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Since our formation in 2008, the Zero Carbon Hub has worked with Government and industry to identify risks, remove barriers to innovation and help demonstrate that energy efficient, healthy new homes can be delivered by the mainstream house building industry.

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INTRODUCTION

This discussion paper draws together the views and advice of experts and professionals from across the construction sector to make preliminary recommendations relating to:

- Defining “overheating” in new dwellings being constructed, and
- Assessing the potential for those buildings overheating in the future.

Our objective is to provide a solid starting point for developing a national policy or standard on overheating, and a focal point for targeted research. The contents of this paper are not intended to be, and should not be construed as legal advice.

The Zero Carbon Hub’s recommendations draw on the evidence-based and expert views and advice of housebuilders, housing associations, local authorities, professional bodies, manufacturers, technical experts, academics and policy advisers. Nearly 100 organisations in total.

Information was gathered during Phase One of the Hub’s Tackling Overheating in Homes project, our Overheating Definitions Workshop on 8 December 2015, and from experts consulted on the draft paper between December and March 2016.

Many technical and practical questions will inevitably flow from the approach proposed. However, the end goal is the development of a mandatory national minimum standard for the construction sector intended to address the risk of overheating in homes. The Hub team is heartened by the level of support for the broad approach set out, and extremely grateful to all those who have contributed.

In a general sense, by overheating we mean the phenomenon of excessive or prolonged high temperatures in homes, resulting from internal or external heat gains, which may have adverse effects on the comfort, health or productivity of the occupants.

1. The paper delivers on the Zero Carbon Hub’s commitment in our 2015 report “Overheating in Homes – The Big Picture” to support the construction sector in making progress in defining overheating.
Who are the recommendations intended for?

The paper is directed at government departments and agencies in England and Wales with a policy interest in the design and delivery of new dwellings, and/or a remit on climate change mitigation or adaptation. Those who directly enforce and apply standards, such as Building Control Bodies and Local Authorities, are also likely to have an interest.

Although our focus is on standards for the construction of new buildings, overheating has been observed in a range of existing buildings across the country.

Detailed work will be required to outline a complementary framework for existing buildings, including the interaction with the Housing Health and Safety Rating System (HHSRS). Early thoughts on this theme are offered.

Key points to clarify

- The proposed approach relates to the design of new dwellings i.e. what minimum standards developers and designers should be aiming for in terms of the thermal performance of dwellings during warmer weather.

- The terms “dwelling”, “residential property” and “home” are used interchangeably. We mean buildings where people will live in England and Wales.

- Although there is a strong focus on the need to maintain acceptable temperatures in bedrooms in this paper, this does not mean the rest of the dwelling can be ignored. The whole property must be risk assessed.

- The framework proposed would not be retrospective. It would apply to new dwellings gaining planning permission or being constructed once the new standard is operational.

- Our hope is that testing and trialling will take place over the next year (before March 2017) to finalise the detail. We do, however, recommend the core principles (from page 9) should stand.

- The proposed standards would need to be reviewed as the climate changes. We suggest every five years, alongside national Climate Change Risk Assessment updates, or every three years alongside revisions to Building Regulations.
Are the recommendations supported by consultees?

The principles in the paper have broad support across the sector, including from government agencies, local authorities, professional bodies, researchers, housebuilders, housing associations and technical experts.

As would be expected, consultees sometimes put forward alternative preferred approaches to applying the detail. The Hub and our technical advisers have taken many of these and woven them into the proposal. A question and answer format has been used to provide a straight-forward way to answer some of the other questions raised during the consultation process.

The ultimate goal is to significantly reduce the potential for overheating in new homes being built, for the benefit of those who will live there. There are many potential ways to do this, and each have pros and cons. The approach in this paper is considered a sensible start.

Are CIBSE also running an exercise to define the overheating assessment criteria to be used for residential development?

Yes. The Hub is collaborating with CIBSE to ensure our recommendations are consistent and complementary. CIBSE will produce a paper to clarify their advice on the detailed assessment criteria to be used for residential development, based on guidance provided in CIBSE Guide A - Environmental Design (2015 edition) and CIBSE TM 52 - The limits of thermal comfort: avoiding overheating in European buildings, 2013.

Their paper will recommend that overheating criteria is chosen based on the type of ventilation or cooling strategy to be installed. It will state that for "homes that are predominantly naturally ventilated, including homes that have Mechanical Ventilation with Heat Recovery (MVHR) with good opportunities for natural ventilation in the summer, should be assessed using the adaptive method described in CIBSE TM 52."

Homes that are predominantly mechanically ventilated, "including homes with MVHR that have no opportunities or restricted opportunities for opening windows, should be assessed using the fixed temperature method, and the rooms should not exceed an operative temperature of 26 °C in the summer, for more than 3% of the occupied hours. Care homes and accommodation for vulnerable occupants, or where external background noise would be unacceptably high when windows are open, should use the fixed temperature method."

In addition, CIBSE Guide A, 2015 states that "it is desirable that bedroom temperatures at night should not exceed 26 °C unless there is some means to create air movement in the space, e.g. ceiling fans."

The approach outlined in this paper dovetails well with CIBSE’s.

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1. See more on this at Annex A.
What happens next?

We propose that the recommendations which follow are adopted, in principle, by government departments as a national policy by March 2017, prior to the next update of Building Regulations. In addition, new research, including monitoring by developers, modelling work, and health-based research over the next year, should inform the detail of implementation.

It is beyond our scope to recommend precisely how the framework should be implemented, e.g. through planning policy, Building Regulations or health-based frameworks. However, the research over the last two years strongly suggests the need for a mandatory requirement or standard. There is widespread support for such a step.

Stakeholders told us that “buildings are already being approved that are bound to overheat”, and suggested that the market alone will fail to drive significant action as long as the costs and consequences of failing to act “always seem to be some time in the future” or “are too difficult to quantify for an individual business”. A number of Housing Providers also feel unable to make a solid case to invest in overheating prevention measures without a strong “push” and that managing overheating inevitably falls lower on the list of priorities compared to other regulated standards.

What do we mean by “definition”?

By “definition” we mean: being able to agree and describe when overheating can be said to occur – i.e. using criteria or thresholds.

By “standard” we mean: a reasonable standard of delivery housebuilders, developers and their supply chains should adhere to. Developing the full detail of a standard is a longer-term project, but this paper provides a robust starting point. In practice, definitions, criteria and standards overlap.

Design guidance and resources

There is a wealth of information available to guide developers and their technical teams when designing dwellings for future climates, including on the Zero Carbon Hub’s website, the NHBC Foundation, CIBSE, BRE, Arup, the ARCC Network and many more. For example:
We recommend the following approach to risk assessment and defining overheating in bedrooms is adopted as a starting point for the development of a national minimum standard (noting that further research, modelling and/or piloting is needed to finalise the detail).

A housebuilder or developer would have taken reasonable steps to reduce the potential for overheating in a new dwelling or scheme if:

1. At the concept/pre-planning stage of the construction project, they conclude and can demonstrate that:
   
   A. To the best of their knowledge (following an appropriately detailed risk assessment), the property or scheme in question has a low risk of overheating, and
   
   B. The rooms intended to be bedrooms at the design stage of the project are capable of not exceeding 26 °C for more than a specified percentage of (fixed) occupied hours.¹

2. And, the method used to assess the risk of the property overheating and to demonstrate compliance with the Bedroom Temperature Threshold is appropriate for the property or scheme. An “appropriate” method would include (but is not limited to) the following elements:

   A. If the property being designed appears, at the outset of the project, to have certain physical characteristics or risk factors which suggest it is very likely to overheat, then a robust and detailed risk assessment exercise should be carried out to inform a suitable response. For schemes where the units are extremely unlikely to overheat, a more basic check/calculation can be made. In either case, the team should ensure the assumptions used when modelling/assessing, such as the occupancy profiles, are realistic and transparent.

   B. The method chosen should take account of the ventilation system. As noted, CIBSE are expected to recommend that the “Adaptive Comfort Method” is used for naturally ventilated buildings. (See Annex A). For schemes which are predominantly mechanically ventilated, or naturally ventilated but with limited opportunity for window opening in practice, fixed criteria should be used.

¹ We call this the “Bedroom Temperature Threshold”.
C. The method must take account of broader contextual factors at the site which could hamper or reduce the effectiveness of strategies intended to minimise overheating (such as the presence or absence of any urban heat island, or noise issues which would prevent window opening).

D. The method must allow the developer and their team to make an estimate of how long the conclusions of the risk assessment are likely to hold true for e.g. until 2020, 2030, 2050 etc. by stating clearly which weather files and climate assumptions have been used. Methods using historical weather data are likely to be less robust.

E. The assessment should be carried out by appropriately qualified people.

3. And, on completion, the developer demonstrates to the Building Control Body that any measures intended to mitigate overheating at the design stage, have been implemented in practice. If changes have been made, then the measures installed must achieve, at least, the same outcome.

4. And, handover information for occupants explains, as a minimum, how to use any measures installed intended to keep the property at comfortable temperatures, including shading devices and ventilators.

The questions and answers throughout the paper explain why the approach has been constructed in this way.

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1. Data on UHIs is available for certain cities, including London. Even where detailed data is not available, a crude assessment of whether there is an UHI or not should still trigger designers to consider more deeply how, for example, to achieve sufficient night-time ventilation or cooling of buildings being constructed in these areas.
At the concept/pre-planning stage, the project team takes an initial view on whether the physical characteristics of the scheme or property suggest it is very likely to overheat (based on recognised risk factors and the site context)\(^1\)

- **Very likely to overheat (or not sure)**
  - A detailed modelling exercise/risk assessment is conducted and any necessary modifications made to the design until the project team is able to demonstrate that the scheme/property has a low risk of overheating (based on appropriate criteria)

- **Very unlikely to overheat**
  - A light-touch modelling exercise/risk assessment is conducted to confirm the initial view. If the assessment suggests the initial view was incorrect, modifications to the design should be made to achieve a low risk rating (based on appropriate criteria)

The modelling exercise should also determine whether the rooms intended to be bedrooms are capable of not exceeding 26 °C for more than a specified percentage of (fixed) occupied hours

The developer confirms at the completion stage of the project that any measures intended to address overheating included in the risk assessment have been implemented

The handover process to the occupants includes information about how to use any measures intended to prevent overheating

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1. If the property is intended to house vulnerable occupants, for example, it is a care home, then it may also be appropriate to carry out a detailed risk assessment.
GUIDING PRINCIPLES

There is wide-spread support for the following principles, practices and assumptions:

**Principle 1 - Resilience**
Dwellings being designed and built now will need to withstand and protect occupants from higher external temperatures than the current climate. New frameworks will need to encourage high-quality, resilient designs. Developers and designers should regularly re-visit adaptation strategies as the climate changes, revising their technical responses as necessary.

**Principle 2 - Proportionality**
Policy frameworks need strengthening to purposefully drive action in the construction sector to tackle overheating. However, frameworks should also recognise that although overheating is clearly already happening in some homes, at present many types of homes are unlikely to overheat. In-depth checks should be reserved for sites and buildings with physical characteristics that make them potentially high risk, or are specifically intended for vulnerable occupants.

**Principle 3 - Integration**
New policies and practices should build on the way the sector already operates as far as possible.

**Principle 4 - Simplicity**
Any framework which causes the sector to have to apply very complicated rules as a minimum standard, or requires detailed dynamic modelling in every case to demonstrate that requirements have been met, would arguably be disproportionate and could lead to unnecessarily high implementation costs. Simplicity is also important for smaller organisations who may not have technical support in-house.

**Principle 5 - Clarifying the minimum standard**
The goal is to clarify the minimum standard and/or process that all developers of residential properties would need to satisfy. Defining a minimum does not preclude organisations from going further if they wish by applying best practice guidance.

**Principle 6 - Control**
There are some factors which affect the likelihood of a property overheating which are beyond the direct control of the developer, such as how residents will use the property in practice, or the intensity of any urban heat island. It should still be possible to account for some of these contextual factors when making assessments of how the property should function, and to develop protocols to guide assumptions on these.

**Principle 7 – Capacity**
The temperature threshold for bedrooms recommended relates to whether or not the property is capable of being maintained at or below the threshold. Developers cannot know whether occupants will choose to keep their homes at different temperatures, but can provide a design which makes it easier for them to control their environment. For new build schemes, standards should be capable of being satisfied prior to the handover of the property i.e. by modelling and risk assessment. However, we also urge those with housing responsibilities to consider monitoring a sample of properties to check real performance in use.
**Principle 8 - Reliance on modelling**
Modelling is a commonly used way to assess the likelihood of a property overheating before it is occupied, and sometimes when it is occupied too. Modelling will continue to be a core part of any future overheating framework. However, it is also important to acknowledge that all models have limitations, especially concerning assumptions about people’s behaviour. The results of modelling exercises should not be viewed as guarantees of performance. Alongside modelling exercises, some organisations view it as good practice to use the knowledge and experience of the team carrying out the project to look out for common sense “red flags” and risk factors which modelling exercises can sometimes miss. In this paper we recommend adopting this approach and have called it a Context Check.

**Principle 9 – Designing-out issues**
Overheating assessments should take place at the concept stage of projects. Leaving assessments until later in the process (as frequently happens now) reduces the opportunity to use the fabric and the design of the building to reduce the potential for overheating. Adopting this principle leaves open the possibility of using national planning policies to drive standards and to ask developers to submit a summary of the steps taken to mitigate overheating at the planning submission stage. In such a framework, guidance for local planning authorities on the importance of measures intended to address overheating, such as external shading, should be issued. Guidance for developers would also be needed on what information they should submit and how its acceptability would be judged.

**Principle 10 – Retrospectivity**
The approach would apply to new development gaining planning permission or being constructed after the implementation of the standard. It would not be retrospective. However, further detailed work will be needed to clarify the position for existing buildings which will have been designed to meet different standards.

**Principle 11 – Behaviour change**
This paper focuses on the design of buildings. By getting this right, occupants will be better able to maintain their homes at comfortable temperatures. However, it is also extremely important to continue to support people in understanding how to help themselves, for example, when to open windows and how to use and maintain their ventilation systems properly.

**Principle 12 – Trialling**
There is still a lot to learn on how to adapt designs for a changing climate. The approach set out in this paper will also be new to some in the sector. A trialling period should therefore be allowed to further test and develop the recommendations.

**Models should be continually improved and validated over time as the evidence base on overheating grows.**

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**Context Check**

The term describes the process of a developer and/or their design team thinking through the realities of a site and deciding whether the characteristics make certain units (or the whole scheme) more or less prone to overheating. For example, because the site is located next to a noisy main road and therefore reliance on window opening alone for purge ventilation may not be sensible, or it very clearly has large areas of un-shaded South, East or West facing glazing. There is the opportunity for technical experts to produce an official set of common-sense questions or rules of thumb which would aid the identification of risk factors for project teams. We propose that an informal, quick Context Check is carried out prior to officially modelling risk. This approach mirrors what some developers are already doing. However, we suggest it would be inappropriate to demonstrate compliance with any future standard with a context check alone. See more on risk factors in our “Introduction to Overheating” guide [www.zerocarbonhub.org](http://www.zerocarbonhub.org)
Which type of risk assessment methodology should be used?

As set out in the summary, the first step would be to decide which methodology is “appropriate” to use to determine whether/demonstrate that the property or scheme in question is predicted to have a low risk of overheating. In addition, the method must be capable of demonstrating that the proposed Bedroom Temperature Threshold is capable of being met (see page 14 for more discussion on the threshold temperature).

Our recommendation is that light-touch risk assessment methods can be used if the physical characteristics and the context for a planned development suggest it is very unlikely to overheat. In such cases, a “steady-state” modelling methodology with a comparatively limited set of input parameters should be sufficient, provided there are also processes in place to check the inputs and assumptions being used are realistic. At present, such light-touch assessments may be possible for many new dwellings, but this is expected to change as the climate changes and average summer temperatures rise.

However, if the initial designs (including the site context) have features and characteristics which suggest the property could be prone to overheating - for example, due to the orientation, the ratio of glazing to floor area, issues with providing adequate ventilation etc. - then a detailed risk assessment should be carried out. Dynamic Simulation Modelling (DSM), or a similar detailed bespoke modelling tool, would be used.

Dynamic thermal simulation models are powerful software tools, which model the energy interactions and internal environmental conditions in a building on an hour-by-hour basis. Developed primarily 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. One benefit of such tools is they help the project team see the impact of making changes to the design, such as altering the glazing specification, or adding shading.
Our recommendation is that the developer and their team should be permitted to decide which is the most appropriate risk assessment methodology to use on a case-by-case basis (and to note the reasons), rather than this being prescriptively set out in regulation. The project team will know the site well. However, as noted on page 10, official guidance setting out rules of thumb and risk factors to watch out for should still be provided.

Lastly, for apartment blocks with communal heating, risk assessments should cover the potential for overheating in communal areas.

The term “triaging” is being used to describe the process of separating out potentially high risk properties for greater attention.

One practical issue is that SAP Appendix P does not currently allow assessors to calculate likely bedroom temperatures. It averages temperatures for the whole property. In addition, the status of Appendix P means there are potentially barriers to using it to demonstrate compliance with specific overheating standards. It was not intended to be used in this way.

The successful implementation of the “light-touch” risk assessment option would therefore be reliant on either developing a re-purposed Appendix P-type methodology, or creating a new simple “steady-state” methodology/tool. Discussions on the practicalities of doing this suggest that the adaptation of existing models or the creation of a new tool, if needed, would not be difficult to do.

It would also be useful for any new tool to continue to be able to draw on some of the data inputted into SAP to achieve consistency and avoid duplication of effort by modellers.

Will there be protocols to guide modellers on the criteria to use when assessing risk?

At present, modellers may decide themselves, based on experience, which criteria to use to judge whether a property “passes”. Alternatively they might be guided by their clients, or use in-built benchmarks, such as those in SAP.

When putting the proposed approach into practice, it appears sensible, as a starting point, to assume:

- When opting for the light-touch risk assessment route, the temperature benchmarks already outlined in SAP Appendix P would be used to generate the risk rating, even if the tool itself changes. Appendix P states that if the average internal temperature in a property during summer months is calculated to be higher than 23.5 °C, then it is considered to have a high risk of overheating. Over time, the benchmarks could be adjusted as the evidence base grows on how closely they match people’s perceptions of overheating. See Annex A for further discussion.

- When going down the detailed modelling route, the criteria most appropriate for the property type and ventilation strategy should be used. The most commonly used criteria is likely to be that produced by CIBSE. If the property passes criteria in Guide A Environmental Design, 2015 (which references TM 52), then it would be deemed to be “low risk”. Similarly, if the Passive House Planning Package (PHPP) is considered most appropriate because the scheme in question is built to Passivhaus standards, then PHPP criteria could be used to produce the risk rating.

To reiterate, for either route, the modeller would always need to check the bedrooms for compliance with the proposed Bedroom Temperature Threshold. Light-touch modelling tool(s), in particular, would likely need an “add on” to be able to perform this function. Importantly, detailed modelling using CIBSE’s criteria, for example, should mean compliance with the Bedroom Temperature Threshold is automatically checked.
**Should there be protocols on which occupancy patterns and climate assumptions to use?**

Yes. The choice of occupancy patterns, internal gains profiles, and weather files for use in dynamic thermal modelling assessments makes a large difference to whether a property passes or fails the overheating criteria.

At present, there is no standard methodology for setting up a modelling or risk assessment exercise. This allows unrealistic conditions and behaviours to be assumed.

However, Arup, CIBSE and Inkling LLP are currently working with modellers to agree a set of protocols, for example, on which weather files, occupancy assumptions, and internal gains profiles to use when assessing overheating risk. This work is extremely important and should lead to greater consistency in the results of modelling exercises.

Further information on weather files and climate scenarios can be found in CIBSE TM 48 (Use of climate change scenarios for building simulation: the CIBSE future weather years) and CIBSE TM49 (Design Summer Years for London).

Experts suggested during the consultation process that risk assessments should use weather data that better reflects what we might expect in the coming decades, and, at the very least, what we might expect in 2020. Otherwise modelling exercises could "pass" buildings which will easily overheat in reality as the external temperature is already warmer than was assumed.

The Appendix P methodology currently uses regional weather data based on historical averages.

**Should organisations who have modelled their standard plans and designs be required to do further modelling?**

The purpose of modelling in this way is so that the plans and designs used for new schemes do not need to be modelled in detail every time. However, site-specific details will differ for every new development. To tackle this, one developer told us they tend to model the “worst case” orientation when updating standard plans and use challenging external weather conditions. If the designs pass these difficult tests, then other less problematic sites are also expected to pass. Alternatively, the Context Check would assist developers in deciding whether they should be concerned enough about a new site to model risk again.
Why is a maximum internal temperature threshold being recommended for bedrooms in addition to risk assessments?

Channelling efforts towards keep bedroom temperatures within acceptable limits is considered a sensible step forward for managing overheating issues in dwellings. Setting an associated standard would provide much needed clarity for the industry.

Officially setting an upper limit on the temperatures bedrooms should be capable of staying within would help to reduce issues associated with sleep deprivation during warm weather, and would mean bedrooms provide a space for people to get respite from the heat of the day. This kind of break from excess heat is even more important for vulnerable occupants, such as the elderly or young infants, to protect their health.

The approach should also drive designers to think strategically and creatively about the layout and performance of the building, such as locating bedrooms in potentially cooler areas (where possible), keeping heat sources away from bedrooms (such as hot water cylinders), shading bedroom windows, and implementing ways to provide adequate, secure ventilation in bedrooms at night.

What should the temperature limit for bedrooms be?

We recommend the following definition/limit is used:

“If the rooms intended to be bedrooms at the design stage of the project are predicted to exceed 26 °C for more than a specified percentage of (fixed) occupied hours, then they would be classed as overheating”.

The definition used does not yet specify whether the air temperature or “operative temperature” should be used. The operative temperature combines the air temperature and the mean radiant temperature in a weighted average, and is considered to be a good indicator of the temperature people actually experience.
The Bedroom Temperature Threshold proposed is put forward as a reasonable limit/definition based on the available evidence (discussed below). However, further work to develop, test and challenge certain details is needed in the next year, including:

1. **Further checks for health protection**

The construction sector tends to understand and encourage the design of dwellings with the aim of allowing occupants to experience ‘thermal comfort’. Thermal comfort has been defined as "that condition of mind which expresses satisfaction with the thermal environment".¹

CIBSE’s 2006 edition of Environmental Design Guide A advised that above 25 °C, people start to feel uncomfortable. Overheating – a more extreme scenario than general discomfort - was deemed to occur in living rooms if temperatures exceeded an operative temperature of 28 °C for more than 1% of the time the rooms were in use. In addition, control of night-time temperatures was considered particularly important for the domestic sector and, as a result, a lower peak threshold temperature of 26 °C was recommended for bedrooms (also with 1% exceedance allowed).

In 2015 CIBSE adopted the "Adaptive Comfort Approach". This allows the maximum peak temperatures permitted in buildings (non domestic and domestic) to vary according to recent outside weather conditions and people’s ability to adapt to higher temperatures.² However, CIBSE continues to advise that a lower maximum peak temperature threshold should still be used for bedrooms (of 26 °C) as the capacity of people to help themselves to cool down when sleeping is more limited.

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¹ BSI (BS EN) ISO 7730 (2005).
Notwithstanding the movement towards the adaptive comfort model, Guide A (2015) continues to advise that sleep quality may be compromised when indoor operative temperatures rise above 24 °C, and recommends that peak bedroom temperatures should not exceed a threshold of 26 °C. As noted on page 4, CIBSE is currently developing further guidance on the application of their 2015 guidance in a residential setting, including on exceedance levels. CIBSE’s guidance, which is based on extensive field trials, forms the starting point for recommendations in this section.

It is, however, recognised that thermal comfort-based temperature thresholds, intended to suit the majority of the population, may not always be sufficient to protect the health of vulnerable groups who are especially susceptible to the effects of excess heat. The practical challenge is that research and guidance which directly links health outcomes to certain temperatures inside dwellings is limited. A paper from 2012 helpfully summarises the sources of World Health Organisation (WHO) guidance on this subject. This states that “In 1982, a WHO Working Group reviewed the evidence on air temperatures in the home and health. The report concluded that there was minimal risk to the health of sedentary people, such as the elderly, in housing in which the ambient air temperature is between 18 ºC and 24 ºC.” It also notes that the guidance had been revised since the 1968 version, which referenced a different temperature range of 15 ºC and 25 ºC, a “so-called ‘zone of indifferent metabolism’”. However, the WHO report provides no references on which the revision of the temperature range was based.

Presumably drawing on WHO guidance, the NHS recommends that “every care, nursing and residential home should be able to provide a room or area that maintains a temperature at 26 ºC or below.”

And that “If temperatures exceed 26 ºC, high risk individuals should be moved to a cool area that is 26 ºC or below.”

Taken together, officially requiring bedrooms to be designed to meet similar standards to those recommended by CIBSE and the NHS is a good starting point, and would provide a greater level of health protection that exists at present.

In line with Principle 3, we therefore recommend that current thermal comfort standards for bedrooms should form the starting point for a minimum design standard - i.e. designing bedrooms to be capable of being maintained at 26 ºC or lower (with a small amount of exceedance allowed).

We also recommend exploring whether an added layer of health protection should be provided by requiring that the exceedance allowed is applied on a night-by-night, or 24 hour period, rather than over a whole summer or year (see more on page 19). Such an approach should, theoretically, prevent very high peak temperatures being allowed to occur in bedrooms night after night. Prolonged cases of overheating are particularly challenging for people to cope with.

Policymakers should also consider whether dwellings being built specifically for elderly people such as care homes and sheltered accommodation should have stricter standards still.


2. Heatwave, supporting vulnerable people before and during a heatwave. Advice for care homes managers and staff, NHS (2010).

3. The amount of time the peak temperature is allowed to be exceeded – to allow for extremes of weather.
2. Checks for feasibility
Although a limit of 26 °C for bedrooms is already included in CIBSE’s best practice guidance, it would be wise to confirm, potentially by modelling, how cost-effectively it can be delivered in a broad range of house types in England and Wales.¹ The goal is to create minimum standards which can be realistically achieved in most cases through good design and through passive measures, without the need for mechanical cooling which uses energy.²

3. Checks of approaches in other countries
Detailed research on standards relating to maximum indoor temperatures in dwellings in a sample of other countries would provide further helpful context. A report published by the Buildings Performance Institute Europe (BPIE) in March 2015³ summarises thermal comfort standards for a range of European Member States, including Belgium (Brussels City-Region), France and Germany. It would be useful to confirm how the standards outlined in that paper were arrived at, how they are implemented (e.g. are they voluntary or regulatory), and what impact they have had on the incidence of overheating. The BPIE’s report provides some evidence that neighbouring countries are also grappling with the issue of overheating and appear to be finding ways to define it.

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¹ And in a range of scenarios including location, climate, occupation levels, and occupation patterns. In theory, very tough standards could be applied, but the cost of delivering these could be so great, little progress would be made in tackling overheating.
² Two consultees suggested that power for cooling could be linked to PV systems so energy consumption/running cost concerns would be alleviated.
³ Indoor Air Quality, Thermal Comfort and Daylight – Analysis of Residential Building Regulations in Eight EU Member States, BPIE, 2015
The Housing Health and Safety Rating System (HHSRS) references 25 °C – won’t the proposed threshold for bedrooms conflict with this?

Environmental Health Officers (EHOs) operating under the Housing Act 2004 use statutory guidance and questions in the HHSRS to assess whether there are deficiencies in dwellings already occupied, or available for use, which could have health impacts for the occupants. This includes threats from excessively high indoor air temperatures. EHOs have a range of powers to require landlords and Housing Providers more generally to carry out works to make properties safe to live in if they have been categorised as a health hazard.

The HHSRS states, in describing the health effects of excess heat, that “high temperatures can increase cardiovascular strain and trauma, and where temperatures exceed 25 °C, mortality increases and there is an increase in strokes.”

Evidence gathered during the preparation of the HHSRS suggests that below this temperature there is no observable effect on the health of vulnerable occupants (see page 16). The effect of temperatures above this level, including for vulnerable groups, would depend on how high temperatures reach and the length of time people exposed to them. The guidance notes that “there is little relevant information in the UK on protection from excess high indoor temperatures”, and references are provided to relevant sections of Building Regulation Approved Documents and CIBSE’s guidance.

Feedback provided during the Zero Carbon Hub’s overheating project is that developers and landlords would benefit from further guidance on how they should demonstrate compliance with the HHSRS, should it be invoked.

The HHSRS is a statutory assessment tool, not a design standard, and we are not suggesting that the temperature thresholds should be aligned. Applying an absolute, fixed internal threshold temperature of 25 °C as a design standard for every room in every house type would be a radical policy, and is considerably stricter than current best practice design guidance.

However, the two frameworks appear to be complementary. One of the goals of design standards is to deliver quality buildings which adequately protect people from the external environment, as well as encouraging intuitive designs which allow the occupants to manage the internal environment as needed. The HHSRS helps to protect the health of vulnerable and susceptible people in particular – those who make the most use of dwellings. The HHSRS therefore provides a safety net should cases of overheating occur in a building after it is occupied (or is available for habitation), and the case is judged severe enough to be a health hazard.

A study carried out by BRE in 2014, which used English Housing Survey data, found that just 0.5% of the housing stock (around 112,000 homes) might be assessed as being a Category 1 health hazard using HHSRS 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.


2. Ibid. Para 3.06 of the annex on Excess Heat.

3. Any dwelling, once available for occupation can be assessed using the HHSRS. If it is determined that a hazard exists, then legal enforcement action can be taken.

What level of exceedance above 26 °C should be permitted?

Setting a peak temperature limit with a small permitted level of exceedance means higher peak temperatures – in excess of comfort temperatures – are technically allowed, but only for small amounts of time. A small amount of exceedance gives some flexibility in extreme weather conditions and recognises that managing overheating risk is not an exact science. The level of permitted exceedance needs to be clearly pinned down.

One of the aims of our recommended approach is to try to prevent high temperatures in bedrooms night after night. Final decisions on how the exceedance rules are framed are therefore important - they are a determining factor in whether our aim is realised. We suggest the options to be explored in the next year include:

1. **The night-time hours option**
   Testing a range of values for the percentage of hours the 26 °C threshold is allowed to be exceeded, on the basis of set night-time hours, every night. For example, if “occupied hours” were defined as 7pm to 7am (12 hours), and an exceedance value of 3% were used, this would allow just 36 minutes of time each night above the threshold. This is quite low. However, it is also possible that by only using night-time hours as the reference period for modelling, the test might not reflect the real-life effects of heat gains during the day. It would therefore be worthwhile testing the effect of fixing the occupied hours as the full 24 hour period, as well as varying the percentage of hours.

2. **Exceedance over months option**
   A similar test as number 1, but instead the modeller would calculate the allowable exceedance over a period of summer months (May to September), or over a whole year. There are 3,600 hours in the five-month period between 1 May and 30 September. If the temperature was permitted to exceed 26 °C for 3% of the time, this would total approximately 4.5 days.

3. **Degree hours option**
   Cooling Degree Hours measure how much (in degrees) and for how long (in hours) the temperature is above a certain level. It would provide a useful sense of how severely a threshold temperature has been exceeded. This type of approach is similar to one of the criteria used in the Adaptive Comfort approach in TM 52 (Criteria 2) and could also be trialled within this broader framework.

When taking a final decision on which type of exceedance is most acceptable, the ease of modelling in static tools under the “light-touch” route should be a consideration.

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1. Which would be intended to cover the time young children and babies are also in bed.

2. Assuming 30 days per month and the 3% applied to a 24-hour period.
Would these rules apply during heat waves?

One consultee raised concerns that simple temperature thresholds do not easily allow extremes of weather to be factored in. We suggest that planned modelling exercises should test the extent to which the Bedroom Temperature Threshold can be satisfied in new properties even during simulated, and possibly real, heat wave conditions. However, we advise against relaxing standards too far during heatwaves as a significant proportion of excess heat-related deaths and ill-health occur during heat waves.

Properties to be located in urban heat islands may also need further exploration as they can be harder to keep cool at night. However, again, we recommend that the starting position is that such properties should not benefit from more relaxed rules by default. The majority of the population lives in urban areas and should be able to benefit from the protection afforded by the frameworks developed. Instead the focus should be on finding ways to provide secure night-time ventilation, and also defining the scenarios when comfort cooling may become a necessity.

What does “rooms intended to be bedrooms” mean?

People may convert rooms originally intended to be living areas into bedrooms. Enabling this type of scenario, for the benefit of older occupants for example, is now encouraged by standards.

Developers and designers might start by assuming that rooms will be used as designed, i.e. people will sleep in bedrooms. Then, building-in capacity to allow occupants to retrofit living rooms (or other rooms) in the future would also be sensible. For example, avoiding making ceilings too low for ceiling fans.

How would developers demonstrate the threshold has been met?

In line with Principle 7, compliance would be demonstrated by modelling at the design stage of the construction project, and again at the completion stage.

How does the approach work for vulnerable occupants or shift workers at home during the day?

Building Control Bodies would not approve properties and schemes which are shown by the risk assessment/modelling exercise to have a high risk of overheating. Future risk assessment reports must also be sufficiently clear and transparent to allow building control colleagues to easily ascertain the steps taken by the developer and their team to limit the potential for overheating.

The framework would therefore encourage the whole house to be designed to avoid high temperatures during the day and at night. However, future occupants will still experience the resulting temperatures differently. Therefore, Housing Providers should also consider providing advice to occupants to help them manage internal temperatures themselves, such as on window opening.

How does this approach work in bedsits, small flats or open plan units where there us little difference in temperatures across rooms?

In open-plan properties, small flats and bedsits, having specific standards for bedrooms compared to the rest of the dwelling may not make much difference in practice if the heat can transfer easily and quickly across the room(s). However, in our view, the core approach still works. Designers would start by focusing their attention on the overheating risk assessment, and then on the bedrooms specifically. If design choices in other areas of the property affect the ability to comply with the Bedroom Temperature Threshold, then modifications to the design would be needed.
Does this mean managing temperatures in other rooms can be ignored?

No. As described on page 11, the property would still be subject to an overheating risk assessment. The framework would therefore drive the use of appropriate overheating prevention measures in the whole house (where needed) in order to “pass” the assessment stage. The addition of a temperature limit for bedrooms provides added protection and clarity.

If a 26 °C threshold in bedrooms is a “recommendation”, how will a final standard be arrived at?

In addition to a risk assessment of the whole property, our recommendation is that the 26 °C Bedroom Temperature Threshold should be adopted, unless within the next year, new research, modelling exercises or piloting of measures, strongly suggests it should be changed.

New research and modelling of the precise configuration of the threshold, e.g. the amount of exceedance permitted, will be needed in any event.

Should the standard be reviewed after a certain amount to time?

Yes. We recommend the temperature threshold and/or level of exceedance is reviewed every five years alongside the Government’s Climate Change Risk Assessment to determine if thresholds are still suitable as the population acclimatises to higher temperatures. Alternatively, the review could happen alongside the three-yearly updates to Building Regulations. However, to provide stability, there should be a presumption against change unless there is compelling evidence to show it is necessary.
Why are standards needed?

Overheating has not, historically, been something the UK housing sector has needed to grapple with. Our leaky, cold housing stock needed attention and fixing this was and continues to be high on the agenda.

The issue has begun to emerge in recent decades, driven in part by increased urban living at high density, changes in building design, appliance loads and an ageing population who are more susceptible to the effects of excess heat. Experts and practitioners began to examine how to deliver buildings which are thermally comfortable in the summer, as well as in the winter. With a changing climate it is becoming even more important to design buildings to be more resilient to heat.

Researchers now estimate that up to 20% of existing homes in England may already overheat, even in relatively cool summers. However, if overheating does occur, it can be a prolonged and difficult issue for occupants and Housing Providers to deal with.

Being unable to keep homes at comfortable temperatures can lead to sleep loss, reduced productivity and general discomfort. In extreme cases, illness and fatalities can result, especially amongst vulnerable elderly or isolated populations, those with chronic health conditions, and young infants.

When experts have looked into why some buildings overheat they usually find a combination of fairly well-recognised causes related to how well buildings keep out unwanted heat from the sun, or how effectively the people living there can reject or purge unwanted heat from internal sources. This gives those working on climate change adaptation reason to be optimistic about being able to support Housing Providers in spotting potentially risky combinations of location, orientation and building design early enough in construction projects to allow modifications to be made.

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1. See Page 17 of the “Overheating in Homes – The Big Picture Report” for an explanation of how the 20% figure was arrived at.
Aren’t there already standards on overheating?

The construction industry’s response to the challenge of tackling overheating has, in part, been to develop thermal comfort temperature thresholds for use when designing new buildings.

The Chartered Institution for Building Services Engineer’s (CIBSE) Guide A – Environmental Design (2015) is a good example. The Guide essentially advises that bedrooms and living rooms within a dwelling should stay within certain temperatures for specified periods of time. The 2015 edition recommends a specific approach which allows indoor comfort temperature thresholds to vary depending on recent outdoor temperatures and the ability of the occupants to adapt to and modify their surroundings to stay cool. This is called the “Adaptive Comfort Model”. An exception is made for bedrooms where CIBSE continues to advise that these should be designed to stay within a threshold temperature of 26 °C. As noted, although thresholds are defined in guidance documents, further work is needed to standardise the methodology for testing whether the criteria have been met, for example, the occupancy, internal gains and weather assumptions made.

CIBSE’s guidance is based on a large number of field trials and is considered best practice.1 However, it is not a regulatory requirement for all new development.

Another basic check used for new homes is contained in the Government’s Standard Assessment Procedure at Appendix P. It provides a method for energy assessors, when carrying out the SAP assessment on a property, to assess the likelihood of high internal temperatures. It uses a relatively simple procedure to calculate the expected temperature of the dwelling for the months of June, July and August. If the average internal temperature (over day and night) is calculated to be above 23.5 °C, it is judged to have a high risk of overheating.

Criterion 3 of Approved Document Part 1A requires that “reasonable provision” is made to limit heat gains in domestic properties. However, this provision is not intended to be an overheating standard, but serves as a reminder to limit the potential for excess heat in dwellings in order to avoid the need for mechanical cooling as much as possible. SAP Appendix P is cited as one of the methodologies which can be used to demonstrate “reasonable provision” has been made. Provided the property is not classed as high risk using that method, then the requirement is deemed to be met. Other methodologies may also be used.

1. A meta-analysis of approximately 700 comfort surveys informed the standards and advice recommended by CIBSE, however, the majority of surveys were in non domestic buildings. This is one reason why further work is needed to clarify the position for residential properties.
Building designers use SAP Appendix P with some caution as it is not intended to inform design decisions. The thresholds are average benchmarks which give an indication of whether a property is likely to have high internal temperatures or not, and therefore whether it may need mechanical cooling. Stakeholders have also raised concerns with how the methodology is used, summarised well by the quote “no one fails Appendix P”. The conclusion is that the process is not separating out properties which are genuinely at risk of overheating as effectively as it should, primarily because the input assumptions used are often unrealistic.

Lastly, as described on page 18, the HHSRS provides statutory guidance for Environmental Health Officers to help them to assess whether a building may be hazardous to the health of the occupants. Again, this mechanism, although powerful, is not intended to be an overheating definition or standard for the design of new dwellings.

These frameworks form pieces of a jigsaw, but none represent an official, agreed sector-wide design “standard” on overheating. There is currently no statutory maximum internal temperature set for new dwellings in English or Welsh Building Regulations, or in health and safety guidance.

The Committee on Climate Change’s Adaptation Sub-Committee called for such a standard in June 2015. The Government’s response, published on 15 October 2015, acknowledged the issue and the work by the Zero Carbon Hub and our partners. Officials are now reviewing next steps.

What is the impact of maintaining the status quo?

There is strong support for agreeing a definition of overheating and a mandatory standard. It is important because:

- Housing associations, housebuilders and others lack clarity on what reasonable steps they must take and what rules they should follow to safeguard their current and future occupants from overheating; and
- Professionals tasked with assessing the risk of a property overheating may choose differing or conflicting criteria to judge the performance of buildings, limiting comparison between them and generating confusion about the ‘right’ test to apply.

To illustrate, one housebuilder consulted during the project said “As an industry we are in a position where it is not possible to currently prove that overheating does not occur. A completely unsatisfactory position which is also resulting in new build units being completed every single day which will overheat. This is far worse than the unintended consequences of introducing regulations which are not 100% perfect... we are dealing with a health & safety issue and all that really matters is compliance...”

3. Government Response to the Committee on Climate Change. Progress on preparing for climate change. HMG (October 2015).
OTHER OPTIONS CONSIDERED
AT THE DEFINITIONS WORKSHOP

Should standards on “purge” ventilation be set instead of temperature-based requirements?

Some stakeholders questioned whether it is simpler to set rules to ensure dwellings can be adequately purge ventilated, rather than setting a temperature-based standard.

Natural ventilation is still the main means of removing excess heat from residential buildings in the UK, although this aspect is not specifically regulated by Approved Document Part F of Building Regulations (or Part L).

“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 inside (which is the case for most of the year), 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.

However, relying solely on rules intended to ensure there is capacity to purge ventilate, without also aiming to reduce heat gains such as by shading or through glazing strategies, would mean the ventilation strategy/system having to work extremely hard. It may also be a risky strategy in cases where mechanical ventilation system are used, especially if they are not performing or being used as intended. Furthermore, any framework which required mechanical systems to deliver a high number of air changes each hour (at least eight times the level required for background ventilation), could be challenging to install in smaller dwellings. Significantly larger ducts would be needed.

It would therefore be sensible to view the provision of purge ventilation as an extremely important part of any strategy to mitigate overheating – but not to frame the delivery of adequate purge ventilation rates alone as the “standard” to be met.
Could benchmarks for acceptable levels of mechanical cooling be an alternative way to frame a standard?

The idea is that if limits are set on the amount of energy a given property can use to provide cooling, this would discourage the use of mechanical cooling where it is unnecessary – which should be the majority of dwellings at present. It should also help to drive a focus on design-based solutions and passive cooling measures.

Moving from a predominantly naturally ventilated to an actively cooled housing stock has potentially negative implications, for example, increased carbon emissions from additional electrical loads that previously did not exist. Also, there is the potential to exacerbate urban heat islands due to increased heat rejection from air conditioning units in summer.

The idea is that “cooling load benchmarks” representing a reasonable cooling demand for different typical dwelling types, based on an optimised design to minimise cooling demand, would be applied. Such benchmarks could theoretically be included in SAP (as the methodology already factors in the energy used for cooling), and one local authority is exploring the potential for this option for apartment blocks.

An issue raised by stakeholders with using this approach (being used as a standard) is that although it could perhaps ameliorate the “energy-using” dimension of the problem, i.e. by encouraging the use of passive approaches, it does not directly address the question of how to define acceptable internal thermal conditions in residential properties.

A second issue is that the vast majority of homes at present do not use mechanical cooling. Their cooling load would therefore be zero, and in these circumstances there would be no trigger in the framework to drive project teams to consider the potential for overheating.

However, continuing to trial this approach in certain types of properties, such as apartment blocks in dense urban areas, would provide valuable new information on the possible impact of using cooling load benchmarks.