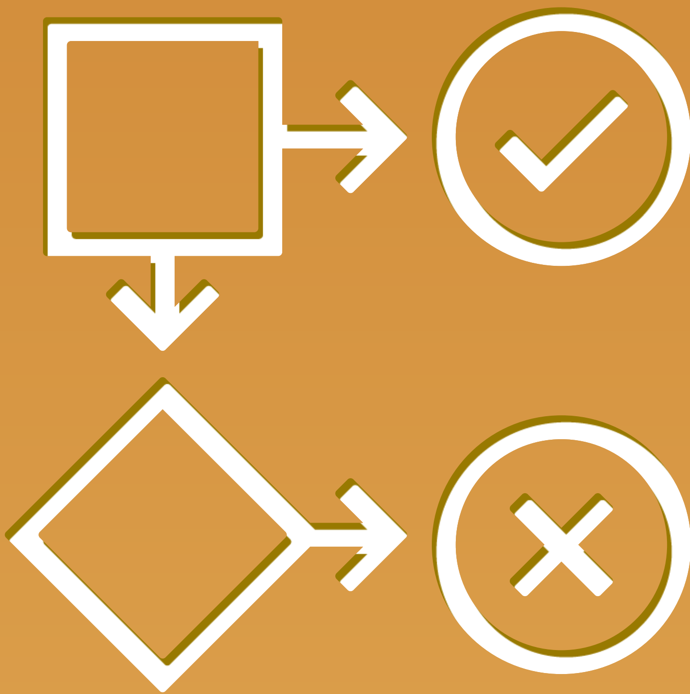
ZERO CARBON HUB

ASSESSING OVERHEATING RISK

LEAFLET



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OVERHEATING IN HOMES

Overheating has not, historically, been something the UK housing sector has needed to grapple with, but it is a growing problem. Potentially up to 20% of the housing stock in England is already affected and the issue is likely to become more prevalent in future.

> "As temperatures rise due to climate change there is an increased risk of overheating in buildings."
> **ENVIRONMENTAL AUDIT COMMITTEE**

WHAT IS OVERHEATING?

Overheating is the term used to describe situations where the temperature inside a person's home becomes uncomfortably or excessively warm. It happens most often during warm weather in the summer, but it can happen in winter months too.

Both sudden spikes in temperature and prolonged periods of excess heat can be difficult for people to cope with, especially if they have an underlying health condition.

HOW CAN OVERHEATING RISK BE ASSESSED?

This leaflet introduces the variety of methods being used by Housing Providers and Building Professionals to assess risk, including SAP Appendix P, detailed dynamic thermal simulation modelling and the Passive House Planning Package.

It is based on work carried out by the Zero Carbon Hub over the past two years as part of a large-scale project on 'Tackling Overheating in Homes', and specifically the detailed evidence review, 'Assessing Overheating Risk'.

THE ZERO CARBON HUB'S OVERHEATING PROJECT

At the request of Government, the Zero Carbon Hub formed the project 'Tackling Overheating in Homes' in 2014 to gather evidence and information on the current and possible future extent and impact of overheating in homes. We also looked at the degree to which the housing sector is already gearing up to tackle the issue and what further action could be required to manage the risk of future overheating.

Our 'Overheating in Homes – the Big Picture' baseline evidence report, published in June 2015, presents our findings from:

- Over 400 research papers and reports;
- 6 thematic Evidence Reviews;
- A survey of 75 Housing Providers (representing 207,728 homes) in partnership with Sustainable Homes;
- 33 in-depth interviews with Housing Providers and other industry experts; and
- Workshops and one-to-one meetings.

All our Overheating publications are available online at **www.zerocarbonhub.org**

The term Housing Provider covers all organisations who build, manage, rent or retrofit domestic properties, for example developers and private and social landlords.

EVIDENCE REVIEWS

As part of the Overheating in Homes project, a series of Evidence Reviews were commissioned from experts on key themes related to overheating.

DEFINING OVERHEATING
by CIBSE, ARCC, UCL, and the LSHTM

ASSESSING OVERHEATING RISK
by Inkling LLP, CIBSE, UCL and ARCC

IMPACTS OF OVERHEATING
by AECOM

OVERHEATING RISK MAPPING
by AECOM

DRIVERS OF CHANGE – OVERHEATING IN HOMES
by the ZCH and AECOM

SOLUTIONS TO OVERHEATING IN HOMES
by BRE

LEAFLETS FOR HOUSING ASSOCIATIONS AND LOCAL AUTHORITIES

MONITORING OVERHEATING – HOUSING ASSOCIATION CASE STUDIES

LOCAL AUTHORITIES – TACKLING OVERHEATING IN HOMES

BUILDING REGULATIONS PART L1A

The English Building Regulations Approved Document Part L1A: Conservation of Fuel and Power in new dwellings is designed to drive the efficient use of energy, rather than set thermal comfort standards. Similar requirements are in place in Scotland, Northern Ireland and Wales.

Part L1A Criterion 3 covers overheating risk and requires ‘appropriate passive control measures to limit the effect of heat gains on indoor temperature in summer’ - even for air conditioned dwellings.

REFURBISHMENT

Compared to the existing building stock, only a small proportion of new dwellings are built every year. But, there is currently no requirement to check overheating risk in existing dwellings when they are refurbished.

STANDARD ASSESSMENT PROCEDURE (SAP)

The Standard Assessment Procedure (SAP) is the Government’s procedure for rating the energy performance of homes and demonstrating compliance with Part L1A of the Building Regulations.

SAP Appendix P provides an “overheating check”, which can be used to demonstrate compliance with Criterion 3.

For each month of June, July and August, a single calculation is carried out to predict the average internal temperature for that month. If the resulting mean internal temperature is greater than 23.5°C, a high risk of overheating is predicted. If it is between 22°C and 23.5°C, the risk of overheating is medium and between 20.5°C and 22.0°C, the risk is slight.

SAP TOOLS

Commercial tools are available which implement the SAP methodology. The BRE website lists SAP tools which are approved by government for the purpose of demonstrating Building Regulations compliance.

SAP only considers average summer temperatures. It does not take into account external temperatures on very hot days or the duration of warm spells.

SAP OVERHEATING CALCULATION

The SAP Appendix P calculation takes account of several factors.

1. Solar gain in the dwelling depending on:
   - glazing orientation;
   - solar shading of glazing;
   - glazing solar transmission.
2. Natural ventilation via openable windows, for which the user inputs
   - type of ventilation opening - trickle vents, slightly open windows, windows open half the time or windows fully open,
   - type of dwelling - single storey or two or more storeys,
   - whether cross ventilation is possible.

   The calculation then takes a single value, from a table, for the effective ‘air change rate’.
3. A design air change ventilation rate for mechanical ventilation, which can be specified by the user.
4. The construction thermal capacity (the thermal mass).
5. Weather inputs for the chosen location. Mean monthly values for June, July, August of:
   - Monthly external temperature;
   - Wind speed; and
   - Solar radiation.
6. Internal heat gains and profiles for occupancy, equipment and lighting depend on the floor area and cannot be adjusted by the user.

BUILDING REGULATIONS PART L2A

Part L2A is primarily aimed at non-domestic buildings, but it does cover some domestic buildings which fall outside Part L1A, for example care homes and student accommodation.

Part L2A Criterion 3 limits solar gains to the building. The aim is to minimize energy used for air conditioning. It does not assess the temperature in a space or consider other heat gains.

BUILDING REGULATIONS PART L1B & L2B

Part L1B and L2B refer to domestic and non-domestic refurbishments in England. They do not include any form of overheating or solar gain check.

CIBSE DESIGN GUIDANCE

The Chartered Institution of Building Services Engineers (CIBSE) has produced guidance on calculating overheating risk.

Unlike SAP, these standards relate to hourly temperatures in bedrooms and living rooms for the period during which the home is occupied, so designers need to use dynamic thermal simulation to calculate them.

CIBSE GUIDE A ENVIRONMENTAL DESIGN: 2006 EDITION

In the previous 2006 edition of CIBSE Guide A Environmental Design, overheating is deemed to occur if the living room temperature exceeds 28°C for more than 1% of the time the room is in use.

High night-time temperatures can lead to disrupted sleep and impair a person's ability to recover from heat stress during the day, so a lower peak threshold temperature of 26°C is used for bedrooms. The Guide suggests that sleep quality may be impaired once indoor temperatures exceed 24°C.

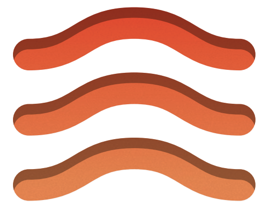
Table 1. **Temperature thresholds for the design of buildings**

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

Adapted with permission from CIBSE's Environmental Design Guide A (2006), recently superseded by the 2015 edition

All these thresholds use the "operative temperature", which combines the air temperature and the mean radiant temperature in a weighted average.

ADAPTIVE THERMAL COMFORT



CIBSE GUIDE A ENVIRONMENTAL DESIGN: 2015 EDITION

The new Guide A adopts the Adaptive Thermal Comfort approach, which states that occupants are 'comfortable' with higher room temperatures during periods of prolonged warm weather.

CIBSE TM52 (2013) – THE LIMITS OF THERMAL COMFORT: AVOIDING OVERHEATING IN EUROPEAN BUILDINGS

TM52 provides a methodology to assess Adaptive Thermal Comfort. Predicted room temperatures are calculated and compared with a band of acceptable, comfortable room temperatures, calculated from recent outdoor temperatures. Two out of three criteria must be fulfilled in order to pass the overheating test.

TM52 CRITERIA

1. Limit temperatures exceeding the upper comfort limit to 3% of summer hours.
2. Limit the severity of overheating on any single day.
3. Limit absolute maximum acceptable temperature.

ADAPTIVE THERMAL COMFORT FOR HOMES

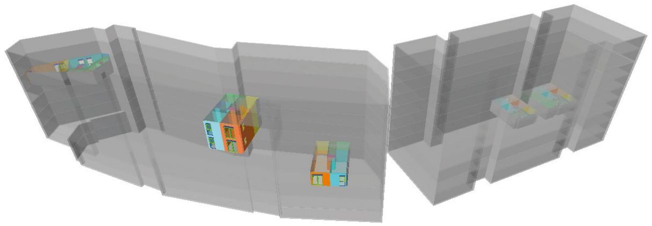
The adaptive thermal comfort model is based on extensive field studies, but these were carried out primarily in the non-domestic sector, for example in offices.

It still needs to be fully road-tested in the domestic sector, particularly to show whether it can be applied to bedroom comfort temperatures during the night.

CIBSE Guide A (2015) continues to advise that sleep quality may be compromised at temperatures above 24°C and recommends that peak bedroom temperatures should not exceed an absolute threshold of 26°C.

DYNAMIC THERMAL SIMULATION MODELS

Figure 1. **Example model of units in an apartment block**



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.

They can model more complex buildings and features, for example, different heating, ventilation and cooling technologies, external shading devices and newer technologies such as Phase Change Materials (PCM).

A significant amount of data is input 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, ventilation and cooling, 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.

Dynamic thermal simulation plays a key role in the design of non-domestic, commercial buildings, but is less frequently used in the domestic sector.

DOMESTIC VS NON-DOMESTIC DESIGN

Researchers at Heriot-Watt University studied current building practices and concluded that the domestic and non-domestic sectors take a significantly different approach to design. Dynamic Thermal Simulation Modelling plays a key role in the design of non-domestic buildings, but is currently rare for domestic developments.

The reasons for this are largely linked to cost and skills availability, so the domestic industry will need to decide whether these tools offer sufficient improvements in design stage predictions to overcome the barriers.

MODEL INPUTS

"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... heat gains tend to be more concentrated inside smaller units."
TECHNICAL EXPERT

SAP INTERNAL GAINS

SAP uses standard internal heat gains and profiles for occupancy, equipment and lighting, which are calculated for each month based on the total floor area of the unit being assessed. They cannot be adjusted by the user.

DYNAMIC THERMAL SIMULATION MODELS

There are currently no standard protocols to guide modellers on which inputs to use for dwellings. Two modelling exercises for the same development could produce very different results.

In practice, designers often make use of the National Calculation Methodology datasets for domestic buildings, even though they are not intended for this purpose.

NATIONAL CALCULATION METHODOLOGY (NCM)

The NCM provides a framework for carrying out assessments for Part L2A of the Building Regulations. Although intended for non-domestic buildings, it does include a database of 'gain profiles' for dwellings.

INTERNAL GAINS SAP VS NCM

For a small 50m² apartment, SAP calculates the number of occupants to be 1.7, the annual lighting energy consumption to be 488kWh (of which 15% is external) and the annual equipment energy to be 1,700kWh.

For the same apartment, the NCM dwelling profiles give annual internal gains of 1,000kWh for lighting, and 766 kWh for equipment. The NCM occupancy gains are low: a small, 17m² living room has 1/3 of an occupant, during the evening only.

ARE ALL HEAT GAINS INCLUDED?

Overheating assessments usually focus on 'occupied areas', omitting communal areas. Hot water distribution pipes are also rarely included, even though they can be a significant risk factor for overheating.

VENTILATION STRATEGY

This is also critical to the overheating risk assessment and must be realistic.

For example, will occupants be able to open the windows properly and ventilate in the way that designers had imagined?

WEATHER DATA

How a building responds to external environmental conditions influences its overheating risk. This is especially true for the domestic sector, as most homes and dwellings use passive measures to stay comfortable during hot weather.

CIBSE provides two standard weather datasets to be used with dynamic thermal simulation software:

- Test Reference Years (TRYs): average years, for energy performance calculations,
- Design Summer Years (DSYs): a year with a hot, but not extreme, summer, used to assess overheating risk,

For 14 locations in the United Kingdom: Belfast, Birmingham, Cardiff, Edinburgh, Glasgow, Leeds, London, Manchester, Newcastle, Norwich, Nottingham, Plymouth, Southampton and Swindon.

These hourly weather datasets use past observations (1981–2012) collected from suburban or rural weather stations. They do not include the Urban Heat Island effect.

CIBSE TM49: DESIGN SUMMER YEARS FOR LONDON

In 2014, CIBSE published nine new Design Summer Years for London. These give a choice of three different London sites,

- Urban – London Weather Centre,
- Semi-urban – Gatwick
- Rural – Heathrow

and three different years, 1989, 2003 and 1976, of varying severity of hot events.

CIBSE is now extending this methodology to the other 13 locations.

CLIMATE CHANGE

As the climate changes, summers in the UK will become hotter and generally drier. We can also expect longer and more frequent heat waves and higher average peak temperatures.

Both CIBSE and the University of Exeter have used the UKCP09 future climate projections for the UK, produced by the Met Office, to develop 'future' weather datasets for modellers to use.

CIBSE also published a set of ProCLiPs (Probabilistic Climate Profiles), a visual representation of the UKCP09 projections, to help communicate climate risk and uncertainty to designers.

OTHER MODELS

COMPUTATIONAL FLUID DYNAMICS (CFD)

Dynamic thermal simulation models assume that the air temperature in each zone is uniform. CFD models can be used to model more complex air movement and temperature patterns but entail significant computational cost.

URBAN AND NEIGHBOURHOOD SCALE MODELS

Modelling for microclimatic effects is highly complex and usually done only for research purposes. These models consider local factors such as detailed urban geometry, street layout and building heights, vegetation and moisture in the form of trees, parks and rivers, types of urban surfaces and materials, and anthropogenic heat emissions.

PASSIVE HOUSE PLANNING PACKAGE (PHPP)

Designers of Passivhaus buildings use the Passive House Planning Package, a complex spreadsheet developed by the Passivhaus Institut in Germany, to calculate overheating risk.

PHPP uses a monthly calculation, similar to SAP, to calculate the frequency of overheating. The key difference is that PHPP is able to use actual data for internal heat gains from occupancy, lighting and equipment.

PASSIVE DESIGN ASSISTANT

This is a free software tool, developed by ARUP that demonstrates the principles of passive thermal design.

THE CASE FOR A NEW METHODOLOGY

The results obtained from modelling overheating risk are very much a product of their user's level of experience and the information inputted.

Building physicists consider there is a strong case for developing a new overheating prediction methodology aimed specifically at informing the design of domestic buildings.

For example, agreeing standard occupancy and internal gains profiles will empower more accurate and consistent overheating risk predictions to be made.

Since our formation in 2008, the Zero Carbon Hub continues to work 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.

Get in touch to find out how we can assist you

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