

Overheating risk in dwellings: a design stage methodology

CIBSE TM59: 2026

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The Chartered Institution of Building Services Engineers
91-94 Saffron Hill, London EC1N 8QP

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Foreword

We are living through a period of rapid climate warming, with each update to the science increasing the recorded and predicted pace of change. The use of shutters for both shading and security has a long history in the UK, arriving from the continent in the Tudor period and then made increasingly popular by the Victorians. Now more than ever we should revisit traditional UK and continental cooling strategies and prioritise passive approaches when designing to limit heat gains and adapt to warmer summers. Even in situations when comfort cooling is unavoidable, passive design can increase comfort, improve resilience and reduce operational energy consumption and cost.

This Technical Memorandum was first published in 2017 and provided a standardised approach to assessing overheating risk for residential building designs (new-build or major retrofit). It was the first technical guidance document to require the use of dynamic thermal modelling to assess overheating risk in the design of homes, an approach that has been largely adopted into the Building Regulations via the introduction of Approved Document O: *Overheating* in England and Wales and Section 3.28 of the *Domestic Technical Handbook* in Scotland.

Since 2017 the modelling of overheating risk has become normalised across the new-build housing market. This has helped raise awareness of the need to design for internal thermal comfort – limiting excessive heat as well as cold. Over this period the evidence base has grown, allowing us to improve our understanding of the variation between the level of overheating predicted by modelling and that recorded in practice. As the authors state, it was always planned to update the methodology based on feedback from its use in practice. For this update, learning from a recent academic study into sleep comfort has led to an easing of the night-time bedroom comfort limit.

I look forward to our industry adopting this latest update to TM59 and proactively considering opportunities for design solutions that capitalise on passive measures to minimise and mitigate unwanted heat gains. It is our responsibility to design and deliver homes that can maintain a comfortable internal environment while minimising energy consumption and cost in a more variable, more extreme future climate.

Tom Lelyveld, MEng, CEng, MCIBSE

Chair, CIBSE Homes for the Future Group

Contributing authors

Susie Diamond (Inkling) (Lead Author), Becci Taylor (Arup), Antonietta Canta (Arup)

Executive editor

Kevin Lomas (Loughborough University)

Peer reviewers

Ben Abel (Hilson Moran), Anna Mavrogianni (UCL), Marguerita Chorafa (Introba), Jack Harvie-Clark (Apex Acoustics Ltd)

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CIBSE Technical Director

Dr Anastasia Mylona

CIBSE Head of Knowledge and Digital

Ahmed Hegazi

Editor

Alasdair Deas

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1 Introduction

1.1 Background

This Technical Memorandum, TM59, provides a methodology for the assessment of overheating risk in dwellings by using dynamic thermal models. This document is not intended to provide design guidance or recommend specific solutions; it is assumed that buildings are designed by competent professionals who will select the most effective design solutions based on each project's specificities. The use of dynamic thermal models in the early design stages can encourage robust heat-mitigated design, minimise costs and reduce delays precipitated by design changes and reanalysis.

The methodology updates the previous version of TM59 (CIBSE, 2017) based on feedback from its use in practice and the latest research. Like its predecessor, this version presumes that experienced modellers are undertaking the overheating assessments using approved, validated software, i.e. software that is compliant with CIBSE AM11: *Building performance modelling* (CIBSE, 2015a). Modelling is very useful to help predict performance and optimise design yet has inherent uncertainty. Those interpreting the results of modelling need to be aware that predicted temperatures may not accurately match reality.

Evidence of the extent, severity and impact of dwelling overheating in the UK, accumulated over two decades, led to the publishing of Approved Document O: *Overheating* in both England (HMG, 2021) and Wales (TWG, 2022) and revisions to the *Domestic Technical Handbook* in Scotland (TSG, 2024). As well as providing a prescriptive method of demonstrating compliance, these documents also offer a more flexible method for compliance based on the use of dynamic thermal modelling. This version of TM59 provides a framework for such analyses. Some of the modelling assumptions and protocols recommended herein may differ from those required for demonstrating regulatory compliance; when this occurs it is clearly noted.

Overheating is a growing concern among the dwelling design, construction and housing community. Increased urbanisation and the changing design of dwellings, especially apartment blocks, have all contributed to the amplification of internal summertime temperatures. Homes that overheat can cause significant discomfort and stress to the occupants, and adverse health and wellbeing impacts, and could lead to litigation and/or costly heat mitigation retrofits.

In the UK and other temperate regions, homes are not traditionally air-conditioned. With effective design, passive measures are generally capable of maintaining thermal comfort during summers typically encountered in the UK in the 2020s. Although most traditional homes in the UK include some passive cooling measures, the newer typologies – and especially modern blocks of flats – can be built with lighter weight construction, single aspect layouts and windows with large areas of glazing and limited openability, which can lead to excess heat building up in the dwelling. The imperative of tackling climate change while constructing dwellings that are affordable to buy and operate militates against the uptake of mechanical cooling, which can generate higher bills for occupants and higher carbon emissions, and contribute to intensification of the local urban heat island.

The methodology outlined in this Technical Memorandum will aid the design of dwellings that remain comfortable in summer by using passive measures, primarily shading and ventilation to control unwanted solar heat gains and remove excess heat. The methodology also tests that such measures will remain effective as the climate warms. In the rare situations where mechanical cooling is unavoidable, the use of passive control measures will reduce the duration for which a cooling system is used, and therefore also the consequent energy demand, fuel costs and emissions.

People differ in their thermal sensitivity, their thermoregulatory capability and their potential to adapt their home in response to elevated temperatures. In particular, older and/or vulnerable people can have poor thermoregulatory control and are badly affected by high temperatures. The indoor temperature thresholds defined in this Technical Memorandum recognise these interpersonal differences.

The guidance in this Technical Memorandum is focused on assessing overheating risk in new UK dwellings and residential buildings, but it is also applicable for assessing the risk of overheating in residential buildings subject to major retrofit. The methodology is also likely to have value for guiding overheating assessments in other regions of the world with a temperate climate.

1.2 About the TM59 methodology

The TM59 methodology is prescriptive. The aim is to bring clarity to the assessment of overheating in residential buildings and thus improve the repeatability and replicability of analyses. It defines the assumptions, weather data, heat gain profiles, overheating criteria and reporting procedures that modellers should use when undertaking dynamic thermal modelling. It is not intended to be applied to measured data nor to short test periods that do not represent a full summer. The TM59 approach encourages good design and prioritises passive heat mitigation in order to minimise the need for, and reliance on, mechanical ventilation and cooling. Although the actual performance of dwellings will not exactly match that predicted by models, the models inform good design, thereby improving resilience to changing weather conditions and the actions of buildings' occupants.

The focus of TM59 is on assessing the overheating risk of dwellings in the UK, both for new dwellings and for dwellings subject to 'major retrofit'. The term 'dwelling' in this document includes apartments (i.e. flats), studio apartments and duplexes, and single family homes, and also houses of multiple occupancy (MHCLG, 2018). The methodology is also applicable to sheltered accommodation, care homes, student accommodation, prisons and other forms of accommodation, such as the bedrooms in hotels and hospitals.

This Technical Memorandum includes updates to the earlier version of TM59 (CIBSE, 2017). These updates are based on industry feedback and testing by professionals with experience of using the previous version of TM59, academic research into the effect of heat on sleep (Lomas and Li, 2023), the method of modelling ceiling fans for improving summertime comfort defined in British Standard BS EN 16798-1 (BSI, 2019), and the availability of *Overheating risk in dwellings: weather file requirements* (CIBSE, 2026a) – which are based on the most recent UK climate change projections. A three-stage modelling strategy is introduced to clarify the overheating criterion to be used when window opening is constrained. The heat gain profile to use for home offices, which has been defined, has been included.

Table 1 Summary of the main updates to TM59

• A revised overheating criterion for assessing bedrooms when people are asleep. • The use of ceiling fans for improving thermal comfort in warm spaces is clarified. • The weather files for use in analyses have been updated in the light of recent climate change predictions. • The overheating criteria and modelling strategy to be followed if window opening is constrained is clarified. • The overheating criterion and internal gains profile to be used for the assessment of home offices has been added.

1.3 Linked documents

Other CIBSE resources support this version of TM59.

- The weather files that must be used in association with the TM59 methodology are specified in *Overheating risk in dwellings: weather file requirements* (2026a). Alternative weather files are also available for testing the resilience of the dwelling to current and future summer weather conditions, different climate change expectations, and summers with differing heat wave intensities and durations. The supporting document provides guidance on the appropriate use of these files. The CIBSE weather files will be periodically updated in line with new predictions of UK climate change.

- A checklist of common errors and oversights made when undertaking overheating assessments is provided in *Overheating risk in dwellings: overheating compliance checklist* (CIBSE, 2026b). Some of the modelling protocols followed when testing regulatory compliance for domestic building in England, Scotland and Wales (HMG, 2021; TSG, 2026; TWG, 2022) may differ from those prescribed in this Technical Memorandum. The checklist also outlines these differences and will be updated periodically to maintain coherence between TM59 and any changes to national guidelines and standards.

Designers and modellers using the TM59 methodology should periodically check for updates to these supporting documents on the CIBSE TM59 (2026) [Knowledge Item](#) webpage.

1.4 Existing dwellings and retrofit

The primary focus of TM59 is the assessment the overheating risk in new UK dwellings. However, the modelling strategy (section 2.3) is also applicable to existing buildings to help identify and mitigate overheating risks.

Where dwellings are subject to a major retrofit such that the design meets contemporary guidelines, standards and regulations, TM59 should be used to ensure appropriate passive heat mitigation measures are installed.

The design of buildings subject to less extensive refurbishment can also benefit from the heat-mitigation guidance, modelling recommendations and overheating criteria in this Technical Memorandum. In particular, TM59 can be used to ensure that the proposed interventions do not exacerbate the risk of overheating; for example, by undertaking a pre- and post-intervention overheating assessment.

1.5 Passive summer temperature control

The intention of TM59 is to influence building design and prioritise the use of passive and low energy solutions to avoid overheating. Passively controlled spaces use shading and natural ventilation, usually via operable windows, as the primary means of summertime heat removal. They may also include manually controlled ceiling fans and ventilation systems designed to meet whole dwelling air requirements, such as mechanical extract ventilation (MEV) or mechanical ventilation with heat recovery (MVHR) which includes an effective summer bypass. However, operable natural ventilation devices should usually be the primary means of controlling summertime temperatures.

The Greater London Authority, in its ‘cooling hierarchy’ (GLA, 2022), has provided a valuable structure for designing dwellings to avoid overheating.

1. Reduce the amount of heat entering the building (in summer) through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure
2. Minimise internal heat generation through energy efficient design
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
4. Provide passive ventilation
5. Provide mechanical ventilation
6. Provide active cooling systems (ensuring they are the lowest carbon options).

Balancing the tensions between energy efficiency requirements, daylighting targets and mandatory or local site-specific window opening constraints, while also limiting overheating risk, can be challenging. However, effective design can be achieved by following existing design guidance, such as that provided in Appendix A, section A.1. This guidance, used in parallel with the TM59 assessment methodology, offers a route to finding pragmatic solutions that resolve these tensions.

When specific spaces cannot meet the TM59 overheating criteria by passive and low energy solutions, active systems, notably full mechanical ventilation and/or mechanical cooling, may be the only means of preventing overheating. This is particularly so when site-specific noise, air quality,

security or other factors constrain the opening of windows in specific spaces in a building. Nevertheless, the dwelling should still incorporate viable passive heat mitigation measures to reduce the operating times and energy demands of mechanical systems. Any necessary mechanical systems should be isolated to those dwellings and spaces that need them, be energy efficient, and have easy-to-use controls so that they operate only when and where passive systems cannot meet the required space temperatures. This principle – passive design, with mechanical systems only when essential – is enforced by the three-stage TM59 modelling strategy, see section 2.3.

Excessively glazed areas, especially on façades facing between 45° and 315° from north, should be avoided to prevent excessive solar gains. Fixed or movable external shading devices are an effective heat mitigation measure, and specifying a low solar energy transmittance (g-value) for glazing can also be beneficial. There is a trade-off to be made between the benefits of passive heating in the winter, maintaining year-round natural light and reducing overheating in the summer. Internal shading (blinds, shutters, curtains) can also be useful but have a lower impact on internal temperatures compared with external shading because they are less effective in preventing solar radiation entering the room.

Well-designed, operable windows and ventilation devices enable effective cooling via natural ventilation. Safety and security issues can constrain occupants' use of natural ventilation devices; however, there are many possible window and ventilation solutions that can provide effective cooling and satisfy safety and security requirements, and which do not clash with shading devices. For example, the use of windows that open inwards, which is common throughout Europe, reduces the risk of falls from height. It also allows for the installation of external shutters that can provide both security and effective shading.

Night-time ventilation is an effective means of removing excess heat when there is sufficient temperature difference between daytime and night-time. However, the opening of windows, especially in bedrooms at night, may be constrained by site-specific security, air quality or noise issues.

Exposed thermal mass is an effective method of reducing peak daytime temperatures, provided night-time ventilation is possible. Exposed thermal mass in spaces where night-time ventilation is ineffective or impossible can result in heat that has accumulated in the thermal mass during the day being released into the space during the night, contributing to night-time overheating. This is particularly pertinent to bedrooms.

The internal layout of dwellings can have a substantial impact on internal temperatures. For example, by ensuring that rooms are big enough for the expected number of occupants, the build-up of heat can be controlled. Dual aspect apartments with windows on at least two sides can benefit from cross ventilation, which can increase ventilation rates. Cross ventilation may be even more effective if internal doors are left open. This may not be possible in some settings due to privacy concerns, for example in care homes or other co-living residences.

Ceiling fans can improve thermal comfort in warm conditions through enhanced evaporative and convective cooling. This version of TM59 provides an approach to modelling the cooling effect of ceiling fans that are installed as part of the base build or a major retrofit.

Heat gains from community heating systems installed in apartment blocks and other residential buildings is a common cause of overheating. Minimising the length of permanently charged hot water pipework within dwellings, operating the system at a lower flow temperature, and providing adequate insulation, which is well installed and maintained, is important for reducing unwanted internal heat gains.

By locating mechanical ventilation extracts above sources of internal heat gain, the potential for summertime overheating may be reduced. Heat from domestic hot water (DHW) cylinders and heat interface units (HIUs), especially those located in enclosed spaces and cupboards, can be effectively extracted in this way.

1.6 Basis of the overheating criteria

The assessment of overheating is based on four overheating criteria, which are intended specifically for use in conjunction with dynamic thermal modelling and the methodology described in this Technical Memorandum. The criteria are defined fully in section 2.4 along with details about how they should be applied and to which spaces. The criteria for passively controlled spaces differ depending on whether people are asleep or awake, as this determines their ability to adapt the occupied space to the prevailing indoor temperatures. Each criterion produces a clear pass or fail outcome.

Overheating Criterion a is unchanged from the previous version of TM59 (CIBSE, 2017). The basis for the criterion, and the temperature thresholds for different categories of buildings, are given in CIBSE TM52: *Limits of thermal comfort: avoiding overheating in European buildings* (CIBSE, 2013) and CIBSE Guide A: *Environmental design* (CIBSE, 2015b). The temperature thresholds are given in British Standard BS EN 16798-1 (BSI, 2019).

Overheating Criterion b differs from the bedroom overheating criterion in the previous version of TM59 (CIBSE, 2017). It is applicable when people are asleep and is used for assessing night-time comfort in both naturally ventilated bedrooms and bedrooms with active mechanical ventilation and/or cooling. The criterion is based on new evidence about the effects of heat on sleep derived from an extensive literature review and measurements in 591 English homes (Lomas and Li, 2023). The research indicated that the night-time overheating criterion should limit the number of nights that sleep is disrupted due to heat, and that the temperature threshold should be based on the mean bedroom temperature during the hours of sleep. The research also showed that the mean operative night-time temperature that may result in sleep disruption is higher than the hourly bedroom temperature thresholds in the previous version of TM59 (CIBSE, 2017).

Overheating Criterion c is clarified in this version of TM59. It is applicable to spaces in which the use of natural ventilation openings is constrained and mechanical ventilation and/or mechanical cooling is installed. The criterion adopts the temperature threshold and exceedance limit given in CIBSE Guide A (CIBSE, 2015b).

Overheating Criterion d is clarified and is now an integral part of the TM59 methodology. It is applicable to naturally or mechanically ventilated and/or cooled communal areas, such as circulation spaces, corridors, stairwells, lift lobbies and similar spaces, that are outside the living areas in multi-dwelling buildings. This criterion is adapted from section 3.9 of the previous version of TM59 (CIBSE, 2017).

Some spaces within dwellings are non-habitable and so less heat sensitive. For the purposes of TM59, such spaces include entrance halls, stairways and landings, conservatories, attached or integrated garages, home gyms, cellars and loft spaces. These spaces should be modelled with realistic internal heat gains and window operation, but there is no prescribed overheating criterion. Acceptable summertime temperatures should be agreed with the client for the modelling work and reported within the overheating assessment report.

For mixed-use buildings, or multi-dwelling buildings with non-domestic activity areas (such as care homes or student accommodations), the non-domestic activity areas should be assessed separately using CIBSE TM52 methodology (CIBSE, 2013).

1.7 Supporting information

There are numerous regulations, standards, technical guides and tools that provide modellers with key information and data to assist with overheating assessments. The most useful of these, many of which are referred to in this Technical Memorandum, are listed, by topic, in Appendix A, section A.2.

2 The methodology

2.1 Selecting spaces for analysis

Professional judgement is needed in the selection of the dwellings to be included and excluded from an overheating assessment. The sample selection will be influenced by the scale of the development and the variety within dwelling designs and orientations, with more dwellings being chosen in larger or more varied developments and multi-dwelling buildings. Ideally at least one of each dwelling type would be included.

Dwellings likely to have a higher risk of overheating should be prioritised within sample selections. The documents listed in Appendix A, section A.1 can help with the identification of such dwellings. Features likely to exacerbate the risk of overheating include:

- large areas of glazing
- glazing orientated between northeast and northwest via south
- limited openable window provision
- site-specific external noise, air quality and security constraints that restrict the use of ventilation openings.

Apartments in larger buildings, and the communal areas that serve them, are particularly at risk of overheating. In addition to the features listed above, areas at higher risk in multi-residence buildings may be:

- single aspect apartments
- upper storeys with high solar exposure
- ground floor apartments with security constraints for opening windows
- communal areas with significant internal heat gains due to community heating systems and pipework.

Where site-specific noise, security and air quality constraints or glazing treatment vary, e.g. with storey height or façade orientation, then this variation should also be factored into the sample selection. In buildings that contain community heating distribution pipework, at least one corridor and stairwell should be included in the sample.

Adjacency to spaces with high gains or overheating risk should also be considered when selecting sample spaces so that the internal heat transfer to occupied spaces is considered.

The sample should be representative of all the dwellings, so dwellings at lower risk of overheating should also be included. This enables the performance of dwellings that are not modelled to be inferred, and any heat mitigation measures can be applied to all relevant dwellings, not just the sample modelled.

The selection of spaces to be modelled should be agreed with the client and justified in the modelling report.

2.2 Modelling the sample spaces

Overheating assessments should be undertaken using a dynamic thermal simulation model operating at a time step of one hour or less. The modelling and analysis of the sample of dwellings and communal areas should include the following elements, and follow the modelling strategy, see section 2.3:

- The weather file used for the assessment should, as a minimum, be the TM59 prescribed Design Summer Year that is most appropriate to the dwellings' location. In addition, other files as agreed with the client may also be used to test the effectiveness and longevity of heat mitigation measures, see section 3.1.
- Each space in each dwelling should be accurately modelled to reflect the dwelling's intended design, location, geometry, orientation, construction, etc., see section 3.2.

- Shading features should be modelled in detail. This includes external and internal shading devices included in the building's design, as well as site shading provided by other buildings, self-shading due to the building's articulation, and other fixed external features that shade glazed areas, see section 3.3.
- All operable windows, patio doors and other ventilation devices should be modelled to accurately reflect the design, including any physical limitations or behavioural constraints on the opening of these, see section 3.4.
- Mechanical ventilation provided, e.g. by MVHR or MEV, should be included in the model, using the proposed supply and extract rates. Heat recovery can be excluded when an effective summer bypass is provided, see section 3.5.
- Manually controlled ceiling fans that are included in the base build or a major retrofit should be modelled, see section 3.6.
- Internal heat gains from people, equipment, lighting and DHW systems should be modelled using the standard heat gain profiles provided, see section 3.7.
- The impact of any mandatory and site-specific safety, security, noise and air quality constraints on the use of natural ventilation openings should be accounted for, see section 3.8.

The overheating assessment report should include the full details of the modelling approach, see section 2.5 and Appendix B.

2.3 The TM59 modelling strategy

To encourage a 'passive first' approach in support of the cooling hierarchy, TM59 adopts a three-stage modelling strategy. The Stage 1 overheating assessment is undertaken using *only* passive heat mitigation measures and assuming no site-specific noise, air quality or additional security constraints on ventilation devices. The TM59 methodology requires that *all spaces in all dwellings* should pass Stage 1. In Stages 2 and 3, any site-specific constraints on the opening of ventilation devices are accounted for. These constraints may affect none or only a subset of the sampled dwellings and the spaces within them. The affected dwellings should be redesigned, using additional passive measures or, if necessary, enhanced mechanical systems, so that they also achieve a Stage 2 or Stage 3 pass.

The operation of this modelling strategy is described below and illustrated in Figure 1. A summary of the assumptions to be made at each stage is given in Appendix B.

In Stage 1, all the sampled dwellings are modelled as described in sections 3.1 to 3.8, in particular adopting the assumptions about occupant-controlled natural ventilation devices described in section 3.4, i.e. site-specific constraints due to local noise, security and air-quality concerns (section 3.8) are ignored. Such passive design may include mechanical systems that provide continuous background mechanical ventilation such as MEV or MVHR with an effective summer bypass; such systems provide ventilation rates that meet only whole dwelling air requirements (section 3.5). If passive heat mitigation measures alone cannot secure a Stage 1 pass, ceiling fans may also be included, see section 3.6.

In Stage 1, the overheating criteria appropriate to predominantly naturally ventilated spaces are used to assess each space in each dwelling, i.e. Criterion a and Criterion b, see section 2.4. If any spaces fail the overheating assessment they should be redesigned using passive heat-mitigation measures and, if proposed within the design, ceiling fans, until all the spaces in all the sampled dwellings achieve a Stage 1 pass. For very many UK dwellings there may be no site-specific constraints on ventilation opening and so no further testing is required. The results of the Stage 1 assessment with and without any internal blinds and ceiling fans should be reported.

In Stage 2, ventilation opening constraints due to site-specific noise, security or air-quality concerns are incorporated into the model (see section 3.8) and all the passive heat-mitigation measures necessary to achieve a pass at Stage 1 are retained. If all spaces in the dwelling still pass the overheating assessment, a Stage 2 pass has been secured, and no further testing is necessary. If spaces do not pass the assessment, they should be redesigned with enhanced passive heat

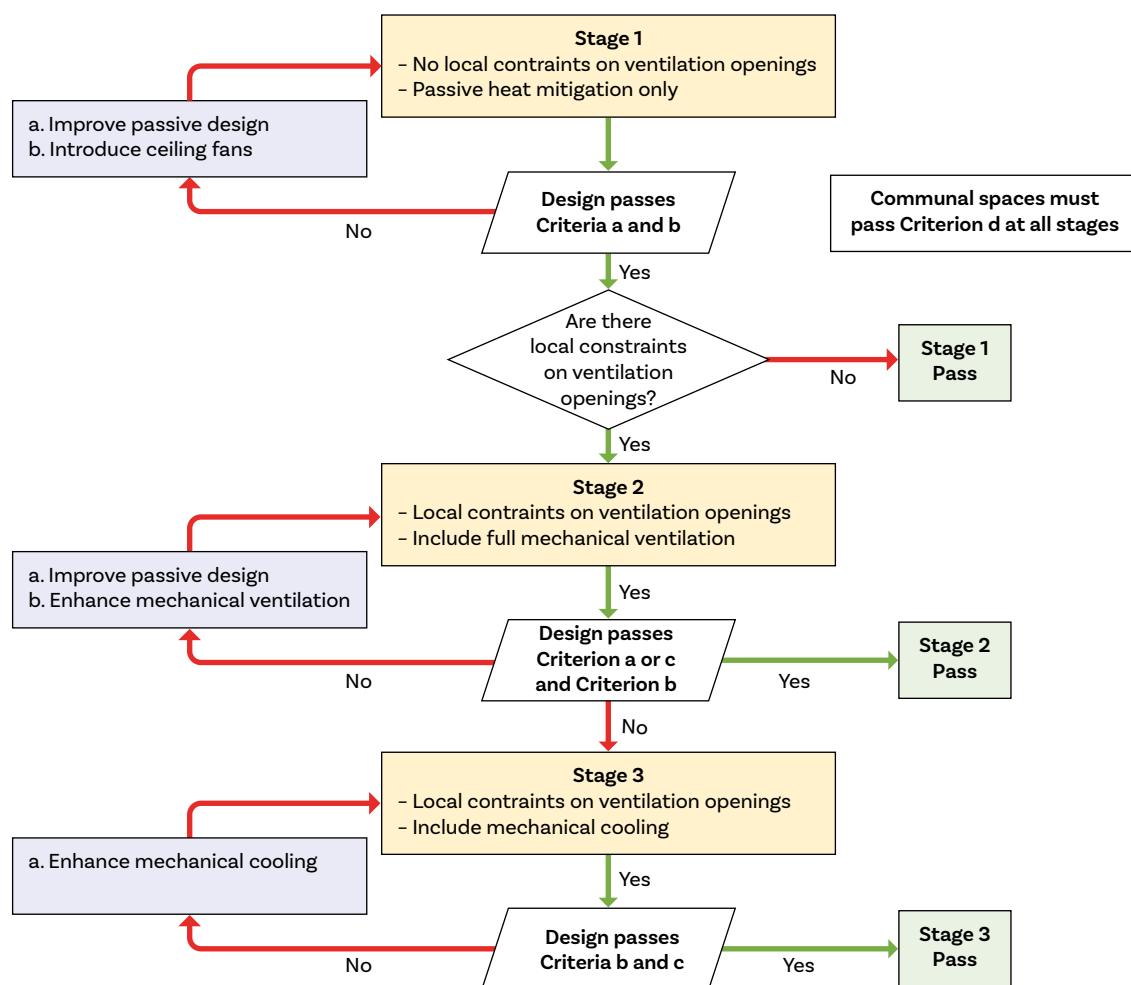


Figure 1 The stages of the TM59 modelling strategy

mitigation measures, and ceiling fans as necessary, to secure a Stage 2 pass. If passive measures alone cannot achieve a Stage 2 pass, then mechanical ventilation systems that deliver higher (than background) rates of air supply may be introduced but *not* any form of mechanical cooling. Mechanical ventilation systems should be controlled so that natural ventilation is used whenever external conditions and constraints permit, see sections 3.4 and 3.5.

In Stage 2, the overheating criteria appropriate to predominantly naturally ventilated spaces, Criterion a and Criterion b, must be used if, during occupied hours between May and September, the opening constraints permit ventilation devices to open or partly open for 50% or more of the time (i.e. fully closed less than 50% of the time). If this condition is not met then the criteria appropriate to predominantly mechanical ventilated spaces must be used, i.e. Criterion b and Criterion c (section 2.4).

Stage 3, in which cooling is introduced, is only undertaken if an assessment pass is not achieved at Stage 2. The ventilation opening restrictions due to site-specific noise, security or air-quality concerns are incorporated in the model and all the passive heat-mitigation measures devised in Stage 1 and Stage 2 are retained. Mechanical ventilation with active cooling may be incorporated in specific spaces where necessary. Cooling systems should be controlled so that natural ventilation or, if necessary, mechanical ventilation is used whenever external conditions and constraints permit, see sections 3.4 and 3.5.

In Stage 3, the overheating criteria appropriate to predominantly mechanical ventilation spaces must be used, i.e. Criterion b and Criterion c (section 2.4).

An overall pass of the TM59 overheating assessment methodology is achieved if every habitable space within every sampled dwelling passes *all* the applicable criteria in Stage 1 and, if applicable, either Stage 2 or Stage 3. At Stage 1 and either Stage 2 or Stage 3, communal areas in multi-dwelling buildings must also pass Criterion d.

The overheating assessment report should state the passing results of the Stage 1 overheating assessment and, if relevant, the results of the Stage 2 and/or Stage 3 assessments, see section 2.5.

2.4 Assessment criteria

The origin and purpose of the four overheating criteria are given in section 1.6. A description of each criterion and guidance on their application are given below. Key details, which highlight the differences between the criteria, are listed in Table 2. There is no applicable overheating criterion for space types not listed in Table 2.

2.4.1 Criterion a (predominantly naturally ventilated spaces)

Criterion a is applicable to spaces in which people are awake, able to adapt their clothing and can personally control shading, ventilation devices and ceiling fans. It is applicable to spaces that are predominantly naturally ventilated during occupied hours between May and September. Ventilation control may be by direct human action or by manually activated electro-mechanical devices, e.g. for inaccessible roof lights and ceiling fans.

Criterion a limits the temperature difference (ΔT) between the hourly operative temperature in the space predicted by a dynamic thermal model and the applicable operative temperature threshold. When applying this criterion, ΔT is rounded to the nearest whole degree as defined in TM52 (CIBSE, 2013): i.e. for ΔT between 0.5 and 1.49, the value used is 1 K; for 1.5 to 2.49, the value used is 2 K, and so on.

Criterion a – for living rooms, kitchens, home offices and bedrooms: the number of occupied hours for which ΔT is greater than or equal to one degree (K) between 1st May and 30th September inclusive shall not be more than 3% of the occupied hours during this period.

The operative temperature threshold depends on the type of occupancy:

- Category I should be used when modelling dwellings designed for thermally sensitive and fragile people, including care homes and sheltered accommodation, and for institutions that provide an element of health care.
- Category II, for which the temperature threshold is 1 K higher, should be used when modelling all other dwellings.

Both temperature thresholds increase linearly with the increase in the running mean of the daily outdoor temperature, T_{rm} , between T_{rm} values of 10 °C and 30 °C. Above a T_{rm} of 30 °C the thresholds should be fixed at 30.7 °C for Category I dwellings and 31.7 °C for Category II dwellings. Below a T_{rm} value of 10 °C the thresholds should be fixed at 24.1 °C for Category I dwellings and 25.1 °C for Category II dwellings.

The T_{rm} values between May and September can be accurately and efficiently calculated using Equation 2.3 in TM52 (CIBSE, 2013) to obtain a reliable start value on 1st May, after which Equation 2.2 is used to calculate the T_{rm} for every day up to 30th September. First, using Equation 2.3, the T_{rm} value for 30th April is calculated using the daily mean temperatures of the seven days between 23rd April and 29th April. Then, using Equation 2.2, T_{rm} for 30th April is fed into Equation 2.2 as T_{rm-1} and, together with the daily mean temperature for 30th April, the T_{rm} value for 1st May is obtained. These calculations would usually be done by the modelling tool.

The TM59 methodology permits the Category I and Category II temperature thresholds to be raised in some spaces when ceiling fans are fitted as part of the base build or a major retrofit. For Criterion a, when ceiling fans are in operation and generating air speeds of 0.6 m/s or more, a maximum operative temperature threshold uplift of 1.2 °C is permitted when the operative temperature in the space exceeds 25 °C. The temperature threshold uplift for ceiling fans that produce air speeds lower than 0.6 m/s can be taken from British Standard BS EN 16798-1 (BSI, 2019); the uplift is approximately 0.20 °C for each 0.1 m/s increment. This uplift accounts for the additional cooling effect over and above any other adaptation implicitly presumed by the adaptive thermal comfort method. Further information on the modelling of ceiling fans is given in section 3.6.

2.4.2 Criterion b (bedrooms)

Criterion b aims to assure thermal comfort when people are asleep. It is applicable to both naturally ventilated bedrooms and bedrooms with mechanical ventilation or active cooling. The criterion limits the number of nights for which the mean night-time operative temperature predicted by the model exceeds the relevant night-time operative temperature threshold, T_n .

Criterion b – for bedrooms only: the number of nights for which the mean operative temperature during hours of sleep exceeds T_n , between 1st May and 30th September inclusive shall not be more than four nights during this period.

The applicable temperature threshold, T_n , is fixed, i.e. not adaptive, and depends on whether a Category I or Category II dwelling is being assessed.

In TM59, the hours during which people may sleep are assumed to be from 11 pm to 8 am. Care should be taken when calculating the mean bedroom night-time temperatures. The mean bedroom temperature for 1st May is based on the temperatures between 11 pm on 1st May and 8 am on 2nd May, and the mean bedroom temperature for 30th September is based on the temperatures between 11 pm on 30th September and 8 am on 1st October.

There is currently limited evidence about the thermal effects of ceiling fans on comfort while sleeping and any consequential improvement in sleep quality. Therefore, TM59 does not permit an uplift in the temperature thresholds associated with Criterion b.

Bedrooms should be designed to pass Criterion b *and* either Criterion a if predominantly naturally ventilated or Criterion c if predominantly mechanically ventilated.

2.4.3 Criterion c (predominantly mechanically ventilated)

Overheating Criterion c is to be used *only* when spaces are predominantly mechanically ventilated or mechanically cooled during occupied hours between May and September.

Criterion c – for living rooms, kitchens, home offices and bedrooms: the room operative temperature shall not exceed 26°C between 1st May and 30th September inclusive for more than 3% of occupied hours during this period.

The temperature threshold in Criterion c is fixed and applicable to both Category I and Category II dwellings.

The TM59 methodology permits a higher temperature threshold to be used in predominantly mechanically ventilated or mechanical cooled spaces, if ceiling fans are fitted as part of the base build or retrofit, see section 3.6. The operative temperature threshold in Criterion c may be increased by a maximum of 2.1°C when the operative temperature in the space exceeds 25°C and ceiling fans are in operation and generating air speeds of 0.6 m/s or more. The temperature uplift for ceiling fans that produce air speeds lower than 0.6 m/s may be taken from CIBSE Guide A (CIBSE, 2015b) or CIBSE AM10 (CIBSE, 2026c), the uplift is approximately 0.35°C for each 0.1 m/s increment. A low background air speed, e.g. 0.1 m/s, should be assumed in the thermal model, see detail in Criterion a above.

2.4.4 Criterion d (communal areas)

Criterion d is applicable to communal circulation areas, such as stair wells, corridors, lift and entrance lobbies, etc.

Criterion d – for communal circulation areas: the operative temperature shall not exceed 28°C between 1st May and 30th September for more than 3% of occupied hours during this period.

The temperature threshold is the same for all modes of ventilation and/or cooling and for both Category I and Category II dwellings.

The TM59 methodology presumes against the installation of manually controlled ceiling fans in communal areas and so no temperature threshold uplift is permitted for Criterion d.

Table 2 Overheating criteria – applicable spaces, temperature thresholds, limits of threshold exceedance and accounting for ceiling fans

Living rooms, home offices, kitchens and bedrooms when people are awake	
Criterion a: predominantly <i>naturally</i> ventilated spaces	Criterion c: predominantly <i>mechanically</i> ventilated and/or cooled spaces
Applicable temperature threshold The adaptive operative temperature threshold differs for Category I and Category II dwellings. Limit of occupied hours above threshold Living rooms, kitchens and home offices are assumed to be occupied from 9 am to 10 pm, i.e. 13 hours a day. Therefore, 3% of occupied hours between May and September (1989 hours in total) is 59 hours. This is the maximum permitted hours of threshold exceedance. Bedrooms may be occupied at any time of day or night. Therefore, 3% of occupied hours between May and September (i.e. 3672 hours in total) is 110 hours. This is the maximum permitted hours of threshold exceedance. Adjustment for ceiling fans When manually controlled ceiling fans are installed as an integral part of the base build or major retrofit, and when the operative temperature in the space exceeds 25°C, the applicable temperature threshold may be increased, see section 2.4.1. This increase applies for both the Category I and Category II temperature thresholds.	Applicable temperature threshold The temperature threshold, 26°C, is applicable to both Category I and Category II dwellings. Limit of occupied hours above threshold Living rooms, kitchens and home offices may be occupied from 9 am to 10 pm, i.e. 13 hours a day. Therefore, 3% of occupied hours between May and September (i.e. 1989 hours in total) is 59 hours. This is the maximum permitted hours of threshold exceedance. Bedrooms may be occupied at any time of day and night. Therefore 3% of occupied hours between May and September (i.e. 3672 hours in total) is 110 hours. This is the maximum permitted hours of threshold exceedance. Adjustment for ceiling fans When manually controlled ceiling fans are installed as an integral part of the base build or major retrofit, and when the operative temperature in the space exceeds 25°C, the temperature threshold of 26°C may be increased, see section 2.4.3. This increase applies for both the Category I and Category II temperature thresholds.
Bedrooms when people are asleep	
Criterion b is applicable during the hours of sleep in both naturally ventilated bedrooms and mechanically ventilated bedrooms in addition to either Criterion a or Criterion c. Applicable temperature threshold For Category I dwellings the fixed mean operative temperature threshold, T_n, is 26°C, for Category II dwelling the operative temperature threshold, T_n, is 27°C. Limit of nights above threshold Bedrooms should be comfortable for sleeping between 11 pm and 8 am from May to September. Four nights is the maximum permitted threshold exceedance for both Category I and Category II dwellings. Adjustment for ceiling fans There is no permitted adjustment for ceiling fans.	
All communal areas	
Criterion d is applicable to communal circulation areas, such as corridors, stair wells, lift and entrance lobbies etc., which are outside the individual dwellings. Applicable temperature threshold The temperature threshold, 28°C, is applicable to both Category I and Category II dwellings, whether the areas are naturally or mechanically ventilated and/or cooled. Limit of occupied hours above the threshold Communal areas may be occupied at any time of day or night. Therefore 3% of the occupied hours between May and September (i.e. 3672 hours in total) is 110 hours. This is the maximum permitted hours of threshold exceedance. Adjustment for ceiling fans There is no permitted adjustment for ceiling fans.	

Notes: All times given are local UK time. For spaces not listed there is no applicable overheating criterion.

2.5 Reporting and implementation

The TM59 methodology requires rigorous and systematic reporting so that others can be confident that the model accurately reflects design proposals and could replicate the overheating analysis if necessary. The report should describe the dwelling's design, the assumed heat mitigation measures and all modelling assumptions. A checklist of reporting requirements is given in Appendix C.

The modelling report should clearly state the results of the analysis. This may include the results of different design iterations to demonstrate the route towards achieving an overall pass. For every space, dwelling and communal area in every dwelling, the report should give the overheating criteria adopted, the assumed dwelling Category (I or II) and the results. The report should also state how any required heat mitigation measures should be applied across the whole site, not just the sample of dwellings assessed.

The Stage 1 results should be reported both with and without any internal blinds and ceiling fans. If applicable, the results for Stage 2 – with relevant noise, security and air quality constraints – and, if necessary, Stage 3 should also be reported. Spaces which do not pass the overheating assessment should be highlighted and recommendations should be made for design modifications, additional heat mitigation measures and further analysis to enable compliance.

All stakeholders should review the input data used, the outcomes and the design implications. Results will only be valid if the parameters modelled match those of the final building. Design assumptions should therefore be followed through procurement, to installation and commissioning.

Should the final dwelling designs differ from the assumptions described in the modelling report, the overheating assessment should be repeated and the report updated accordingly. This is especially important if the subsequent design changes affect the risk of overheating.

The dwelling designs, and the heat and noise mitigation measures incorporated, should form part of the client's contract requirements. The modelling results will inform the content of the Home User Guide (England) or Home Energy Guide (Wales) which should be provided with new dwellings, see Approved Document L (HMG, 2026a; TWG, 2026a) and written information provided to building occupiers in Scotland (TSG, 2026). The documents should include information on the heat mitigation measures incorporated in the dwelling and provide guidance on the effective operation of shading and ventilation devices by the occupants or by those responsible for the residents of care homes and other institutional buildings.

3 Guidance on modelling

3.1 Weather files

The weather files to be used for TM59 assessments are identified in *Overheating risk in dwellings: weather file requirements* (CIBSE, 2026a), see section 1.3. This document prescribes the specific Design Summer Year (DSY) most relevant to the building's location that must be used for overheating assessments made using this version of TM59. The weather data and guidance will be updated as new, future weather projections emerge and insights into the appropriate use of the weather files evolve. Modellers should check that the correct weather files are used in analyses.

The overheating assessment report should include the precise weather files used, including the version number, and an explanation of why these have been selected as appropriate for the site, see section 2.5 and Appendix C.

3.2 Geometry and construction

The geometry of each sample dwelling and communal area should be accurately modelled. The model should capture each space's shape, internal volume and orientation, including all the walls, roofs and floors that form the envelope and the internal partitions. Close attention should be given to elements that influence overheating risk, such as the position and size of window and door apertures.

The model should include all the spaces in the sampled dwellings, including non-habitable spaces such as halls, stairs and landings, conservatories, attached or integrated garages, lofts and cellars. Such spaces may influence the temperatures in the adjacent spaces, provide routeways for cross ventilation or stack ventilation, and/or be a source of internal heat gains.

Risers, ceiling voids and other unconditioned spaces adjacent to modelled dwellings in multi-apartment buildings should be modelled as such, i.e. as unconditioned spaces; the related

partitions should be modelled with thermal performances as per the design. Ceiling/floor voids should be modelled as separate zones when they are likely to have an impact on the space temperatures, e.g. they are being used as a ventilation plenum. Care should be taken to ensure that space volumes are represented accurately in models, especially when there are significant floor/ceiling voids. Ceiling voids should be modelled as separate unconditioned spaces when their total thickness (i.e. from the top finish level of the floor above to the bottom finish level of the ceiling below) is equal to or greater than 15% of the typical floor-to-ceiling height of the spaces below.

The thermo-physical characteristics of the construction elements should be modelled accurately including the long and short wave radiation properties of surface materials, the heat transmission and thermal storage capacity of opaque internal and external construction elements. The reflectivity, absorption and transmission characteristics of glazed elements, for both daylight and solar radiation, should be accurately represented. Dynamic thermal models often provide databases of material properties, as do other guidelines and standards, see Appendix A, section A.2.

The thermal influence of adjoining buildings and dwellings may be modelled explicitly, or they may be represented implicitly by assigning suitable boundary conditions to the party walls, ceilings or floors of the modelled dwelling. Partitions between spaces likely to have similar temperatures may be modelled as adiabatic.

The modelling report should provide full geometry and construction details, see Appendix C.

3.3 Solar gain control and shading

Caution: *The guidance given here on the modelling of shading may differ from that prescribed in guidelines for demonstrating compliance with building regulations: Approved Document O – for use in England; Approved Document O – for use in Wales; and, in Scotland, the Building Standards Technical Handbook: Domestic.*

Features that may provide shading to the sampled dwellings and communal areas should be modelled explicitly. Design guides provide illustrations of different forms of shading, see Appendix A, section A.1. This includes external and internal shading devices incorporated in the building's design, such as balconies, overhangs and substantial window reveals, as well as site shading provided by other buildings, fixed site features, self-shading due to the building's articulation and other fixed external features that shade glazed areas.

The shading characteristics of features such as louvres and blinds should be modelled as accurately as possible. Manually operated external shading, e.g. shutters, sliding panels, blinds, mid-pane (interstitial) blinds, awnings and canopies, can also be included provided that assumptions on how these are operated are simple enough to represent a typical user behaviour, are clearly described in the report and are included in the dwelling's operation manual.

The performance of solar shading devices is sensitive to the orientation and dimensions of the device, their solar reflectivity and other features; the shading effect delivered varies with time of day. In multi-dwelling buildings, different shading solutions may be adopted depending on façade orientation and storey height. The number of dwellings selected as a sample should cover all variations present in the design.

Solar control glazing, e.g. low g-value glass, provides an effective form of shading by reducing the amount of solar energy that is transmitted into a space. When a 'whole-window' g-value is quoted, the value includes the shading effect from the window frames and so is always lower than the equivalent 'centre-pane' value. Modellers should always clarify with designers and manufacturers whether the g-values provided are centre-pane or whole-window values and then model accordingly.

Trees and vegetation should not be included as shading objects in the modelling as they are not a fixed element; their size, conditions and shading effect can vary significantly depending on the season and the size and health of the plant. This is a conservative approach, and the shading effect of plants could improve summer comfort.

Internal shading devices can be included in the model, but only when they form part of the dwelling's base build or a major retrofit.

All shading should be designed to avoid conflicting with operable windows and ventilation devices, which could compromise natural ventilation. Any restrictions to air flow created by shading devices should be represented in the model.

The approach to modelling operable devices will depend on the modelling software's capabilities. The advice of software providers should be followed on how best to model complex shading devices, especially when they are moveable.

In care settings and for other institutional buildings, shading should be designed for residents who may have limited mobility, dexterity and cognitive ability. In some settings, shading devices may be operated by others on behalf of residents. The operational assumptions modelled in such settings should reflect this and the assumptions made stated clearly in the modelling report.

The modelling report must describe the assumptions made about all shading features, see Appendix C.

3.4 Natural ventilation, window and door openings

Caution: *The guidance given here on the modelling of ventilation openings may differ from that prescribed in guidelines for demonstrating compliance with building regulations: Approved Document O – for use in England; Approved Document O – for use in Wales; and, in Scotland, the Building Standards Technical Handbook: Domestic.*

Ventilation provision should satisfy all relevant regulatory requirements, particularly those related to purge ventilation – Approved Document F: *Ventilation* in England or Wales (HMG, 2026b; TWG, 2026b) or the *Building Standards Technical Handbook* in Scotland (TSG, 2026) – and fire regulations – the Fire Safety (England) Regulations 2022 (HMG, 2022) and the equivalent in Scotland and Wales. All openings must also provide the required guarding and protection from falling.

Natural ventilation openings may include operable windows, roof lights and patio doors – whether opening onto the ground floor or a balcony – and ventilation panels (opaque or transparent openings, often to the side of glazing, with or without louvres, security protection and insect or bird mesh). The design guides listed in Appendix A, section A.1 provide illustrations of many different types of ventilation devices. Internal doors if opened, may improve cross ventilation and stack ventilation.

A dwelling may have many different operable devices, each of which opens in a different way and by a different amount. Modellers must explicitly model each ventilation device and internal door present in each modelled space.

In dynamic thermal models, the calculation of the air flow rate through openings is generally specified using the *effective area* or a *discharge coefficient*. Calculators are readily available that produce the equivalent area and/or discharge coefficient for simple windows and doors of different type, size and opening angle, e.g. the Part O Simplified Method Calculator (FHH, 2024) and the Discharge Coefficient Calculator (DfE, 2018). CIBSE AM10 (CIBSE, 2026c) includes guidance on how to calculate discharge coefficients using the statistically effective area model technique. Manufacturers can provide the discharge coefficients of geometrically complex ventilation devices, such as louvres. Clarification on the way that the air flow through ventilation devices is defined can be found in Appendix D as well as in CIBSE Guide A (2015b).

Design has a significant effect on the *air flow through* natural ventilation openings. Features of importance include the following:

- The overall size, the sash thickness and overlap with the fixed frame, and the mode of opening (top hung, side hung, sliding, tilt and turn, etc.).
- The angle through which hinged devices can be opened. This defines the distance, called the thrust length, between the fixed frame and open window's sash frame. For windows that open outwards, this will be limited by the distance that people can safely reach, often taken as 650 mm from the inside face of the wall (HMG, 2021; TWG, 2022). The angle of opening may be limited to less than this by the length of the window stay or by window opening restrictors.

- Clashes with fixed or movable internal or external objects, such as safety barriers or shading devices, in which case the consequential reduction in the equivalent area or discharge coefficient of the opening should be accounted for in the modelling.

Tall buildings and communal areas are particularly likely to have window opening restrictors. Windows and other devices can be modelled as operable without restrictors, provided they have sill heights or guarding that complies with safety requirements in the relevant statutory guidance (HMG, 2021; TSG, 2026; TWG, 2022). However, site-specific noise, security and air quality concerns may limit when and the extent to which windows may be opened, see section 3.8.

The following modelling assumptions, applicable to all days in the year, should be followed:

Windows, roof lights and ventilation panels, or other natural ventilation openings, may open differently depending on whether or not the space is occupied. For assumed occupancy periods see section 3.7 and Table 2.

- When spaces are occupied, openings should be modelled as closed when the operative temperature in the space is below 22 °C and fully open at operative temperatures of 26 °C or more. Between 22 °C and 26 °C, openings should be assumed to open linearly as the operative temperature in the space increases.
- When spaces are unoccupied, i.e. living spaces other than bedrooms between 10 pm and 9 am, openings should be modelled as closed and only modelled as open if each opening in the space is designed such that it remains safe and secure, e.g. using lockable opening devices or security shutters. These security provisions often prevent the ventilation device opening to its full extent. The opening should be modelled with the equivalent area and/or discharge coefficient appropriate to the secure opening for these hours.

Patio doors have an opening regimen that is different during the day and at night.

- During the day, i.e. 9 am to 10 pm in living rooms and 8 am to 11 pm in bedrooms, patio doors should be modelled in the same way as other openings.
- At night, i.e. 10 pm to 9 am in living rooms and 11 pm to 8 am in bedrooms, patio doors should be modelled as closed. However, if patio doors in bedrooms have a tilt-and-turn operation, or some other security mechanisms such as shutters or bars, they may be open and modelled with the equivalent area and/or discharge coefficient appropriate to the secure opening.

Internal doors have an opening regimen that differs for bedrooms and other spaces.

- Internal bedroom doors can be modelled as open or closed during the day. At night, i.e. between 11 pm and 8 am, bedroom doors should be modelled as closed.
- Internal doors to rooms other than bedrooms may be modelled as open or closed at any time.
- If the opening of internal doors would contravene fire safety requirements or other constraints, such as privacy, the affected internal doors should be modelled as closed.

Access doors, which provide the primary means of entering or leaving a dwelling and securing the property, should be modelled as closed at all times.

Where there are site-specific noise, security or air quality constraints that (further) limit the use of natural ventilation devices (section 3.8), these should be applied in Stages 2 and 3 of the modelling strategy described in section 2.3.

The modelling report should include a detailed description of all the windows, doors and other ventilation devices, the assumed physical constraints due to security and safeguarding concerns and any further constraints due to site-specific noise, pollution or other air-quality concerns, see Appendix C.

3.5 Infiltration, mechanical ventilation and cooling

Infiltration should be modelled as zero for new builds and in retrofits where airtightness is expected to meet new-build standards.

For existing buildings and retrofit projects the modelled infiltration rates should be based on the targeted airtightness for the dwellings. CIBSE Guide A includes tables that provide empirical values for infiltration (ach) based on predicted airtightness levels ($\text{m}^2/\text{m}^2/\text{h}$ @50 Pa). The CIBSE tables also include ACR50 divisor figures, but these need to be adjusted based on the correct volume-to-envelope area ratio for the building – see CIBSE TM23 (CIBSE, 2022a).

The air supply and/or extract rates and locations from any MVHR or MEV systems should be set for each space based on the design specification. If the MVHR system has an effective summer bypass mode, then it should be modelled as operating in this mode between May and September, i.e. discounting the heat recovery. When the system's characteristics are not available, modellers may adopt the requirements of Approved Document F (HMG, 2026b; TWG, 2026b) or, in Scotland, the *Building Standards Technical Handbook* (TSG, 2026).

Mechanical ventilation systems that operate continuously, to provide air flows that meet background, i.e. whole dwelling, air requirements, are common, quiet and efficient. Such systems often have two fan speeds, a slow speed for background ventilation and a higher (boost) speed for occasional purge ventilation. Operating at the slow speed to provide background ventilation, such systems are compatible with a Stage 1 assessment, see section 2.3. If, in Stage 2, systems with higher rates of air flow are proposed, they should have manual controls, and the higher flow rates modelled only when they are necessary. Fans operating at higher speeds usually produce elevated noise levels. Modellers should only adopt ventilation rates that have been confirmed as compliant with the project's acoustic design criteria, i.e. that operate quietly. CIBSE Guide A (2015b) and the *ANC Acoustics, Ventilation and Overheating: Residential Design Guide* (ANC, 2020) suggest an upper limit for noise levels in the region of 30(±5) dBA for bedrooms and 35(±5) dBA for living rooms, see Appendix A, section A.2.

At modelling strategy Stage 3, mechanical cooling of *specific spaces* may be the only strategy possible to provide thermal comfort given the local, site-specific ventilation constraints on window opening. Systems include whole dwelling air conditioning and systems that provide space-specific 'comfort cooling', 'air tempering', 'trim cooling' or 'peak lopping'. Systems with low energy demands should be prioritised. The available cooling capacity should be set within models, taken from the design specification. Such systems should be modelled so that they operate only at times when natural ventilation systems cannot achieve the required space temperatures.

The modelling report should include a detailed description of how infiltration, background and/or additional mechanical ventilation were modelled and a description of the modelling of any mechanical cooling systems, see Appendix C.

3.6 Ceiling fans

Ceiling fans are an effective and low energy way of improving thermal comfort in warm indoor environments. Fans generate air movement, which creates a personal cooling effect by increasing the rate of heat loss by evaporation and convection. Where used in conjunction with mechanical ventilation and cooling systems, ceiling fans can reduce energy demand.

Ceiling fans are acceptable systems in all three stages of the modelling strategy, provided that they are:

- installed as part of the base build or a major retrofit
- under the personal control of the space's occupants, e.g. by a manually operated switch or via electro-mechanical controls
- designed to operate within acceptable noise limits, as defined in relevant regulations and best practice guidance.

Fans with low energy consumption should be chosen and installed so that they are safe, quiet in operation and do not cause light flicker or other undesirable effects. Ceiling fans are unlikely to be feasible in spaces with low ceilings, e.g. below 2.4 m. Guidance on the selection, performance and installation of ceiling fans can be found in the *Ceiling Fan Design Guide* (Raftery and Douglass-Jaimes, 2020).

The cooling effects of the increased air movement generated by ceiling fans is accounted for within this version of TM59 by applying an uplift to the temperature thresholds within the compliance criteria. The uplifts permitted for Criterion a and Criterion c are detailed in section 2.4. No uplift in the temperature thresholds is permitted in conjunction with Criterion b or Criterion d. The increase is applicable to all occupant types, including vulnerable people. The increase in the temperature threshold for predominantly naturally ventilated spaces is prescribed in British Standard BS EN 16798-1 (BSI, 2019). For spaces that are predominantly mechanically ventilated, the temperature threshold uplift is given in CIBSE Guide A: *Environmental design* (2015b) and CIBSE AM10: *Natural ventilation in non-domestic buildings* (CIBSE, 2026c).

Modellers should seek guidance from the thermal modelling software vendor as to whether the uplift in temperature thresholds is applied automatically by the software. If not, the uplift can be accounted for easily by post-processing the predicted operative temperatures.

The modelling software must not double count the benefit of ceiling fans by adjusting the calculation of operative temperature (e.g. the weighting of air and mean radiant temperature) as well as uplifting the operative temperature threshold. For software that provides an option to set the background air speed, a low value should be selected, e.g. 0.1 m/s whether or not ceiling fans are operating, mechanical ventilation systems are functioning and natural ventilation devices are open or closed.

The modelling report should explain how any ceiling fans were modelled, including their presumed locations, performance and mode of operation, see Appendix C. Guidance on the use of proposed ceiling fans, including the increased risk of dehydration, should also be included in the Home User Guide.

3.7 Internal heat gains and profiles

Overheating risk can be exacerbated by internal heat gains from people, equipment, lighting and heating systems.

The internal heat gains and profiles to be used for the purposes of assessing overheating risk in houses and apartments using dynamic thermal models and the TM59 methodology are provided in Appendix E, Tables E.1 and E.2. They are intended to represent an upper level of reasonable occupancy to give a rigorous test of a dwelling's ability to mitigate overheating. The profiles should only be modified for other residential buildings, such as care homes, student accommodation, prisons, hotels, etc., provided that assumptions are reported and justified in the modelling report.

The amount of heat gain to an individual space is determined by the purpose of the space. This should be identified from the description provided with the dwelling design details. The minimum space standards for rooms in UK homes (DCLG, 2015) will aid the designation of rooms, especially whether bedrooms can be used for single or double occupancy, or whether they could be classed as a home office. Home offices are here defined as rooms that are smaller than the minimum permitted size for a bedroom but can accommodate a 60 × 100 cm desk and chair for home working. The required floor areas of bedrooms in houses of multiple occupancy are given in MHCLG (2018).

3.7.1 Heat gains from occupants, equipment and lighting

The heat gains assumed for living rooms, kitchens, bedrooms and communal areas are unchanged from those given in the previous version of TM59 (CIBSE, 2017). This version of TM59 also includes heat gains for home offices (Table E.1). The potential for home working in bedrooms and living rooms is already factored into the heat gain profiles for these spaces.

The daily heat gain profiles are presented as a peak gain and the fraction of the peak that applies at each hour of the day (Table E.2). All times given are local time (i.e. British Summer Time from April to October approx., which is one hour ahead of Greenwich Mean Time). If necessary, modellers should shift the profiles to match the timing convention in other geographical locations. The profiles are based on a UK household electricity survey conducted in 2010/11 (Palmer et al., 2013; Intertek, 2012) and will be updated as new data emerges. Modellers may use the split between the radiant and convective portions of the sensible heat gains that is assumed within the model. Bedrooms are assumed to be occupied for 24 hours each day and other spaces (living rooms, kitchen, home offices) from 9 am to 10 pm. The same profiles should be applied throughout the year for both weekends and weekdays.

The heat gains from occupants to the living rooms, kitchens and living/kitchen areas increase with the number of bedrooms in the dwelling. Each active person should be assumed to generate a peak sensible heat gain of 75 W and a peak latent heat gain of 55 W; heat gains from people who are asleep are 70% of these values (CIBSE, 2015b).

Studio apartments are assumed to have two people living in one space – a combined bedroom, small kitchen and working and living area. The occupancy heat gains for dwellings with up to three bedrooms are given in Tables E.1 and E.2. The gains from occupants should be increased pro-rata for dwellings with more than three bedrooms.

The heat gains from equipment depend on the type of space: kitchen, living room, living/kitchen, bedroom or home office (Tables E.1 and E.2). These heat gains account for both equipment installed as part of the base build and any electrical items likely to be introduced by the occupants.

The occupancy heat gains can be assumed as zero in spaces for which there is no specified profile. This includes circulation areas within dwellings as well as communal spaces, e.g. the hall, stairs and landings, which tend to be irregularly and only lightly occupied. Heat gains from lighting and, where present, community heating systems and DHW pipework (section 3.7.2) should be applied where applicable to these spaces.

The heat gains from people, equipment and lighting may be assumed to be zero for some other spaces within dwellings, e.g. conservatories, utility rooms, home gyms, bathrooms, ensuite bathrooms, WCs, cellars, lofts, walk-in storerooms and wardrobes, etc.

Lighting heat gains to all the occupiable spaces within dwellings should be 2 W/m² of usable floor area from 6 pm to 11 pm, which assumes that all spaces are well daylight. The same value is applicable to all communal areas unless passive infrared (PIR) sensors are installed, in which case zero lighting heat gains may be assumed.

The modelling report should clearly state the gains and profiles applied to all spaces, see Appendix C.

3.7.2 Gains from heating systems

When applying the TM59 methodology, it may be assumed that during the May to September period space heating systems are inoperative.

Heat gains from DHW cylinders, HIUs, hot water distribution pipework and heat maintenance tape should be accounted for in the modelling as they can increase overheating risk within dwellings and communal areas.

In buildings with a community heating system, the distribution pipework often runs along corridors and through other communal areas. These heat gains should be imposed uniformly along the circulation route and applied at every hour of every day throughout the year. In new buildings, where design data is not available, the guidance on maximum permitted heat losses from pipework given in Approved Document L for England or Wales (HMG, 2026a; TWG, 2026a) or the *Domestic Building Services Compliance Guide for Scotland* (TSG, 2023) can be used. The heat gains from heat tape may be taken as 8 W per metre run and should be applied in addition to the heat loss from the pipework itself unless there is a confirmed heat tape control system, in which case only the standing losses from the pipework need be modelled.

The heat gains from any DHW cylinders and HIUs located within modelled dwellings should be allocated to the spaces in which they are located, often a cupboard within a bathroom or off a landing or hallway. The gains should be applied at a constant rate every hour throughout the year. The standing gains from the HIU should be based on the manufacturer's data.

For new dwellings that have individual heating systems, the heat gains from the heating systems should comply with Approved Document L in England or Wales (HMG, 2026a; TWG, 2026a) or the *Building Standards Technical Handbook* in Scotland (TSG, 2026). The hot water pipework should therefore be well insulated and not permanently charged and so, for the purpose of this assessment, the related heat gains may be assumed to be negligible and can be excluded from the model. The heat gains from DHW cylinders should be based on the manufacturer's data or, if not available, by using the maximum permitted heat losses (HMG, 2026a; TWG, 2026a; TSG, 2026).

When assessing buildings subject to a major retrofit where existing heating systems are retained, assumptions about pipework and DHW gains should be adjusted according to the heating system type, the year of construction and the relevant minimum energy efficiency requirements at the time of installation; when this information is not available, it should be assumed that pipework and DHW cylinders are not insulated.

The modelling report should state clearly the assumed heat gains from space heating and DHW systems and pipework and the spaces in each dwelling and/or communal area where these gains were assumed to occur, see Appendix C.

3.8 Noise, security and air quality constraints

Site-specific noise, security and air quality concerns may constrain the opening of ventilation devices in some spaces, in some buildings and at specified times of the day (e.g. different constraints for daytime and night-time periods). Such constraints may preclude the modelling of windows, doors, etc. in the manner prescribed in section 3.4. These additional site-specific constraints are accounted for in Stages 2 and 3 of the TM9 modelling strategy, see section 2.3.

External noise is a key concern that can deter occupants from opening windows and other ventilation devices in warm weather, thus limiting the effectiveness of natural ventilation for cooling. If occupants do choose to open ventilation devices, they are left subject to excessive noise.

Noise may affect only some areas of a building, e.g. only one side and/or the lower floors. A report by a qualified noise consultant should indicate the largest opening areas that are acoustically permissible for each window or space, on each façade, of each storey, of each building, both during the day and at night. Acoustic reports should state the maximum *equivalent areas* for openings that their assessments are based on. If following the ANC guidance (ANC, 2020), the noise consultant may recommend a maximum number of hours or nights for which it is acoustically acceptable to keep specific windows open to a particular (equivalent area) extent. If assessing to the night-time noise criteria in Approved Document O (HMG, 2021), any constraints may only concern bedroom windows during the night-time period. Constraints due to noise should be applied to models only for the hours recommended by the noise consultant. Physical restrictors are not intended or required to enforce these opening limits; modellers apply the limits to demonstrate that a reasonable balance between thermal and acoustic comfort is achievable by the occupant. Night-time noise can cause sleep disturbance, so, in typical sound environments, night-time constraints on open areas are likely to be more onerous than daytime constraints.

The opening regimens assumed in Stage 2 (section 2.3) should align with the recommendations of the noise report while simultaneously being modelled to provide effective heat mitigation. For example, windows may be open only during the hottest days of the year, or the extent and duration of openings at night may be reduced.

If acoustically attenuated ventilation devices are adopted, the corresponding equivalent areas or discharge coefficients must be used when modelling the airflow through these devices, see section 3.4.

Security concerns may constrain window opening, especially for windows on the ground floor or windows that can be easily accessed, e.g. off balconies and adjacent roofs. Such openings may be

protected with fixed or lockable louvred shutters, window grilles or railings, or have a limited, but lockable open position. These may, but need not, constrain the extent to which windows can be opened. The design guides in Appendix A, section A.1 give illustrative examples.

Site-specific air quality concerns, e.g. due to dust, pollution and particulates, may also constrain the operations of external openings. These constraints should also be incorporated at Stage 2 of the TM59 modelling strategy.

The modelling report should clearly state the spaces to which noise, security or air quality constraints apply and how these have been addressed and modelled, and identify the spaces that do not meet the TM59 criteria as a result of the constraints, see Appendix C.

Appendix A: Further reading

A.1 Sources of guidance on dwelling design to minimise overheating

Acoustics, Ventilation and Overheating: Residential Design Guide (ANC, 2020). This guide provides advice, supported by detailed analytical methods, to enable design and retrofit for the passive control of overheating while limiting the effects of noise.

CIBSE TM60: Good practice in the design of homes (CIBSE, 2018). The principles of designing energy efficient and comfortable new dwellings are outlined. A subsection focuses on avoiding overheating, and a useful checklist of the common causes of overheating and mitigation measures is included.

Part O 2021 Technical Guidance (FHH, 2022). This illustrated guide explains the steps in designing dwellings to meet either the simplified method or the dynamic thermal modelling method for demonstrating compliance with Approved Document O for England. The sequence of steps that can be followed to reduce overheating risk are presented. Illustrations provide a spur to innovation, especially in the design of windows and shading.

Overheating in New Homes: Tool and guidance (GHA, 2019). This guide contains advice, supported by images, about the design of UK dwellings to avoid and mitigate overheating. An early-stage design tool provides a scoring system to quickly check if new dwelling is likely to overheat.

Shading for Housing: Design guide for a changing climate (GHA, 2023). This guide identifies 19 different static and dynamic strategies of shading dwellings. For each strategy, a case study, with illustrations, is presented. A common template is used to indicate each shading strategy's characteristics: overheating mitigation potential, operability, daylight provision, maintainability, etc. This guide is a stimulus to more innovative window design.

Solar Shading of Buildings (Littlefair, 2018). This BRE report describes commonly used shading devices for domestic and non-domestic buildings. The advantages and disadvantages of each device are explained; photographs provide inspiration for designers and other construction professionals.

Energy, Overheating and Daylight in Tall Buildings Study (Buro Happold, 2018). Houses and apartments in London are especially at risk of overheating. London has planning requirements that require large developments to be assessed for overheating risk. This document explores the viability and technical feasibility of meeting and surpassing targets for the passive energy performance in tall developments. It illustrates which tall buildings are at risk of overheating and the measures that can be used to mitigate the risk. The guidance is supported by illustrations, diagrams and the results of modelling.

Avoiding Summer Overheating (Passivhaus Trust, 2021). This guide provides general advice on the avoidance of overheating, focused specifically on Passivhaus dwellings, and introduces an overheating design tool. The overheating criterion adopted in Passivhaus design tools differs from those described in this Technical Memorandum.

Solutions to Overheating in Homes: Evidence review (ZCH, 2016). This review provides a thorough treatment of measures to mitigate overheating in new dwellings and refurbishments. It covers all aspects, from the design of the urban realm, through dwelling form and fabric, to details of glazing, ventilation and building services. Other documents by the Zero Carbon Hub focus on various aspects of the overheating problem.

A.2 Overheating: relevant regulations, standards, guidelines and tools

Overheating regulation

Approved Document O: *Overheating* (HMG, 2021; TWG, 2022) and the *Building Standards Technical Handbook* (TSG, 2026). These three documents describe the approved methods of demonstrating compliance with building regulations on overheating in England, Wales and Scotland, respectively. All three offer a simplified method and a method based on dynamic thermal modelling which follows, with some modifications, the TM59 methodology. The Welsh and Scottish documents require that all dwellings are assumed to be Category I, not Category II, for which the lower temperature thresholds are applicable in Criterion a and Criterion b.

Overheating guidance for regulation compliance

Part O 2021 Technical Guidance (FHH, 2022). This guide is targeted at modellers and other specialists wishing to assess dwellings against the Part O compliance requirements. It includes flowcharts, diagrams and illustrations of the dwelling design solutions that can reduce overheating risk.

Part O Simplified Method Calculator (FHH, 2024). This Excel spreadsheet tool is an implementation of the simplified method of compliance in Approved Document O for England. The illustrations and user guide are particularly useful for defining the key dimensions of windows and doors and the calculation of the equivalent areas and discharge coefficients of windows and doors.

Basis of overheating criteria

BS EN 16798-1:2019: *Energy performance of buildings. Ventilation for buildings – Indoor environmental input parameters for design* (BSI, 2019). This British Standard defines the indoor environmental quality threshold to be achieved in buildings of Categories I, II, III and IV. These encompasses air quality, thermal environment, lighting and acoustics. The thermal comfort thresholds follow those in CIBSE TM52. The threshold uplifts if ceiling fans are installed are tabulated.

CIBSE TM52: *Limits of thermal comfort: avoiding overheating in European buildings* (CIBSE, 2013). Operative temperature and its use in calculating thermal comfort and discomfort is explained. The field studies that underpin the adaptive thermal comfort thresholds for different categories of building are explained. Three adaptive overheating criteria are presented and their application for interpreting the predictions of dynamic thermal models demonstrated.

Fundamental data for design and modelling

CIBSE Guide A: *Environmental design* (CIBSE, 2015b). This handbook provides guidelines, design criteria and fundamental data about: thermal comfort; overheating Criteria a, c and d; ambient indoor noise limits; thermal properties of materials and construction U-values; ventilation requirements; glazing solar transmission; the cooling effect of fans in mechanically ventilated spaces; and internal heat gains.

Shading design

CIBSE TM69: *Dynamic thermal modelling of basic blinds* (CIBSE, 2022b). Advice on representing the thermal and shading characteristics of operable, internal fabric blinds in dynamic thermal models is provided. Practical guidance is given about the selection, design and shading properties of internal fabric blinds.

Solar Shading for Low Energy and Healthy Buildings (ES-SO, 2018). This technical guidebook explains the thermal and solar processes influencing heat gains through windows with and without shading. Example calculations are based on methods provided by European and international standards. Although intended to be used by solar shading manufacturers and installers, it is also useful to building designers and other construction professionals.

Natural ventilation

Discharge Coefficient Calculator (DfE, 2018). This simple Excel tool can be used to calculate the discharge coefficient and equivalent area of hinged and sliding windows and doors based on either the angle of opening or thrust length.

CIBSE AM10: Natural ventilation in non-domestic buildings (CIBSE, 2026c). This guide provides practical guidance on the design of natural ventilation in non-domestic buildings. It is intended for all members of the design team and focuses on the implementation of natural ventilation strategies in contemporary practice.

Infiltration

Approved Document L (HMG, 2026a; TWG, 2026a) and the **Building Standards Technical Handbook** (TSG, 2026). These three documents describe the approved methods of demonstrating compliance with building regulations for maximum infiltration rates in England, Wales and Scotland, respectively.

CIBSE Guide A: Environmental design (CIBSE, 2015b). This handbook includes a section which outlines the main drivers of infiltration and provides indicative rates for different building types and airtightness levels. It also summarises estimation methods – from simple empirical approaches to multizone models – and highlights how infiltration affects energy use and moisture risk in design.

CIBSE TM23: Testing buildings for air leakage (CIBSE, 2022a). This document includes guidance on measuring infiltration by outlining approved airtightness testing methods, such as blower-door and low-pressure pulse techniques. It sets out the methodology for assessing air leakage in buildings and explains how infiltration is influenced by wind- and stack-driven pressure differences.

Mechanical ventilation

Approved Document F (HMG, 2026b; TWG, 2026b) and the **Building Standards Technical Handbook** (TSG, 2026). These three documents describe the approved methods of demonstrating compliance with building regulations for the design of mechanical ventilation systems and the limiting of noise levels in different spaces in England, Wales and Scotland, respectively.

Ceiling fans

Ceiling Fan Design Guide (Raftery and Douglass-Jaimes, 2020). This guide explains the benefits of ceiling fans, describes how ceiling fans work, and discusses the types and sizes of fans and their energy performance. It provides guidance and resources for the selection of fans and the design of spaces to accommodate them.

Heat gains from hot water

Approved Document L (HMG, 2026a; TWG, 2026a) and the **Building Standards Technical Handbook** (TSG, 2026). These documents prescribe (by reference) the maximum heat loss permitted from DHW pipework and storage vessels to ensure regulatory compliance.

Noise

Approved Document O Noise Guide (ANC, 2024). This guide sets out a method of demonstrating, to the building control body, compliance with the noise constraints in Approved Document O (HMG, 2021). The guide aims to provide clarity for practitioners and regulators so that assessments can be carried out consistently, and the outcome is repeatable and reliable.

Acoustics, Ventilation and Overheating: Residential Design Guide (ANC, 2020). This guide focuses on reconciling the competing requirements of ensuring dwellings do not overheat while retaining acoustic integrity. Its focus is new residential developments exposed to airborne sound from transport and internal mechanical services. A two-level approach to assessing ambient noise levels and the effects on likely window opening is described. The potential noise attenuation possible using alternative window designs is presented.

Other building typologies

CIBSE RI04: *ClimaCare: Climate resilience in care settings* (CIBSE, 2020). This CIBSE Research Insight summarises work undertaken by academic partners at University College London, Oxford Brookes University and the London School of Hygiene and Tropical Medicine as part of the ClimaCare pilot project, which monitored thermal conditions in five UK care homes and assessed overheating risks for vulnerable residents. It evaluates passive strategies for reducing overheating and highlights the need for climate-resilient design and management practices in care settings as heatwaves become more frequent and severe. Further studies carried out by the ClimaCare team are available (ClimaCare, n.d.) and the CIBSE Research Insight will be updated to reflect these additional findings.

Appendix B: Summary of the modelling strategy: opening constraints, ventilation and cooling assumptions, applicable overheating criteria and reporting

Stage 1: Assessment assuming unconstrained natural ventilation

- Only passive heat mitigation measures are included in the model.
- Any constraints on natural ventilation openings due to site-specific noise, security or air quality concerns are not modelled.
- Natural ventilation devices (windows, patio doors, etc.) are modelled as in section 3.4.
- Background mechanical ventilation may be included (section 3.5).
- Ceiling fans may, if necessary, be included (section 3.6).
- Full mechanical ventilation and active cooling systems must *not* be included.
- Criteria a and b should be used for spaces inside dwellings.
- Criterion d should be used for communal areas (section 2.4.4).
- The Stage 1 results should be reported with and without any internal blinds and ceiling fans.

Stage 2: Assessment incorporating ventilation constraints

- All the passive heat mitigation measures, including any ceiling fans, as modelled in Stage 1 should be retained in the model.
- All applicable constraints on natural ventilation openings should be modelled for the appropriate time periods (section 3.8).
- Additional passive heat mitigation measures may be introduced.
- Ceiling fans may be included (section 3.6).
- Additional mechanical ventilation may be included (section 3.5).
- Active cooling systems of any kind must *not* be included.
- Criteria a and b should be used for spaces which are predominantly naturally ventilated, i.e. natural ventilation devices operable $\geq 50\%$ time.
- Criteria b and c should be used for spaces which are predominantly mechanically ventilated, i.e. natural ventilation devices operable $< 50\%$ time and with mechanical ventilation installed.
- Criterion d should be used for communal areas (section 2.4.4).
- The Stage 2 results should be reported.

Stage 3: Assessment with full mechanical ventilation and active cooling

- All the passive heat mitigation measures assumed in Stage 1 and any introduced in Stage 2 should be retained in the model.
- All applicable constraints on ventilation openings should be modelled (section 3.8).
- Enhanced mechanical ventilation and active cooling systems may be included (section 3.5).
- Ceiling fans may be included (section 3.6).
- Active cooling systems may be included.
- Criterion b and c should be used for spaces with mechanical cooling.
- Criterion d should be used for communal areas (section 2.4.4).
- The Stage 3 results should be reported.

Overall: Compliance must be demonstrated at Stage 1 and then again at either Stage 2 or Stage 3 where constraints apply.

Appendix C: Reporting requirements checklist

Modelling approach and weather data

- Give the dynamic thermal modelling software used, its name and version number.
- State the sample of dwellings and circulation spaces chosen for the assessment with an explanation of why this was appropriate and representative of the whole development.
- State precisely which weather file(s) were used for the assessment, including version number, and justify the choice given the location of the dwellings.
- Confirm whether the analysis follows the guidance in TM59 and/or is being undertaken to test compliance with building regulations on overheating.
- Provide details of the modeller and reviewer.

Geometry and construction

- Provide a plan of the development, showing the site position, layout of dwellings and north pointer.
- Identify significant site features, and explain if and how these shade each of the dwellings in the sample and the method of modelling them.
- Provide illustrations of the exterior of the modelled dwellings and communal areas showing clearly the position and size of windows, doors and other ventilation devices, and self-shading features such as balconies.
- Show the internal layout for the dwellings as modelled with the use of each space indicated, e.g. double or single bedroom, home office, living, living/kitchen, circulation, etc.
- Describe the construction details of each internal and external building element (walls, floors, ceilings, roof) indicating the layers of material, their thickness and assumed thermo-physical properties, including overall U-values.
- For each window provide the area of glass and the glazing specification. Include the assumed glazing g-value, confirming whether this is a centre-pane or whole-window value.
- Explain the assumptions made about heat flow through surfaces bounded by other spaces that are not explicitly modelled.

Shading

- Provide the geometry of fixed external shading features, e.g. the length, depth and solar transmission properties of overhangs, side fins, louvres and brise soleil.
- State the assumed solar transmission characteristic and assumed operation of all operable shading devices, e.g. external movable shading, within-pane window blinds, and internal curtains, louvres and blinds.
- Describe if and how the assumed internal and external shading devices clash with the opening of window and ventilation devices. Explain how this was accounted for in the natural ventilation modelling.
- Comment on any potential benefits of local trees and confirm they were not included in the overheating assessment.

Ventilation, windows and door openings

- Describe each window, patio door and ventilation device and how they operate.
- Provide the following information both with and without any noise, air quality or security constraints:
 - the assumed maximum opening angle or thrust length for each window opening
 - the free area and maximum equivalent area and/or discharge coefficient assumed for all ventilation openings and how these were established

- the limitations assumed for patio door and window opening, e.g. human reach, maximum stay length, tilt-and-turn capability, clashes with internal or external shading, guarding or security provision, etc.
 - the opening and closing regimen assumed for each ventilation opening. Any deviations from the TM59 opening regimen prescribed above should be highlighted and justified.
- The assumed opening and closing regimen of internal doors.

Infiltration and mechanical background ventilation

- State how the background infiltration rate has been modelled for both the dwellings and communal areas.
- Describe any mechanical MEV and MVHR background ventilation systems that were modelled.
- Give the times of operation of the mechanical systems, the spaces where air was supplied and extracted, and the assumed ventilation rates.
- For MVHR systems give the assumed operation of any heat recovery/summer bypass functionality.
- Describe any necessary cooling systems included at Stage 3 including the cooling capacity, supply temperatures and room set points.

Ceiling fans

- Indicate which spaces are assumed to have ceiling fans and provide the fan specification, e.g. size and performance, assumed operating times and assumed air speed.
- Outline any design constraints imposed by the ceiling fans, e.g. on ceiling height, internal furnishings or artificial lighting provision.

Internal heat gains

- Confirm that the TM59 occupancy, equipment and lighting heat gain profiles have been used or state, and justify, the assumed heat gain profiles for every space where this is not the case.
- Provide the heat gains assumed for the space heating and DHW systems and define the spaces in which the gains were assumed to occur.
- Explain the heat gain mitigation measures implicit in the assumptions, e.g. the insulation of DHW tanks, pipework and other heating system components.

Noise, security and air quality constraints

- State whether a report produced by a qualified noise consultant, or other expert, informed the modelling.
- Describe which building façades, dwellings and spaces are affected by site-specific noise, security or air quality issues and the mitigation measures that have been modelled.
- Describe if and how noise, security, air quality and safety concerns have imposed constraints on the modelled size, design and operation of windows and other ventilation devices.

Overheating criteria

- State whether dwellings were assumed to be Category I or Category II.
- For each modelled space, state which overheating criteria were used at each Stage of the modelling strategy. Including any criteria applied to spaces other than those addressed by the TM59 criteria.
- Identify, for Criteria a and c, the spaces for which a temperature uplift due to ceiling fans has been assumed.

Overall assessment

- State whether each space, and the dwelling overall, passed the overheating assessment at Stage 1. Report the results with and without any internal blinds and ceiling fans.
- For those dwellings subject to Stage 2 modelling, state whether each space, and the dwelling overall, passed the overheating assessment at Stage 2.
- For those dwellings subject to Stage 3 modelling, state whether each space, and the dwelling overall, passed the overheating assessment at Stage 3.
- Clearly state the results of the overheating assessment, for each space, dwelling and communal area, and whether overall compliance has been achieved.
- State how any mitigation measures required to achieve a pass should be applied across the whole site not just the sample of dwellings assessed.
- Where compliance is not demonstrated, make recommendations for how results might be improved.

Recommendations

- Highlight the heat mitigation measures adopted in producing the results both for passive dwellings and those reliant on mechanical ventilation and cooling systems.
- Provide recommendations for further passive heat mitigation measures that could be adopted to further reduce overheating risk.
- In larger developments, explain how the passive designs, and the designs with mechanical ventilation or cooling, should be applied to the other, unmodelled dwellings.
- Advise on any further analysis that may be necessary, especially if the final designs will deviate from those which were modelled.
- Be clear about which information should be included in the client's contract requirements and the Home User Guide.

Appendix D: Modelling ventilation openings

Dynamic thermal modelling software tools generally calculate the air flow through an opening as a function of the ‘effective area’ and the pressure difference across the opening. The effective area can be calculated from the ‘free area’ and the ‘discharge coefficient’ of the ventilation device. The free area and effective area differ from the ‘equivalent area’. Dynamic thermal models use either the equivalent area (and a discharge coefficient of 0.62) or the discharge coefficient (and the free area) to calculate the effective area of a ventilation device, such as a louvre or window.

The *free area* of a ventilation device (window, louvre system, etc.) is the area of the aperture in the building envelope (e.g. height × width) if the opening part of the device was removed.

The *effective area* is the product of the free area and the ventilation device’s discharge coefficient. The effective area can be measured using laboratory experiments or predicted using computational fluid dynamics (CFD) software: it cannot be determined directly based on the device’s geometry.

The *discharge coefficient* of a ventilation device is always less than 0.62. This is because air flow through the opening is impeded by the framing around glazing or by louvre blades, insect mesh, security components, etc., all of these also create flow friction. The manufacturers of complex ventilation devices can provide the discharge coefficients of their products, or they can be calculated using CFD.

The *equivalent area* is the area of a circular orifice (hole) in a flat plate which achieves an equivalent flow performance to the ventilation device. The flow performance of a thin sharp-edged circular orifice is well documented and has a fixed discharge coefficient of 0.62. The equivalent area may also be expressed as a percentage of the free area.

For windows, there are useful tools that calculate the discharge coefficient, equivalent area and effective area of windows. The Part O Simplified Method Calculator (FHH, 2024) has been developed specifically for testing compliance with regulatory requirements. The Discharge Coefficient Calculator (DfE, 2018) is referred to in Approved Document O (HMG, 2021). Both calculators are spreadsheet tools that require as input: the height and width of the window’s free area, the opening type, and the angle of opening or stroke length. Both tools can also be used for hinged, sliding or tilt-and-turn openings, including patio doors.

To illustrate the typical output of these tools, consider a top-hung window measuring 1.5 m wide by 1.0 m high with a maximum opening angle, α , of 30° (Figure B.1). The Discharge Coefficient Calculator tool yields the following outputs:

- free area, 1.5 m²
- stroke length (d), from the fixed frame to moving window (sash) frame, 0.52 m
- discharge coefficient, 0.40
- effective area, 0.59 m²
- equivalent area, 0.96 m², or 64% of the free area.

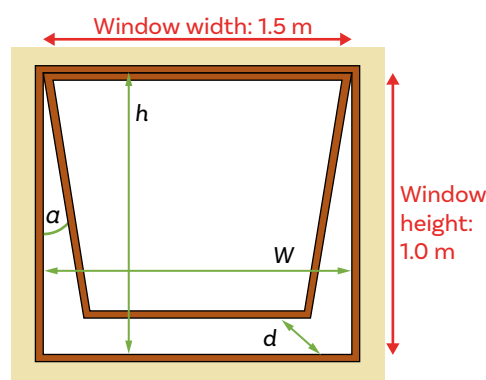


Figure B.1 Illustration of example window opening (DfE, 2018)

Dynamic thermal model inputs are then either a modelled opening of 0.96 m² or 64% (depending on the model software) with a discharge coefficient of 0.62 (usually the model default), or a modelled opening of 1.5 m² (100%) and a discharge coefficient of 0.40. To be consistent with noise ingress calculations by acousticians, the equivalent area approach to modelling is preferred.

Appendix E: Heat gain profiles

Table E.1 Occupancy and equipment heat gains

Dwelling/room type	Occupancy ^[1,2]	Equipment ^[1,2]
Studio apartment	2 people at 70% gains from 11 pm to 8 am 2 people at 100% gains from 8 am to 11 pm	Peak gain 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 gain of 85 W for the rest of the day
1-bedroom dwelling: living room/kitchen	1 person from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain 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 gain of 85 W for the rest of the day
1-bedroom dwelling: living room	1 person at 75% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain 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 gain of 35 W for the rest of the day
1-bedroom dwelling: kitchen	1 person at 25% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain of 300 W from 6 pm to 8 pm Base gain of 50 W for the rest of the day
2-bedroom dwelling: living room/kitchen	2 people from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain 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 gain of 85 W for the rest of the day
2-bedroom dwelling: living room	2 people at 75% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain 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 gain of 35 W for the rest of the day
2-bedroom dwelling: kitchen	2 people at 25% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain of 300 W from 6 pm to 8 pm Base gain of 50 W for the rest of the day
3-bedroom dwelling: living room/kitchen	3 people at 75% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain 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 gain of 85 W for the rest of the day
3-bedroom dwelling: living room	3 people at 75% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain 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 gain of 35 W for the rest of the day
3-bedroom dwelling: kitchen	3 people at 25% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain of 300 W from 6 pm to 8 pm Base gain of 50 W for the rest of the day
Single bedroom	1 person at 70% gains from 11 pm to 8 am 1 person at full gains from 8 am to 11 pm	Peak gain of 80 W from 8 am to 11 pm Base gain of 10 W during sleeping hours
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 gains from 9 am to 10 pm	Peak gain of 80 W from 8 am to 11 pm Base gain of 10 W during the sleeping hours
Home office ^[3]	1 person at 75% gains from 9 am to 10 pm; unoccupied for the rest of the day	Peak gain of 150 W from 9 am to 10 pm Base gain of 19 W for the rest of the day
Communal spaces	Assumed to be zero	Heating system gains only

Notes: [1] All times given are local time. [2] In addition to occupancy and equipment heat gains the spaces listed also have heat gains from lighting. [3] Home offices are rooms that are smaller than the minimum required size for a bedroom but can accommodate a 60 × 100 cm desk and chair for home working.

Table E.2 Heat gain profiles: the peak heat gains and the fraction of the peak applicable at each hour of the day, all timings are local time.

		Heat gain period and the hour at the end of the period																							
Peak heat gain		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	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
Sensible	Latent																								
(W)																									
Occupancy heat gains																									
Studio, 2 people	150	110	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
	75	55	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	75	55	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
	75	55	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
Two bed living/kitchen, 2 people	150	110	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
	150	110	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
Two bed kitchen, 1 person	150	110	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
	225	165	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Three bed living/kitchen, 3 people	225	165	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
	225	165	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, 1 person	75	55	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
	150	110	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
Home office, 1 person	75	55	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
Equipment heat gains		(W)																							
Studio	450	-	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
	450	-	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
One bed living room	150	-	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
	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	1	1	0.17	0.17	0.17	0.17
Two bed living/kitchen	450	-	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
	150	-	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
Two bed kitchen	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	1	1	0.17	0.17	0.17	0.17
	450	-	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
Three bed living/kitchen	450	-	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
	150	-	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
Three bed living room	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	1	1	0.17	0.17	0.17	0.17
	450	-	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
Single bedroom	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	0.13
	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	0.13
Double bedroom	150	-	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	0.13
	150	-	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	0.13
Lighting heat gains		(W/m²)																							
Lighting profile	2	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
	2	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0

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