Design methodology for the assessment of overheating risk in homes

CIBSE

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Note from the publisher

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Foreword

Recent evidence has shown that overheating risk needs to be taken seriously in the residential sector. Many new or refurbished homes have designs that contribute to overheating risk by, for example, having high proportions of glazing (resulting in excessive solar heat gains), inadequate natural ventilation strategies or mechanical ventilation systems that are not delivering intended air change rates.

Overheating risk is also affecting existing homes, especially in buildings that do not have adequate methods for dissipating heat gains and are less resilient to climate change.

The health and wellbeing impacts of overheating can be significant for residents, resulting in stress, anxiety, sleep deprivation and even early deaths in heat waves, especially for vulnerable occupants. The situation is predicted to get worse. The Committee on Climate Change has estimated that mortality rates arising from overheating could rise from 2000 per year in 2015 to 7000 per year by the 2050s.

Assessing overheating risk in homes is a complex issue and not adequately assessed by building regulations. Indeed, it would be wrong to assume that a home that complies with building regulations that were designed to focus on energy conservation also gives sufficient assurance of avoidance of overheating. Hence the recommendation that comfort conditions are separately assessed if it is felt that there could be a risk.

Many factors influence overheating in homes, including the intensity of heat gains, occupancy patterns, orientation, dwelling layout, shading strategy and ventilation method. Dynamic thermal modelling can be used to simulate the internal temperature conditions and will therefore help establish whether threshold conditions of discomfort will be reached. Given the complexity of the factors influencing overheating it is important that a standardised methodology is used to assess risk and hence the need for this technical memorandum. It can be applied to dwellings, care homes and student residences. Early analysis of overheating risk is recommended so that mitigation strategies can be reviewed in design proposals.

In summary, the application of this technical memorandum, by standardising the assessment methodology, should play a key role in limiting overheating risk in new and refurbished homes.

Ashley Bateson, CEng., CEnv., FCIBSE, MEI
Chair, CIBSE Homes for the Future Group

Contributing authors

Cecilia Bonfigli (ARUP)
Marguerita Chorafa (AECOM)
Susie Diamond (Inkling)
Chris Eliades (ARUP)
Anastasia Mylona (CIBSE)
Becci Taylor (ARUP)
Dane Virk (UCL/CIBSE sponsored EngD)

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Editor

Ken Butcher

CIBSE Technical Director

Hywel Davies

CIBSE Head of Knowledge

Nicolas Peake

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1 Introduction

Overheating risk has been a growing concern amongst the domestic design, construction and provider community for at least a decade. Domestic overheating has not always been a problem in the UK but climate change, increased urbanisation, construction of highrise apartment blocks and winter energy efficiency measures have all contributed in the amplification of high internal temperatures. Homes that overheat cause significant discomfort and stress to the occupants and can ultimately lead to litigation and costly mitigation measures for the owners/developers.

Yet overheating is subjective — the point at which 'hot' becomes 'too hot' will vary from person to person and depend upon a variety of factors. Whilst this means that not all occupants will be satisfied all the time and that, in a heatwave, it may still be very warm in a naturally ventilated dwelling, there should be a reasonable limit set on how much warmer a dwelling can be inside than outside. There should also be a standard that precludes the worst levels of overheating and enables designers to find cost effective options to limit overheating risk whilst also delivering all the other aspects occupants look for in their homes (e.g. daylight, insulation, view etc). The methodology described here attempts to define that threshold.

An evidence review, *Assessing overheating risk* (Zero Carbon Hub, 2015), concluded that there was no existing guidance that provided this definition, and made a call for a methodology such as this to be produced.

As a result of the Zero Carbon Hub's work on domestic overheating risk, a group of building physicists and engineers worked with CIBSE to develop this domestic overheating risk assessment methodology and test it on live projects.

The methodology needs to be prescriptive so as to be consistently applied. It uses dynamic thermal modelling tools, defined internal gain profiles, and specific weather files with clearly defined thresholds to provide a clear pass/fail result. This does entail some resource, but the process of evaluating overheating risk in this clearly defined way is much more efficient than each assessment needing to define its own methodology, as has previously been the case.

The methodology includes clear reporting requirements to enable all stakeholders to review the outcome and understand its basis and implications for the design. It is vital that the mitigation options selected as a result of the assessment are fully incorporated into the design or the assessment will have no value.

The methodology has been through several rounds of testing on a variety of real and prototype projects. The majority of the testing has focused on developments of apartments, but some houses and extra-care units have also been evaluated. The results of the testing indicate that the methodology works well, but the real proof will come in future years when the units tested are built and occupied. CIBSE is planning further research to provide monitoring and feedback, which may lead to future refinements of the methodology.

1.1 About the methodology

This is a standardised approach to predicting overheating risk for residential building designs (new-build or major refurbishment) using dynamic thermal analysis. The testing of the methodology has focused on flats, as they tend to represent a higher overheating risk than houses. However, the methodology should also be applicable to houses.

The aim is to produce a test that encourages good design that is comfortable within sensible limits, without being so stringent that it over-promotes the use of mechanical cooling. The test needs to be simple to ensure it is used.

This document provides a set of profiles that represent reasonable usage patterns for a home suitable for evaluating overheating risk. Where possible the magnitude of gains is taken from CIBSE guidance. Profiles are developed to test the building design, not to cover all usage modes.

Of necessity, many assumptions have been made to derive the profiles. Further work is warranted, but this methodology was developed due to the importance of defining a consistent approach for use in the interim.

This methodology is intended for use by designers in order to influence building design for the better. It could be used at the planning stage to assess risk, as well as at later stages of design.

1.2 Clarifications

This methodology will:

— allow different designs to be compared with a common approach, based on reasonable assumptions

— support design decisions that improve comfort without cooling

— provide consistency across the industry as all consultants will be using the same methodology for overheating risk prediction.

This methodology will not:

— guarantee that people will always be comfortable in compliant spaces, however they act

— take into account unusual use.

The methodology provides a baseline for all domestic overheating risk assessments. Studies for student accommodation, care homes, prisons or unusual accommodation uses, and heatwave strategy analysis, can employ this methodology as a starting point, provided that such studies state clearly where variations have been made and provide a justification for these changes.

It should be noted that the weather file will have the largest impact on the overheating results. We cannot control the weather or the behaviour of people in their own homes. We can, however, encourage building forms and façade designs that support better comfort in hot weather.

1.3 Basis of design comfort criteria

CIBSE TM52: *Limits of thermal comfort: avoiding overheating in European buildings* (2013) provides the principles of thermal comfort and should be the main reference for any additional detail.

CIBSE Guide A: *Environmental design* (2015a) includes advice regarding sleep quality (that may be compromised at temperatures above 24 °C), and recommends that peak bedroom temperatures should not exceed an absolute threshold of 26 °C.

1.4 Implications of applying the methodology

Balancing the tensions between the energy efficiency requirements (such as the fabric energy efficiency requirements (FEEs) in Building Regulations Part L1A for England (NBS, 2013)), daylighting targets and limiting overheating risk is often a challenge. The intention of this document is to provide pragmatic solutions for resolving these tensions.

Based on the testing undertaken during the development of this methodology, it is anticipated that there will be certain housing developments, particularly those in south east England, with a lightweight construction, large amounts of glazing and single aspect that may not pass the proposed test.

External, moveable shading may be promoted by the methodology for high risk properties. Designers could look to continental northern European examples and publications such as CIBSE TM37: *Design for improved solar shading control* (2006) and BRE 364: *Solar shading of buildings* (Littlefair, 1999) for how to implement this.

Another key area is achieving sufficient ventilation when there are constraints such as noisy or polluted environments, health and safety considerations limiting wide openings, and security concerns (e.g. ground floor or accessible windows). Considering window design that will allow versatile openings or use of acoustically attenuated vents may provide robust solutions within these constraints.

Importance of installation of assumed parameters

This guidance is based on assumptions about installation. The results will only be valid if the parameters used match those of the final building. Design assumptions therefore need to be followed all the way through procurement to installation (e.g. performance and quality of pipework insulation, façade performance, aerodynamic areas of openable windows, blind/external shading performance etc).

All assumptions and mitigations must form part of the construction contract, or the model will need to be re-run to prove compliance of any changes.

2 The methodology

2.1 Identification of risk

This methodology is based on the use of dynamic thermal modelling for the treatment and assessment of overheating risk in residential buildings.

This methodology is proposed for all residences and should especially be considered for:

— large developments

— developments in urban areas, particularly in southern England

— blocks of flats

— dwellings with high levels of insulation and air-tightness

— single aspect flats.

Individual houses and developments with a low risk of overheating may not require the use of dynamic thermal modelling.

Professional judgement must be used when taking the decision to omit dynamic thermal modelling to test overheating. The risk must be considered in the context of the project and the decision should be taken jointly with the client, design team and planners. A list of risk factors for identifying properties at high risk of overheating is provided in *Energy Planning — Greater London Authority guidance on preparing energy assessments* (GLA, 2016) and in BRE's *Home Quality Mark* (BRE, 2015).

2.2 Methodology overview

The assessment should follow the following steps:

(1) A suitable sample of units within a development should be selected, see section 3.1.

(2) Zoning: all sample units should be zoned into the separate rooms including kitchens, living rooms, bedrooms, bathrooms and halls.

(3) Building constructions should be modelled as proposed, accurately reflecting thermal properties such as thermal mass, insulation and solar transmittance for glazing.

(4) Standard profiles should be applied for occupancy, lighting and equipment gains, see section 5.

(5) Guidance on the treatment of communal corridors from section 3.8 should be followed.

(6) Pipework and equipment, e.g. heat interface unit gains from community heating systems, should follow the guidance given in section 3.9.

(7) Operable windows should be included in the model and follow the guidance given in section 3.3.

(8) Any internal or external shading provision should be included in the model and follow the guidance included in section 3.7.

(9) Additional mechanical ventilation including mechanical ventilation with heat recovery (MVHR) or extract systems should be included in the model and follow the guidance given in section 3.5

(10) Air speed assumptions should be based on the guidance given in section 3.6.

(11) The weather file used for the methodology should be the DSY1 (design summer year) file most appropriate for the site location for the 2020s, high emissions, 50% percentile scenario; the guidance given in section 3.2 should be followed.

(12) The assessment should be undertaken using hourly dynamic simulation modelling, which includes all the relevant features of the building.

2.3 Suggested reporting requirements

The methodology recommends a full written report that documents the following details for the assessment:

— dynamic thermal analysis software name and version used for the assessment, which must comply with the requirements of CIBSE AM11: *Building performance modelling* (2015b)

— site location and orientation

— images of the model indicating the sample units selected and the basis for selection

— images showing the internal layouts for the sample units

— information on the construction type with layers of construction (used to determine *U*-values and *g*-values) for all external and internal building elements, plus any additional shading features (including any blinds, and demonstrating that the blinds do not clash with opening windows if blinds are used to contribute to a pass)

— thermal mass, with a written explanation of where the thermal mass is incorporated in the construction

— the ventilation strategy modelled, including details of window opening assumptions, free areas calculated, infiltration rates assumed and any mechanical supply/extract flow rates

— the weather file(s) used for the assessment

— the thermal comfort category assumed based on CIBSE TM52 (2013); this should be Cat. II by default, but Cat. I for vulnerable residents (see section 4.4); Cat. III for existing buildings should not be used for the purposes of this methodology

— the results of the analysis:
  - reports should be clearly reported based on criteria (*a*) and (*b*) in section 4.2
  - a unit is only shown to comply if all occupied spaces meet relevant overheating criteria
  - corridors should be included where there is communal heating pipework
  - the report may include the results for several iterations explored, to demonstrate the route to compliance
  - if blinds were part of the strategy used to gain a pass, then results without blinds must also be included for information

— the report should state clearly whether the project passes or fails the assessment and, where a pass is indicated, it should make clear on what design features this depends (e.g. the inclusion of glazing with *g*-value below *x*, reduced window sizes, etc).

The assessor must discuss with the client any need to assess overheating risk under heatwave or future climate change conditions using more extreme DSYs (i.e. DSY2 or DSY3) or future weather years. The same overheating tests described herein can be used.

3 Guidance

3.1 Sample size

The assessment should try to identify all the dwellings that are at risk of overheating. These are likely to be those (*a*) with large glazing areas, (*b*) on the topmost floor, (*c*) having less shading, (*d*) having large, sun-facing windows, (*e*) having a single aspect, or (*c*) having limited opening windows.

The report should justify the sample of units chosen for the assessment and explain why this is appropriate. The number analysed will depend on the scale of the development, its geographical location and the results of the modelling as they emerge. In addition, lower risk dwellings can be included for illustration of performance to this.

At least one corridor should be included in the assessment if the corridors contain community heating distribution pipework.

3.2 Weather files

Developments should refer to the latest CIBSE design summer year (DSY) weather files and be required to pass using the DSY1 file most appropriate to the site location, for the 2020s, high emissions, 50% percentile scenario.

Other files including the more extreme DSY2 and DSY3 files, as well as future files (i.e. 2050s or 2080s), should be used to further test designs of particular concern, as described below, but a pass is not mandatory for the purposes of the simpler test presented in this document.

Design summer years (DSYs) should always be used for analysis of overheating, and it is good practice to take into account future weather files (see CIBSE TM48: *Use of climate change data in building simulation: the CIBSE Future Weather Years* (2009), TM49: *Design Summer Years for London* (2014a) and CIBSE's *Probabilistic Climate Profiles* (ProCliPs) (2014b) for further advice).

However, a minimum requirement for passing the test is proposed here by using a single DSY (DSY1), with the use of additional weather files recommended to explore performance where there is particular concern (e.g. the presence of vulnerable occupants) and/or where required in the client's brief or for demonstrating mitigation options under more extreme events (e.g. heatwaves). The analysis based on additional weather files can be used to develop a heatwave plan.

3.3 Window and door openings

Windows in each room should be controlled separately and modelled as open when both the internal dry bulb temperature exceeds 22 °C and the room is occupied. If additional security and rain protection details are included in the design then the opening hours during the night could be extended. For example, patio doors should only be modelled as open in unoccupied rooms or at night if they can be locked securely open, and the locked percentage of free area used in the model.

Open areas should be based on the architecturally designed windows including any restrictors that are required. The guidance in CIBSE Guide A (2015a) and CIBSE AM10: *Natural ventilation in non-domestic buildings* (2005) should be followed for calculation of free areas.

Opening areas assumed should take into account any security, acoustic or air quality issues that limit opening area (e.g. on ground floors).

If blinds are to be included in the modelling, they must not interfere with the opening of windows, or the reduction in free area when they are operating should be taken into account in the model.

Internal doors can be included and left open in the model in the daytime, but should be assumed to be closed when the occupants are sleeping.

The compliance report should explain the basis of all assumptions.

3.4 Exposure type

Models should be set up with the appropriate exposure type for the site location and façade orientation, based on the software definitions, and justified in the compliance report.

3.5 Infiltration and mechanical ventilation

The infiltration and the mechanical ventilation rate should be set for every zone based on what is specifically designed for normal, acoustically compliant modes of operation. Refer to CIBSE Guide A (2015a) for more detail on infiltration rates and noise design limits.

Mechanical boost mode (included for occasional use with louder fan noise) should not be assumed in the overheating risk analysis.

3.6 Air speed assumptions

Operative temperature calculations (used within CIBSE TM52 (2013)) require assumptions on air speed. The modelled air speed in a space must be set at 0.1 m/s where the software provides this option unless there is a ceiling fan or other means of reliably generating air movement.

Where fixed ceiling fans are installed as part of the new-build or refurbishment the assumed elevated air speed assumptions must be reported. Typically this should not exceed 0.8 m/s.

3.7 Blinds and shading devices

Blinds and shading devices can be used for the analysis only if specifically included in the design, provided in the base build and explained within associated home user guidance.

Blinds cannot be used properly if they clash with the opening of windows. If blinds are used to pass the overheating test, the report must either demonstrate that there are no clashes with the opening of windows, or the reduction in air flow due to the clashes must also be calculated and included in the model. These calculations must be explained in the compliance report.

The assumed solar transmittance/reflectance properties and usage profiles for blinds will need to be justified and well described in the compliance report.

Where blinds are used to enable a pass, the analysis results without blinds must also be provided for reference.

3.8 Pipework, HIU and heat maintenance tape heat loss

Heat losses from pipework, heat interface units (HIUs) and heat maintenance tape should be included for community heating systems, and/or where heat maintenance tape is used.

When space and water heating is provided by a community heating system, the HIU and the pipework connecting it to the central system is permanently charged with hot water all year around to meet the hot water demand. The distribution pipework for the community heating system often runs through the corridors and common spaces. Since this pipework is constantly emitting heat, even if well-insulated, it can cause an increase in temperature in these spaces.

The assessment should take into account heating pipework distribution gains on the communal side of the HIU (calculated in accordance with guidance in CIBSE Guide C: *Reference data* (2007)), as well as losses from the HIU itself. The modelling should reflect the design of the specific project/property being assessed. However, a default value for pipework (per metre of pipe run) has been provided in case these values are not available at time of analysis; these are based on the simplified method provided by the *Domestic Building Services Compliance Guide* (HMG, 2013).

Table 1 Default heat losses from pipework (HMG, 2013; Table 5)

Outside diameter of pipe (mm)	Maximum heat loss per metre run of pipe (W/m)
8	7.06
10	7.23
12	7.35
15	7.89
22	9.12
28	10.07
35	11.08
42	12.19
54	14.12

Within the home itself, standing gains should be based on primary side (domestic hot water) pipework length up to the HIU in accordance with guidance in CIBSE Guide C (2007). Standing gains from the HIU should be based on manufacturers' recommendations.

Heat maintenance tape to reduce hot water wait times on the secondary side domestic hot water pipework within the apartment, if included, shall be modelled as 8 W/m of pipe, or as calculated according to design.

3.9 Communal corridors

The inclusion of corridors in the overheating analysis is mandatory where community heating pipework runs through them. The overheating test for corridors should be based on the number of annual hours for which an operative temperature of 28 °C is exceeded.

Communal corridor heat gains should be modelled based on calculated losses from pipework (see CIBSE Guide C (2007) and/or the *Domestic Heating Design Guide* (DBSP, 2015)), or based on the simplified method provided in Table 5 of the *Domestic Building Services Compliance Guide* (HMG, 2013). Calculated values based on the design temperatures and specified insulation performance may be lower and can be used if justified.

Corridor ventilation should be included in the analysis as designed.

Whilst there is no mandatory target to meet, if an operative temperature of 28 °C is exceeded for more than 3% of the total annual hours, then this should be identified as a significant risk within the report.

4 Compliance criteria

4.1 Definitions

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 assess overheating using the adaptive method based on CIBSE TM52 (2013), as described in section 4.2 below.

In order to allow the occupants to 'adapt', each habitable room needs operable windows with a minimum free area that satisfies the purge ventilation criteria set in Part F of the Building Regulations for England (NBS, 2010), and equivalent regulations in other countries, i.e. the window opening area should be at least 1/20th of the floor area of the room (different conditions exist for windows with restricted openings, and the same requirement applies for external doors). Control of overheating may require accessible, secure, quiet ventilation with a significant openable area.

Homes that are predominantly mechanically ventilated because they have either no opportunity or extremely limited opportunities for opening windows (e.g. due to noise levels or air quality) should be assessed for overheating using the fixed temperature method based on CIBSE Guide A (2015a), as described in section 4.3 below.

4.2 Criteria for homes predominantly naturally ventilated

Compliance is based on passing *both* of the following two criteria:

(*a*) *For living rooms, kitchens and bedrooms*: the number of hours during which ΔT is greater than or equal to one degree (K) during the period May to September inclusive shall not be more than 3 per cent of occupied hours. (CIBSE TM52 Criterion 1: *Hours of exceedance*).

(*b*) *For bedrooms only*: to guarantee comfort during the sleeping hours the operative temperature in the bedroom from 10 pm to 7 am shall not exceed 26 °C for more than 1% of annual hours. (*Note*: 1% of the annual hours between 22:00 and 07:00 for bedrooms is 32 hours, so 33 or more hours above 26 °C will be recorded as a fail).

Criteria 2 and 3 of CIBSE TM52 may fail to be met, but both (*a*) and (*b*) above *must* be passed for all relevant rooms.

4.3 Criteria for homes predominantly mechanically ventilated

For homes with restricted window openings, the CIBSE fixed temperature test must be followed, i.e. all occupied rooms should not exceed an operative temperature of 26 °C for more than 3% of the annual occupied annual hours (CIBSE Guide A (2015a)).

4.4 Adjustments for homes with vulnerable occupants

Care homes and accommodation for vulnerable occupants, which are predominantly naturally ventilated (see definition above), should use criteria (*a*) and (*b*) from section 4.2 above but should assume Type I occupancy (see CIBSE TM52 (2013) for description).

If they are predominantly mechanically ventilated (see definition above), the fixed temperature method should be used, see section 4.3.

Where there is particular concern of high risk of overheating in accommodation for vulnerable occupants, a heatwave strategy should also be developed using additional weather files (see section 3.2) to explore performance and for demonstrating mitigation options under extreme events (e.g. heatwaves).

4.5 Corridors: assessment criteria

The overheating test for corridors should be based on the number of annual hours for which an operative temperature of 28 °C is exceeded. Whilst there is no mandatory target, if an operative temperature of 28 °C is exceeded for more than 3% of total annual hours, this should be flagged as a significant risk within the report.

5 Internal gains profiles

The following occupancy and equipment gains and profiles have been developed for the purposes of this methodology. They represent a robust test that ensures the key aspects of overheating are captured, namely the hours when risk is highest (i.e. the middle of the day and early afternoon) and night-time hours when, if rooms do not cool down, sleep can be disrupted.

Whilst all homes will be occupied differently, this test is intended to ensure that the units tested will perform reasonably throughout the day and night.

It is important that these profiles are used for all assessments following this methodology.

5.1 Occupancy and equipment

See Table 2.

Based on CIBSE Guide A (2015a), a maximum sensible heat gain of 75 W/person and a maximum latent heat gain of 55 W/person are assumed in living spaces. An allowance for 30% reduced gain during sleeping is based on Addendum g to ANSI/ASHRAE Standard 55-2010: *Thermal environmental conditions for human occupancy* (ASHRAE, 2013), Table 5.2.1.2 'Metabolic rates for typical tasks'.

5.2 Lighting

For the purposes of the assessment, lighting energy is assumed to be proportional to floor area, and lighting loads are measured in W/m^2. From 6 pm to 11 pm, 2 W/m^2 should be assumed as the default for an efficient new-build home. This assumes that good daylight levels are available (also noting that only May to September is assessed within CIBSE TM52).

For existing buildings, or specialist lighting designs, a calculated higher value should be used.

For communal corridors, use 2 W/m^2; this may be assumed as zero if passive infrared (PIR) sensors are present.

5.3 Gain profile tables and charts

Figure 1 (page 8) describes the same data listed in Table 2 in section 5.1 above.

It is assumed that apartments with the same number of occupants and bedrooms are usually provided with the same appliances, therefore the heat loads given by them should be assumed to be independent of floor area for the purpose of overheating risk assessment. Therefore, the equipment loads are defined in watts (not W/m^2).

Figures 2 to 7 (pages 8 and 9) show the occupancy and equipment profile data for each room type. The factors included in the table shown as Figure 1 need to be multiplied by the peak gain for each room to provide the total gains for each hour.

Notes:

(1) Larger or unusual apartments should follow the same principles — assessors should explain the basis of any alternative profile developed for other room types in the compliance report.

(2) Single bedrooms are those that cannot accommodate a double bed.

(3) Bathrooms and halls do not have to pass the criteria, but should be included in the assessment.

6 Supplementary information on profile development

The occupancy and equipment gain profiles listed in section 5 are strongly recommended for the purposes of this methodology. They include the following characteristics:

— Bedrooms are set with a 24-hour occupancy profile, which means that one person is always considered in each bedroom during the daytime, and two people in each double bedroom at night.

— For the 2-bedroom flat, one person is considered during the daytime in both the bedrooms in order to assess robustly. This means that one excess person (a visitor) to the assumed total number of occupants will be considered in the flat during the daily hours.

— Kitchens/living rooms are unoccupied during the sleeping hours and occupied during the rest of the day. This is the worst-case scenario since the room will be modelled as occupied only during the hottest hours of the day.

Table 2 Occupancy and equipment gain descriptions

Unit/ room type	Occupancy	Equipment load
Studio	2 people at all times	Peak load of 450 W from 6 pm to 8 pm*. 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and 10 pm to 12 pm Base load of 85 W for the rest of the day
1-bedroom apartment: living room/kitchen	1 person from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
1-bedroom apartment: living room	1 person at 75% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
1-bedroom apartment: kitchen	1 person at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm Base load of 50 W for the rest of the day
2-bedroom apartment: living room/kitchen	2 people from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
2-bedroom apartment: living room	2 people at 75% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
2-bedroom apartment: kitchen	2 people at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm Base load of 50 W for the rest of the day
3-bedroom apartment: living room/kitchen	3 people from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
3-bedroom apartment: living room	3 people at 5% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
3-bedroom apartment: kitchen	3 people at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm base load of 50 W for the rest of the day
Double bedroom	2 people at 70% gains from 11 pm to 8 am 2 people at full gains from 8 am to 9 am and from 10 pm to 11 pm 1 person at full gain in the bedroom from 9 am to 10 pm	Peak load of 80 W from 8 am to 11 pm Base load of 10 W during the sleeping hours
Single bedroom (too small to accommodate double bed)	1 person at 70% gains from 11 pm to 8 am 1 person at full gains from 8 am to 11 pm	Peak load of 80 W from 8 am to 11 pm Base load of 10 W during sleeping hours
Communal corridors	Assumed to be zero	Pipework heat loss only; see section 3.1 above

* All times in GMT

— No differences between weekdays and weekend are considered. Moreover, the overall apartment will be modelled as occupied for 24 hours.

— Occupied hours should be totalled, as described in CIBSE TM52, as 3672 hours per year for bedrooms (24/7 for the May–September dates covered) and 1989 hours per year for living rooms (13 hours per day for 153 days May–September). This provides a useful check that profiles have been correctly applied. See section 4 for compliance criteria.

The reasons for using this occupancy pattern include:

— The purpose of the assessment is to test the ability of the building design to mitigate overheating risk, and therefore lengthy occupied periods need to be evaluated.

— Having found that the CIBSE TM52 test is very sensitive to occupied hours (as only occupied hours are assessed), spaces with daytime-only occupancy find it more difficult to comply. Night-time-only occupancy only assesses the cooler, no solar gains periods which makes it relatively easy to pass and does not take into account more critical situations (e.g. bedroom used during the daytime by children or people who might use the bedroom as a study/ home office).

— It helps to address the most critical health concerns associated with overheating: vulnerable people (i.e. elderly people, disabled people and babies) who tend to be at home most of the day.

— Most building modelling (e.g. daylighting analysis, SAP assessments) assumes (directly or indirectly)

Figure 1 Heat gain profile

Number of people	Description	Peak load (W) Sensible	Peak load (W) Latent	00–01	01–02	02–03	03–04	04–05	05–06	06–07	07–08	08–09	09–10	10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24
			Hour-ending	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
1	Single bedroom occupancy	75	55	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.7
2	Double bedroom occupancy	150	110	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.7
2	Studio occupancy	150	110	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1-bed: living/kitchen occupancy	75	55	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
1	1-bed: living occupancy	75	55	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0	0
1	1-bed: kitchen occupancy	75	55	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
2	2-bed: living/kitchen occupancy	150	110	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
2	2-bed: living occupancy	150	110	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0	0
2	2-bed: kitchen occupancy	150	110	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
3	3-bed: living/kitchen occupancy	225	165	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
3	3-bed: living occupancy	225	165	0	0	0	0	0	0	0	0	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0	0
3	3-bed: kitchen occupancy	225	165	0	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
	Single bedroom equipment	80		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.13
	Double bedroom equipment	80		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.13
	Studio equipment	450		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	1	1	0.44	0.44	0.24	0.24
	Living/kitchen equipment	450		0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	1	1	0.44	0.44	0.24	0.24
	Living equipment	150		0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	1	1	1	1	0.4	0.4
	Kitchen equipment	300		0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	1	1	0.17	0.17	0.17	0.17
	Lighting profile	2 (W/m2)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0

that the dwelling is constantly occupied. Adopting a different approach for overheating is inconsistent and could be confusing.

The profile and the associated loads are based on DECC's Household Electricity Survey (DECC, 2012a) and *Electrical appliances at home: tuning in to energy saving* (DECC 2013).

For reference, the annual electricity usage estimated by UK Power for a 'small house or flat' is 2000 kW·h (UK Power, 2017).

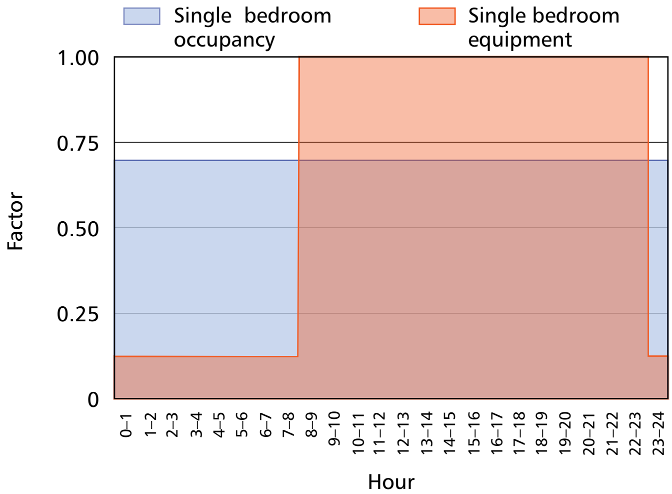

Figure 2 Heat gain profile: single bedroom

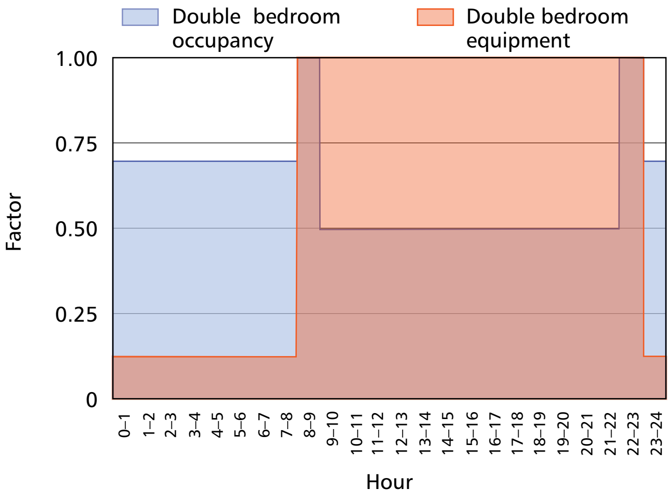

Figure 3 Heat gain profile: double bedroom

Figure 4 Heat gain profile: combined living room/kitchen

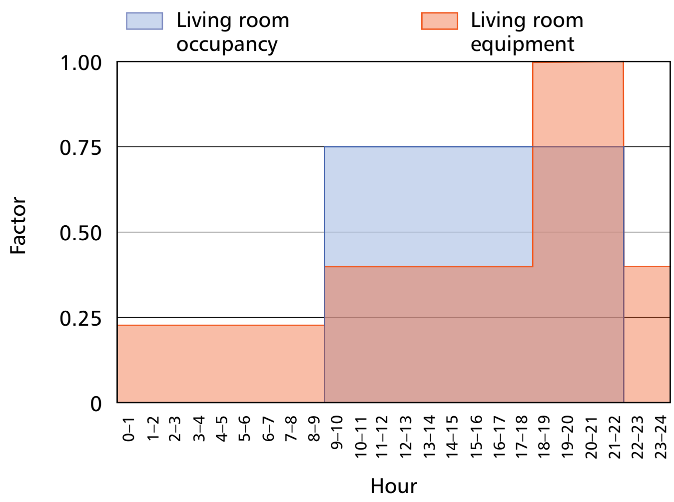

Figure 5 Heat gain profile: living room

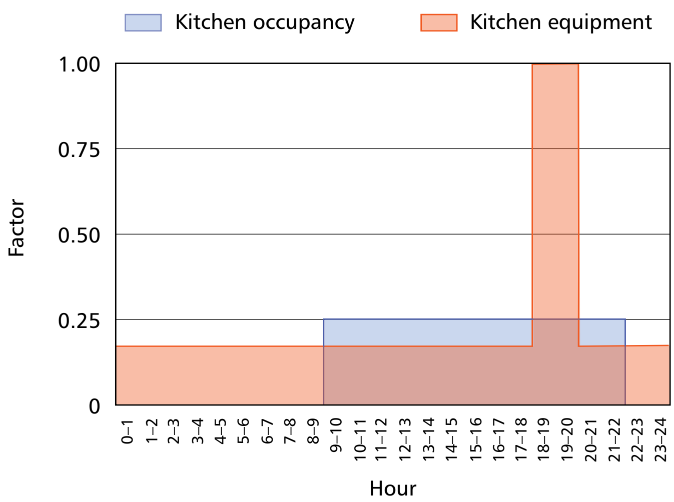

Figure 6 Heat gain profile: kitchen

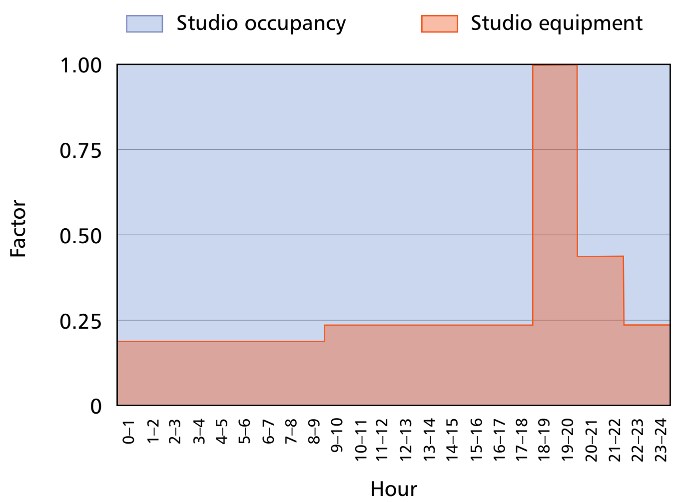

Figure 7 Heat gain profile: studio

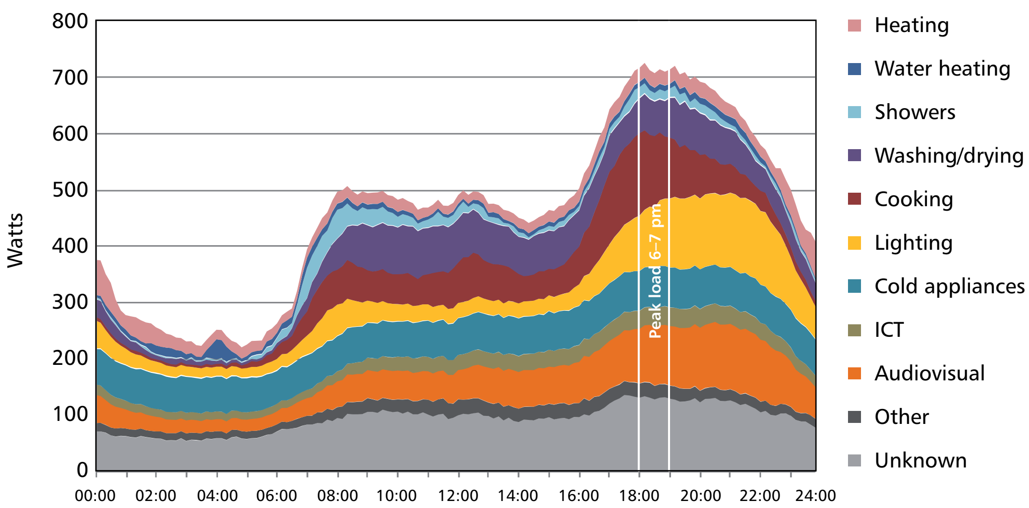

Figure 8 Average 24-hour profile for 250 homes (*source*: DECC, 2013)

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The Chartered Institution of Building Services Engineers
222 Balham High Road, London SW12 9BS
+44 (0)20 8675 5211
www.cibse.org