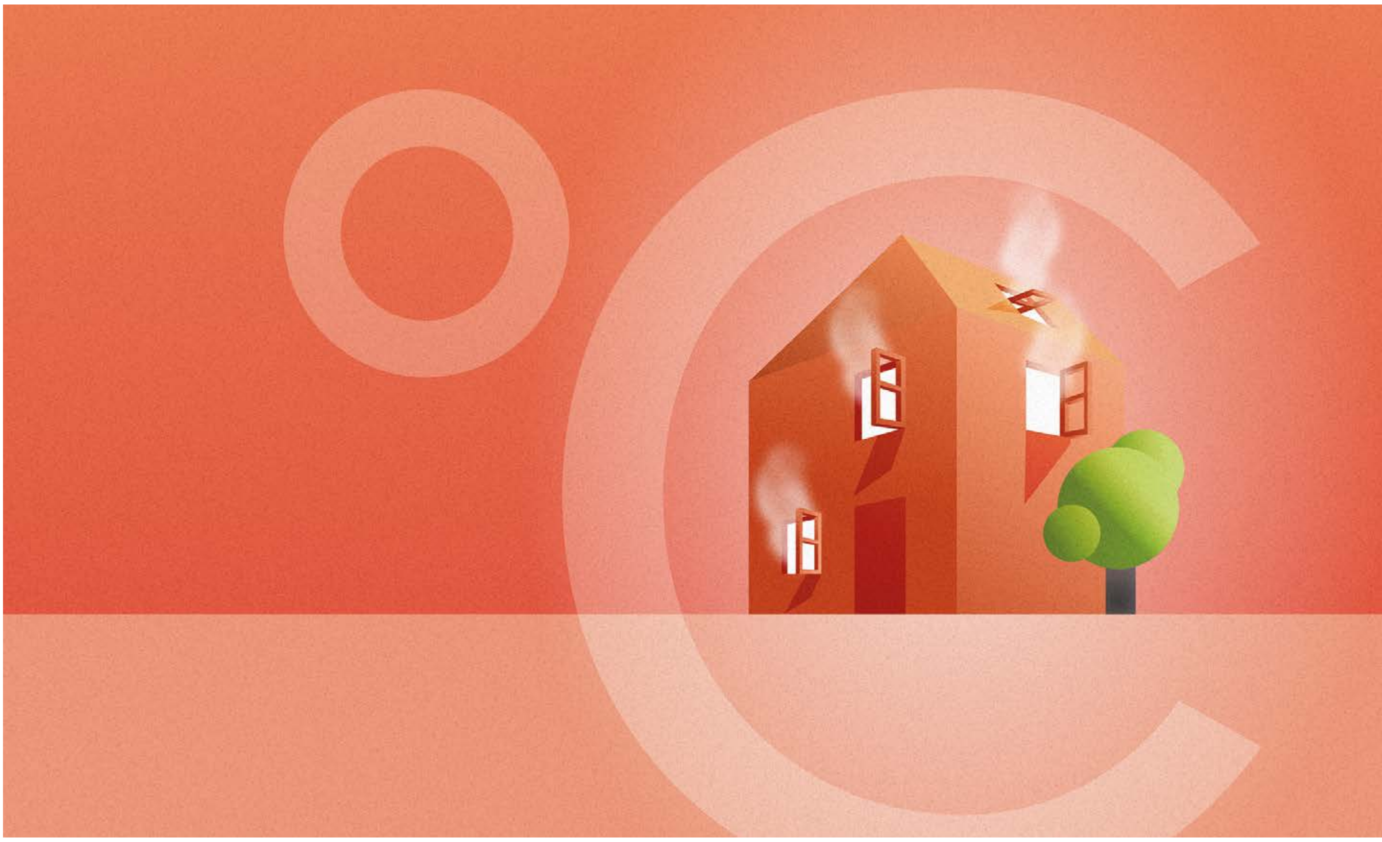
The level of concern about future overheating in the sector appears to be mounting. Most organisations the ZCH engaged with are in the very early stages of figuring out whether their stock might be at risk of overheating in the future, and what to do about this. Others, and particularly those who have experienced difficult to treat overheating cases in the past, are determined to minimise or prevent future cases and are looking closely at their businesses processes, or have already made changes to them. A small number are in the strong position of having not had any significant overheating issues to date, but have invested in overheating prevention measures in any event because it made sense for their business.

Experts and practitioners raised issues about the policy frameworks and regulations which guide the sector. The most challenging being the lack of an agreed sector-wide definition, but also issues with risk assessment processes and enforcement. The current regime does not actively encourage Housing Providers to give serious consideration to whether any of their stock might overheat in the future.

> Our conclusion is that overheating cannot yet be considered to be a managed risk for much of the sector. There are gaps and uncertainties in current frameworks which mean inherently risky designs and buildings can be approved. Secondly, despite evidence gaps, there is enough information and evidence about the causes, extent of, and solutions to overheating in homes to warrant taking careful yet concerted action to tackle the issue.

Despite this, the ZCH also found impressive examples of Housing Providers working hard to future proof their stock by making changes to internal processes to fully embed strategies intended to minimise and design-out overheating as far as possible. This focus on prevention is important as the range of options available to tackle overheating become more limited once a building's form and orientation is fixed.

Anecdotal evidence from stakeholder interviews suggests that those with strong overheating risk assessment processes felt confident that their stock will not overheat further down the line, compared to those who did not.



"My general view of the overheating issue is that this, together with indoor air quality, will be the two predominant issues over the next 5 to 10 years [for the sector]. We have learnt how to keep buildings warm successfully and our Building Regulations deliver a high quality level of heating performance."

TRADE BODY

Early indications are that future policies and frameworks which support the sector in minimising and preventing overheating, as far as possible, by identifying and giving particular attention to high risk homes, could prove feasible, effective and relatively low cost compared to other blanket approaches. During Phase Two the ZCH will explore the practicalities of this approach, amongst others, and aim to quantify the costs and benefits.

Finally, we have highlighted the effects of the 2003 heatwave and the expectation that similar heatwaves will become much more frequent in the future. With this in mind, we must ensure that the new homes being built, as well as the existing stock, can cope with such events – even when built to high standards of energy efficiency. This will be even more important with the introduction of the Zero Carbon Standard for new homes in 2016. It is clear that overheating can happen in cooler summers too. Increasing our overall level of preparedness must therefore be an ongoing process – a core part of the frameworks that guide building design and retrofit activity.

NEXT STEPS

The objective of Phase Two is to make recommendations to government and industry decision-makers on the types of frameworks which could cost-effectively incentivise the construction and energy efficiency sector to take action to tackle overheating in homes. To support this core analysis, the ZCH will work in full consultation with partners and stakeholders to:

1. Raise awareness on overheating by publishing a series of short, targeted documents, including: (by July 2015)
   - A publication written by the BRE describing the types of technical and behavioural solutions available to Housing Providers to mitigate or manage overheating;
   - Case studies of temperature monitoring projects carried out by housing associations setting out what prompted the research, what the results were and how this information informed future strategies to address overheating; and
   - A leaflet aimed at local authorities showcasing examples of the work being carried out by certain Local Planning Authorities and others to map heat risk, reduce the incidence of overheating at the neighbourhood or city level, and to plan for future heat-related health and social care provision.

2. Identify potential (short-term) updates to the overheating check in SAP Appendix P and analyse how the role of Appendix P could evolve over time as the sector's approach to tackling overheating changes and new modelling protocols are developed. (by October 2015).

3. Commission work to draw together guidance to link advice on technical solutions to known causes of overheating, and describe the possible impacts of solutions in a range of potential scenarios. (by October 2015).

4. ZCH to work with the research community to determine whether it is possible to develop a methodology to model the potential future incidence of overheating at the national and local level and what this could tell us. (by December 2015).

5. Make recommendations to Government on what form an overheating definition or standard could take, and how it would be implemented. (by March 2016).

6. Provide a preliminary assessment of the costs and benefits of a range of potential policies and frameworks designed to tackle overheating and describe how they would be implemented in practice. For example, would regulatory changes be needed? Particular attention will be given to testing the feasibility and effectiveness of policies which better support Housing Providers in identifying and treating high-risk homes. (by March 2016).

7. Work with partners and legal experts to develop example clauses and templates on overheating for inclusion in design and procurement contracts. (by March 2016).

8. Take advice on whether to commission economic analysis and what a robust methodology would be to:
   - Quantify the cost of productivity losses resulting from overheating in homes, especially at night; and
   - Quantify what reductions in future healthcare costs may be possible at the local level in a range of hypothetical scenarios with low, medium and high levels of future overheating.

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- Aecom
- AES Southern Limited
- Adaptation and Resilience in the Context of Change Network
- Arup
- Asset Skills
- Association for Decentralised Energy
- Aster Group
- Barratt Developments PLC
- BASF
- BioRegional
- BRE
- Briary Energy
- BSRIA
- Carr and Carr (Builders) Limited
- Chartered Institution of Building Services Engineers
- Climate UK
- Construction Industry Training Board
- Committee on Climate Change (Adaptation Sub-Committee)
- Constructing Excellence in Wales
- Construction Products Association
- Crest Nicholson
- The Concrete Centre
- Db-associates
- Department for Communities and Local Government
- Department of Energy and Climate Change
- Department for the Environment, Food and Rural Affairs
- Department of Health
- East Sussex County Council
- Elmhurst Energy
- Environment Agency
- First Wessex
- Federation of Master Builders
- Fourwalls
- Dr Jacquelyn Fox (independent)
- Gentoo
- Professor Bill Gething (independent)
- Good Homes Alliance
- Gillard Associates
- Greater London Authority
- Greenoak Housing Association
- Hanover
- House Builders Association
- Home Builders Federation
- Hoare Lea
- Homes and Communities Agency
- HTA Design LLP
- Hull City Council
- Inkling LLP
- Innovate UK
- Islington Council
- Joseph Rowntree Foundation
- LABC
- Lend Lease
- Levitt Bernstein
- London Metropolitan University
- Linden Homes
- Local Adaptation Advisory Panel
- Local Government Association
- London Climate Change Partnership
- London School of Hygiene and Tropical Medicine
- Loughborough University
- McCarthy and Stone
- Melin Homes
- Modern Masonry Alliance
- National Energy Services
- Newcastle County Council
- NHBC Foundation
- North Wales Housing
- NPT Homes
- Oxford Brookes University
- Peabody
- Pollard Thomas Edwards
- Radian Group
- Richards Partington Architects
- Rickaby Thompson Associates
- Robust Details Limited
- Saint-Gobain
- SE2
- SE Controls
- SIG PLC
- South Gloucestershire Council
- SummitSkills
- Brian Spires (independent)
- Stewart Milne Group
- Stroma
- Structural Timber Association
- Sustainable by Design
- Sustainable Homes
- Sustainable Housing Action Partnership
- Swansea Council
- Town and Country Housing Group
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- Public Health England
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