




Part O 2021 (England)
Technical Guidance

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AIM OF THIS DOCUMENT

This document provides guidance on how to comply with the Building Regulations Part O requirement to assess and limit overheating risk in residential buildings. It focuses on homes ("residential dwellings" in Part O). While much of it is applicable to other types of residential buildings, specific considerations will apply to accommodation such as care homes.

The document provides the following:

Who should read this?

Chapter 1: Overview of Part O and Future Homes hub guidance:
- 1-page overview: Part O requirements, compliance routes, recommendations
- Overview diagram of Part O and both compliance routes
- 1-page overview of Simplified Method compliance route
- 1-page overview of Dynamic Modelling compliance route
- Recommended timeline of actions on projects, to reach Part O compliance

Housebuilders, for an overview of design and process implications

Designers and modellers, for an introduction

Chapters 2, 5 and 6: Requirements in both compliance routes: Part O requirements and reporting, Home User Guide

Chapters 3 and 4: more detailed guidance on each method, including flow chart diagrams, and a recommended step-by-step process

Chapter 6: Guidance on good practice principles, to deliver comfortable and well-performing homes, beyond simply compliance with Part O

Chapter 9: Worked example under each compliance route, following the recommended step-by-step process

Chapter 10: Case studies illustrating the calculations, modelling, and type of measures taken to achieve compliance in a range of schemes

Designers and modellers, for more advice on following either compliance route and on design implications

Throughout this document, text which is a direct quote from Approved Document O and references to the FAQs provided by DLUHC ("DLUHC FAQs") are shown in green italic.

Part O & limiting overheating risk in homes

1. OVERVIEW

1.1. Why overheating matters and what causes it

Homes in the UK are increasingly at risk of overheating, and this will worsen with climate change. This affects the comfort and health of residents, especially if it impairs sleep.

Overheating can be caused by the design of homes, in particular large glazed areas exposed to solar gains and without shading, and insufficient summer ventilation, for example because of small or very restricted openings. Contextual factors such as external noise or concerns about security and safety also matter, as they may prevent residents from opening windows for long periods of time.

1.2. Part O and Approved Document guidance

Building Regulations Part O introduces a new requirement to assess and limit the risk of overheating in homes, other types of residences and associated common rooms and spaces (e.g. corridors). Following guidance from Approved Document O (AD-O) requires compliance with:

- Either design limits under the new Simplified Method (defined in AD-O), OR comfort criteria under the dynamic thermal modelling route based on CIBSE TM59
AND
- requirements for "usability", including noise, pollution, safety (protection from falling and entrapment), and security, which apply to openings and features such as louvres and shading.

The Simplified Method sets maximum limits on glazed areas and minimum limits on free areas for ventilation through openings. These limits depend on:

- the location: a large part of London is defined as high risk, and the rest of the country moderate risk. Glazing and free area limits differ, and shading is required in high risk locations.
- the orientation of the façade with the largest area of glazing. Limits are generally more onerous in South and West orientations i.e. smaller glazed areas, larger free areas.
- whether the home is cross-ventilated i.e. with openings on opposite sides: if not, the glazing and free area limits are more onerous.

The dynamic modelling route uses the CIBSE TM59 comfort criteria and approach (with small adaptations). Compared to the Simplified Method, which relies on natural openings to dissipate heat, compliance may be demonstrated with more design flexibility and using mechanical ventilation where night-time openings cannot be relied on (e.g. because of noise). If this is not sufficient and passive measures have been exhausted, cooling may also be accepted towards compliance.

1.3. Recommendations

Part O has important implications for the design of homes and the project processes.

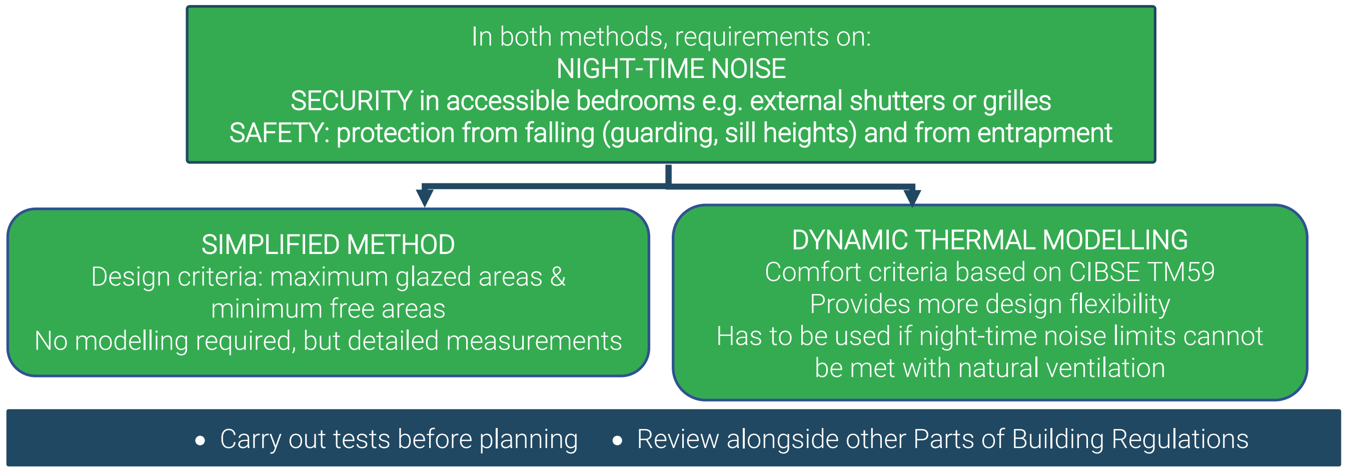
It is essential to consider the design of homes, in their context, to reduce overheating risk alongside other key requirements such as ventilation, beneficial winter solar gains, views and daylight. This will help ensure Part O compliance while also creating comfortable, energy efficient and resilient homes. Such integrated design must start at the early stages to capture the most effective passive design solutions and avoid the need for later changes and planning amendments.

Part O cannot be considered in isolation: it has planning implications, and its requirements overlap with other Parts of the Building Regulations including - among others - Part M (accessibility), Parts K (Protection from falling), B (Fire), and L (Energy). Ideally, a library of suitable products and configurations should be developed which can be applied across projects, reducing the need for iterations on each project.

Advice from a noise consultant should be sought early. On many sites across England, opening windows would mean exceeding the Part O limits for night-time noise, and these schemes will need dynamic modelling. Mitigation measures should be incorporated (e.g. landscaping, site and building layout, attenuated openings), and mechanical ventilation may be needed to provide much higher rates than background ventilation and to do so quietly.

Designing homes to be cross-ventilated is strongly recommended: it will make compliance easier in both methods, and is generally useful for effective ventilation and good quality homes.

Glazed areas should be of reasonable size, and those exposed to solar gains should be shaded, especially in London and the South. Most should be openable and allow good air flow. However, openings and other features must also ensure safety and security e.g. guarding, cill height minimum of 1100mm. Note Part B requires a maximum cill height of 1100mm for openings used as escape routes - in practice DLUHC consider a tolerance of +0 / -100mm to be reasonable. Openings in accessible bedrooms (e.g. on ground floors) should be secure. e.g. shutters, external grilles.



When to use each method?

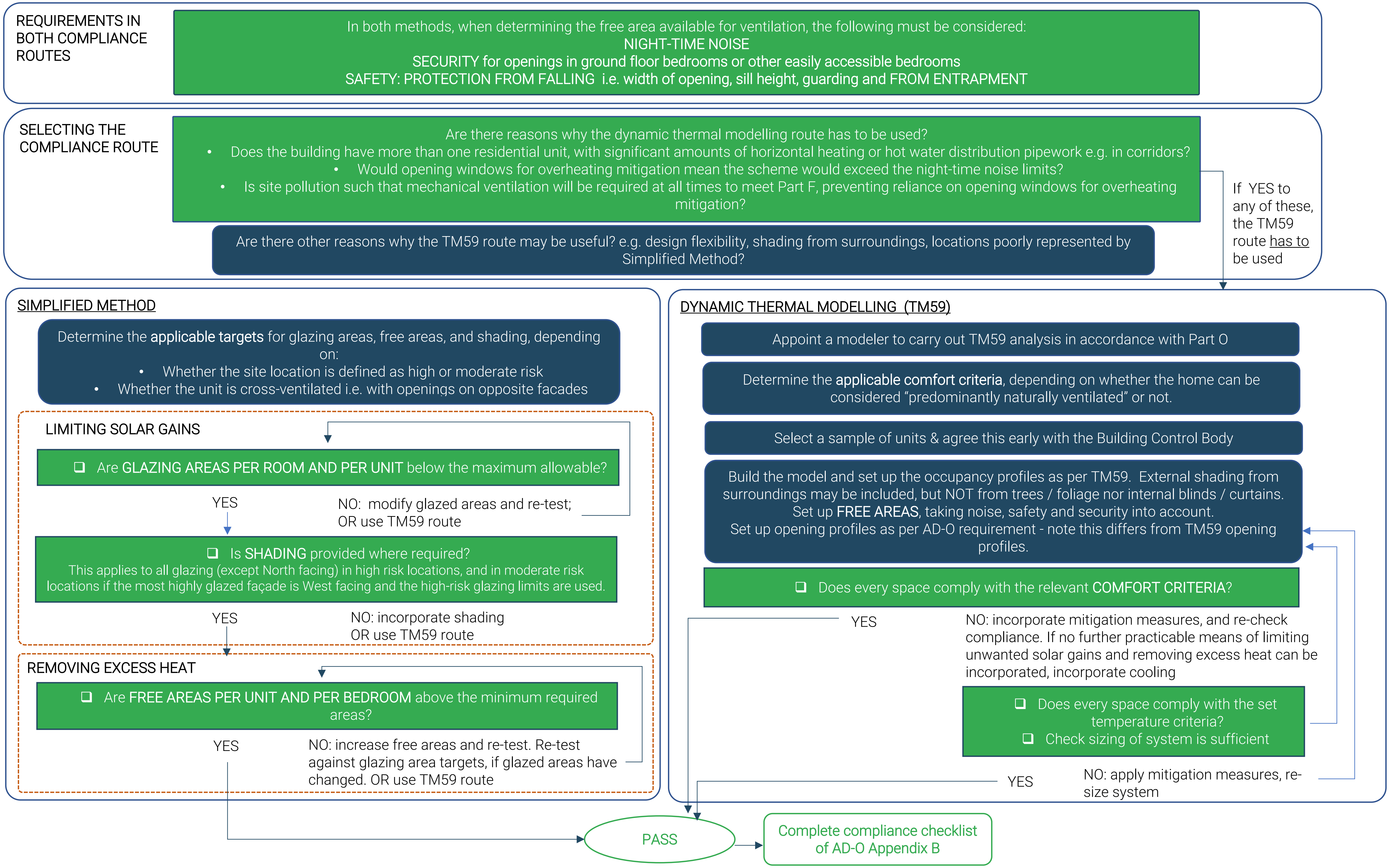
It is important to identify early which compliance route to adopt, as each route is time-consuming and may lead to different design options.

The dynamic modelling route must be used for schemes which have long corridors with horizontal heating / hot water pipes. It is also recommended if natural ventilation cannot be relied on for heat dissipation, in particular to meet night-time noise limits, or possibly due to pollution. Generally, it offers more design flexibility and can take account of factors such as shading from neighbouring buildings, which the Simplified Method does not. An experienced modeller should be appointed at an early stage.

The Simplified Method is typically more appropriate for "traditional" housing types outside of London. It does however require detailed measurements of the glazed areas, room areas, and openings, and there are idiosyncrasies in its criteria which mean that a detailed check is strongly recommended early on, before planning, in order not to require later design changes.

1.4. Overview of Part O

The following diagram provides an overview of Part O, including the requirements which apply in both compliance routes, criteria to select the most appropriate compliance route, and a high-level process under each route. Green boxes are compliance requirements in Part O; blue boxes are actions or questions recommended in this guidance, as part of the compliance assessment.



1.5. Simplified Method route: Overview

HOW IT WORKS: THE BASICS

- The Simplified Method does not require modelling, it is based on measurements of the design proposals, and a series of simple calculations using these measurements.
- The method sets design criteria as maximum glazed areas and minimum free areas, depending on the home's dominant orientation (South, West, East, North) and its location in the country (divided into two zones: "high" risk, which includes a large part of London, and "moderate" risk). Homes in "high risk" locations must also incorporate shading.
- In addition, the design must meet requirements on security and protection from falling and from entrapment, and must take noise at night and air pollution into account, as in the TM59 method.

WHEN TO USE THIS COMPLIANCE ROUTE

- The scheme does not include communal heating or hot water system running through long corridors (otherwise, AD-O states that TM59 must be used)
- Night-time noise limits in bedrooms are not exceeded (otherwise, it is unlikely the scheme will comply using the Simplified Method)
- The home has reasonable proportions of glazing and the openings provide large free areas e.g. wide-angle, side-hung windows, bi-fold or hinged patio doors, while being secure and safe.

THINGS TO WATCH OUT FOR

- Despite its name, the Simplified Method is not entirely simple, and it does require detailed information, often earlier than had been the case until now.
- Every single home and common space / room must be tested and shown to comply.
- Combined with the requirements for security and protection for falling and from entrapment (which apply in both compliance routes), the Simplified Method places significant restrictions on the design of elevations and opening systems, covering glazing proportions, shading, and the design of openings.
- Restrictions on glazing provision are particularly onerous for homes where the most-glazed façade faces South or West.
- Part O compliance cannot be checked in isolation, as it will have implications on compliance with other Parts of the Building Regulations including Parts M (accessibility), B (safety), K (security), and L (energy / efficiency), and with the planning system (e.g. design of elevations, daylight provision). This is also the case under the dynamic thermal modelling route, but design flexibility is more restricted under the Simplified Method.

GOOD PRACTICE APPROACHES TO COMPLIANCE

- Where standard house types are available, it is useful to test them in different locations and orientations, incorporate changes as required, and build a library of approved products (including windows, shading, and opening details)
- All, or the large majority of, glazing provided should be openable, and openings should be designed to maximise air flow: it is otherwise difficult to meet both the free area minima and the glazing maxima. This is important in all cases, but especially for homes in locations defined by Part O as "high risk" for overheating and which that are not cross-ventilated, as the free area should be at least 95% of the glazing area: this means that either, all glazed areas should be fully openable (e.g. side-hung, wide-angle), or that non-glazed openings should also be provided.
- Noise, pollution, security and safety requirements must be considered early to design integrated solutions, rather than relying on late design changes or "add-on" features.
- All homes in high risk locations (i.e. a large part of London) should incorporate external shading and/or solar control glazing.
- Wherever possible, homes should be designed so they can be cross-ventilated (i.e. with openings on opposite sides), as this provides more flexibility in glazing and free area targets. Beyond compliance issues alone, this is very useful to create more enjoyable and comfortable homes.
- The implications for energy use (e.g. winter solar gains), daylight and views must be reviewed alongside Part O compliance, for example when designing the size and location of glazed areas or incorporating shading: all these need to be considered as a whole.

Figure 1

House type "Room-in-roof semi-detached"; dual aspect; the South elevation, at the rear, is the most highly glazed façade. This house type can be assessed using the Simplified Method in moderate risk locations: it passes once more window panes are made openable - see details in Worked Example, section 8

1.6. Dynamic thermal modelling (TM59) route: Overview

HOW IT WORKS: THE BASICS

- This compliance route is based on dynamic thermal modelling. It is largely based on the CIBSE TM59 methodology, with a small number of adaptations. It requires specialist software and the input of an experienced modeller.
- Rather than setting design limits, this route is based on comfort criteria, and the modelling can take account of a wider range of parameters than the Simplified Method. This route therefore offers much more design flexibility.
- In addition, under this route compliance may be achieved using mechanical ventilation, especially on noisy sites where night-time window opening cannot be relied on. Where passive measures have been exhausted, cooling provision may be acceptable to comply with the TM59 criteria.
- Unlike the Simplified Method, it can be used on a sample of homes, to be approved with the Building Control Body (BCB), rather than every single homes. This should be agreed early on with the BCB, to avoid late requests for additional modelling and potential design changes.
- The design must also meet requirements on security and protection from falling and from entrapment, and must take noise at night and air pollution into account, as in the Simplified Method.

WHEN TO USE THIS COMPLIANCE ROUTE

- To follow AD-O, the dynamic thermal modelling route must be used if the home is served by a communal heating or hot water system, with long horizontal pipes in internal spaces).
- The dynamic thermal modelling route will likely be required if night time noise limits are exceeded. This is not strictly a requirement, but it is unlikely the scheme would comply through the Simplified Method, since openings would need to be assumed closed or very limited, and therefore unlikely to meet free area requirements.
- While not a requirement, AD-O recommends the dynamic thermal modelling route for buildings with specific site conditions that mean the building is not well represented by the two locations available in the Simplified Method e.g. project teams may decide to do so for some sites in Manchester city centre (see Appendix C of AD-O).
- The method allows to account for types of shading which cannot not be accounted for in the Simplified Method (e.g. shading from neighbouring buildings).
- This route generally offers more design flexibility on glazing provision and free areas than the Simplified Method. For example, it may be particularly useful in high-rise schemes, or where exemplar levels of passive design are being sought, with larger glazed areas to maximise winter solar gains alongside shading for summer overheating protection.

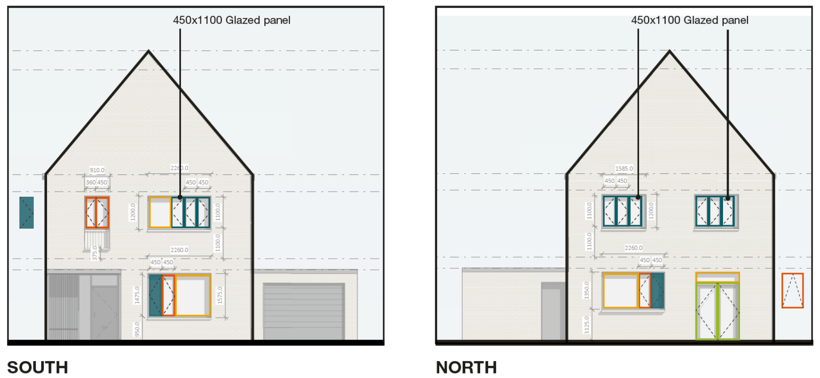
THINGS TO WATCH OUT FOR

- Dynamic modelling is an expert task. For the best advice and value, it requires an experienced modeller, who should be appointed ideally at an early design stage.
- Dynamic modelling can take time. Early involvement of the modeller reduces the risk of delays and late design changes. Experienced modellers can advise on how to build the numbers of sample homes and detail into their model, to best inform design development.
- Dynamic modelling is only as good as the inputs used. Design teams should provide the modeller with as much detail about the building as possible e.g. window reveal depths, which window panes open, and how much of the thermal mass is exposed. Teams should never assume the model matches the building just because it is complete: they should discuss the inputs as the design develops, and review modelling reports carefully.

- Shading from trees and other foliage, and from internal shading (e.g. blinds) cannot be taken into account in the model for Part O compliance purposes.
- Night-time window opening profiles are different from those in the "standard" CIBSE TM59. Software manufacturers are expected to release updates that will provide this functionality.

GOOD PRACTICE APPROACHES TO COMPLIANCE

- Because it allows more design flexibility, the dynamic thermal modelling route may often offer more opportunities to incorporate good practice design principles, and to consider the balance of glazed areas (location and amount), shading, and openings.
- This route offers opportunities to use the dynamic model beyond Part O compliance, for example for exploring design, energy use or daylight calculations.
- Using passive means to reduce reliance on mechanical systems (even if they are provided) will improve comfort by offering users a choice, and will help improve resilience and reduce energy use. While in this route mechanical cooling can be used towards compliance, this must be as last resort, once all passive means has been used and mixed solutions, including enhanced mechanical ventilation, have been explored. AD-O states that *Any mechanical cooling (air-conditioning) is expected to be used only where requirement O1 cannot be met using openings.* While no guidance is provided in AD-O, a reasonable approach could be to demonstrate that, if night-time window opening was not limited by noise levels, then compliance with TM59 criteria would be achieved.



KEY AND OPENING SCHEDULES

- Fixed glazed panel
  Closed
- Openable glazed panel in non secure location
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Locked to 6° open (night vent)
- Openable glazed panel
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Open if internal temp. > 22°
- Openable glazed panel with fixed louvres to outside
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Open if internal temp. > 22°
- Openable glazed door, fully closed at night
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Closed

Figure 2

Illustrations of house type well suited to tm59 route

1.7. Timeline

(Pre-project) Portfolio appraisals	Test standard home types. Build library of approved products and systems for glazing, openings, security and shading features.
Site selection	Seek advice from an acoustic consultant on noise conditions on site, especially at night. Review early design measures such as site layout, landscaping and building layout (e.g. dual aspect units, locating bedrooms away from a busy road), to ease compliance under both routes, reduce reliance on mechanical systems and create more comfortable and resilient homes. If the acoustician's advice is that mitigation measures are unlikely to be sufficient for internal noise levels in bedrooms to meet AD-O limits, dynamic modelling will be needed, and mechanical ventilation for heat dissipation is likely to be required, sized to provide much more than background ventilation rates.
Early design, up to planning application	Identify passive design opportunities and agree key design principles: orientation, glazing, shading, openings, single or dual aspect layouts. Together with the site noise appraisal, identify the likely compliance route for all homes (this could be a mix). Allow sufficient time (at least a few weeks) for tests and design iterations. If dynamic modelling is required, appoint an experienced modeler. Agree the design of openings and other features to meet Part O requirements for noise, pollution, safety and security: sill heights, guarding, opening angle etc. Test a sample of units for compliance, including higher risk ones (e.g. highly glazed, facing South or West, or single aspect). Tests should include a "buffer" for design development and variations across units e.g. in the Simplified Method, assume glazing areas on the upper end, and free areas on the lower end. Identify whether additional mechanical ventilation or even cooling may be required. Do not carry out Part O tests in isolation: check related implications, especially planning and Building Regulations requirements and features which are difficult to change post-planning e.g. glazing, shading, external security features, mechanical ventilation, cooling.
Design development	Engage with Building Control well ahead of submission, to agree the approach to compliance and evidence requirements, including: • Compliance route for all homes and relevant spaces. • Noise. • Security. • Protection from entrapment. • Protection from falling, including guarding and acceptable tolerance on the 1100mm limit for sill heights, if applicable . • In the TM59 route, the sample to be modelled and the ventilation approach. If cooling is proposed, agree how it will be demonstrated that all reasonably practical passive means have been implemented. Carry out checks on impact on other performance, quality and regulatory criteria, as part of overall design development. Prepare compliance tests, report and evidence.
Building Control design submission	Submit Part O tests, compliance checklist and evidence pack for approval, on the basis of final design. For the simplified method, this should include compliance tests on all homes; in TM59, this can be a sample, as agreed with the BCB. If cooling is relied upon, the evidence should demonstrate that all reasonably practical passive means have been implemented.
During construction	Monitor impact on Part O and other performance, quality and regulatory criteria, as part of overall change management e.g. changes to glazing specifications and g-value; opening details. Check implementation on site including glazing and shading systems, installation and commissioning of ventilation systems, tolerances e.g. guarding height (including small tolerance as agreed with building control), setting of security and safety features if any. Ensure defects are rectified and remedial works implemented if needed. Produce Home User Guide, including relevant Part O information. Gather evidence throughout installation, as per evidence requirements agreed with BCB.
Building Control as-built submission	Revise design submission with final as-built scheme, including compliance checklist, and submit for approval.

Technical Guidance

2. PART O REQUIREMENTS IN BOTH THE SIMPLIFIED METHOD AND DYNAMIC THERMAL MODELLING ROUTE

Regardless of the compliance route followed, projects have to meet Part O requirement O1(2)(a).

This states that, when achieving compliance with the overheating mitigation requirement:
"(a) account must be taken of the safety of any occupant, and their reasonable enjoyment of the residence; and
(b) mechanical cooling may only be used where insufficient heat is capable of being removed from the indoor environment without it."

The Approved Document states that point (a) is met if the overheating mitigation strategy takes account of the following factors, covered in this section:

- Noise at night: section 2.1
- Pollution: section 2.2
- Security: section 2.3
- Protection from falling: section 2.4
- Protection from entrapment: section 2.5.

Point (b) is covered in more detail in section 0.
These are areas of large overlap with other Parts of the Building Regulations and with the planning system.

All these considerations have significant implications in the design of the elevations and opening systems.

The noise and pollution considerations have significant implications in determining the suitable compliance route, and should therefore be examined early on in the project (see also timeline in section 1.7). They may mean that projects cannot use the Simplified Method and have to use the TM59 route; potentially, they may also mean that mechanical ventilation systems will be needed for night-time dissipation of heat (much beyond background ventilation rates).

2.1. Noise

The Approved Document states that noise at night must be taken into account in order to meet the Part O requirement O1(2)(a).

To meet this, the Approved Document makes recommendations aimed at limiting noise levels in bedrooms at night.

The noise limits

3.2 In locations where external noise may be an issue (for example, where the local planning authority considered external noise to be an issue at the planning stage), the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (11pm to 7am).

3.3 Windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits.
a. 40dB LAeq,T, averaged over 8 hours (between 11pm and 7am).
b. 55dB LAFmax, more than 10 times a night (between 11pm and 7am).

Note the planning process may make other requirements for overheating and noise, for example in other room types, and during the daytime in all room types. There may also be other requirements for noise that are not related to mitigating overheating.

3.4 Where in-situ noise measurements are used as evidence that these limits are not exceeded, measurements should be taken in accordance with the Association of Noise Consultants' Measurement of Sound Levels in Buildings with the overheating mitigation strategy in use.

The Institute of Acoustics (IOA) and Association of Noise Consultants (ANC) are preparing an IOA/ANC ***Guide to noise assessment in AD-O*** on demonstrating compliance with these noise limits. It will detail procedures for a suitably qualified person to:

- Establish the external noise environment with either an appropriate survey utilising calibrated equipment, or appropriate predictions with established methods
- Establish noise levels over at least one complete night time period
- Make an appropriate assessment of the findings
- Calculate the impact at relevant facades of the proposed buildings and establish appropriate levels of noise control
- Record the findings in a suitable report, indicating how the assessment has been carried out and what measures are required to make the overheating strategy useable
- Take in-situ noise measurements, when they are used as evidence, following appropriate methods.

Compliance options when noise criteria are exceeded

The impact of exceeding these night time noise limits will be constraints on using open windows to mitigate overheating risk at night, with knock-on effects for achieving compliance with AD-O. The principle in AD-O is that if bedroom windows need to be closed or use limited openings at night in order to meet the noise limits then this should be factored into the overheating risk assessment. If noise limits are exceeded with windows open, then the simplified method is no longer an option and the scheme must be assessed using the TM59 route. The dynamic model can help explore the equivalent areas required to meet the overheating and noise criteria, and whether this can be achieved using opening windows or an acoustic louvre, for example.

Noise issues are likely to affect all buildings located near main roads, rail lines and airports. Based on data in the National Noise Incidence Survey 2000, local authority commissioned exposure surveys, and more recent correlation between overall night time ($L_{Aeq,T}$) levels and maximum (L_{AFmax}) levels, it is estimated that more than 30% of existing dwellings in England and most dwellings in city centres would not comply with the AD-O night time limits with windows open (Apex acoustics ref: https://www.apexacoustics.co.uk/noise-constraints-in-approved-doc-o-overheating-part-1/). Noise levels on site should, therefore, be examined very early on to determine if mitigation or alternative design features will be required.

Mitigation measures such as site layout, landscaping and building layout should be incorporated early in the design, to reduce reliance on mechanical systems. Dual aspect designs are particularly useful here, as they may help locate bedrooms away from the noisier elevations (in addition to allowing cross-ventilation). See design guidance in section 7.

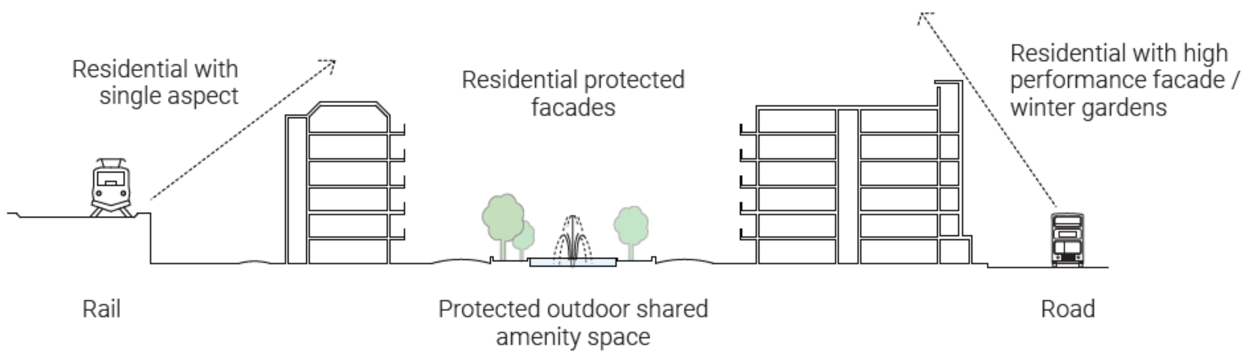


Figure 3

Noise mitigation measures through landscaping, site and building layout: noise from rail and road is buffered by the taller buildings, protecting the dwellings and landscaped areas on the other side (provided by Studio Partington)

Removing excess heat in noisy environments

Where noise levels are only slightly excessive, then it may still be possible to rely on natural ventilation at night. Passive means such as reducing how wide bedroom windows are assumed to open, acoustic barriers on site, or adding balconies with solid balustrades might be sufficient to reduce night time noise in bedrooms to within the required limits.

Where natural ventilation solutions are not sufficient to achieve compliance then mechanical ventilation should be incorporated that can operate (quietly) at night to deliver sufficient air movement to remove excess heat. This will require much higher air change rates than for background ventilation, and will therefore have design implications. Guidance on noise from mechanical systems for this purpose is available in the IOA/ANC Acoustics, Ventilation, Overheating: Residential Design Guide.

Mechanical cooling (e.g. air conditioning) should be the last resort and is probably only essential in warmer locations and where noise levels exceed targets during the day and night.

Where there are additional daytime noise constraints highlighted through planning or client requirements, then an acoustic report may recommend that windows on particular facades or floor levels are not relied upon for overheating mitigation during the day. Such additional constraints should also be included in the TM59 analysis and a suitable solution found; while strictly speaking not covered by Part O requirements, in practice such daytime noise constraints may also influence conditions at night (e.g. change the temperature reached by some rooms towards the evening), so they need to be considered early on and the TM59 assessment should provide an overall and consistent solution to meet both planning and Building Regulations requirements.

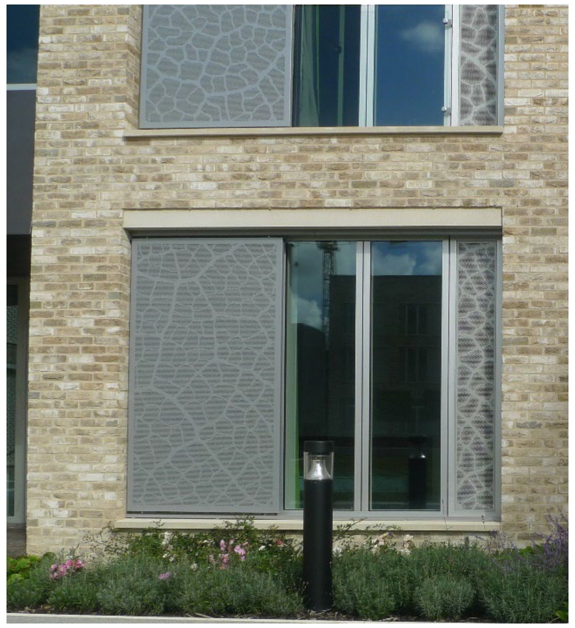


Figure 4

Image of acoustically attenuated openings: North West Cambridge student residences (images courtesy of Nick Conlan, Apex Acoustics)

2.2. Pollution

The Approved Document states that pollution must be taken into account in order to meet the Part O requirement O1(2)(a).

To meet this, it simply states *"Buildings located near to significant local pollution sources should be designed to minimise the intake of external air pollutants",* and for this refers to guidance in Section 2 of Approved Document F, Volume 1: Dwellings.

This is not as clear cut as the guidance on night-time noise levels. Project teams should be mindful of external air quality and work with the BCB and with the local authority's Environmental Health Department (EHO) to agree the approach to meeting, jointly, Part O and Part F requirements and both associated Approved Documents.

In many situations it may be that, in the case of sites exposed to high air pollution, the EHO and/or BCB will recommend or require mechanical ventilation with filters for background ventilation year round, but accept reliance on opening windows for overheating mitigation purposes.

In many cases, high air pollution levels are likely to be caused by road traffic, which will also cause noise: this noise will therefore also require attention for Part O compliance, and may drive the choice of compliance route and night-time ventilation strategy regardless of the approach agreed with regards to pollution.

2.3. Security

The Approved Document states that security must be taken into account in order to meet the Part O requirement O1(2)(a).

To meet this, it states the following:
*§3.6 "When determining the free area available for ventilation during sleeping hours, **only the proportion of openings that can be opened securely should be considered to provide useful ventilation.** This particularly applies in the following locations, where openings may be vulnerable to intrusion by a casual or opportunistic burglar.*
a. Ground floor bedrooms.
b. Easily accessible bedrooms."

§3.7 "Open windows or doors can be made secure by using any of the following.
a. Fixed or lockable louvred shutters.
b. Fixed or lockable window grilles or railings.

This means that if security measures such as louvred shutters are installed, their effect should be taken into account when calculating the equivalent area available - see guidance box on how to do this in dynamic modelling. For some measures lockable window grilles or railings, the effect on equivalent area may be negligible; this will have to be discussed within the project team and agreed with the BCB.
>> DLUHC FAQ17

See on the right illustrations of secure windows and doors.

Figure 5

Figure 6

Illustrations of secure side openings (provided by Studio Partington)

Taking into account the effect of louvres performance in dynamic simulations

The equivalent free area should be estimated in 2 steps:
1) account for the equivalent area of the window, discounting frame and the solid area which obstruct the air flow
2) account for the modification of air flow once louvres/shutters are applied (additional discharge coefficient). Manufacturers should be able to provide discharge coefficients for their products.

The modeller should check how these are accounted for in the software packages they are using. For example, in IESVE, the discharge coefficient contribution is automatically calculated by the software (equivalent orifice area) by selecting the 'louvre mode'.

2.4. Protection from falling

The Approved Document states that protection from falling must be taken into account in order to meet the Part O requirement O1(2)(a). Note this must be met in addition to Part K requirements.

To meet this, AD-O states that *"Only the proportion of openings which can be opened with a very low risk of occupants falling from height should be considered to form part of the overheating mitigation strategy."*

This applies to all windows which can be opened wider than 100mm (i.e. most windows, unless on restrictors - however, in effect, restrictors are strongly discouraged by Part O, as with them in place it would be quite difficult to meet the required free areas and air flow for heat dissipation). Restrictors can also impact egress in the event of a fire, if people struggle to disengage them.

The ventilation provided by opening windows/vents can only be included in the AD-O assessment if they meet ALL of the following conditions (a) to (c):

a. Window handles on windows that open outwards are not more than 650mm from the inside face of the wall when the window is at its maximum openable angle.

Note this 650mm only applies when calculating the equivalent area for the compliance calculations (whether for the Simplified Method or dynamic thermal modelling route). It does not need to be a physical restriction and in practice the opening distance may be wider.
>> DLUHC FAQ15

b. Guarding meets the minimum standards in Table 3.1. i.e.:

if the change in floor level between inside and outside is less than 600mm: as per Approved Document K
if the change in floor level between inside and outside is more than 600mm: guarding height should be at least 1100m.

See Figure 7 for illustrations of how to meet these standards, and Figure 8, where windows in the standard house type had their cill raised, but were made wider.

Building Regulations Part B requires windows that are used for escape to have a maximum cill height of 1100mm. Meeting the requirements of both Part O and Part B therefore, in theory, leaves zero tolerance; in practice, DLUHC have clarified that a tolerance of +0 / -100mm is reasonable.
>> DLUHC FAQ16

For accessible homes, Building Regulations Part M requires:

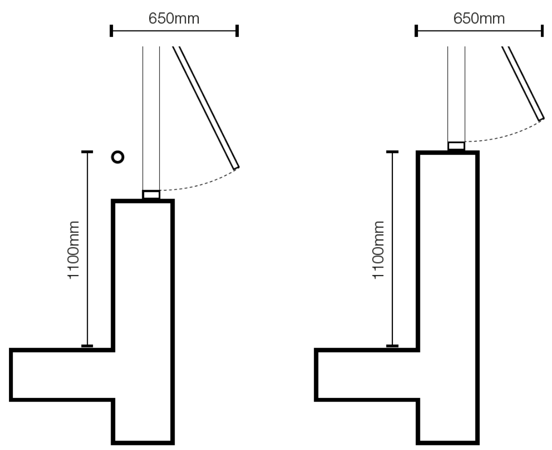
- a maximum guarding of 850mm, which is exceeded by the 1100mm requirement.
- a handle height of :
  - 700-1,000mm (Part M4(3)) for the primary window, which is also exceeded by the 1100mm requirement. One way of resolving could be with a cill below 1000mm, an inward opening window and guarding outside e.g. as a fully guarded perforated opening, also making the opening secure; or guarding at regular intervals (min 100mm to protect from entrapment). Alternatively, guarding could in theory be inside with an outward opening window, but this is likely to make the handle difficult to reach.
  - 450-1,200mm (Part M4(2)) & other windows (M4(3)): this could be resolved in the same manner as above, or potentially with a with top hung window and handle between 1100mm and 1200mm.

This difficult resolving of requirements will apply to accessible homes where the 1100mm guarding requirement applies i.e. those that are not on the ground floor, or on ground floors on sloping sites such that the change in floor level between inside and outside is more than 600mm.

c. Guarding does not allow children to easily climb it. For example, horizontal bars should generally be avoided.

Guarding for large openings could include, but is not limited to, either of the following:

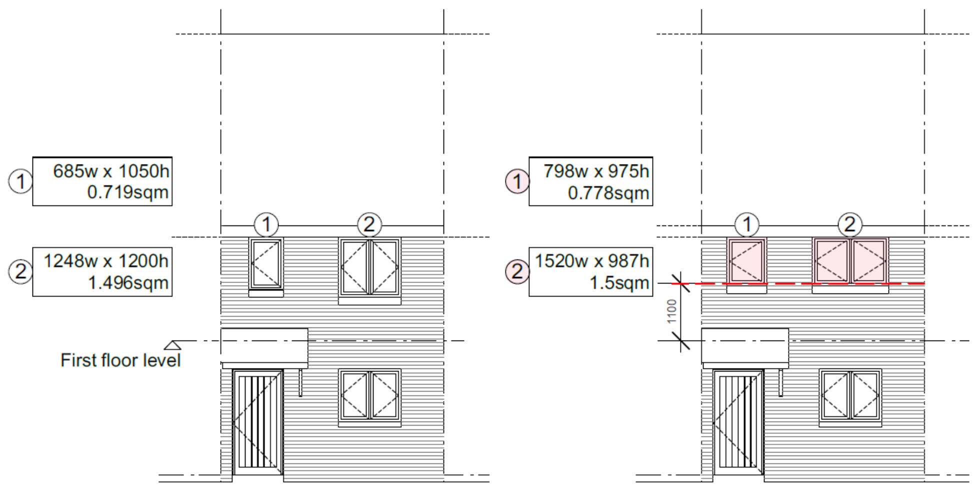
- *Shutters with a child-proof lock.*
- *Fixed guarding.*



Examples of protection from falling

Figure 5

Illustrations of guarding meeting the standards of Table 3.1 (courtesy of AHMM) Note that:
- the 650mm distance is for the purpose of calculating equivalent areas, but the window may open wider in practice >> DLUHC FAQ15
- while horizontal bars are typically not encouraged in AD-O where they may allow children to climb, in this case this is acceptable because the bar is above 600mm height >> DLUHC FAQ19



Key
--- Window cill level

Figure 6

Case study house where cill heights were raised to 1100mm in order to meet the guarding standards of AD-O Table 3.1, and openings made wider (left: original design; right: raised cill heights). This changes external appearance and therefore would have planning implications: this is one example why Part O should be considered early in the design process; on sites with existing planning permission, the changes should be discussed with the Local Authority and in some cases may require a re-submission.

2.5. Protection from entrapment

The Approved Document states that protection from entrapment must be taken into account in order to meet the Part O requirement O1(2)(a).

To meet this, it states that louvered shutters, window railings and ventilation grills should comply with all of the following (a) to (c):

(a) "Not allow the passage of a 100mm diameter sphere."

(b) Any hole which allows the passage of an 8mm diameter rod should also allow the passage of a 25mm diameter rod. Such holes should not taper in a way that allows finger entrapment

(c) Any looped cords must be fitted with child safety devices

3. PART O SIMPLIFIED METHOD

3.1. Guidance flow chart

This guidance provides a process through the Simplified Method, including establishing the targets and making all the measurements, evaluations and calculations assess the design against those targets.

The process is illustrated in the flow chart below, and in the following sections of this chapter, which provide detailed information on both the requirements and how to meet them, and the process in practice for checking compliance and reporting. Numbering of each section (Step X) relates to the steps in the flow chart (the numbers in green circles on the flow chart).

A worked example is provided in Chapter 8.

In practice project teams may carry out the assessment in a different order to suit their workflow.

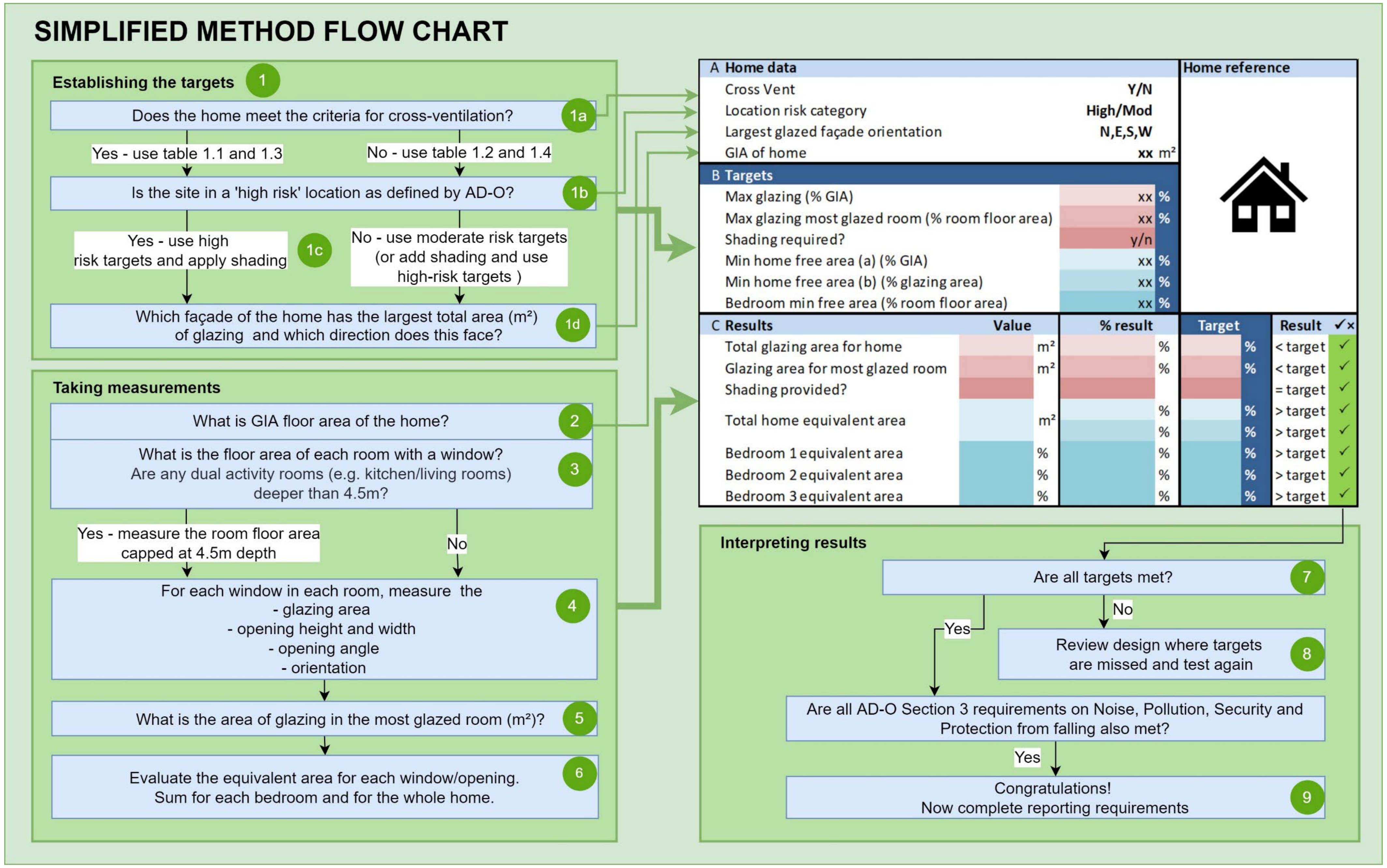


Figure 7

Simplified Method flow chart, along with illustrative template for recording the targets and results

3.2. Establishing the targets 1

There are two sets of targets in the Simplified Method:

- the first limits solar gains by giving maximum glazing areas for the home and for the most glazed room: detailed in Tables 1.1 and 1.2 of AD-O
- the second focus on the removal of excess heat by requiring minimum free areas for natural ventilation; there are two targets to meet (i.e. exceed) here: one based on the floor area and another based on the total glazing area for the home: detailed in Tables 1.3 and 1.4 of AD-O

These targets are set based on:

- whether the home is defined as having cross-ventilation
- the location of the site
- the orientation of the façade within each home that has the largest glazing area.

The case studies provide examples of what the targets may look like in practice.

Cross ventilation 1a

In order to qualify as having cross-ventilation a home needs *"the ability to ventilate using openings on opposite facades"*. Openings on facades that are not opposite does not qualify e.g. corner apartments.

Location 1b

For the purpose of AD-O, England is divided into two overheating risk groups:

– High risk locations are in London (there is a list of qualifying postcodes in AD-O Appendix C). AD-O also advises that while not required, project teams may choose to treat some postcodes in Manchester (M1, M2, M3, M5, M15, M16 and M50) as high risk.
>> DLUHC FAQ6
– Moderate risk locations are defined as everywhere else within England.

There are no low risk locations defined.

If a home is in a high risk location, then shading requirements also apply – see section 3.3.

These two location definitions are quite crude: in practice some parts of the South outside of London can experience hot, sunny and still periods, and are likely to see higher temperature rises with climate change, while some sites in Northern England, particularly in windy and/or coastal locations, may be at much lower risk. The TM59 method provides more granularity, as weather files are available for 13 locations in England, including 3 in Greater London.

Orientation of "most glazed façade" 1d

The "most glazed façade" is that with the largest m² area of glazing. This will sometimes be immediately apparent from drawings but to be certain and evidenced, will require the glazing to be measured and quantified for each façade - see section 3.4.

Where a home has equal glazing on two facades then the most onerous targets of the two options should be selected (i.e. the lower glazing limits and the higher free areas).
>> DLUHC FAQ4

The closest compass point should be selected. Where the orientation of the most glazed façade is exactly between two compass points, the most onerous targets of the two options should be selected (i.e. the lower glazing limits and the higher free areas).
>> DLUHC FAQ5

For homes where the most glazed façade faces West, the glazing limits are particularly onerous in moderate risk locations. For these, DLUHC have clarified that it is possible to use the solar gain limits for high risk locations, if external shading is provided that meets the criteria (see section 0). This approach can also apply for other orientations, but provides no benefit in the glazing limits, as illustrated in the figure below.
>> DLUHC FAQ2

Table 1.1 Limiting solar gains for buildings or parts of buildings with cross-ventilation[1]

	High risk location		Moderate risk location	
Largest glazed façade orientation	Maximum area of glazing (% floor area)	Maximum area of glazing in the most glazed room (% floor area of room)	Maximum area of glazing (% floor area)	Maximum area of glazing in the most glazed room (% floor area of room)
North	15	37	18	37
East	18	37	18	37
South	15	22	15	30
West	18	37	11	22

NOTE:
1. Floor area and floor area of room are as defined in Appendix A.

Figure 8

The high risk location glazing target can be used if compliant shading is provided. This only provides more flexibility where the "most glazed façade" faces West

3.3. Shading 1c

External shading or solar protection is an additional requirement for all sites in high risk locations. This must be applied to all glazed areas between NE to NW via South, as one of the following:

a. External shutters with means of ventilation.
b. Glazing with a maximum g-value of 0.4 and a minimum light transmittance of 0.7.
c. Overhangs with 50 degrees altitude cut-off on due south-facing façades only.

External shading is a valuable design option for reducing overheating risk and is recommended whether or not the benefits can be taken into account within the Part O assessment. See section 7 on good practice design e.g. movable shading.

Note that the maximum g-value referred to here is a centre-pane value for the glass itself. This is different to the whole window g-value quoted in BFRC data ("solar factor"), which takes account of the effect of the window frames and is therefore significantly lower - see illustration 3-1. This means that even if the whole window g-value was below 0.4, this would not necessarily mean that the glazing g-value is below: this needs to be checked, for this option to meet Part O shading requirements.
>> DLUHC FAQ3

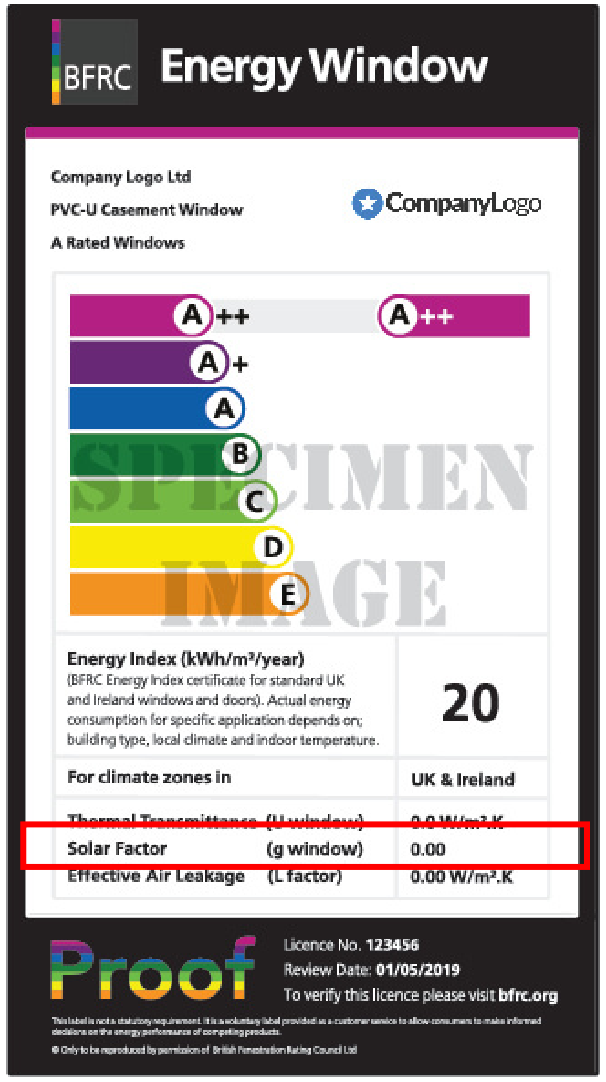


Figure 10

Illustration: The g-value requirement in Part O is for centre-pane g-value. Note the BFRC "solar factor" are g-values for the whole window, including the impact of frames, i.e. lower than the centre pane g-value.

In practice, there may be other ways that glazed areas are shaded e.g. through the articulation of the building or from neighbouring buildings. This cannot be accounted for in the Simplified Method, but can in the TM59 route, allowing more design flexibility on balancing glazing and shading provision.

Examples of external shading are provided in the design guidance section 7, and in the case studies.

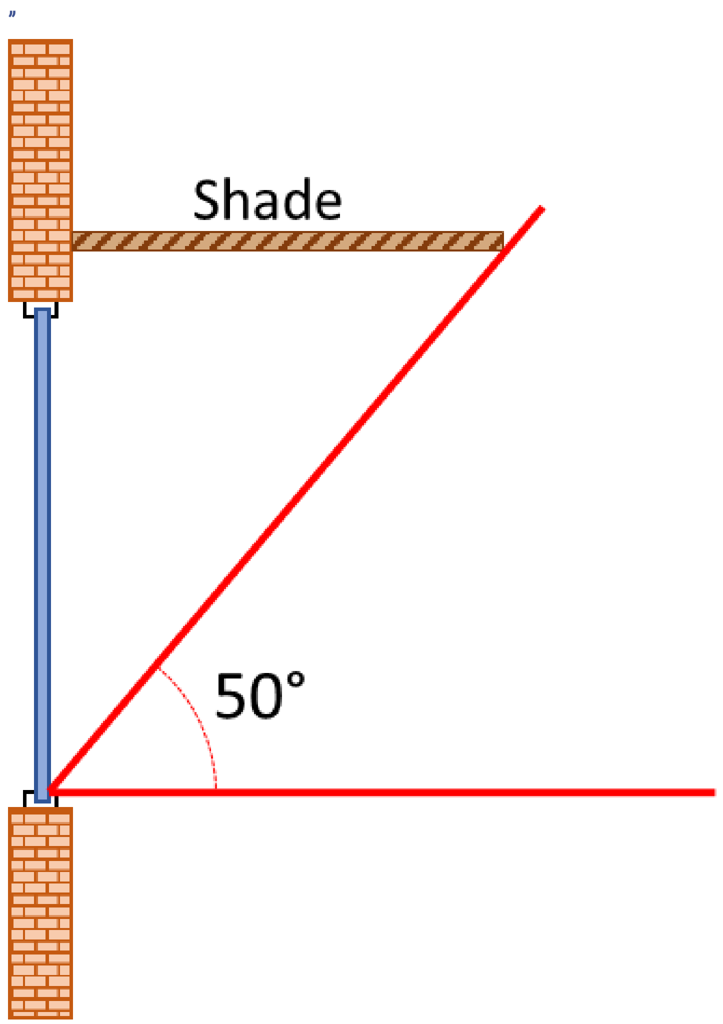


Figure 9:

Illustration of "overhang with 50 degree altitude cut-off (from DLUHC FAQs, FAQ7)

3.4. Taking measurements

There are a significant number of measurements required to complete the Simplified Method. Some overlap with those needed for SAP calculations, and some are also required if using the TM59 route, but there are some differences.

At an early stage, the measurements and associated calculations should be on the side of caution in order to cater for future design development, in homes which have not yet been tested etc. This means over-estimating glazed areas, and under-estimating equivalent areas.

What is the floor area of the home? 2

The floor area for the home is defined as the area measured to the internal face of the perimeter walls at each floor level. This is also known as the Gross Internal Area (GIA).

What is the floor area of each room? 3

See illustration below for how the floor area should be measured.

Measure the floor area of each room containing a window to the internal face of each wall i.e. this includes floor area taken up by internal partitions, cupboards etc. Rooms without windows do not need to be measured for this assessment. Bear in mind the requirement for dual activity rooms deeper than 4.5m – see Step 4.

Are any dual activity rooms deeper than 4.5m?

This needs to be checked as it will impact how the floor area of a room, for the purpose of the Simplified Method, is calculated: *"Where a room serves more than one activity, e.g. open-plan kitchen and living room, the area with the largest glazing area should be assessed and the room area calculated based on a room depth no greater than 4.5m from the glazed façade."* (as per note in AD-O Appendix A)

This will usually only apply to kitchen/living, kitchen/dining, living/dining rooms, and means the floor area for these rooms must be truncated at 4.5m depth from any glazing. This has implications for meeting the 'maximum area of glazing in the most glazed room (% floor area of room)' as the smaller room floor area will increase the glazing:floor area ratio.

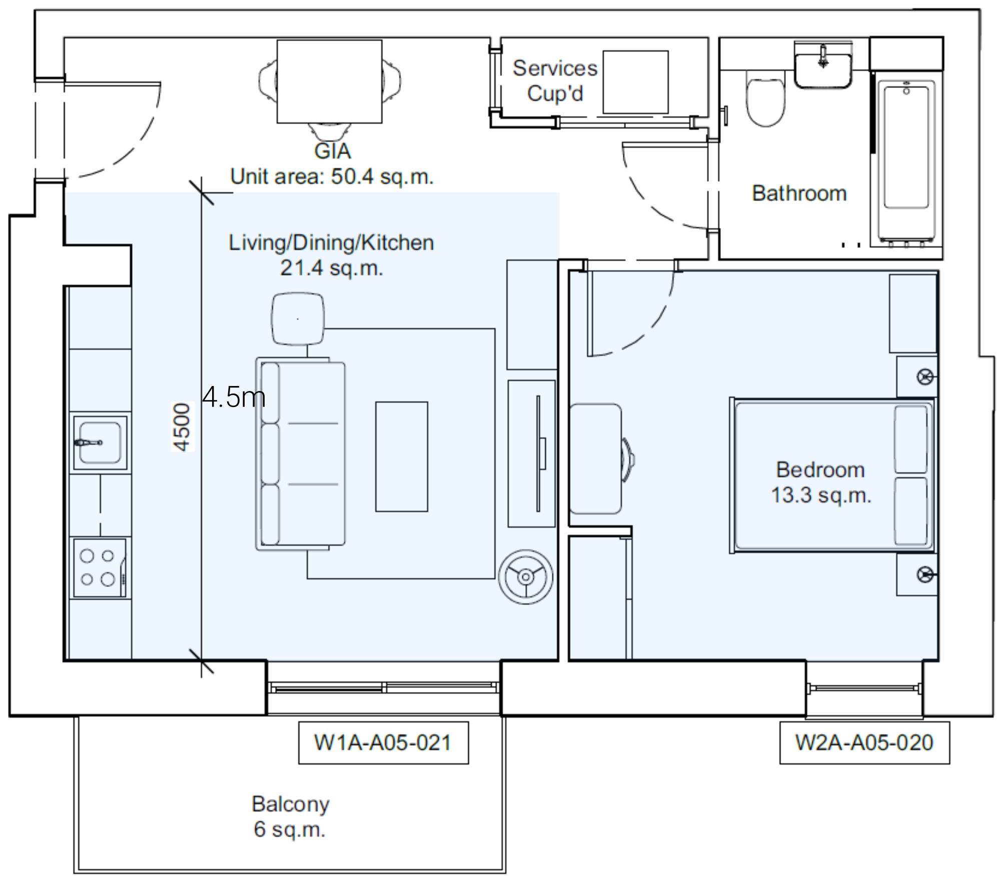


Figure 11

Illustration of living room measurement truncated at 4.5m (Studio Partington)

Window and opening measurements 4

A number of measurements and characteristics are required for each window and opening:

- Glazing area
- Opening height and width
- Opening angle
- Orientation
- Shading / solar protection.

Glazing area – the m² area of glazing for each window (excluding frames). It might be possible to estimate this from the size of the structural opening, and a frame factor (representing the glazed fraction of the window, and available from manufacturers), but it is recommended that a conservative estimate is made i.e. with a frame factor veering on the low side so that glazing area isn't underestimated.

Opening height and width – the height and width (in m) of any opening panes, including any non-glazed panels used for natural ventilation (including any frame that opens too). This can be hard to get accurate measurements for, especially at earlier design stages. Depending on the window opening mechanism there can be more or less overlap between the opening part of the frame and the section that stays fixed. Manufacturers should be able to provide this information ultimately, but conservative estimates (i.e. on the smaller side) may need to be used until more accurate data is available.

Note that sliding doors or sash windows can only count one pane as openable (even if both are moveable) as only one will be fully open at a time.

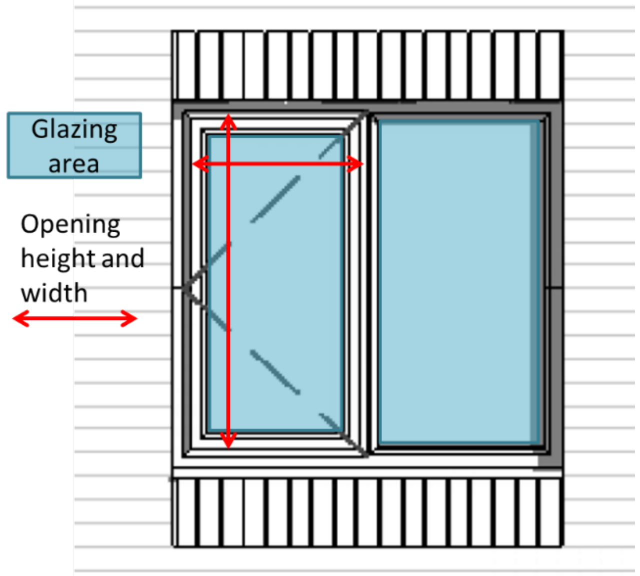


Figure 12

Illustration showing window measurements

Opening angle – the maximum angle that each window will be openable to. This angle will depend on the window opening mechanism. Side hung openings such as patio doors will often be designed to achieve the maximum 90° opening angles, whilst top or bottom hung openings are likely to achieve smaller maximum opening angles. Part O compliance requires generous ventilation openings in order to provide effective removal of excess heat, and discourages the use of restrictors for this reason.

The opening angle used to calculate the equivalent area needs to take account of the requirements on noise, security and safety – in particular the requirement on maximum reach of 650mm – see sections 2.1, 2.3, 2.4.

Orientation – the direction each window faces. This is needed in order to add up the total glazing for each façade of each home so that the most glazed façade can be identified and used to determine the correct targets.

Recording the information - While not a requirement in the AD, for the purpose of the calculation, plus design development, auditing, and gathering of evidence, it is recommended to record each of these measurements for the windows in each room as illustrated in the worked example – see section 8.1.

Which is the "most glazed room"? 5

The most glazed room is defined as the room with the highest (m^2) area of glazing.

Where a home has equal areas of glazing in two or more rooms (e.g. where the same window types and number of windows are used) then the glazing:floor area ratio for each room should be calculated and the room with the highest ratio selected as the "most glazed".

This is also the point where, if this has not been measured before, the total area of glazing on each façade can be calculated, to determine the "most glazed façade" and confirm the applicable targets (Step 1d)

3.5. Evaluating window equivalent areas 6

The Simplified Method requirement on removing excess heat is based on minimum free area targets. The AD states that *"The equivalent area of the opening should meet or exceed the free area of the opening."* This means that for the purposes of this assessment equivalent areas must be evaluated for each ventilation opening and compared against the free area targets.

This part of the compliance assessment requires detailed measurements, and some design iteration is likely to be needed to reach compliance. It is important to establish the natural ventilation design principles early, to avoid the need for late and substantial design changes:

- All or the large majority of glazing provided should be openable: it is otherwise difficult to meet both the free area minima and the glazing maxima.
- Openings should be designed to maximise air flow, while also meeting noise, security and safety requirements - see sections 7.7 and 2 for guidance and illustrations.
- This is important in all cases, but especially for homes in high risk locations that are not cross-ventilated, as the free area should be at least 95% of the glazing area: this means that all glazed areas should be fully openable (e.g. side hung, wide angle), or that non-glazed openings should be provided in addition.

There are three options for evaluating the equivalent areas:

1. Measurement of the product to BS EN 13141-1
2. Using values from the lookup tables (D1-D9) provided in Appendix D
3. Calculate values using the Discharge coefficient calculator spreadsheet downloadable from this link.. This is more accurate than using the lookup tables, and is recommended where possible.

The equivalent area needs to be assessed for every openable window, door and vent to be used as part of the overheating strategy of the dwelling.

For windows and rooflights, the opening angle is required in order to determine the equivalent area. The opening angle used must comply with the maximum 650mm reach criteria, which applies to all windows. As the reach criteria is measured from the inside face of the external wall to the window handle, care must be taken to translate this distance into a window pane opening distance. In particular, the position of the window frame within the depth of the wall will have an impact on how far the window pane can be opened.

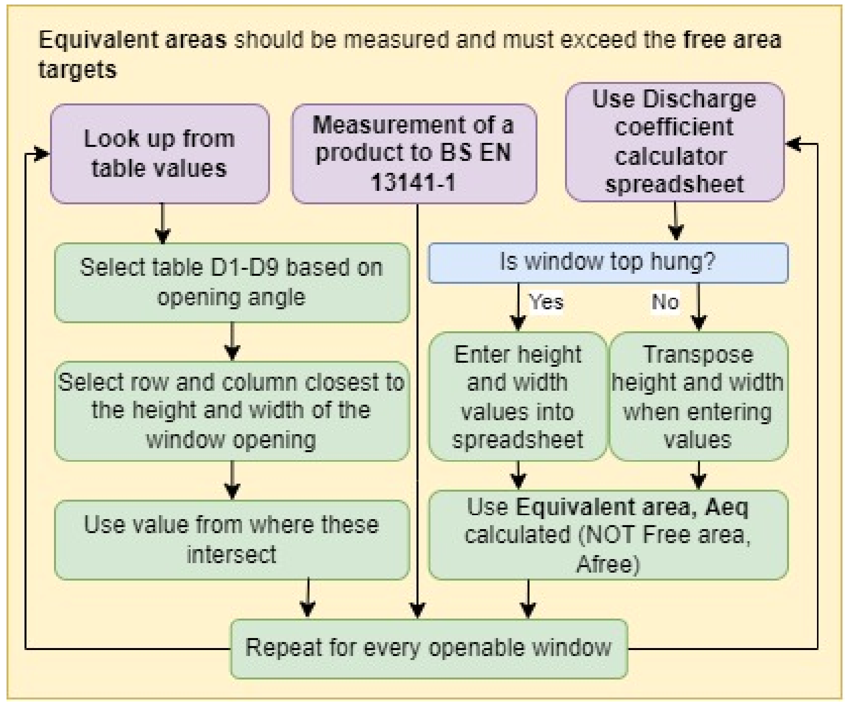


Figure 13

Illustration of the 3 possible methods to measure equivalent areas for Part O

Measurement of the product to BS EN 13141-1 - manufacturers may be able to provide figures for equivalent area for their products on request. However, these calculations must also comply with the 650mm maximum reach requirement so may prove difficult to obtain.

Using values from the lookup tables – the tables D1-D9 provided in Appendix D of AD-O give equivalent area values based on the opening height and width (to the nearest 0.25m), and the opening angle (to the nearest 10°) which determines which table to use.

Note that these values assume a side-hung opening. If the window being assessed is top-hung then the height and width measurements should be swapped.

Calculate values using the Discharge coefficient calculator spreadsheet – the spreadsheet can be downloaded from this link:

There are two important notes about using this tool:

- The tool assumes openings are top hung by default, so if you are assessing side-hung openings then the measurements for the opening height and width need to be swapped (it does make a difference).
- The tool calculates equivalent area (A_{eq}), but also calculates a value for free area A_{free} which it highlights in bold. It is important not to get confused as the free area figure in the context of this tool is the total area of the window, NOT the same definition of free area used in Part O. For the purpose of Part O calculations, use the equivalent area value calculated by the spreadsheet!

Project teams carrying out multiple Simplified Method calculations may want to copy this calculation into their own spreadsheet to automate the calculating of equivalent areas from the measurements recorded. This is possible but not as simple as it first appears; the values and calculations in hidden columns (E:I) and rows (5:7) must be included so that the discharge coefficient is correctly calculated.

>> An example of calculation is also provided in DLUHC FAQ8.

For the Simplified Method, it has been confirmed by DLUHC that the 'total minimum free area' requirement of AD-O is in effect a daytime requirement and the 'bedroom minimum free area' requirement is in effect a night-time requirement. The implication of this is that in certain circumstances it is possible that two equivalent area values may be used for the same opening – i.e. those within bedrooms which are either on the ground floor or considered 'easily accessible' (where AD-O Para 3.6 & 3.7 on security apply). For example, for a ground floor bedroom with a patio door, this door may be assumed open during the day (contributing to the total (whole house) equivalent area) but closed at night. Or alternatively, where an easily accessible bedroom has a security arrangement which allows for the window to be opened to a greater extent during the day than at night when required to be secure.

3.6. Checking performance against targets

7

Once all the measurement and analysis have been carried out the results can be assessed against the target criteria (as determined in section 3.2).

The glazing areas assessed must be lower than the target values.

The free areas assessed must be higher than the target values.

If all measured criteria meet the targets then the home is demonstrated to meet the criteria and passes Part O using the Simplified Method.

This must be done for every home in the scheme, as well as common spaces.

The worked example and case studies using the Simplified Method in this guidance follow a standard template for recording and reporting the results, as illustrated below.

C Results	Value		% result		Target		Result	✓×
Total glazing area for home		m²		%		%	< target	✓
Glazing area for most glazed room		m²		%		%	< target	✓
Shading provided?							= target	✓
Total home equivalent area		m²		%		%	> target	✓
				%		%	> target	✓
Bedroom 1 equivalent area		%		%		%	> target	✓
Bedroom 2 equivalent area		%		%		%	> target	✓
Bedroom 3 equivalent area		%		%		%	> target	✓

Figure 14

Illustrative template for reporting results against targets in the Simplified Method

3.7. What if a home does not meet the criteria?

8

Reason for non-compliance	Mitigation measures to look into
Glazing areas exceed target for whole home or for most glazed room	Look for where glazing areas might be reduced. Low level glazing can provide views out, but rarely contributes usefully to daylight levels so are there low level, fixed panes that could be removed? It may be possible to reduce or remove fixed glazing in or above front doors. Be wary of removing opening panes as this might impact on the ability to meet the free area targets. Higher frame factors will reduce the area of glazing. If the home is in a moderate risk location and faces West then consider adding external shading and using the targets for a high risk location.
Glazing does not have shading in a high risk location	Add external shading or low-g glazing specification (g<0.4).
Total equivalent area doesn't meet the highest free area target or Bedroom equivalent area does not meet bedroom free area target	Look for where additional ventilation openings can be provided or existing openings widened. Where possible make all window panes openable. Swap sliding doors for side hung pairs. Remove any restrictors from windows to allow them to open wider (bearing in mind 650mm reach limit for the calculation). If necessary, increase the size of windows to meet the free area target, but ensure that this doesn't impact on meeting the limiting solar gain targets.
Can't meet all targets at once	The simplified method targets are challenging to meet, especially in West facing homes, high risk locations and without cross-ventilation. Where designs cannot be modified to comply with all criteria then options include: Re-designing the scheme so that all homes include cross-ventilation Use the dynamic simulation method as this offers more design flexibility with a balanced approach to glazing and shading, can take account of shading provided by surroundings e.g. nearby buildings (which isn't accounted for in the Simplified Method) and allows cooler/windier site locations to be better accounted for.

3.8. Reporting on the Simplified Method

9

The AD-O requires the reporting checklist to be completed for the scheme and submitted to building control *as evidence that the building has been constructed as designed to reduce the risk of overheating*.

An illustrative filled-in compliance checklist is provided in the worked example, section 8.1.7.

It is extremely valuable to ensure there is a detailed record of the analysis undertaken, so that this can be reviewed for quality assurance, and updated in response to any design changes.

Results should be presented clearly and transparently so that it is apparent how each home was assessed, what targets have been used, and how the results compare against these targets.

4. PART O DYNAMIC THERMAL MODELLING (TM59) METHOD

4.1. Guidance flow chart

This guidance provides a process through the dynamic thermal modelling route, including establishing the targets and carrying out the modelling assess the design against those targets. Modelling is an expert task and therefore the modelling process is not explained in detail, instead the sections of this chapter provide an overview of the process for the purpose of Part O, and where it may differ from a "generic" TM59 assessment.

The process is illustrated in the adjacent flow chart, and in the following sections of this chapter, which provide detailed information on both the requirements and how to meet them, and the process in practice for checking compliance and reporting. Numbering of each section relates to the steps in the flow chart (the letters in red circles on the flow chart).

A worked example is provided in section 8.

4.2. Integrating the modelling process into the project

Selecting the modeller

Dynamic thermal modelling is an expert task. The appointed modeller should :

- Be skilled at using a dynamic thermal modelling package that complies with CIBSE AM11
- Be knowledgeable and experienced about overheating risk and potential mitigations from a building performance perspective, not just "compliance" with Part O or TM59. They should also be able to highlight associated implications, for example on daylight or energy use.
- Be experienced at completing TM59 assessments
- Be knowledgeable about AD-O
- Be able to write clear reports detailing the analysis undertaken, the results found, with explanation and advice on any non-compliance.

There is no existing accreditation scheme for modellers to demonstrate these skills. Level 5 Energy Assessor accreditation requires use of the same dynamic modelling tools, but for a very different type of assessment so is not directly applicable.

Fees and timescales will vary according to the number of homes included in the assessment, how complex their geometry is to model (higher variation in glazing configuration, external shading features etc can be more time consuming to represent), and the risk level of the scheme (designs with higher risk factors are likely to take more iterations to find mitigations that work for all homes in the scheme).

It is highly recommended that an initial assessment is made pre-planning to give confidence that the scheme can comply with AD-O since mitigations such as reduced glazing areas or additional external shading may require planning permission. Experienced modellers can help select a suitable sample of homes, and some guidance is provided in section 4.3.

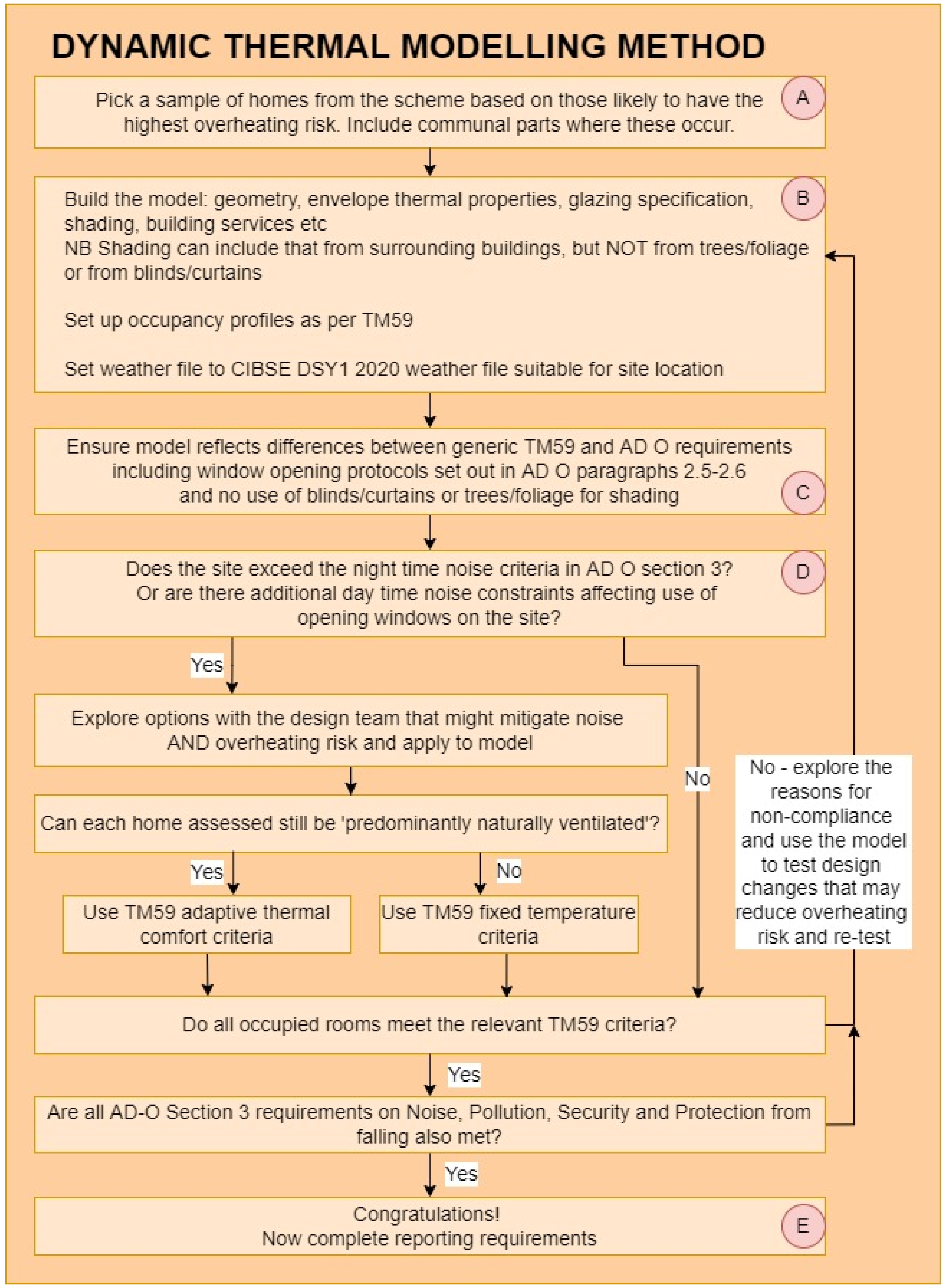


Figure 15

4.3. Selecting a sample of homes

A

The dynamic thermal modelling method allows that a sample of homes be assessed instead of testing every single home in a scheme. The AD-O includes the following reporting requirement:
Number of sample units modelled, including an explanation of why the size/selection has been chosen.

The sample selection is an important aspect of the assessment. The bottom line is the functional requirements of Part O which is to limit overheating risk in new homes. If a home designed under this regulation suffers significant overheating problems in-use then designers will be answerable as to whether this assessment should have picked this up and the risk designed out.

There is no guidance in AD-O on how to select a sample of homes, but TM59 §3.1 provides some guidance on this:

"*The assessment should try to identify all the dwellings that are at risk of overheating. These are likely to be those (a) with large glazing areas, (b) on the topmost floor, (c) having less shading, (d) having large, sun-facing windows, (e) having a single aspect, or (c) having limited opening windows.*
The report should justify the sample of units chosen for the assessment and explain why this is appropriate. The number analysed will depend on the scale of the development, its geographical location and the results of the modelling as they emerge. In addition, lower risk dwellings can be included for illustration of performance to this.
At least one corridor should be included in the assessment if the corridors contain community heating distribution pipework. "

Designers and modellers experienced with overheating can help identify homes which are likely to be at greatest risk of overheating. Guidance can also be obtained by reviewing the scheme against the Good Homes Alliance one page tool and guide freely available from here:
https://goodhomes.org.uk/overheating-in-new-homes . This tool covers the significant overheating risk and mitigation factors addressable at an early design stage, and gives an approximation of their relative impacts.

In the broadest terms, homes with the most solar exposure, least shading, most glazing areas, lowest free areas (when windows are open) and any constraints limiting the use of opening windows (e.g. due to noise or security concerns) should be included in the sample. Ideally at least one of each home type, and the example with the worst case (most solar exposed or constrained) orientation.

For blocks of apartments with repeating floor layouts then the whole of one story might be appropriate – usually the top floor is the most solar exposed - unless there are varying noise or security constraints at different heights which would also need taking into consideration.

Think about whether there are any homes on the ground floor or that are "easily accessible" and whether this might have implications for security, leaving windows open, and how this might be addressed.

If in doubt, include a larger sample.

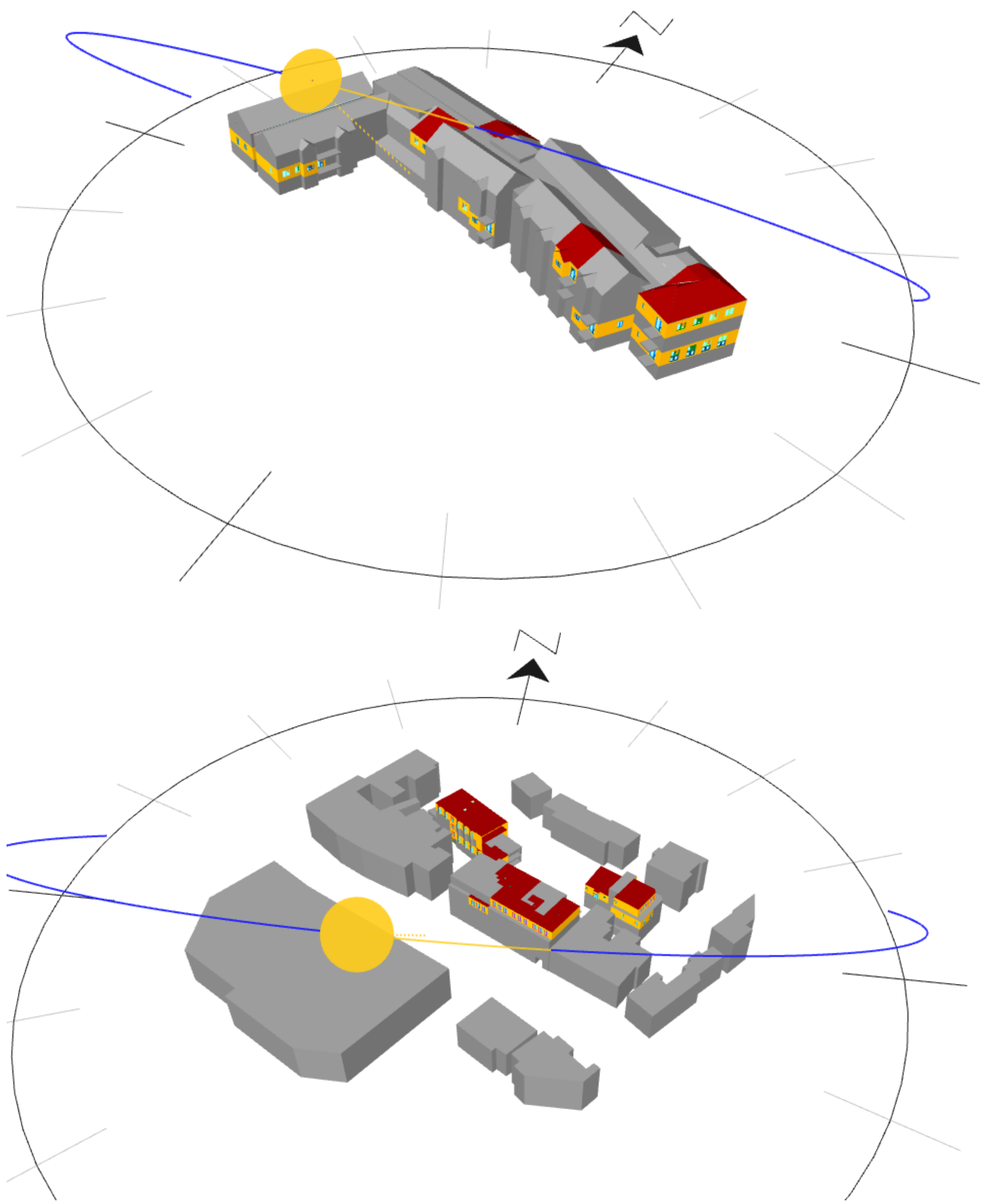


Figure 16

Examples of schemes showing (in colour) the sample homes selected. Selections were based on higher solar exposure, glazing area and window openings and to include a range of home types

4.4. Creating the TM59 model B

The dynamic thermal model should be built following the TM59 methodology, though with small modifications for the purpose of Part O. This guidance is not intended as a modelling guide but for non-modellers the steps are essentially:

- Build model geometry according to design drawings, including internal partitioning and glazing to all sample homes
- Apply the thermal properties (construction type and U-values/g-values) for the main building elements including floors, roofs, external walls and glazing
- Set window opening schedules following AD-O requirements, which differ from TM59 – see section 4.6
- Include any external shading devices proposed including any surrounding buildings that might provide shading. As per AD-O, do NOT include internal shading e.g. blinds.
- Apply TM59 internal gain profiles
- Add additional heat gains due to any community heating pipework and Heat Interface Units
- Apply CIBSE 2020 DSY1 weather file suitable for the site location. There is a choice of 13 weather locations for England including three files covering Greater London.
- Simulate the model for a full year and extract TM59 results for each home (differentiating bedrooms from other occupied rooms), and from common spaces and rooms where Part O applies.
- Report on the results highlighting any areas of non-compliance and suggesting potential mitigations
- Iterate the model testing mitigation options until all relevant rooms and spaces meet the criteria.

Important checks on a TM59 model for Part O compliance	
Do all the window opening assumptions follow AD-O where it deviates from the original TM59? – see section 4.6	✓×
Are the noise limits in AD-O exceeded at night and have the implications for this been taken into account within the model – see section 0	✓×
Have all security constraints, especially for ground floor windows that might require extra measures (grilles, shutters or railings), been factored into assumed window opening proportions? - see section 2.3	✓×
Have all safety constraints, including a check that all window cill heights and opening reach comply with AD-O requirements? - see section 2.4	✓×
Have all blinds, curtains, trees or foliage been excluded from the model? – see section 4.6	✓×
Have any community heating pipework and HIU heat gains been included in the model, both in any communal corridors/stairwells and within sample homes?	✓×
If mechanical cooling is included in the design, or mechanical ventilation is relied upon for overheating mitigation during the day then have the TM59 fixed criteria for 'predominantly mechanically ventilated' homes been used?	✓×

4.5. Shading

Dynamic modelling tools allow most forms of external shading to be represented. This includes shading due to surrounding buildings, or due to the shape of the building being modelled. Balconies can provide helpful shading - note that to protect the top floor rooms, this may need to be replicated with overhangs of similar dimensions. Awnings, horizontal or vertical louvres and overhangs can all be represented within dynamic models, as well as the impact of deeper window reveals, and glazing specifications with greater solar control (lower g-values).

Unlike within the Simplified method, external shading can be taken into account in any location, and this route allows more flexibility to design the shading to suit the development. The dynamic model can be used to inform the design of this shading to optimise the benefits to where they are needed most.

It is important to note that the shading benefit from internal blinds or curtains cannot be included in the model (see section 4.6). Fixed internal shutters would be allowable provided these are installed as part of the base build, and their effect on natural ventilation free areas is also taken into account in the model.

4.6. Differences between "generic" and Part O TM59

C

According to AD-O, modelling should be according to the CIBSE TM59 guidance, but with the following important distinctions:

Window opening patterns

a) When a room is occupied during the day (8am to 11pm), openings should be modelled to do all of the following.
i. Start to open when the internal temperature exceeds 22°C.
ii. Be fully open when the internal temperature exceeds 26°C.
iii. Start to close when the internal temperature falls below 26°C.
iv. Be fully closed when the internal temperature falls below 22°C.

This is fairly self-explanatory. While in TM59 the windows should be fully open from 22°C, for Part O the model must set windows to open (and close again) gradually between 22 and 26°C based on the room dry bulb temperature.

b) At night (11pm to 8am), openings should be modelled as fully open if both of the following apply.
i. The opening is on the first floor or above and not easily accessible.
ii. The internal temperature exceeds 23°C at 11pm.

These are two important points:
- windows that cannot be defined as secure should not be opened at night
- if windows are secure to open, then rather than use the sliding scale described above, bedroom windows should be set to open wide (within maximum reach of 650mm – see section 2.4) all night if the room dry bulb temperature >23°C at 11pm. See section 4.8 on software implications.

c) When a ground floor or easily accessible room is unoccupied, both of the following apply:
i. In the day, windows, patio doors and balcony doors should be modelled as open, if this can be done securely, following the guidance in paragraph 3.7 below.
ii. At night, windows, patio doors and balcony doors should be modelled as closed.

Note that point (ii) does not apply to ventilation louvres or other secure openings. Windows on restrictors are NOT considered secure in this case.
>> DLUCH FAQ11.

This differs from TM59, which states: "*Opening areas assumed should take into account any security, acoustic or air quality issues that limit opening area (e.g. on ground floors)*" and "*patio doors should only be modelled as open in unoccupied rooms or at night if they can be locked securely open, and the locked percentage of free area used in the model.*"

d) An entrance door should be included, which should be shut all the time.

Blinds and shading

2.8 Although internal blinds and curtains provide some reduction in solar gains, they should not be taken into account when considering whether requirement O1 has been met.
2.9 Foliage, such as tree cover, can provide some reduction in solar gains. However, it should not be taken into account when considering whether requirement O1 has been met.

Shading from blinds/curtains or trees CANNOT be included within the Part O model.

This is a significant change from TM59 which does allow blinds/curtains with certain strict provisos. This change is likely to make compliance significantly more challenging, especially for locations in London and the South-East, and may necessitate reductions in glazing areas.

4.7. Where noise criteria are exceeded

D

Passive solutions must be implemented *as far as reasonably practicable* to reduce reliance on mechanical systems. There is a gradient in approaches, but beyond a certain point the compliance criteria within TM59 change from the adaptive thermal comfort criteria used for homes that are 'predominantly naturally ventilated, to the fixed criteria used for homes that are 'predominantly mechanically ventilated'.

The TM59 'predominantly naturally ventilated' criteria can still be used in the following situations:

a) the maximum opening proportion for bedroom windows is reduced at night to a level that sufficiently reduces the noise ingress (i.e. windows provide further noise attenuation than in a fully open situation)

or

b) the bedroom windows are closed at night, and mechanical ventilation is provided (quietly) at sufficient rates for heat dissipation during these night time hours.

>> DLUHC FAQ12
>> DLUHC FAQ14

If these options are pursued, they should be clearly explained in the report, and raised in BCB discussions early on.

If these options are not feasible or are insufficient to meet both the noise and overheating limits in AD-O, then mechanical cooling solutions may be considered, but *it should be demonstrated to the building control body that all practicable passive means of limiting unwanted solar gains and removing excess heat have been used first before adopting mechanical cooling*. One approach could be, for example, to show that if night-time opening of windows was not limited by noise constraints, then compliance with TM59 criteria would be achieved. - see case study 2, Single aspect apartment. Where cooling is used, the 'predominantly mechanically

4.8. Software implications

The assessment must use a dynamic thermal modelling software package that complies with the requirements of CIBSE AM11: Building performance modelling (2015b).

The additional requirement covered in section 4.6 on setting the night time schedule for windows is (at the time of writing) not straightforward to apply in all dynamic thermal modelling software. Not all dynamic modelling tools previously allowed this, but updates are anticipated from the software developers which will allow this functionality.

Some dynamic modelling tools are now able to factor in the benefit of installed ceiling fans on occupant comfort. Care should be taken to ensure that the air speeds, and sensible gains assumed within the model are in-line with manufacturer data for the type of fan specified. See section 1.1 for more information on the benefits of fans.

4.9. Reporting on the TM59 route

E

AD-O requires the reporting checklist to be completed for the scheme and submitted to Building Control *as evidence that the building has been constructed as designed to reduce the risk of overheating*. An illustrative filled-in compliance checklist is included in the Worked Example in section 8. The BCB should also be provided with a report demonstrating compliance, and including the information recommended in TM59 section 2.3. This includes the following:

- *dynamic thermal analysis software name and version used for the assessment, which must comply with the requirements of CIBSE AM11: Building performance modelling (2015)*
- *site location and orientation*
- *images of the model indicating the sample homes selected and the basis for selection*
- *images showing the internal layouts for the sample homes*
- *information on the construction type with layers of construction (used to determine U-values and g-values) for all external and internal building elements, plus any additional shading features (including any blinds, and demonstrating that the blinds do not clash with opening windows if blinds are used to contribute to a pass)*
- *thermal mass, with an explanation of where it is incorporated.* In that case, it would also be useful to detail night-time ventilation strategy - see guidance in section 1.1
- *the ventilation strategy modelled, including details of window opening assumptions, free areas calculated, infiltration rates assumed and any mechanical supply/extract flow rates*
- *the weather file(s) used for the assessment*
- *the thermal comfort category assumed based on CIBSE TM52 (2013); this should be Cat. II by default, but Cat. I for vulnerable residents (see section 4.4); Cat. III for existing buildings should not be used for the purposes of this methodology*
- *the results of the analysis:*
  - *reports should be clearly reported based on criteria (a) and (b) in section 4.2*
  - *a home is only shown to comply if all occupied spaces meet relevant overheating criteria*
  - *corridors should be included where there is communal heating pipework*
  - *the report may include the results for several iterations explored, to demonstrate the route to compliance*
  - *if blinds were part of the strategy used to gain a pass, then results without blinds must also be included for information*
- *the report should state clearly whether the project passes or fails the assessment and, where a pass is indicated, it should make clear on what design features this depends (e.g. the inclusion of glazing with g-value below x, reduced window sizes, etc).*

In addition, for the purpose of Part O, if cooling is provided it is recommended that the report should include the results without cooling and detail the passive measures incorporated, to demonstrate that "*all practicable passive means of limiting unwanted solar gains and removing excess heat have been used first before adopting mechanical cooling*."

Beyond compliance requirements only, it is extremely valuable to document the analysis undertaken, and all the assumptions used within the model as well as the results. The benefits include:

- establishing a clear record of the assessment and the basis of the results
- enabling the design team to review the design information that the model and results are based on so that errors or misinterpretations can be picked up and corrected
- design changes made as the scheme evolves are more readily identified and the model updated.

5. PART O REPORTING

Reporting requirements are detailed in AD-O Appendix B:

- Part 1 and 3 are independent of the compliance route followed and require basic information about the site and the designer, and a declaration from the builder that the construction matches what has been assessed.
- Part 2 of the reporting requirements depends on the route followed. More details are provided in the sections of this guidance on each compliance route, and in the worked example in section 8.

Building Control may require additional supporting information such as detailed calculations.

6. THE HOME USER GUIDE

It is good practice to produce a user guide that explains to occupants the key features of the scheme, and this is now a requirement in the 2021 revision of Building Regulations (https://www.gov.uk/government/publications/home-user-guide-template).

The home user guide should be a short and visual document in simple language. It should cover measures they can take to prevent overheating in their home and include the following information as a minimum:

- Simple concepts and tips, such as the benefits of cross-ventilation (if present) and of ventilation at high levels (e.g. windows on upper floors in houses)
- Presence and operation of secure openings that can help ventilation at night or when occupants are not in the room e.g. side panels, window locks
- Presence and operation of movable shading devices
- Whether the dwelling has high thermal mass, and if so how to take its benefits with secure nigh-time ventilation
- Presence and operation of ceiling fans, or the ability to install them in the future, and advice on hydration
- Specific advice for vulnerable residents
- Presence and operation of a summer bypass, if present and not automated
- The importance of changing filters and maintaining mechanical ventilation systems: while not an overheating mitigation measure on its own as background ventilation rates are much lower than those required for overheating mitigation, low ventilation rates (or systems switched off) due to poorly maintained systems can contribute to high temperatures.

Note this guidance addresses homes in general; specific situations such a care homes are likely to need additional considerations for the residents, and to ensure staff are trained.

7. GOOD PRACTICE PRINCIPLES TO LIMIT OVERHEATING RISK

This section provides an overview of the main underlying reasons for overheating in housing, and principles to mitigate this risk. The scope is slightly wider than the measures considered in Part O alone, but much of the guidance can be used when seeking Part O compliance e.g. on effective openings for ventilation.

7.1. Why limiting overheating risk matters

Overheating in UK homes is widespread, with heat-related deaths expected to more than triple, to 7,000 a year by the 2050s [Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s. Journal of Epidemiology and Community Health]. The Climate Change Committee (CCC) has classified overheating in its highest risk to health and well-being category [Progress in adapting to climate change 2021]. Temperature increases are expected to be more pronounced in the south of England (CCC, 2021).

Excessive temperatures are particularly problematic when people are trying to sleep, as they can degrade sleep quality, with detrimental impacts on health and wellbeing.

The introduction of the new Part O requirement is therefore welcome. However, as the Approved Document itself states "*The guidance and regulations are written for the purposes of protecting health and welfare. Following this guidance does not guarantee the comfort of building occupants*."

It is important that project teams give sufficient consideration to reducing overheating risk at the early design stage, alongside other key requirements such as ventilation, beneficial winter heat gains, views, and daylight. This should inform design decisions such as site and dwelling layout, limiting the risk of extensive design changes being required later on, as well as reducing reliance on mechanical solutions.

7.2. Designing for comfort and good performance, not just compliance

While the introduction of the Part O requirement is a significant step in assessing and limiting overheating risk, there are a number of reasons why, as for many aspects of Building Regulations, it cannot be, on its own, relied upon to deliver performing homes:

- The Approved Document itself states that the requirement is about protecting the safety of occupants, not a guarantee of thermal comfort
- As a first revision, some of its requirements are still relatively untested, and may evolve in the future. For example:
  - the approach to very restricted glazing proportions to the West (compared to South);
  - the simple division of the country into broadly two risk locations: in practice, inland locations in southern England are likely to experience more overheating risk than those in northern coastal locations, and this may further increase with climate change
  - the approach to "most glazed façade" and "most glazed room" specific building layout and façade configurations could fall within loopholes, and some homes or rooms could end up quite highly glazed but complying, or overly restricted in their glazing provision.
- Restrictions on window openings due to noise are only required to be considered for night-time. In practice, very noisy locations during the day may also cause issues for occupants and create an overheating risk. There is an implied expectation in Part O that this is addressed through the planning system, however it may not always be the case.
- Features incorporated for overheating risk mitigation often rely on occupants activating them; they need to be easy to understand and operate. This needs to be covered by simple guidance as part of the Home User Guide for new dwellings (Section 9 of AD-L) - see section 6.
- Using the TM59 route, once "*all practicable passive means*" have been explored mechanical cooling may be incorporated, in order to achieve compliance. This should not be overly relied upon, due to the effect on energy use and associated carbon emissions, costs for residents, and possible impacts on neighbouring properties - see section 6.3 below.
- As with other requirements of the Building Regulations, designing to comply with Part O cannot be done in isolation or considered a "tick box" exercise, as the design measures will have an effect not only on Part O, but on other regulatory aspects (e.g. Part L, planning) and on important factors for building performance, health and wellbeing including energy efficiency, daylight, winter thermal comfort etc.

7.3. What about cooling?

Under Part O, cooling provision can be used as part of the approach to show compliance, using the TM59 method, but only once all passive measures to reduce and mitigate heat gains have been implemented - see details in section 4.9.

Mechanical cooling has energy use implications, with associated energy costs and carbon emissions, and there may also be carbon emissions from refrigerants. It also creates an additional cost of maintenance, may have negative impacts on neighbours if it is noisy, or through heat rejection (which itself may create an overheating risk for neighbours).

Therefore, designing for passive overheating mitigation should be the priority. It should only be provided once alternatives have been explored, and the reliance on it should be reduced even where it is provided, to reduce its impacts and improve the resilience of homes.

7.4. Key risk factors

Put simply, an internal space is considered to be overheating when it is too hot for the comfort and health of occupants, even when the outside temperature is not necessarily high. This is caused by an imbalance between heat gains (from the sun, external air, and internal gains) and heat dissipation.

The main considerations are:

- Solar gains from glazed areas, and any protection through shading (whether dedicated devices, the shape of the building itself, or surroundings)
- External temperatures, affected by the regional climate as well as very local factors such as proximity to urban centres, proximity to green / blue spaces, windy and coastal locations etc
- Heat gains from occupants and systems (e.g. heating & hot water systems, plug loads, cooking)
- The capacity for heat dissipation through ventilation, which is influenced by the design of openings and ventilation systems but also by contextual factors such as noise outside.

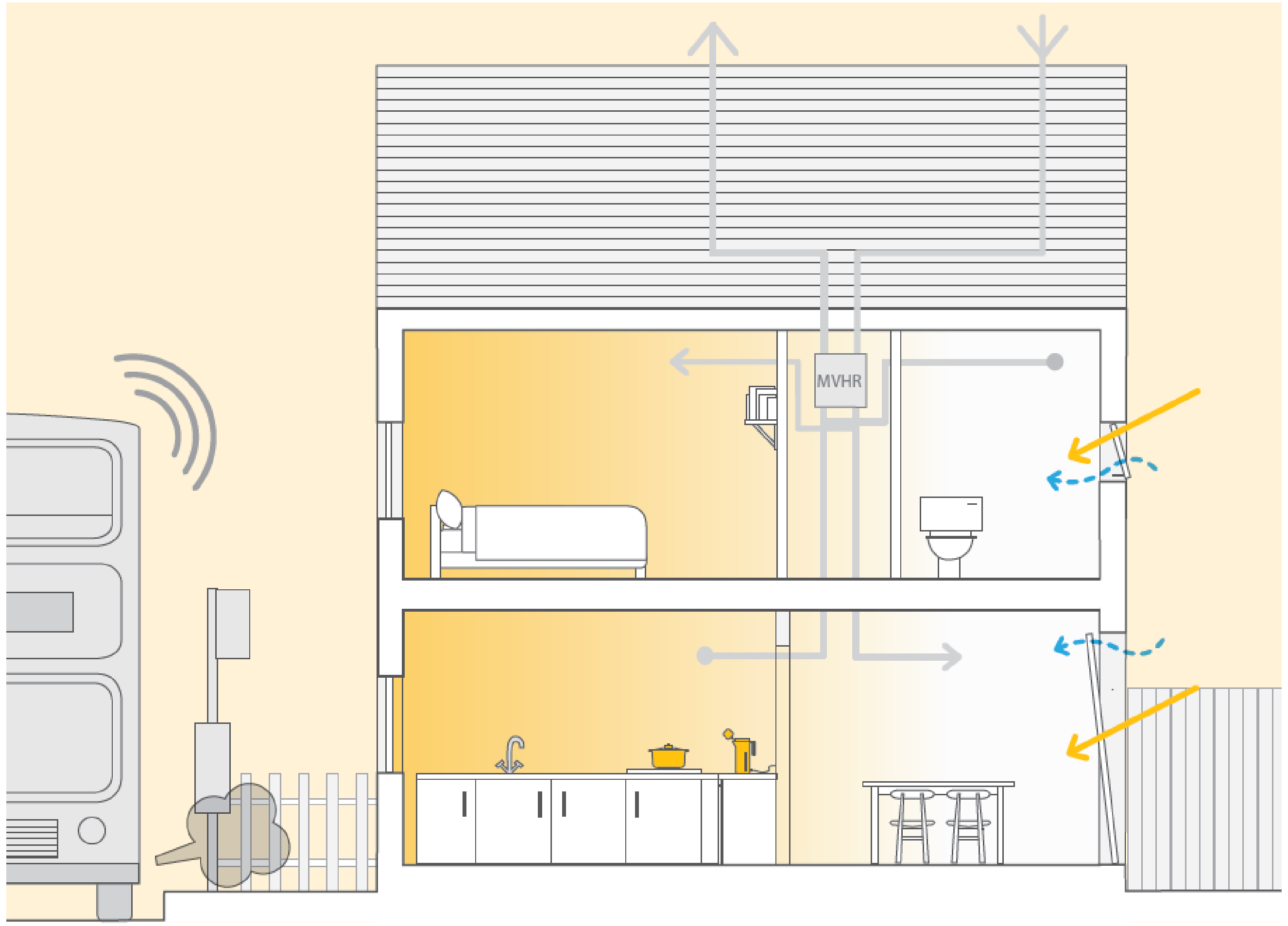


Figure 17

Openings may be limited by design or by contextual factors (e.g. noise, security), limiting the potential for heat dissipation through natural ventilation (illustration from NF44, 2012)

7.5. Site considerations

Site location influences solar gains and air temperatures.

Geographical location influences external temperature and heat gains from solar radiation. Both are typically higher in the South of the UK, and projections indicate that future temperature increases may be more pronounced in the South, further compounding the risk there.

In addition to regional climate, in cities and built-up areas the preponderance of hard surfaces leads to higher average air temperatures (by a few degrees, especially at night) as these surfaces absorb solar heat during the day and release it at night. This is increased by factors including heat rejection from vehicles and air conditioning equipment. This is known as the Urban Heat Island (UHI) effect. The UHI effect occurs throughout the day but is stronger at night, with night-time temperatures sometimes significantly higher than in surrounding rural locations. Higher night-time temperatures can impact on sleep and the ability to cool building fabric.
The proximity to green and blue spaces reduces local temperatures. This is true at the regional / local authority scale, but also very locally: even within an UHI such as London, there can be variations of a few degrees at night between very built-up dense locations and low-rise ones adjacent to large green / blue spaces.

Software and calculation tools are typically limited in how they can take account of micro-climates.

Figure 18

Illustration of the Urban Heat Island effect, with indicative temperature differences which may be experienced at night-time (illustration from NF44, 2012)

Site conditions may in practice affect the ability to dissipate heat through natural openings

Ventilation is one of the key measures to mitigate overheating risk by dissipating heat from solar and internal gains, and ideally by promoting a cooling air movement within / through a dwelling.

Ventilation is sometimes physically limited by the design of the window or opening - see section 7.7 on good practice openings. However, even if occupants can physically open windows or other openings, they may be deterred from doing so by other reasons, the main ones being:

- Noise levels: this is known to be a significant barrier to window opening, particularly in urban areas and near transport routes. The risks and possible mitigation measures should be evaluated as part of the planning application process, with advice from the project team's acoustic consultant (if available) and the local authority's environmental health department on site conditions and how best to balance the needs for ventilation, temperature management and acoustics. Noise at night is of particular concern as it can affect sleep. Mitigation measures include early design considerations (e.g. site and building layout, locating sensitive uses away from sources of noise, mitigation through landscaping or through other buildings) and ventilation design (e.g. mechanical ventilation, acoustically attenuated openings). Approved Document O sets night-time noise limits in bedrooms; where these are exceeded, sites will need to be assessed using the TM59 modelling route, and potentially need mechanical ventilation for heat dissipation at night - see section 0.

- Poor air quality/smells: this should be evaluated as part of the planning application process, with advice from the project team's air quality consultant (if available) and the local authority's environmental health department on mitigation measures such as mechanical ventilation, filters, location of air inlets etc. While poor air quality as such may not necessarily change people's behaviour to window opening, smells from neighbouring uses such as busy roads, car park areas, factories, or commercial kitchens, could. See section 2.2
- Security risks/crime: this should be assessed as part of the planning application process as well as Part O, with advice from the local security officer or police force where there are concerns. Ground and lower floors are likely to be more susceptible, but generally any accessible room. Thought should be given to whether occupants would feel safe leaving their windows open, particularly at night when sleeping, or day-time when they are not in that room - see section 2.3
- Safety concerns: the design of openings and other features such as louvres, shading devices etc should consider safety, such as the risk of falling from higher floors; strong winds in high-rise buildings making it difficult to open windows safely; the risk of small children escaping from openings on ground floors or through patio doors to balconies (especially in non-master bedrooms, which may be used for children and therefore not left open at night); risks of small children or limbs getting trapped in devices such as louvres or guarding etc - see section 2.4
- Directly adjacent heat rejection plant: in cases where heat rejection plant is located near window openings, this may prevent residents from opening their windows due to noise issues and potentially higher local air temperatures, which means that openings and air inlets may draw hot air inside and therefore increase rather than mitigating the risk of overheating.

Apartments and other dense dwelling types are typically more at risk

Apartments are typically more prone to overheating. This is due to a number of reasons including their (typically) smaller size, denser occupation, fewer opportunities for cross ventilation, and surrounding dwellings and communal areas preventing heat dissipation or even adding to heat gains. Apartments in upper floors are even more at risk, as heat rises, and because upper floors tend to be more solar exposed (less shaded from trees or neighbouring buildings); in addition, top floor rooms receive heat gains from the roof.

While these factors are exacerbated in apartments, they may be similar in other types of dwellings, especially small ones.

Homes in London are more at risk than the rest of the country

Most of these factors, combined, explain why properties in London are generally much more at risk of overheating than those in the rest of the UK. However, this is on a gradient and project specific, as other locations in the South will also experience high temperatures and solar gains in the summer, and inversely, locations in a Northern city may suffer overheating risk due to noise levels limiting the likelihood of occupants open windows for long periods of time, particularly at night.

7.6. Limiting solar gains

Limiting solar gains through well balanced and located areas of glazing, complemented by shading, is a vital part of limiting overheating risk.

Glazing provision

Higher proportions of glazing allow greater levels of solar heat gains to enter spaces. Windows are a vital feature for daylight access, views and ventilation, but excess glazing on solar-exposed facades i.e. West, South and East facing elevations (and those in between) can have severe consequences in aggravating overheating risk.

Ultimately, it is the proportion of glazing in relation to the volume of the internal space which will directly affect the rise in internal temperature, however at the early design stages it is usually easier to consider the provision of glazing in relation to the façade. For performance and design flexibility, this is best considered alongside shading provision, as part of the overall facade design.

Reducing glazing areas without compromising daylight

In order to maintain good daylight levels, the location, and not just the quantity, of glazed areas matters. While lower-level glazing is useful to provide views out when seated, especially in living rooms and rooms occupied by elderly or reduced mobility residents, low-level glazed areas (say, below 700mm) and those in room corners allow less light penetration into the space, but still contribute to winter heat losses and summer overheating risk.

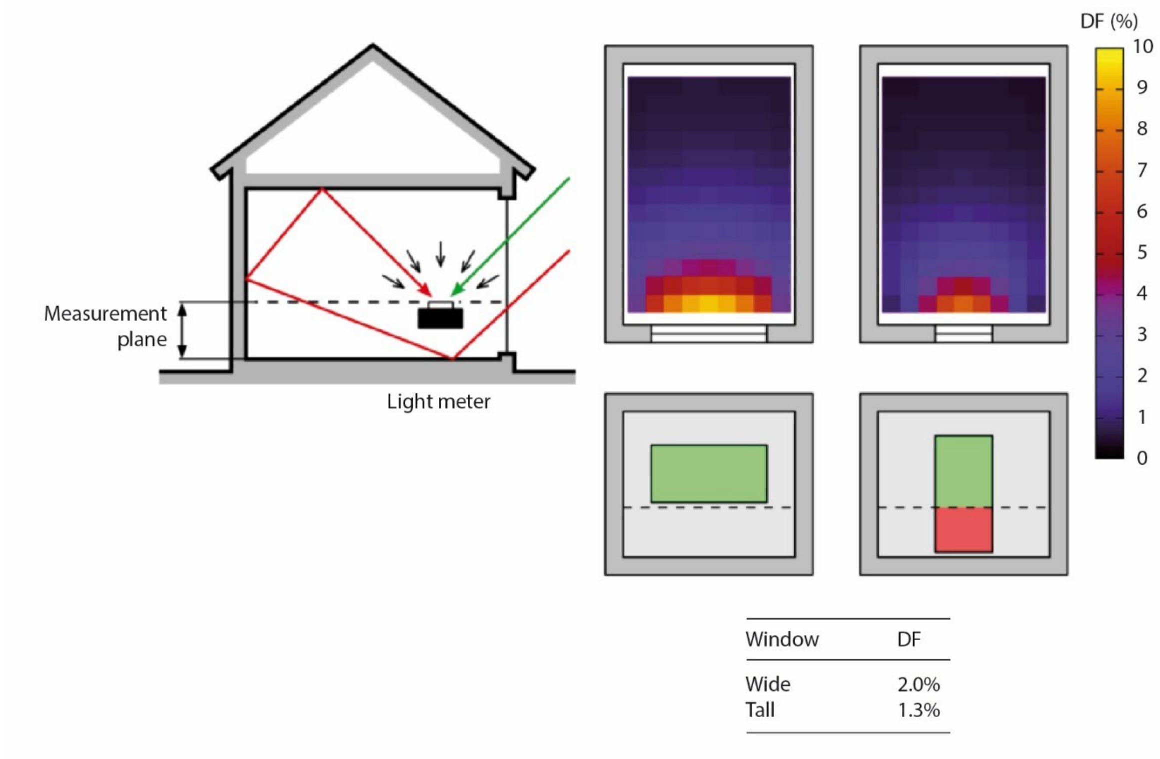


Figure 19

For daylight penetration and distribution into the room, glazing location matters, not just its amount (illustration from Hoare Lea, CIBSE TM60, 2018)

Figure 20

Illustration of façade with second floor window, without glazing at low level (Photo credit: Solution provider: Studio Partington Photographer: Tracey Whitefoot)

Shading

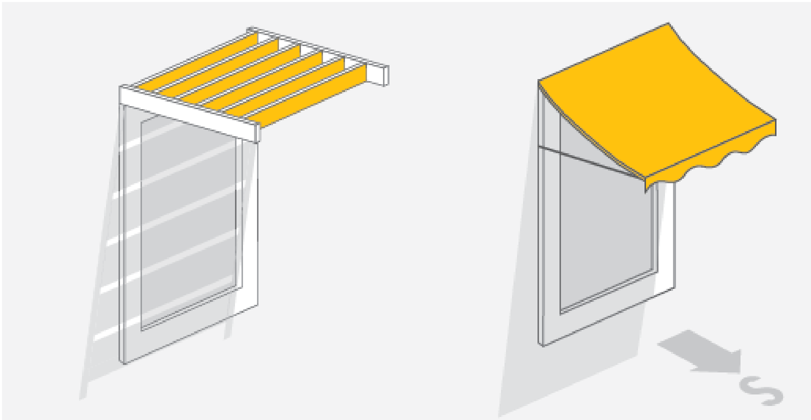
External shading can significantly reduce the solar gains admitted into a space. This can be through a range of features such as shutters, external blinds, overhangs and side-fins, the articulation of the building itself, or the surroundings.

The effectiveness of the shading feature, and its impact on the overall performance of the home, does rely on good design. South-facing glazing will benefit most from horizontal shading (e.g. overhangs, balconies above), though morning or afternoon gains from the sides may still be important. The horizontal overhang can be designed so as to retain solar gains in the winter, when the sun is lower. On east and west facing glazing, vertical shading (e.g. deep recesses and/or vertical fins) is more effective, but it will also affect winter gains.

Typically, movable external shading devices which allow a level of adaptation by occupants are preferred. In some cases, the design of devices such as shutters means they can be closed while windows are left open and still allow a level of secure ventilation e.g. at night, or when people are not in the room. If devices are movable, a simple explanation on their use should be provided to occupants in the home user guide - see section 6.

Internal shading, such as blinds, also mitigates solar heat gains to some extent, but has less effect as heat is already in the space; it can also impede air flow or conflict with window opening. Blinds/curtains with reflective linings are more effective at reducing heat gains as are heavy thermal lined curtains, but both will affect internal light levels and air flow. Internal shading cannot be accounted for in Part O assessments (whether the Simplified Method or dynamic modelling route).

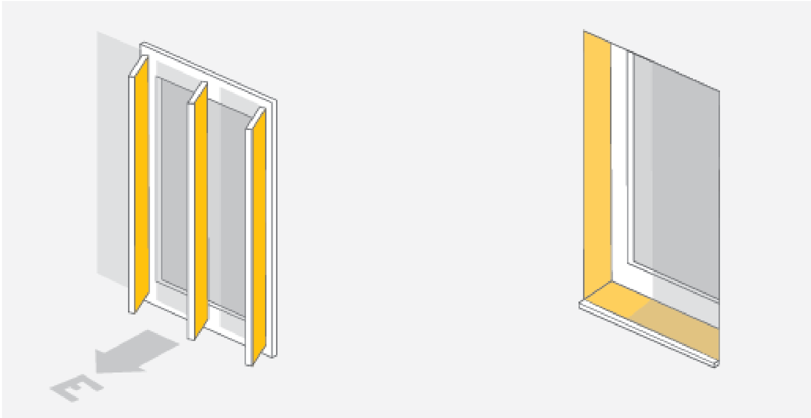
Solar control glazing or films also help, but limit useful heat gains in winter and, in some cases, affect light transmittance, with potential detrimental effects on internal appearance (if light transmittance is really low, rooms may appear gloomy), and lighting consumption may increase. When low g-values are proposed (e.g. below those required to meet the Part O shading requirements), glazing properties should be examined carefully, to ensure the effects on light transmittance, tint and energy performance are acceptable before selecting that glazing product.



High-level sun

South-facing windows need to be protected from high-level sun. This may be done either by projections of the building form itself or balconies or overhanging eaves. Generally these devices block the sun, with a limited impact on views out.

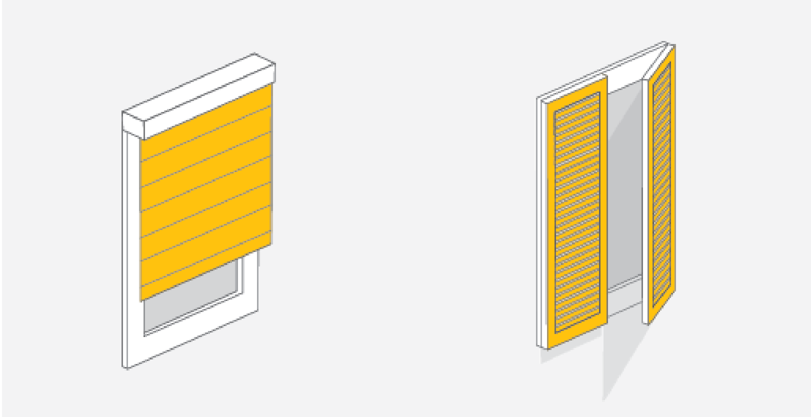
Far left: brise-soleil
Left: awning



Low-level sun

Vertical shading devices are most effective for windows facing the east or west, which are vulnerable to low-level sun. These often reduce the external views and, to a lesser extent, daylighting.

Far left: vertical louvres
Left: deep window reveals



General shading

Shading features which cover the windows are the most effective for both high- and low-level sun, but they may completely restrict views to the outside and daylighting.

Far left: external blinds
Left: external shutters

Figure 21

(illustration from NF44, 2012)

7.7. Dissipating heat gains: ventilation

Dissipating heat accumulated inside with flexible and generous ventilation is the second key element to limiting overheating risk.

Large and widely openable windows or other natural ventilation openings help create good air flow and a pleasant breeze in hot weather.

Poor design of windows and other openings can limit the air flow, and therefore limit the capacity of a dwelling to dissipate heat. Common installations that restrict air flow include:

- Restrictors that cannot be overridden, or which would lead to unsafe openings. In effect restrictors are strongly discouraged by Part O, especially in the Simplified Method, as with them in place it would be very difficult to achieve the required free areas and air flow. However, in addition to Part K requirements, Part O does place requirements to protect from falling for windows which open wider than 100mm (see section 2.4).
- Few small panes openable in larger glazing areas
- Deep internal or external reveals limiting the gap obtained when windows are open
- Louvres/shutters which decrease the equivalent free area.

Info box: summer ventilation vs background ventilation vs purge ventilation

The ventilation rates required for overheating risk mitigation are much higher than what is required year-round for background ventilation. They are best provided using natural ventilation openings as mechanical ventilation systems are typically not designed to provide sufficient rates, or may be uncomfortable and noisy when they do.

Approved Document F purge requirements are intended for occasions when high ventilation rates are needed to deal quickly with temporary situations, such as fresh paint or burnt toast. While this provision may in some cases be used to provide thermal comfort by removing excess heat, this is not their primary function. Provisions for purge ventilation may therefore not be appropriate for longer and more regular use, to prevent overheating.

For example, restrictors are often installed on windows for safety or security reasons, and strategies for meeting Approved Document F purge requirements tend to assume that restrictors would be overridden for short periods.

Relying on mechanical ventilation systems for overheating mitigation therefore will generally require a dedicated system to be installed. It should be treated with much caution, as systems can be noisy, and the required air change rates (typically, 4 air change rates are needed as a rule of thumb) have significant design implications and can result in potentially uncomfortable conditions. In any case, natural openings (e.g. windows) should always be provided, to add resilience and give a choice to occupants.

Designing effective openings

The opening type (top hung, side hung, sash, patio door etc) makes a key difference to how wide a window will open and how well air can flow.

Roughly speaking, sliding windows or doors, and sash windows can achieve up to 40% openings in relation to the pane area. Side hung windows can often create wider areas for air flow (potentially the full pane area, if able to open safely to 90°) than top or bottom hung windows. Hinged or bi-folding patio doors usually allow very large free areas.

It is worth considering the external reveal depth and how far the window opens to be sure that effective ventilation can be achieved.

Windows in high rise buildings often have more limited openings due to concerns over high wind speeds or safety: good design can enable good ventilation whilst managing these risks.

The summer ventilation strategy may require dedicated approaches in order to provide sufficient rates while also addressing other issues such as noise. For example, louvered side vents can be secure, provide noise attenuation, a large free area, and not increase summer solar gains.

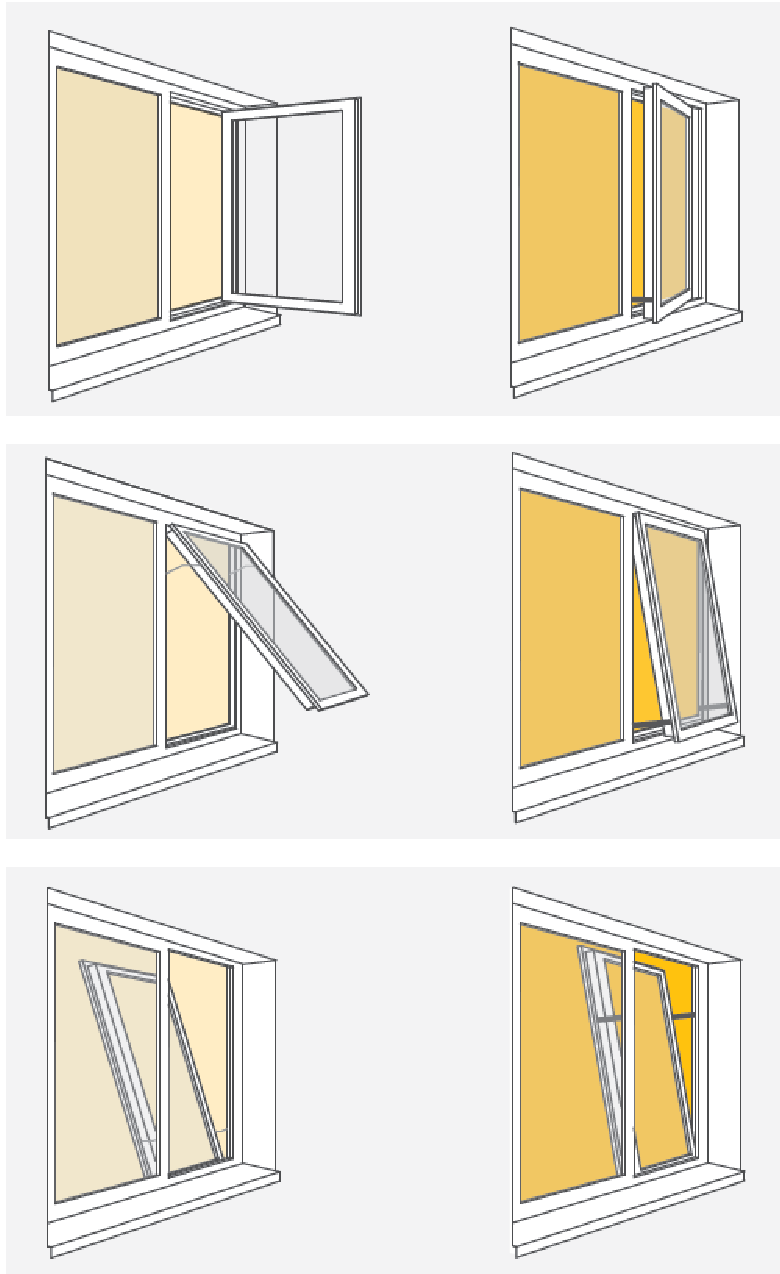


Figure 22

(illustration from NF44, 2012)

Prioritising dual aspect dwellings for cross ventilation

Dual aspect dwellings are where windows are provided on opposite sides; this facilitates cross-ventilation i.e. the potential for air to pass through the home from one facade to another. Dual aspect homes often offer other opportunities that will help mitigate overheating risk, such as openings onto a quieter facade away from the main elevation on the road. Beyond their benefits against overheating, they are also appreciated by occupants, as they provide variations in solar exposure throughout the day. Even in apartment blocks, it is possible to design efficient floor layouts with a majority of dual aspect homes.

Single aspect dwellings are where all rooms, and therefore windows, are on the same façade e.g. in apartment blocks where floor layouts are designed with long corridors and homes on each side. In homes like this, natural ventilation is less effective (lower flow rate), which limits the amount of heat that can be purged. In addition, all solar gains occur at the same time, increasing the total peak solar gains.

Note that bay windows or small articulations in the facade do not mitigate for this. Corner dwellings offer some benefit compared to single-aspect ones, but less than dwellings with windows or openings on opposite sides.

7.8. Other opportunities to reduce overheating risk

While solar gains and ventilation are the primary factors to effectively address overheating risk, a number of other design measures can be considered. Their effect is typically much smaller, but they can still contribute to the user's comfort and experience of their home. These include:

Ceiling heights: higher floor-to-ceilings mean large volumes, so a smaller effect on air temperature for given heat gains, and more stratification so possibly a more comfortable temperature in the zone occupied by people. They also facilitate the installation of ceiling fans, now or in the future.

This measure is not accounted for in the Part O Simplified Method. The volume of the space is accounted for in the dynamic thermal modelling route, but stratification will usually not be.

Fans, particularly ceiling fans but also free-standing fans: air movement creates a cooling effect, which can improve comfort. Care should however be taken not to overly rely on them, particularly with elderly or vulnerable residents, as they can mask dehydration. They should also be selected and installed to be quiet, particularly if they are to be used in bedrooms.

This measure is not accounted for in the Part O Simplified Method. In theory it may be in the dynamic thermal modelling route, although this is not necessarily straightforward - see section 4.8.

Thermal mass & night-time ventilation: High thermal mass (e.g. dense masonry walls with wet plaster finish, or exposed concrete), if it is exposed, has overheating mitigation benefits by absorbing and slowing the impact of heat on internal temperatures. The heat absorbed needs to be efficiently removed again through ventilation when temperatures drop (i.e. at night) otherwise it re-radiates and increases internal temperatures, which could actually exacerbate overheating, particularly in bedrooms: if exposed thermal mass is proposed, night-time ventilation should be designed alongside (taking considerations such as noise, safety and security into account), and the importance of night purge ventilation should be explained in the home user guide (see section 6).

This measure is not accounted for in the Part O Simplified Method, but can be in the dynamic thermal modelling route.

Communal / district heating: Centralised heating systems (e.g. per block or scheme) can contribute to overheating risk through a range of issues including lack of individual controls and heat gains from distribution pipework and Heat Interface Units (HIUs). Heat may be released 24/7 and, when this happens in internal spaces which are not well ventilated, it accumulates and can significantly contribute to overheating of these and neighbouring occupied spaces. A number of mitigation measures are available, and most also align with energy efficiency considerations i.e. reducing unwanted heat losses through distribution and storage:

- Insulation to pipework, HIUs and storage vessels
- Lower flow temperatures, following current best practice or with systems circulating water at low temperatures, such as "ambient loops".
- More efficient control strategies
- Minimising pipe runs, particularly in enclosed areas such as hallways and corridors
- Ventilating any enclosed areas where heat is released to avoid the gradual build-up of heat (e.g. using actuated louvres or mechanical extract). This should include corridors and risers with pipework, and areas where the HIU and associated storage (if any) are located.

This issue is taken into account to some extent in Part O: if the scheme has long corridors with horizontal heating and hot water pipework then the Simplified Method cannot be used and the dynamic modelling route has to be used; corridors will then be modelled including gains from pipework, and the effect of the corridors on adjacent dwellings will be accounted for in the model.

Worked examples and case studies

8. WORKED EXAMPLES

In this chapter a worked example is provided to demonstrate how both methods can be applied in practice.

The example is a 4-bedroomed semi-detached house type with two bedrooms in the roof level, assumed to be located in Birmingham. It is dual aspect North (front) - South (rear).

It is assumed that no noise, security or air pollution issues constrained reliance on openable windows for overheating mitigation. All bedrooms are on the first floor or above and do not qualify as 'easily accessible' so bedroom windows are deemed able to open securely at night.

Figure 23

House used in the worked example: 4 elevations. Front is North facing, rear is South facing

8.1. Simplified method

The worked example follows the steps in section 0. It uses the following format/template for reporting information and results. AD-O does not require results to be presented in this specific format, but a consistent approach to recording and presenting results for each home assessed is advisable.

A Home data					Home reference
Cross Vent	Y/N				
Location risk category	High/Mod				
Largest glazed façade orientation	N,E,S,W				
GIA of home	xx m²				
B Targets					
Max glazing (% GIA)	xx %				
Max glazing most glazed room (% room floor area)	xx %				
Shading required?	y/n				
Min home free area (a) (% GIA)	xx %				
Min home free area (b) (% glazing area)	xx %				
Bedroom min free area (% room floor area)	xx %				
C Results	**Value**	**% result**	**Target**	**Result**	**✓✗**
Total glazing area for home	m²	%	%	< target	✓
Glazing area for most glazed room	m²	%	%	< target	✓
Shading provided?				= target	✓
Total home equivalent area	m²	%	%	> target	✓
		%	%	> target	✓
Bedroom 1 equivalent area	%	%	%	> target	✓
Bedroom 2 equivalent area	%	%	%	> target	✓
Bedroom 3 equivalent area	%	%	%	> target	✓

Figure 24

Template reporting box

8.1.1. Basic information on the home

The house meets the criteria for cross-ventilation as it has windows on opposite facades.

As the site is assumed to be in Birmingham, it is considered in a "moderate risk location" for Part O.

The floor area (GIA) of the home is 113m².

A Home data	
Cross Vent	Yes
Location risk category	Moderate
Largest glazed façade orientation	South
GIA of home	113.0 m²

Figure 25

Template box A listing basic information for the worked example house

8.1.2. Establishing the targets (Step 1)

The façade with the largest area of glazing is, in this worked example, straightforward to establish without detailed measurements: it is the rear one and faces South. For certainty and reporting this can be checked later on, once all measurements are available (end of Step 4).

The targets for this house are therefore those for homes with cross ventilation, for moderate risk locations with the most glazed façade facing South. As this home is in a moderate risk location, additional shading is not a requirement.

Table 1.1 Limiting solar gains for buildings or parts of buildings with cross-ventilation[1]

Largest glazed façade orientation	High risk location: Maximum area of glazing (% floor area)	High risk location: Maximum area of glazing in the most glazed room (% floor area of room)	Moderate risk location: Maximum area of glazing (% floor area)	Moderate risk location: Maximum area of glazing in the most glazed room (% floor area of room)
North	15	37	18	37
East	18	37	18	37
South	15	22	15	30
West	18	37	11	22

NOTE:
1. Floor area and floor area of room are as defined in Appendix A.

Figure 26

Solar gain limits from AD-O, marked up for the example home

Table 1.3 Minimum free areas for buildings or parts of buildings with cross-ventilation

	High risk location	Moderate risk location
Total minimum free area[1]	The greater of the following: a. 6% of the floor area[2] b. 70% of the glazing area[3]	The greater of the following: a. 9% of the floor area[2] b. 55% of the glazing area[3]
Bedroom minimum free area	13% of the floor area of the room[4]	4% of the floor area of the room[4]

NOTES:
1. The total minimum free area is the free area for the whole dwellinghouse, residential unit, shared communal room or common space, including any bedrooms.
2. 'Floor area' is a key term. See Appendix A.
3. 'Glazing area' is a key term. See Appendix A.
4. 'Floor area of the room' is a key term. See Appendix A.

Figure 27

Minimum free areas from AD-O, marked up for the example home

B Targets		
Max glazing (% GIA)	15	%
Max glazing most glazed room (% room floor area)	30	%
Shading required?	N	
Min home free area (a) (% GIA)	9	%
Min home free area (b) (% glazing area)	55	%
Bedroom min free area (% room floor area)	4	%

Figure 28

Template box B listing targets identified

8.1.3. Taking measurements (Steps 2-7)

There are 10 rooms that contain windows in this example home, and there are a number of measurements and evaluations needed for every window.

The following steps were followed to complete the example window data shown below.

1. Measure the floor area for each room in m². Note that dual activity rooms deeper than 4.5m should be measured with maximum depth of 4.5m – see section 3.4 Step 4
2. Record the details of each window type in the room and what kind of opening mechanism they will use (if they open), and the glazing area (excluding frames)
3. Record the orientation that each window faces
4. Sum the glazing area for the whole room
5. Measure the opening width and height for any openable windows (including opening portion of frame)

The illustration shows the measurements taken for the kitchen window. In this example, only the left hand pane opens. The glazing is split into 4 for each window, and this was taken into account in the measured glazed area; at an early stage, a quicker assessment could include the whole area (including the middle frame), which also means the measurement would be on the side of caution, by providing a slightly higher glazed area than the actual one.

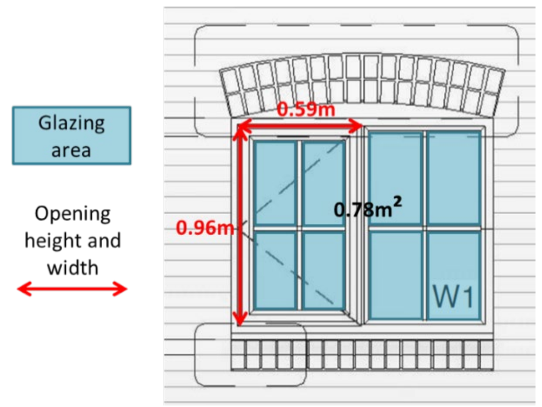


Figure 29

Glazing measurements taken for the kitchen window in the example home

Room	Windows	Opening type	Room floor area (m²)	Glazing area (m²)	Orient-ation of glazing	Room glazing total (m²)	Room glazing:floor ratio	Opening pane width (m)	Opening pane height (m)
Living/Dining	Patio doors W5	side hung x2		1.87	S			0.74	1.96
	Side panes W3 & W4	Side hung x2		1.22	S			0.70	1.26
	W2	Side hung	23.15	0.41	E	3.50	15.1%	0.62	0.96
Kitchen	W1	Half side hung	7.94	0.78	N	0.78	9.8%	0.59	0.96
WC	W6	Side hung	1.78	0.18	N	0.18	10.0%	0.40	0.96
Hall	Front door	Fixed	5.08	0.04	N	0.04	0.8%		
Bed 1	W9	Half side hung		0.98	S			0.59	1.11
	W10	Half side hung	14.82	0.98	S	1.95	13.2%	0.59	1.11
Bed 2	W11	Half side hung	11.48	0.92	N	0.92	8.0%	0.59	1.11
Bed 3	W7	Half side hung	8.23	0.92	N	0.92	11.2%	0.59	1.11
Bed 4	W13	Roof light	7.6	0.33	S	0.33	4.3%	0.55	0.88
Bathroom	W8	Side hung	4.04	0.35	N	0.35	8.8%	0.62	0.57
Shower	W12	Roof light	4.61	0.33	S	0.33	7.1%	0.55	0.88

Figure 30

Worked example window data with kitchen window illustrated

6. Estimate the opening angle for each window. This must be determined taking into account the maximum 650mm reach criteria, and any restrictions placed on opening distance, for example by security features. For the purposes of this worked example opening angles have been assumed as 90° for patio doors, 70° for all side hung windows and 50° for roof lights.
7. Calculate the equivalent area for each window. Manufacturer data was not available for this case study so this can either be done using the lookup tables in AD-O Appendix D or the Discharge coefficient calculator spreadsheet.

Using the same kitchen window example the equivalent area given by AD-O table D7 (70° opening angle) is 0.41m² as shown below.

Table D7 Equivalent area of a window with an opening angle of α = 70°

Opening height, h (m)	Opening width, w (m): 0.5	0.75	1	1.25	1.5
0.5	0.21	0.34	0.46	0.61	0.73
0.75	0.32	0.48	0.69	0.86	1.03
1	0.41	0.64	0.85	1.15	1.37
1.25	0.51	0.80	1.07	1.33	1.72
1.5	0.62	0.93	1.28	1.60	1.92
1.75	0.72	1.08	1.49	1.87	2.24
2	0.82	1.23	1.65	2.13	2.56
2.25	0.93	1.39	1.85	2.40	2.88
2.5	1.03	1.54	2.06	2.57	3.20
2.75	1.13	1.70	2.26	2.83	3.52
3	1.23	1.85	2.47	3.09	3.70

Figure 31

Illustration of using lookup tables to determine equivalent area for the kitchen window
An alternative method to determine the equivalent area is to use the Discharge coefficient calculator spreadsheet, which is able to more accurately calculate the equivalent area from the exact window measurements. In this case, the spreadsheet gives an equivalent area of 0.48m² for the same window, i.e. higher than using the lookup tables.

The information needed to use the Discharge coefficient calculator spreadsheet is illustrated below. Note that the opening height and width values have been transposed as the spreadsheet assumes a top-hung window while in fact the kitchen window is side-hung.

WINDOW DISCHARGE COEFFICIENT CALCULATOR		
Window width, w	0.960	m
Window height, h	0.590	m
Opening angle, α	70	°
Stroke length, d	0.677	m
Orifice Discharge Coefficient, C_{d0}	0.62	-
Equivalent area, A_{eq}	0.484	m²
Effective area, A_{eff}	0.300	m²
Free area, A_{free}	**0.566**	**m²**
Discharge coefficient, C_d	**0.53**	-

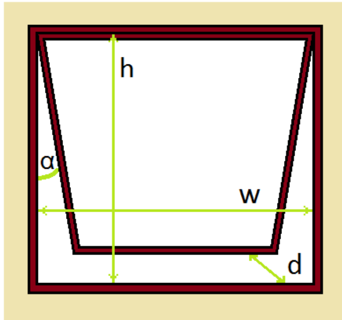


Figure 32

Illustration of using the Discharge coefficient calculator spreadsheet to determine equivalent area for the kitchen window

Room	Windows	Opening type	Room floor area (m²)	Opening pane width (m)	Opening pane height (m)	Opening angle, α	Equivalent area - Aeq (m²)	Bedroom free area totals	Bedroom free area:floor area
Living/Dining	Patio doors W5	side hung x2		0.74	1.96	90	2.48		
	Side panes W3 & W4	Side hung x2		0.70	1.26	70	1.49		
	W2	Side hung	23.15	0.62	0.96	70	0.51		
Kitchen	W1	Half side hung	7.94	0.59	0.96	70	0.48		
WC	W6	Side hung	1.78	0.40	0.96	70	0.31		
Hall	Front door	Fixed	5.08			70	0.00		
Bed 1	W9	Half side hung		0.59	1.11	70	0.56		
	W10	Half side hung	14.82	0.59	1.11	70	0.56	1.11	7.5%
Bed 2	W11	Half side hung	11.48	0.59	1.11	70	0.56	0.56	4.8%
Bed 3	W7	Half side hung	8.23	0.59	1.11	70	0.56	0.56	6.7%
Bed 4	W13	Roof light	7.6	0.55	0.88	50	0.38	0.38	5.0%
Bathroom	W8	Side hung	4.04	0.62	0.57	70	0.32		
Shower	W12	Roof light	4.61	0.55	0.88	50	0.38		

Figure 33

Worked example window opening data with kitchen window illustrated

8.1.4. Extracting result values

Once all windows have been assessed then the totals (equivalent areas, glazing area etc) can be calculated. They are shown in box C within the reporting template below.

Room	Windows	Room floor area (m^2)	Glazing area (m^2)	Orient-ation of glazing	Room glazing total (m^2)	Room glazing:floor ratio	Opening pane width (m)	Opening pane height (m)	Opening angle, α	Equivalent area - Aeq (m^2)	Bedroom free area totals
Living/Dining	Patio doors W5		1.87	S			0.74	1.96	90	2.48	
	Side panes W3 & W4		1.22	S			0.70	1.26	70	1.49	
	W2	23.15	0.41	E	3.50	15.1%	0.62	0.96	70	0.51	
Kitchen	W1	7.94	0.78	N	0.78	9.8%	0.59	0.96	70	0.48	
WC	W6	1.78	0.18	N	0.18	10.0%	0.40	0.96	70	0.31	
Hall	Front door	5.08	0.04	N	0.04	0.8%			70	0.00	
Bed 1	W9		0.98	S			0.59	1.11	70	0.56	
	W10	14.82	0.98	S	1.95	13.2%	0.59	1.11	70	0.56	1.11
Bed 2	W11	11.48	0.92	N	0.92	8.0%	0.59	1.11	70	0.56	0.56
Bed 3	W7	8.23	0.92	N	0.92	11.2%	0.59	1.11	70	0.56	0.56
Bed 4	W13	7.6	0.33	S	0.33	4.3%	0.55	0.88	50	0.38	0.38
Bathroom	W8	4.04	0.35	N	0.35	8.8%	0.62	0.57	70	0.32	
Shower	W12	4.61	0.33	S	0.33	7.1%	0.55	0.88	50	0.38	
GIA	**113.0**				**9.31**					**8.56**	

C Results	Value	
Total glazing area for home	9.31	m^2
Glazing area for most glazed room	3.50	m^2
Shading provided?	N	
Total home equivalent area	8.56	m^2
Bedroom 1 equivalent area	1.11	m^2
Bedroom 2 equivalent area	0.56	m^2
Bedroom 3 equivalent area	0.56	m^2
Bedroom 4 equivalent area	0.38	m^2

Figure 34

Template illustrating the calculated areas in the reporting template

8.1.5. Determining compliance (Step 8)

The final stage is to convert the value results in areas (sqm) into % values

- Divide the total glazing area for the whole unit by the floor area of the unit (GIA).
- Divide the total glazing area within the most glazed room by the floor area of that room.
- Divide the total equivalent area for the whole unit by the floor area of the unit (GIA).
- Divide the total equivalent area for the whole unit by total glazing area summed for the whole unit.
- Divide the total equivalent area for each bedroom by the floor area of that bedroom.

C Results	Value		% result		Target		Result	✓✗
Total glazing area for home	9.31	m^2	8.2	%	15	%	< target	✓
Glazing area for most glazed room	3.50	m^2	15.1	%	30	%	< target	✓
Shading provided?	N		N		N			✓
Total home equivalent area	8.56	m^2	7.6	%	9	%	> target	✗
			92.0	%	55	%	> target	✓
Bedroom 1 equivalent area	1.11	m^2	7.5	%	4	%	> target	✓
Bedroom 2 equivalent area	0.56	m^2	4.8	%	4	%	> target	✓
Bedroom 3 equivalent area	0.56	m^2	6.7	%	4	%	> target	✓
Bedroom 4 equivalent area	0.38	m^2	5.0	%	4	%	> target	✓

Figure 35

Value results converted to % results

Now the glazing and free area (equivalent areas) provision, in % results, can be compared against the targets. The glazing areas must be lower than the target limits, while the equivalent areas must be higher than the free area target. All targets must be met for the home to comply.

Note that there are two targets based on the total minimum free area – one based on the floor area of the home, and the other on the total glazing area for the home, both these must be exceeded to demonstrate compliance.

In this example the minimum free area based on % of floor area for the whole home is not met.

8.1.6. Applying mitigations

In this example the home does not provide sufficient equivalent to meet the whole home free area target, so the equivalent area was increased by:

- Making more panes openable
- Increasing the size of one of the rooflights

These changes enabled the total equivalent area from openings to increase from 8.56m² (7.6% of GIA) to 10.24m² (9.1% of GIA).

Figure 36

Mitigations applied to increase free area for worked example (left: before, failing; right: after, passing)

A Home data			RinR Semi-detached
Cross Vent	**Yes**		
Location risk category	**Moderate**		
Largest glazed façade orientation	**South**		
GIA of home	**113.0**	m²	

B Targets		
Max glazing (% GIA)	15	%
Max glazing most glazed room (% room floor area)	30	%
Shading required?	n	
Min home free area (a) (% GIA)	9	%
Min home free area (b) (% glazing area)	55	%
Bedroom min free area (% room floor area)	4	%

C Results	Value		% result		Target		Result	✓✗
Total glazing area for home	9.43	m²	8.3	%	15	%	< target	✓
Glazing area for most glazed room	3.50	m²	0.2	%	30	%	< target	✓
Shading provided?	n		n		n			✓
Total home free area	10.24	m²	9.1	%	9		> target	✓
			108.7	%	55	%	> target	✓
Bedroom 1 free area	1.67	m²	11.2	%	4	%	> target	✓
Bedroom 2 free area	1.11	m²	9.7	%	4	%	> target	✓
Bedroom 3 free area	1.11	m²	13.5		4	%	> target	✓
Bedroom 4 free area	0.95	m²	12.5	%	4	%	> target	✓

Figure 37

Updated case study results with increased equivalent area to show compliance with all targets

8.1.7. Reporting

The compliance checklist provided in Appendix B of AD-O must be completed for each home.

It is completed here for the example home:

1.1 Building and site details	
Residential building name/number	Example House
Street	Test Street
Town	Home town
County	County
Postcode	XX1 2YY
Proposed building use/type of building	House (home)
Are there any security, noise or pollution issues?	No
1.2 Designer's details	
Designer's name	Designer A
Company	Company B
Address line 1	Street Address C
Address line 2	
Postcode	XX2 3YY
Telephone number	555 555 5555
Email address	example@company.com

2a.1 Site details	
Site location, assigned using paragraph 1.3	Moderate risk (Birmingham)
Building category, assigned using paragraph 1.4	Cross ventilation (semi-detached house)
2a.2 Designed overheating mitigation strategy	
Details of standards selected:	
a. Maximum area of glazing	
b. Maximum area of glazing in the most glazed room	
c. Shading strategy	
d. Total minimum free area	
e. Bedroom minimum free area	

C Results	Value		% result		Target		Result	✓✗
Total glazing area for home	9.43	m^2	8.3	%	15	%	< target	✓
Glazing area for most glazed room	3.50	m^2	0.2	%	30	%	< target	✓
Shading provided?	n		n		n			✓
Total home free area	10.24	m^2	9.1	%	9		> target	✓
			108.7	%	55	%	> target	✓
Bedroom 1 free area	1.67	m^2	11.2	%	4	%	> target	✓
Bedroom 2 free area	1.11	m^2	9.7	%	4	%	> target	✓
Bedroom 3 free area	1.11	m^2	13.5		4	%	> target	✓
Bedroom 4 free area	0.95	m^2	12.5	%	4	%	> target	✓

2a.3 Designer's declaration	
Designer's name	Designer
Designer's organisation	Designer Organisation
Designer's signature	Signed
Registration number (if applicable)	xxx
Date of design	15/06/2022

Figure 38

Compliance checklist filled in for illustration for the example home

8.2. Dynamic thermal modelling method

The same example home was also assessed using the dynamic thermal modelling method.

8.2.1. Model summary

A detailed modelling report is not included here, but the headlines are provided where they illustrate specific aspects of carrying out a TM59 assessment for the purpose of Part O compliance, and or where they may lead to different design options than in the Simplified Method.

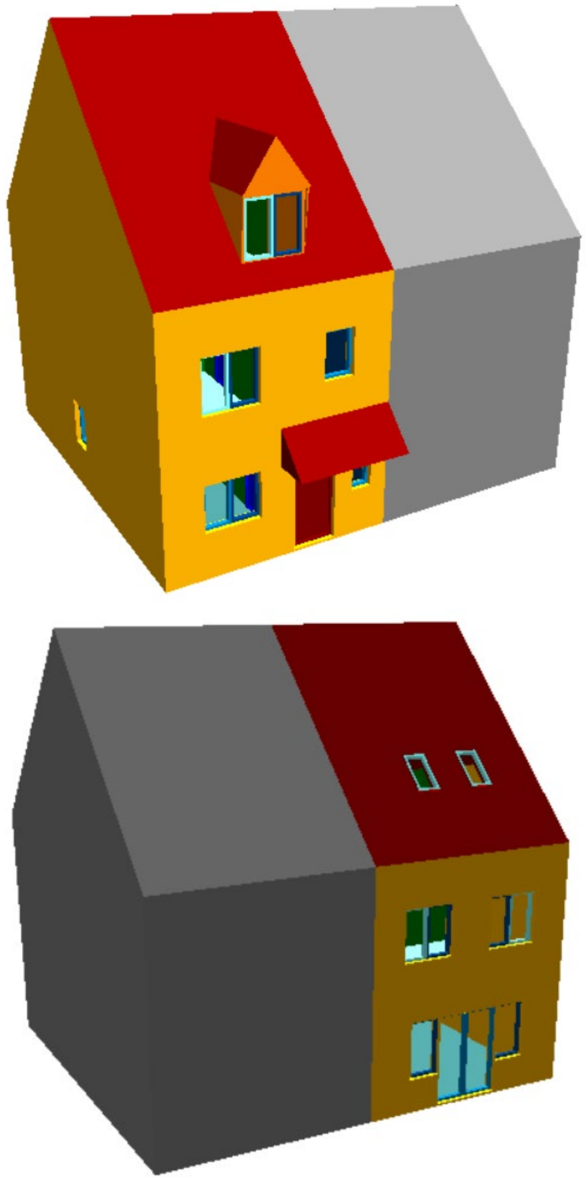


Figure 39

Images of the worked example house as modelled in the dynamic thermal modelling package (right)

Construction elements were applied. The house has its own heating and DHW system so no additional heat gains due to community heating pipework or HIU heat gains were included.

Occupancy, equipment and lighting gains were applied in accordance with TM59 protocols.

The house is designed to achieve an air permeability of no higher than 5m³/hr/m²@50Pa. As a conservative i.e. low estimate (in terms of overheating risk), this was taken to correspond to an average infiltration rate of 0.15ach.

A background ventilation air change rate equivalent to the minimum levels detailed in Clause 1.24 of Approved Document F (2021) was applied evenly throughout the dwelling. This rate was based on 0.3 litres per second per m^2 of internal floor area.

The maximum window openings were set using the same opening angles and opening mechanisms as in the Simplified Method, matching the free areas. Window opening patterns were set to follow the AD-O requirements in response to internal temperatures during the day and at night – see section 4.6 of this guidance document.

No blinds or curtains were included in the model.

The CIBSE DSY1 weather file for Birmingham (2020's 50th percentile, high emissions) was used, in line with TM59 guidance.

8.2.2. Results

The results of the dynamic thermal modelling analysis for this home are shown below.

All zones pass without the additional mitigations needed via the Simplified Method.

Zone Name	Occupied Summer Hours	Max. Exceedable Hours	Max Exceedable Night Hours	Crit. 1	Crit. 2	Result
W Bedroom 1	3672	110	32	13	1	
W Bedroom 2	3672	110	32	12	3	
W Bedroom 3 (S)	3672	110	32	7	1	
W Bedroom 4 (S)	3672	110	32	16	5	
W Kitchen	1989	59	N/A	4		
W Living/Dining	1989	59	N/A	15		

Figure 40

Dynamic thermal modelling example results

8.2.3. Reporting

The compliance checklist provided in Appendix B of AD-O must be completed for each home.

Section 2b is shown below, completed for the worked example. Note the building control body may request to see the full modelling report.

2b.1 Modelling details	
Dynamic software name and version	TAS v9.5.2 from EDSL Ltd
Weather file location used, including any additional, more extreme weather files	CIBSE Birmingham DSY1 (2020 50th percentile, high emissions)
Number of sample units modelled, including an explanation of why the size/selection has been chosen	1 - individual house example
2b.2 Modelled occupancy	
Has the project passed the assessment described in CIBSE's TM59, taking into account the limits detailed in paragraphs 2.5 and 2.6?	Yes
Details of the occupancy profiles used	TM59
Details of the equipment profiles used	TM59
Details of the opening profiles used	AD O opening protocols.
2b.3 Modelled overheating mitigation strategy	
Free areas	Opening angles assumed are 90° for patio doors, 70° for all side hung windows and 50° for roof lights. These were used to calculate equivalent areas using Classcool spreadsheet
Infiltration and mechanical flow rates	0.15ach based on an air tightness target of $5m^3/hr/m^2$@50Pa $0.3l/s/m^2$ included as background ventilation.
Window g-value	0.63
Shading strategy	No additional shading
Mechanical cooling	None
2b.4 Modelling results	
Has the project passed the assessment described in CIBSE's TM59, taking into account the limits detailed in paragraphs 2.5 and 2.6?	Yes
What is the overall overheating strategy (i.e. what design features are key to the project passing)?	Open the windows wide in warm weather.
2b.5 Designer's declaration	
Has the building construction proposal been modelled accurately?	Yes
Designer's name	Designer
Designer's organisation	Designer Organisation
Designer's signature	Signed
Registration number (if applicable)	xxx
Date of design	15/06/2022

Figure 41

Compliance checklist filled in for illustration for the example home

9. CASE STUDIES

The case studies illustrate a range of scenarios and approaches to design solutions and compliance:

1: Dual aspect apartment in a high risk location in London, complying with the Simplified Method. This required changes to reduce glazing areas (e.g. removing a fixed glazing panes) and increase free areas (e.g. widen vent panels)

2: Single aspect apartment in a high risk location in London, using the thermal dynamic modelling route. It illustrates the implications of the site exceeding the noise criteria, in the compliance route and possible overheating mitigation options including noise attenuation through reduced openings, mechanical ventilation, and cooling.

3: Corner apartment in a high risk location in London, using the thermal dynamic modelling route. It illustrates the approach to compliance route and balancing overheating and views out requirements using a combination of fixed and openable glazed areas, and external shading; it assumes night-time ventilation through openings is possible.

4: Detached house in southern England, using the thermal dynamic modelling route. It illustrates a varied approach to openings, including secure night-time natural ventilation.

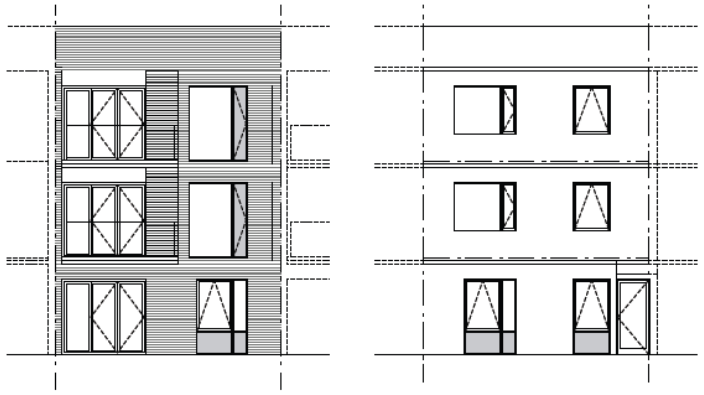
9.2. Case Study 1 – Dual aspect apartment

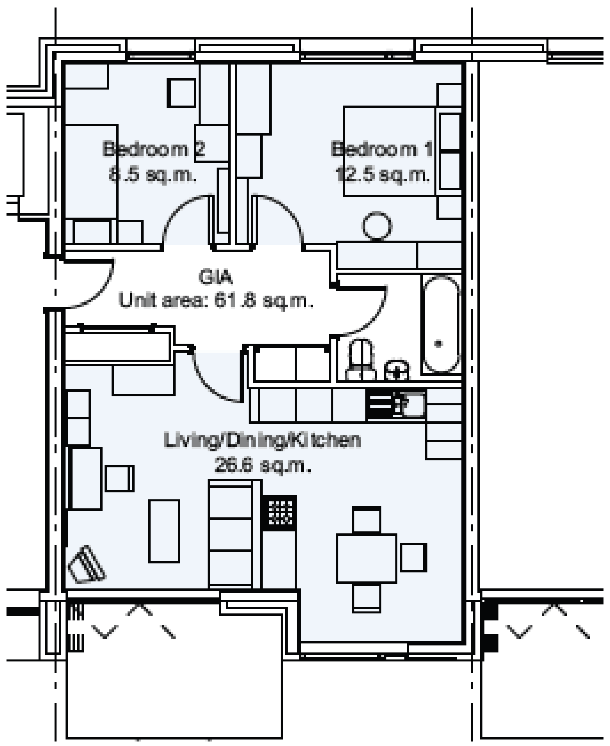
Overview

This example is a 2-bedroom dual aspect apartment within a 3 storey walk-up block in London. Mitigations are proposed to enable the apartment to pass using the Simplified Method, and the implications of a ground floor location are discussed.

Compliance route: Simplified Method

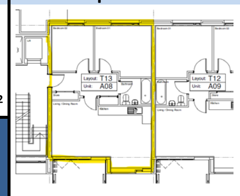
This apartment is orientated with the front elevation facing South, in a high risk location (London). It qualifies as having cross ventilation as is has windows on opposite facades.





A Unit data		
Cross Vent?	Yes	
Location risk?	High	
Largest glazed façade orientation?	South	
GIA of unit	61.6	m^2

2B dual aspect enclosed

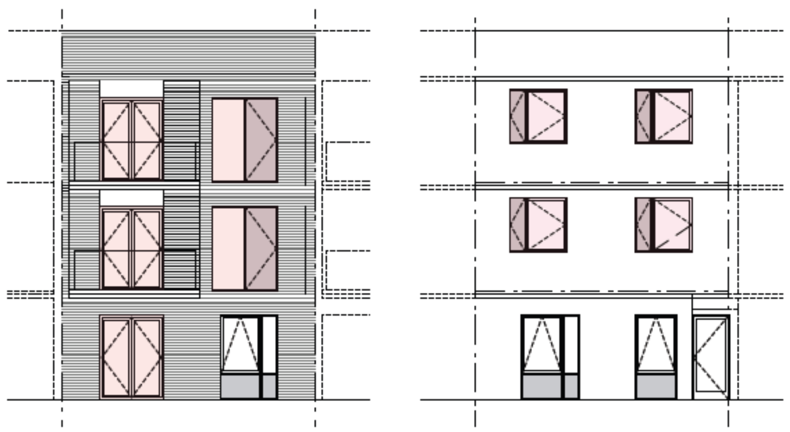


B Targets		
Max glazing % FA	15	%
Max glazing room	22	%
Shading required?	y	
Min unit free area (a) GIA	6	%
Min unit free area (b) glazing area	70	%
Bedroom min free area	13	%

C Results	Value		% result		Target		Result	✓×
Total glazing area for home	12.09	m^2	19.6	%	15	%	< target	×
Glazing area for most glazed room	8.01	m^2	30.4	%	22	%	< target	×
Shading provided?	n		n		y			×
Total home equivalent area	7.06	m^2	11.5	%	6	%	> target	✓
			58.4	%	70	%	> target	×
Bedroom 1 equivalent area	0.50	m^2	4.0	%	13	%	> target	×
Bedroom 2 equivalent area	1.55	m^2	18.1	%	13	%	> target	✓
Bedroom 3 equivalent area		m^2		%			> target	

Initially the apartment did not meet the Simplified Method targets for either glazing area or free area, so mitigations were applied to the design:

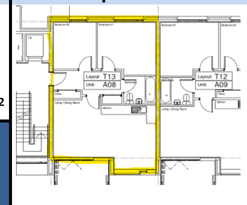
- The fixed pane next to balcony doors was removed
- The vent panel next to the fixed pane in the living room was widened from 450mm to 900mm (with matching reduction in the width of the glazed panel)
- The windows in both bedrooms were replaced with a different window type which includes an openable pane and a side vent panel
- Window glazing specification was enhanced to include solar control with centre-pane g-value <0.4



These are significant changes to external appearance, and would therefore need to be considered pre-planning, and likely require amendments or even re-submission for schemes which already have permission.

A Unit data		
Cross Vent?	Yes	
Location risk?	High	
Largest glazed façade orientation?	South	
GIA of unit	61.6	m^2

2B dual aspect enclosed



B Targets		
Max glazing % FA	15	%
Max glazing room	22	%
Shading required?	y	
Min unit free area (a) GIA	6	%
Min unit free area (b) glazing area	70	%
Bedroom min free area	13	%

C Results	Value		% result		Target		Result	✓×
Total glazing area for home	9.00	m^2	14.6	%	15	%	< target	✓
Glazing area for most glazed room	5.56	m^2	0.2	%	22	%	< target	✓
Shading provided?	y		y		y			✓
Total home equivalent area	6.93	m^2	11.2	%	6	%	> target	✓
			77.0	%	70	%	> target	✓
Bedroom 1 equivalent area	1.64	m^2	13.1	%	13	%	> target	✓
Bedroom 2 equivalent area	1.64	m^2	19.2	%	13	%	> target	✓
Bedroom 3 equivalent area		m^2		%		%	> target	

With these design changes the apartment meets all the Simplified Method targets.

More information:

Further analysis demonstrates that with these mitigations this apartment will pass the Simplified Method in all locations and all orientations. Note that if it is West facing in moderate risk locations then it will not meet the whole unit glazing area criteria unless the shading (low-g glazing) is specified.

Ground floor instances of this apartment would need additional security measures to allow bedroom windows to be open at night. As these would still need to deliver free area 13% of bedroom floor areas to comply, louvred panels are unlikely to be sufficient and alternative measures such as well designed bar systems that don't interfere with the window opening mechanism might be appropriate.

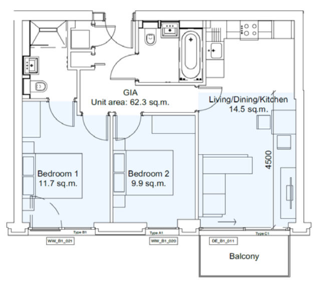
9.3. Case Study 2 – Single aspect apartment

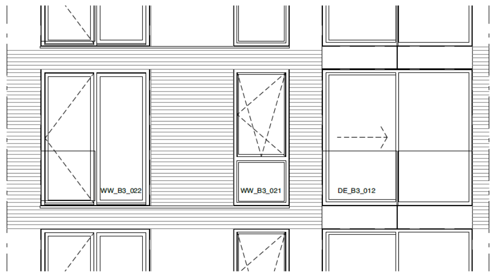
Overview

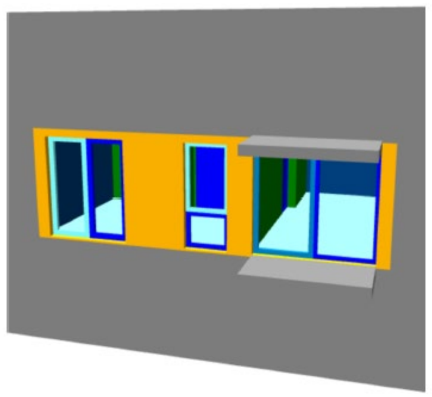
This example is a 2-bedroom single aspect apartment within an 8-storey block in London. Two mitigation options are proposed, and the implications of the site exceeding the noise criteria are discussed and explored.

Compliance route: Dynamic thermal modelling

The apartment is orientated with the front elevation facing South, in a high risk location (London). The dynamic modelling route was selected due to the size of the scheme, noise conditions, and desire for design flexibility. It was modelled using TAS software v9.5.2.





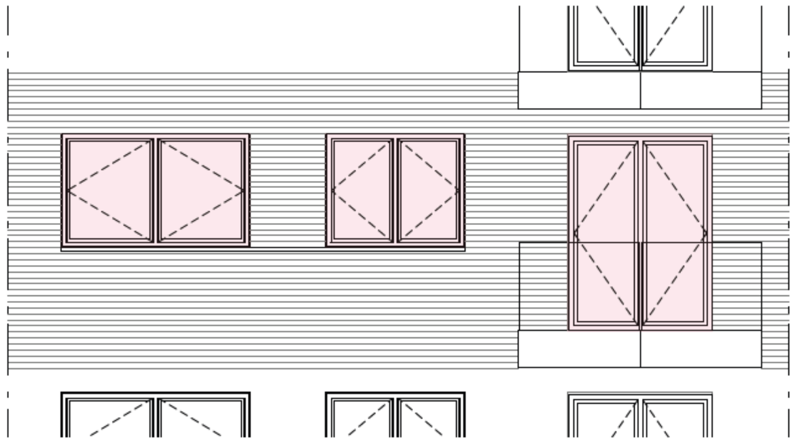


The initial results with all windows allowed to open wide according to the AD-O protocols, show that none of the occupied rooms meet the TM59 criteria.

Zone Name	Occupied Summer Hours	Max. Exceedable Hours	Max Exceedable Night Hours	Crit. 1	Crit. 2	Result
F5 Bedroom 1	3672	110	32	220	40	
F5 Bedroom 2	3672	110	32	150	38	
F5 Living/Kitchen	1989	59	N/A	149		

The following mitigations measures were applied to the design.

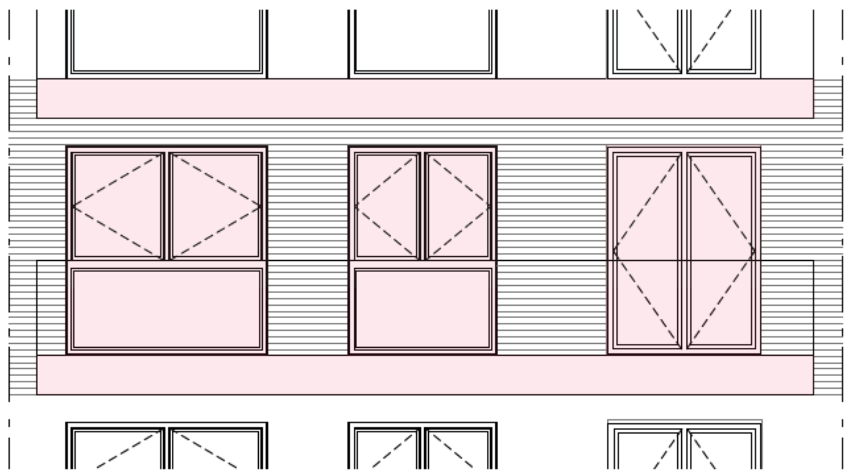
- The height of all windows was reduced to a maximum of 2440mm
- The windows in both bedrooms were swapped for a pair of openable casements with a cill height of 1100mm
- The large sliding patio door in the living room was swapped for a smaller pair of double doors that both open.



Zone Name	Occupied Summer Hours	Max. Exceedable Hours	Max Exceedable Night Hours	Crit. 1	Crit. 2	Result
F5 Bedroom 1	3672	110	32	74	23	
F5 Bedroom 2	3672	110	32	75	31	
F5 Living/Kitchen	1989	59	N/A	51		

With these design changes the unit meets both the TM59 criteria.

Alternatively, the balcony could be extended to the full width of the apartment to provide more shading. This enables more glazing to be included and still achieve compliance:



If this apartment was orientated to face East or West then some further/different mitigations would be needed to achieve compliance.

Exceeding noise criteria

If the site conditions mean that the night time noise limits within AD-O were exceeded in bedrooms at night – see section 2.1- then additional design measures would be needed to maintain compliance.

If the noise levels are exceeded by just a small amount, then some passive solutions might still be possible:

The model was run with the windows reduced to 100mm openings at night. For this room and window arrangement, a 100mm opening is calculated to achieve an 8 dB reduction from outside levels (compared with only a 4 dB reduction with the windows wide open). Depending on the external noise levels, this may be sufficient to meet the internal noise level limits. However, the results for this scenario do not pass TM59 for this London location (it may do in another, cooler, part of the country).

The model was then run with the same reduced window openings and an additional 6ach of mechanical ventilation. Based on the bedroom volumes of approx. 30m², this would require fans that could deliver supply and extract (quietly) at roughly 50l/s. This scenario **does** pass the TM59 criteria. The ducts would need to be around 160 mm diameter (extract) and 200 mm (supply) to avoid excessive regenerated noise.

If noise levels are higher on site such that bedroom windows cannot be relied upon at night at all then a fully mechanical ventilation solution will be required for those hours.
The modelling demonstrated more than 8ach would be needed (nearer 70l/s) which would be challenging to deliver quietly. The ducts would need to be around 200 mm diameter (extract) and 250 mm (supply) to avoid excessive regenerated noise.

The introduction of mechanical ventilation providing these rates has significant design implications, so the model also tested a scenario which uses full mechanical cooling instead. This would require a change in the TM59 criteria to the fixed temperature threshold criterion (no more than 3% of occupied hours above 26°C). In order to meet this target for this home the model predicts that the mechanical cooling would need to be sized to deliver 419 W of cooling in Bedroom 1, 351W in Bedroom 2 and an additional 820W if cooling was also installed in the kitchen/living room. This is based on meeting a cooling set point of 26°C for these rooms 24/7.

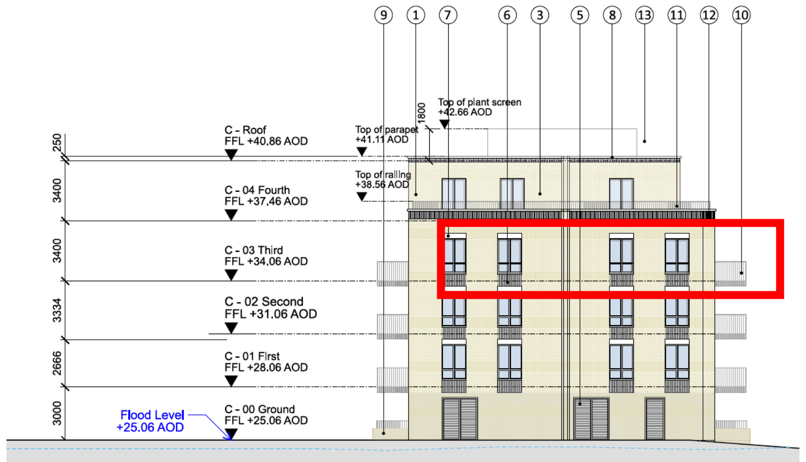
9.4. Case Study 3 - Corner apartment

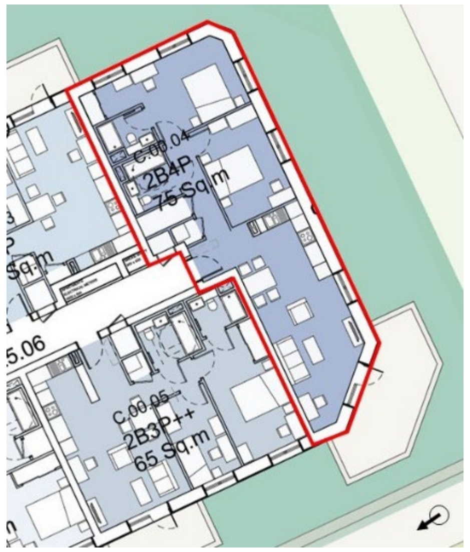
Overview

The scheme is located in London (high risk location) and includes residential apartments grouped in several multi-stories blocks. The apartments are similar but small changes occur throughout the scheme to accommodate different orientations and to diversify the residential offer. A South oriented apartment located on the 3rd floor has been selected as worst-case scenario to illustrate Part O modelling flow and design implications.

Compliance route: Dynamic thermal modelling

The dynamic thermal modelling route was selected due to the: architect's in-house modelling skills, the high number of residential apartments to be assessed within the scheme, the chance to use a specific weather file, the potential to quickly test and compare the effectiveness of different design mitigation measures.





The model was created in IES VE 2021 3.1.0. It includes context buildings and balconies to account for local shading.
The weather file used is London_LHR_DSY1_2020High50.epw.
Occupancy and equipment profiles are according to TM59.
It is assumed there are no noise and air pollution constraints to rely on opening windows at night.

The following points summarise the main features which ensured compliance with TM59 criteria:

- The apartment is located in the South facade
- Glazing to Floor Area: Living /Kitchen (S-W-oriented), 22%; Bedroom (S-oriented), 22%; Bedroom (S-E-oriented), 49%. All windows have centre-pane g-value=0.4
- Free area to Floor Area for the apartment: Living /Kitchen (S-W-oriented), 17%; Bedroom (S-oriented), 16%; Bedroom (S-E-oriented), 35%.
- External shading is applied to all glazing for Living/Kitchen room.
- No blinds or curtains are included in the model.

TM59 results: compliance

TM59 Results	Criterion 1			Criterion 2	
Spaces	B (S)	B (S-E)	L/K(S-W)	B (S)	B (S-W)
	%	%	%	Hours	Hours
Threshold	≤ 3	≤ 3	≤ 3	≤ 32	≤ 32
Result	2.0	2.0	2.9	28.0	19.0

More information:

- To guarantee the view out at lower level and comply with AD-O, fixed low-level glazing (below 1100m) was used.
- To comply with AD-O requirement that "Window handles opening outwards are within 650mm from the inside wall face", the maximum angle opening has been set to 62°.
- To maximize daylight, mitigate summer solar gains and meet TM59 comfort criteria, movable shading louvres which can be adapted by the occupants have been applied to the glazing of the Living/Kitchen room.
- The secure opening on balcony is kept open at night in the model as it is not easily accessible (above first floor).

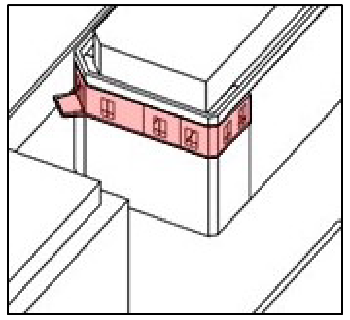


Illustration of glazing and opening strategy:

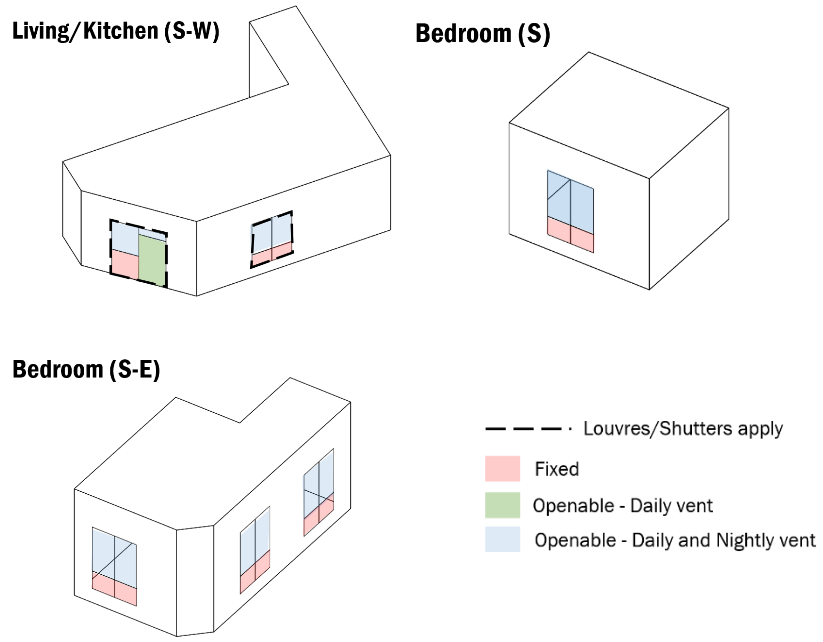


Illustration of possible movable shading systems:

This case study is provided by AHMM Architects.

9.5. Case Study 4 - Detached Home

Overview

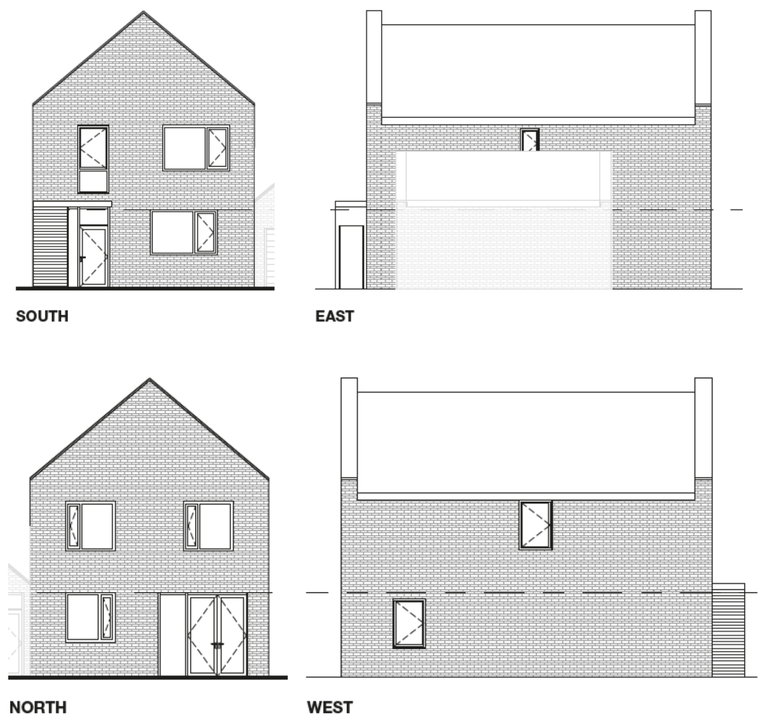
This example is from a large-scale residential scheme located outside London, in Southern England, including detached, semi-detached and terraced homes. The homes are similar but small changes occur throughout the scheme to accommodate different orientations and diversify the residential offer.

Compliance route: Dynamic thermal modelling

The dynamic thermal modelling route was selected due to the architect's in-house dynamic thermal modelling skills, the high number of homes to be assessed within the scheme, and the potential to quickly test and compare the effectiveness of different design mitigation measures.

A N-S oriented 4-bedroomed detached house (South-front, North-rear) located at the 3rd floor (worst-case scenario) has been selected to show the Part O modelling flow and design implications.

The model has been created in IES VE 2021 3.1.0.
The weather file used is London_LHR_DSY1_2020High50.epw. Occupancy and equipment profiles are set according to TM59.



The following points summarise the main features which ensured compliance with TM59:

- Dominant façade: North-South
- Glazing to Floor Area: Kitchen (N-oriented), 34%; Living room (S-oriented), 20%; Bedroom 1 & Bedroom 4 (S-oriented), 20.5%, 15%; Bedroom 2 & Bedroom 3 (N-oriented), 14%, 16.7%.
- Free area to Floor Area: Kitchen (N-oriented), 1.6%; Living room (S-oriented), 2.3%; Bedroom1 & Bedroom 4 (S-oriented), 11%, 5.5%; Bedroom 2 & Bedroom 3 (N-oriented), 11%, 13%.
- Fixed shading louvres are applied on the ground floor and to upstairs non-secure locations.
- The panes of windows have centre-pane g-value=0.4
- It is assumed that noise and air pollution tests show no constraints to relying on opening windows at night.

TM59 results: Compliant with both criteria, for all spaces.

More information:

- A wide range of windows and openings have been used to ensure comfort and comply with Part O requirements.
- To increase the ventilation potential, multiple openable panels have been added to the double bedrooms.
- To allow for secure night-time natural cooling, louvred panels has been added to easily accessible openings.
- Given the presence of a platform roof close to the 1st floor, the bedroom 4 window on S-elevation has been classified as non-secure and louvres are assumed to be applied in the model.
- No blinds or curtains were included in the model.

KEY AND OPENING SCHEDULES

- Fixed glazed panel
  Closed
- Openable glazed panel in non secure location
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Locked to 6° open (night vent)
- Openable glazed panel
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Open if internal temp. > 22°
- Openable glazed panel with fixed louvres to outside
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Open if internal temp. > 22°
- Openable glazed door, fully closed at night
  08:00 - 23:00 | Open if internal temp. > 22°
  23:00 - 08:00 | Closed

This case study is provided by AHMM Architects.

10. GLOSSARY

Background ventilation – low level ventilation rate provided 24/7 (as required by Part F) to prevent homes becoming stuffy and reduce risk of mould growth. Usually provided via MVHR systems or trickle vents. Background ventilation is not usually sufficient to mitigate overheating risk in warmer weather.

Cross-ventilation – defined in AD-O as when a home that has openings on opposite facades. Corner dwellings do not qualify.

Discharge coefficient – a factor that reflects the reduction in fluid flow through an orifice, in this case air flow through a window or vent as a result if the shape of the opening and the opening mechanism and angle.

Dual activity room: defined in AD-O as rooms that serve more than one activity, e.g. open-plan kitchen and living room. This affects how the room area is measured for the purpose of the Simplified Method - see section 3.4

Dual Aspect home – a home with windows or openings on more than one façade. Note that the AD-O definition of cross-ventilation requires openings on opposite facades not simply dual aspect.

Dry bulb temperature – measure of air temperature. Note that this does not include any radiative effects such as the additional heat experienced by sitting in the sun. Resultant or Operative temperatures are used to take account of radiative effects and the effect of increased air flow.

Equivalent Area – a measure of the aerodynamic performance of an opening. This is calculated based on the opening mechanism, opening angle and the dimensions (height and width) of the opening. These values are calculated for each opening and used to meet the 'free area' targets within the simplified method or applied to the model using the dynamic thermal modelling method.

Frame Factor - ratio of glazing area of the window to the whole window.

Free Area – the geometric open area of a ventilation opening. It is important to note that AD-O simplified method states minimum free area targets but expects that equivalent areas are calculated to meet these targets.

Floor Area: used in this document to refer to Gross Internal Area - see definition below.

Glazing Area - area of glazing within a window i.e. excluding the frame.

Gross Internal Area – the area of the home measured to the internal face of the perimeter walls at each floor area.

g-value: total solar heat gain / incident solar radiation- In the context of Part O, this is the centre pane value.

High risk location: most areas of London, with list of postcodes defined in AD-O Appendix C. Optionally, project teams may also decide to treat some areas of Manchester as high risk.

Moderate risk location: all other locations in England, which are not "high risk".

Most glazed façade - defined in AD-O and used in the Simplified Method to mean the façade with the largest m² area of glazing, which then determines the applicable glazing and free area targets. Note that in blocks of apartments or other buildings with multiple homes, this has to be considered on each individual home, not for the whole building.

Most glazed room – defined in AD-O and used in the Simplified Method to mean the room within the home with the largest total area of glazing (in m²). The Simplified Method sets a maximum limit on this.

Purge Ventilation – usually defined as ventilation provision intended for the rapid dilution of indoor pollutants such as burnt toast or a steamy shower. Part F states requirements for purge ventilation. Higher ventilation rates may be required to meet overheating mitigation under Part O.

Simplified Method – see Chapter 3.

Single Aspect home – a home with windows or openings on one façade only. Air flow through windows in single aspect homes tends to be lower as there is no cross-ventilation.

Solar Control Glazing: glazing with a solar protection factor (g-value) intended to reduce solar gains.

Solar Factor: used in BFRC data to refer to the whole window g-value.

Summer Bypass – an operational mode for ventilation systems which re-routes in-coming air in warmer weather to reduce heat recovery.

Light transmittance – a property of glazing which describes the proportion of visible light transmitted through to inside. Tinted glazing tends to have lower light transmittance.

TM59 – CIBSE publication providing a protocol and criteria for assessing overheating risk in homes at the design stage using dynamic thermal modelling tools.

Total free area – the sum of all the equivalent areas calculated for each window and opening within the home. The Simplified Method sets a minimum limit on this.

11. ACRONYMS

AD-O: Approved Document O

BCB: Building Control Body

BFRC: British Fenestration Rating Council

EHO: Environmental Health Officer

GIA: Gross Internal Area

HIU: Heat Interface Unit

SAP: Standard Assessment Procedure

TM: Technical Memorandum

12. REFERENCES

DLUHC, Statutory Guidance, Approved Document O: Overheating, frequently asked questions, Updated 15 June 2022 https://www.gov.uk/government/publications/overheating-approved-document-o/approved-document-o-overheating-frequently-asked-questions

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