Part O 2021

Dynamic Thermal Modelling TM59:

Some worked examples and guidance

Future Homes Hub

Part O 2021 (England)

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Purpose of this guide

The Future Homes Hub has produced this guide to help explain the potential advantages of using Dynamic Thermal Modelling (TM59) to demonstrate compliance with Building Regulations Approved Document O - Overheating 2021 (ADO).

In this Guide the term 'TM59' has been used as shorthand for Dynamic Thermal Modelling to assess overheating, following the CIBSE TM59 guidance supplemented by the requirements of ADO.

The Hub has also produced 'Part O 2021 Builders Guidance - Where to start guide' and a full 'Part O 2021 Technical Guidance', which are available ***here*** and this guide should be read alongside both of these publications.

The guide is intended to help small builders and developers.

It has some introductory pages explaining briefly the differences between the ADO Simplified Method and Dynamic Thermal Modelling and uses four example houses to illustrate the principles of Dynamic Thermal Modelling and some of the benefits. The example houses have been chosen to illustrate:

- The regional differences resulting from weather files in twelve locations
- The benefits when aspects of the house design have been fixed (for instance a house or house type designed before the introduction of ADO in 2021)
- The effect of orientation and the limitations imposed on opening windows that are not secure
- The potential benefits using measures that are not available when using the ADO Simplified Method.

Future Homes Hub

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Foreword

The consequences of rising temperatures are a cause of increasing concern and the introduction of ADO will help mitigate the impact of overheating in new homes. However, with a new regulation comes new challenges. The tools to analyse overheating are unfamiliar to many and the advantages and limitations of the two methods in ADO, Simplified and Dynamic Thermal Modelling, will only emerge with experience and familiarity with each.

Smaller developers don’t have the resource to keep revising designs, so it is imperative that we can understand the implications of different options on the comfort of our customers. As such, we are really pleased with this useful guide from the Future Homes Hub on the use of Dynamic Thermal Modelling to test homes for compliance with ADO.

This guide looks at the modelling results for four sample houses put forward by developers and builders, demonstrating the greater flexibility and potential advantages of using Dynamic Thermal Modelling. These include the possibility of using established designs with fewer changes, the increased flexibility in the size and position of windows and the ability to optimise a design for different orientations and aspects.

We are very grateful for the time and input given by those people and organisations who have worked to put this guide together and we hope others find it as helpful as we do.

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Approved Document O in summary

There are many design factors which can contribute to overheating risk in new homes, in particular large unshaded glazed areas exposed to solar gains and insufficient summer ventilation. Contextual factors such as external noise and pollution or concerns about security and safety are also important, because they may limit a resident's ability to open windows for ventilation.

ADO makes provisions to limit the risk of overheating, taking into account all of these factors, with the aim of encouraging good passive design to limit the risk without introducing active cooling.

ADO provides two approaches to demonstrate compliance. One, the Simplified Method, sets design criteria for maximum glazed areas and minimum free areas, depending on the home's dominant orientation and its location in the country. The locations are divided into two zones: 'high' risk, which includes a large part of London, and 'moderate' risk. The ADO Simplified Method does not require modelling, it is based on measurements of the design proposals and a series of calculations using these measurements.

The second route, Dynamic Thermal Modelling, simulates the complex ways that homes respond to ventilation and external temperatures and provides a more sophisticated analysis of these interactions. It requires a competent person to model the home and review the results using TM59 method but will provide more flexibility when devising solutions.

Structure of this guide: worked examples

The guide illustrates the model outputs for four example homes and highlights the design changes that were applied to each in order to achieve compliance with ADO.

Note that each of the final design solutions would still fail under the ADO Simplified Method (the calculations are summarised in the appendix) demonstrating one of the advantages of using Dynamic Thermal Modelling: compliance can usually be achieved with less radical changes to the starting design.

Overheating and Approved Document O

Limitations of ADO Simplified Method

The ADO Simplified Method uses an assessment of glazing areas and ventilation areas to demonstrate compliance. Various changes can be made to a design that fails the ADO Simplified Method including reducing glazing areas on relevant façades or increasing ventilation by replacing fixed windows with openable windows. It is also possible to add shading and change the g-value of the glass to demonstrate compliance. However, the thresholds for compliance are set in a way to prevent overheating in the majority of cases and are quite conservative.

It is possible to achieve a more refined solution using Dynamic Thermal Modelling TM59 assessment route. The TM59 model looks at mitigation measures as a dynamic system of interacting features including: location, glazing type, ventilation type and rates of air change. It also models the home with project specific information about construction, which has some bearing on the thermal mass. This leads to a more accurate assessment of risk than from the 'elemental' approach of the ADO Simplified Method.

When to use TM59

There are circumstances when the TM59 model must be used for instance on a site exceeding the external noise criteria set down in ADO and for certain home types for instance single aspect flats in buildings with communal heating. It is also essential for inner London locations where schemes are required to comply with the London Plan.

However, there will be many circumstances when it will be beneficial to invest in a TM59 model. The Dynamic Thermal Modelling approach can help to avoid additional costs. It can also help demonstrate compliance for schemes where there may be very little design flexibility: a scheme that already has planning consent and where window areas and positions cannot easily be altered or where there are good reasons for larger glazed areas on certain façades or certain orientations to do with aspect, views or urban design requirements.

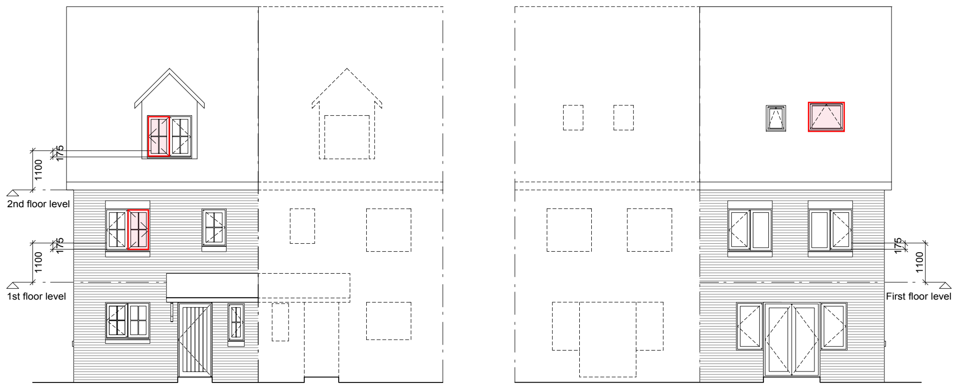
Potential benefits of TM59

A simple example of the benefit is shown in the comparison below where a house design using the ADO Simplified Method must be altered to comply, but when the location is Birmingham (moderate risk) it can be shown to pass with TM59. In practical terms the model is assessing more information and is giving a more accurate assessment for this particular house.

In the example below, the home does not provide sufficient equivalent area to meet the whole home free area target using the ADO Simplified Method, so the equivalent area was increased by:

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

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



Front Elevation _ Mitigation: Passed   Rear Elevation _ Mitigation: Passed

Figure 1. Mitigations applied to increase free area for ADO Simplified Method.

In contrast, the same house was modelled through Dynamic Thermal Modelling analysis, without the additional mitigations and all zones passed. Refer to the FHH Part O 2021 Technical Guidance pages 55-58.

Overheating and Approved Document O

Adapting or applying measures to existing house types

Once designers understand and anticipate the requirements of ADO the compliance process should only require detailed refinement rather than wholesale changes to a design. However, decisions about overheating must be made early in the design process before a planning application is submitted as solutions will invariably affect the appearance of a building. Some very early considerations:

- **Think about orientation particularly of the most glazed façade.**
- **Understand the context, are there noise or pollution issues?**
- **Understand the limitations on safe opening of windows.**
- **Be realistic about the capacity of ventilation systems.**
- **Accessible windows must be secure without compromising ventilation.**

Some aspects that apply to both methods

There are some requirements of ADO that apply whatever approach is taken, for instance the rules that help ensure safe provision of ventilation by limiting opening distances and cill heights. These ground rules are explained more fully in the FHH Part 0 2021 Technical Guidance available ***here*.**

Criterion 1 and 2

The ADO Dynamic Thermal Modelling is suitable for homes that are predominantly naturally ventilated, including homes with mechanical ventilation that have sufficient window openings for daytime natural ventilation in summer.

In Criterion 1 the conditions in the living rooms, kitchens and bedrooms is assessed with the assumption that occupants will tolerate different internal conditions at different times of the year depending on the external conditions. This is known as adaptive comfort. In order to 'adapt' occupants need to be able to moderate the environment for instance by increasing ventilation.

To pass Criterion 1 the number of hours during which the internal temperature is one degree (K) more than a maximum acceptable temperature, based on a running mean calculated from the external temperature, must not be more than 3% of the occupied hours (between May and September, inclusively). In practice this a complicated calculation based on algorithms built into the software.

Criterion 2 only applies to bedrooms and it limits the amount of time that the bedroom temperature can exceed 26°C, the temperature above which sleep could be disturbed. The temperature in the bedroom must not exceed 26°C from 10 pm to 7.00 am for more than 1% of annual night-time hours (note 1% of annual hours between 10 pm and 7.00 am is 32 hours).

Early design decisions – principles

One advantage of using TM59 route with expert advice, is that a number of factors can be tested interactively to get the right balance and inform early design decisions. For instance, different glazing specifications, shading devices and reduced glazing areas can be in-putted into the model to help reduce overheating risk. Other measures that may not impact external appearance (such as mechanical ventilation) can also be assessed.

Analysing orientation

The amount of solar gain depends on the distribution of windows, their size, and the orientation of the home. This could mean that a house design that passes in one orientation will fail when the living room (assuming it's on the most glazed side) is rotated to face south or south west. The TM59 route could give different solutions for the same configuration of house or identify where a shading device might be incorporated to protect the same configuration of windows.

Optimising glazing area

Although an obvious route to compliance may be to reduce glazing areas to limit unwanted solar gains there may be other good reasons to optimise the amount of glazing, to do with outlook and view and the perception of lightness and space within the home.

Achieving daylight standards without causing overheating

There will also be circumstance in urban projects where planning requirements to achieve a certain internal level of natural lighting seeming in conflict with the need to reduce glazing areas for overheating. Here the TM59 model is invaluable.

Dynamic Thermal Modelling (TM59) route

Advice on selecting a modeller

There is no accreditation scheme for modellers undertaking Dynamic Thermal Model (TM59) assessments and no particular qualifications are required. You will therefore need to make a judgement about the modeller's competence based on recommendations and past experience. Many organisations have case studies and references to previous assignments on their websites.

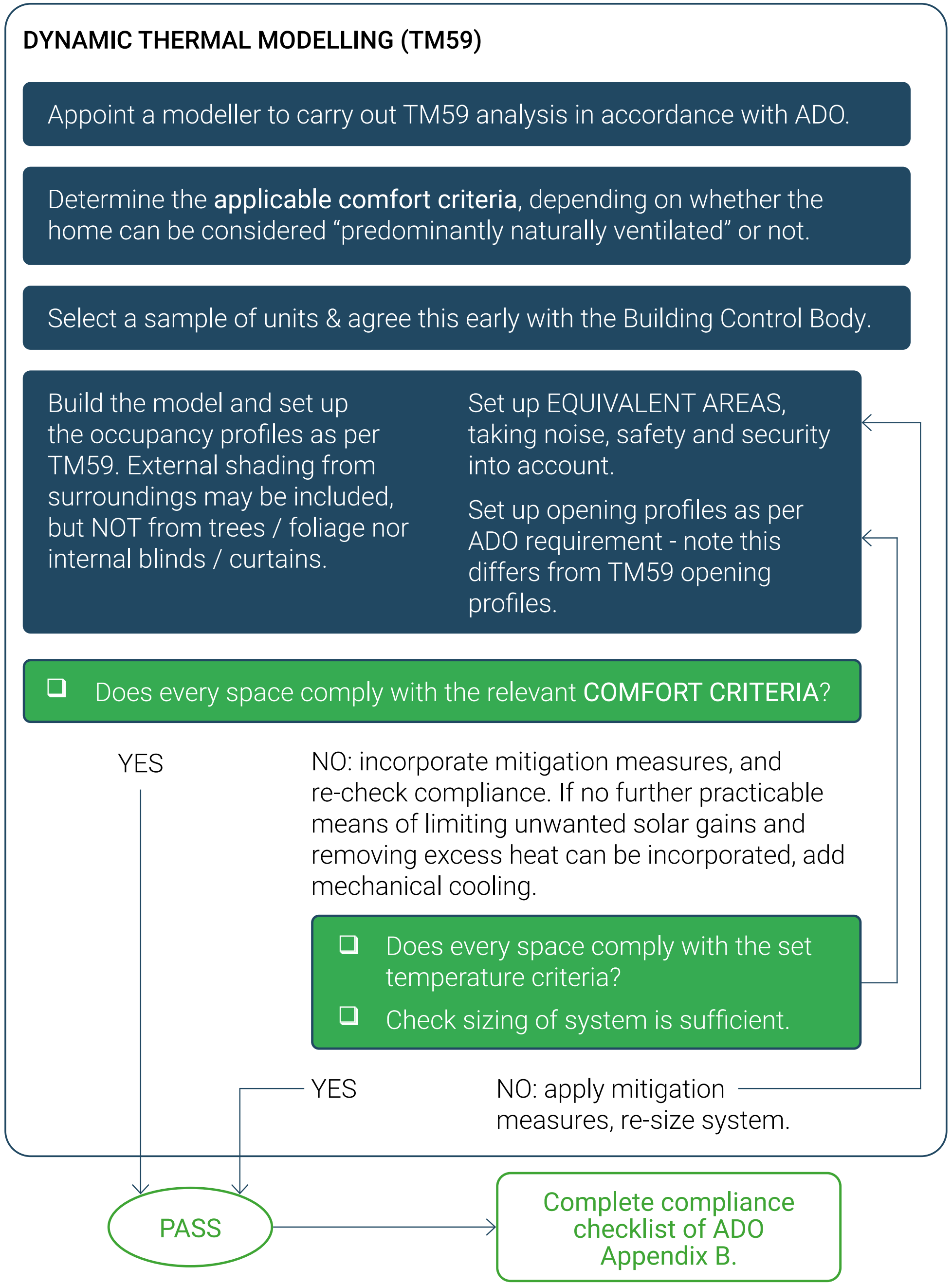
There are different modelling tools available but the differences between these are not important for the builder commissioning a model.

You will need to provide at least the following information together with other project specific information that the modeller might request, for instance balcony details or shading details:

- A site plan with an accurate north point and project location
- Information about heights and outlines of surrounding buildings
- A site layout for larger schemes with types identified so that the modeller can agree the representative sample of homes to be modelled
- Construction build-ups and U-values
- Window configurations and opening types (top hung, pivoting etc)
- Glass types (centre pane g-value)
- Information on location and values for distribution losses from any community heating pipework, heat interface units and hot water storage cylinders
- Construction build-ups and U-values.

When you get quotations for a model make sure that the modeller has priced for several (typically 3-5) iterations of the model. You will need somebody who can give advice on the best mitigation measures and who can assist or advise your other designers and specifiers. A model that is done solely to demonstrate compliance will only tell you whether the house has passed or failed. If the house fails you will probably need advice about what to change to achieve a pass, and of course a re-run of the model to show the measures have worked.

Modelling process



Example House Types

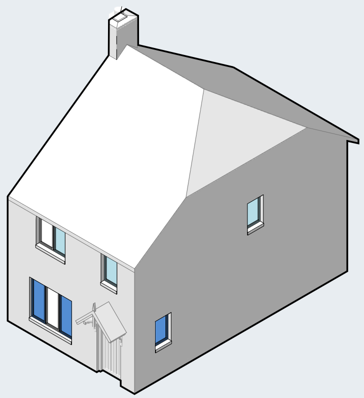
Four house types were selected to test a variety of scenarios: two semi-detached house types tested in multiple geographic locations and orientations, a detached bungalow; and a detached house type in West Sussex. All four house types were tested through Dynamic Thermal Modelling (TM59) route. Two criteria are tested for compliance. If the dwelling fails either of the criteria, it is deemed to be at risk of overheating. Each example has a table of results illustrating the target and results for Criterion 1 and 2.

Criterion 1 tests the number of occupied hours exceeding comfort range in the living rooms, kitchens and bedrooms.

Criterion 2 tests the number of night hours exceeding 26°C for bedrooms only. (See detailed explanation on page 5)

Where there are fails in either criterion, the house type is re-tested with mitigations, for instance modifying windows to have openable sections rather than fixed glazing to increase natural ventilation, or reducing the amount of fixed glazing to reduce solar gains. Other mitigations included security shutters to enable windows to be safely open at night and shading devises.

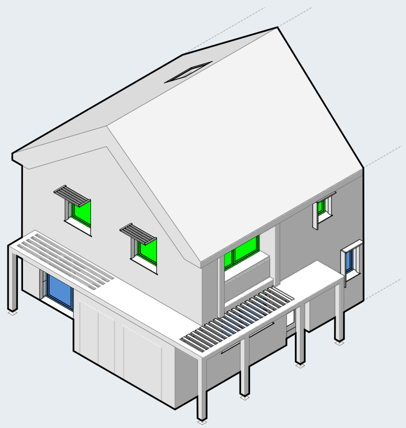
For each table of results, the red highlighted numbers indicate a fail and the gradation of red tones indicate the severity of the fail. Knowing the severity of the fail will help inform the choice and scale of mitigations required.



EXAMPLE 1:

Semi-detached typical house type

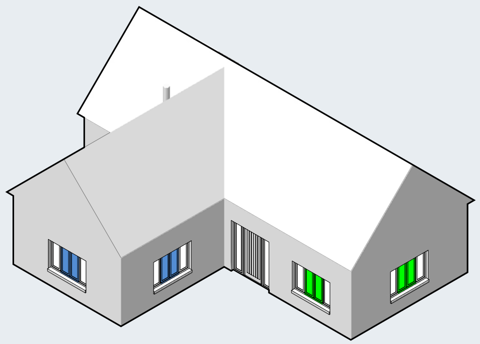
Typical house type tested in various locations.



EXAMPLE 2:

Suburban semi-detached house type

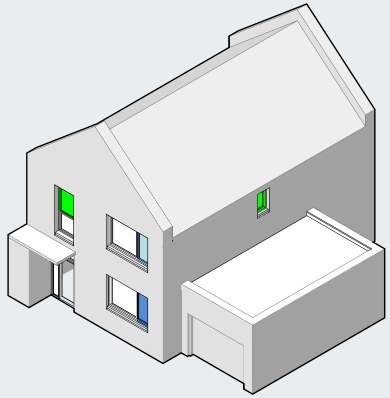
Tested for all orientations.



EXAMPLE 3:

Detached bungalow house type

Bespoke design with planning consent.



EXAMPLE 4:

Detached house type

Bespoke home in West Sussex illustrating changes to window configuration.

Example 1: A typical house tested in various locations

SEMI-DETACHED _ TYPICAL HOUSE TYPE

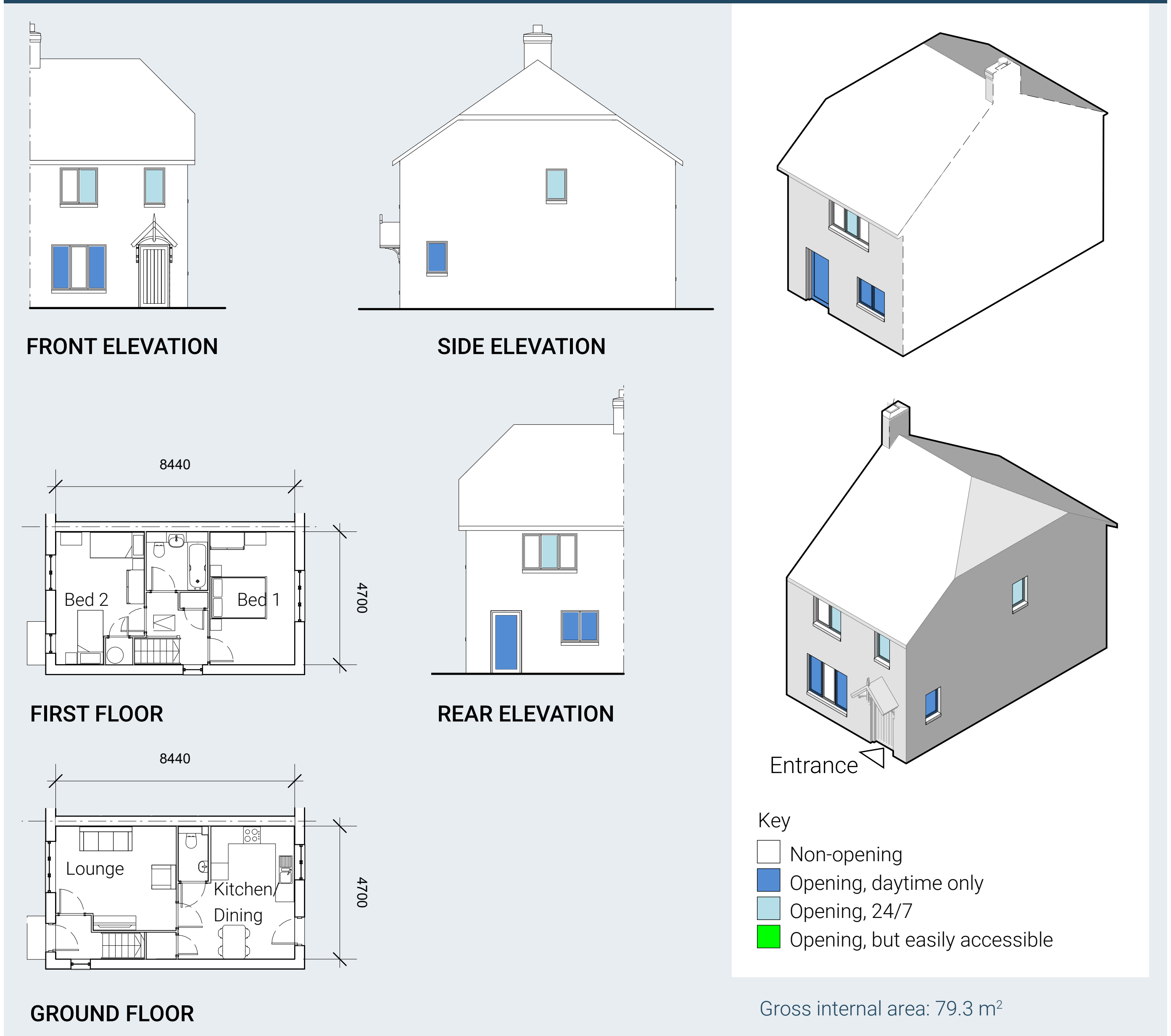


Figure 2. Semi-detached typical house type - case 1.

The house was put forward by a national housebuilder and is a typical semi-detached house that might be built anywhere in the country. The TM59 model was run for a number of locations and the house was tested in different orientations for each location. From tables 1.1 and 1.2 (page 9) it can be seen that the house passes in most locations but fails for the Gatwick and Heathrow weather files, which are typically the most challenging.

TM59 results Case 1 house as illustrated on p.8

EAST	CASE 1											
Zone name	Birmingham			Cardiff			Leeds			London Gatwick		
	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✗
1_Bed 1	12	0		0	1		1	8		41	42	
1_Bed 2	9	21		0	1		3	4		38	50	
G_Lounge	6			0			0			30		
G_Kitchen/Dining	11			0			1			37		
Zone name	Heathrow			Manchester			Newcastle			Norwich		
	Crit. 1	Crit. 2	✗	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓
1_Bed 1	82	78		3	1		0	0		23	14	
1_Bed 2	72	82		0	1		0	0		20	31	
G_Lounge	60			0			0			11		
G_Kitchen/Dining	74			1			0			18		
Zone name	Nottingham			Plymouth			Southampton			Swindon		
	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓
1_Bed 1	20	5		0	0		1	1		10	1	
1_Bed 2	18	4		0	2		1	1		1	10	
G_Lounge	17			0			0			2		
G_Kitchen/Dining	19			0			2			11		

Table 1.1: Case 1.

Various locations	CASE 1			
	E	N	S	W
Birmingham				
Cardiff				
Leeds				
London Gatwick				
London Heathrow				
Manchester				
Newcastle				
Norwich				
Nottingham				
Plymouth				
Southampton				
Swindon				

Table 1.2: Case 1. TM59 results for house type in various locations and orientations. TM59 model orientation stated is for the front entrance façade.

Generally, the house passes Criterion 1, the percentage of hours that cannot exceed the target temperature in all occupied spaces, except for Heathrow. The house also fails Criterion 2, the number of hours exceeding 26°C in bedrooms at night, for the Gatwick and Heathrow locations, see table 1.1 opposite.

For the two failing locations, the house design is managing the unwanted solar gains during the day for Gatwick but it is not providing enough ventilation at night for the bedrooms in both locations. The simplest design solution is to change the fixed glazing panels to opening windows in each of the bedrooms as indicated in figure 3, page 10.

For all of the locations apart from Heathrow (and partly for Norwich) this solution worked (tables 1.3 and 1.4, page 10). The house now passes for Gatwick.

Note, that when using the ADO Simplified Method the house still failed with these measures for moderate and high risk locations. The full results from the ADO Simplified Method are shown in Appendix A.

Even though there are fewer window openings, Case 1 has better performance for Criterion 2 under half of the weather files tested compared to Case 2 (table 1.3) with increased openings. Further investigation suggests that this is a quirk of the ADO methodology.

ADO requires that windows are only left open at night if the internal temperature at 11pm is 23°C or greater. With more window openings, the chances of this threshold being exceeded are reduced, so the windows are more likely to remain closed at night. However, with fewer window openings, the night-time temperature threshold is more likely to be met, meaning that the windows are more likely to stay open at night, thus helping to reduce the number of night-time overheating hours.

TM59 results

Case 2 house with mitigations (increased opening windows)

EAST	CASE 2 - MITIGATIONS AS FIGURE 3											
Zone name	Birmingham			Cardiff			Leeds			London Gatwick		
	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓
1_Bed 1	9	8		0	0		0	0		29	10	
1_Bed 2	8	16		0	0		2	12		29	26	
G_Lounge	5			0			0			26		
G_Kitchen/Dining	11			0			0			34		
Zone name	Heathrow			Manchester			Newcastle			Norwich		
	Crit. 1	Crit. 2	✗	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✗
1_Bed 1	60	55		0	0		0	0		15	9	
1_Bed 2	64	99		0	8		0	0		16	51	
G_Lounge	59			0			0			9		
G_Kitchen/Dining	68			1			0			18		
Zone name	Nottingham			Plymouth			Southampton			Swindon		
	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓
1_Bed 1	18	0		0	0		0	14		8	0	
1_Bed 2	16	2		0	2		1	2		4	28	
G_Lounge	17			0			0			2		
G_Kitchen/Dining	18			0			1			10		

Table 1.3: Case 2.

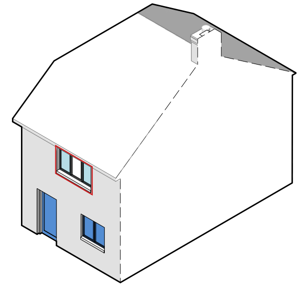
Various locations	CASE 2			
	E	N	S	W
Birmingham				
Cardiff				
Leeds				
London Gatwick				
London Heathrow				
Manchester				
Newcastle				
Norwich				
Nottingham				
Plymouth				
Southampton				
Swindon				

Table 1.4: Case 2. Results of house type TM59 in various locations and orientations. TM59 model orientation is based on the property front door.

Technical note:

Second test pass results are better, with TM59 fails only occurring in Heathrow and Norwich (E and W facing). This passes in Gatwick for all orientations, helped by modest glazing proportions and all bedroom window panes being openable.

SEMI-DETACHED _ CASE 2 - MITIGATIONS



Mitigation: 2 fixed panes replaced with openable windows. See results in table 1.3.

Key

- Non-opening
- Opening, daytime only
- Opening, 24/7
- Opening, but easily accessible

Figure 3. Semi-detached Case 2 mitigations.

For the most demanding location, Heathrow, a combination of measures would be needed. The bedroom window opening areas could be enlarged and tested again in the model but some care would be needed to make sure that the additional glazing is not causing a problem with the unwanted solar gains during the day and a fail under Criterion 1. A combination of extra windows with shading or reduced g-value could be applied.

This example shows the value of being able to test house designs across different locations and the result allows for fewer design changes than would be required with the ADO Simplified Method.

Alternatively, if the house was intended to be used as a standard type in multiple locations the ventilation rate from continuous mechanical extract could be increased for certain locations and the window size standardized.

Note, that the rules that help ensure safe provision of ventilation by limiting opening distances and cill heights, apply whichever method is chosen. For this house, internal rails would be needed to prevent falling if the cill heights are kept at the designed position (approx. 850mm above floor level). Alternatively, the aspect ratio of the windows could be changed to preserve the free areas whilst raising the cill heights to at least 1100mm.

Lessons learnt

Dynamic Thermal Model shows compliance with fewer changes.

The model can be used to test the same house in different locations and different orientations.

More mitigation measures are available, especially helpful for high risk locations and where noise or pollution are an issue.

Example 2: A suburban semi-detached house tested for all orientations

SEMI-DETACHED HOUSE TYPE

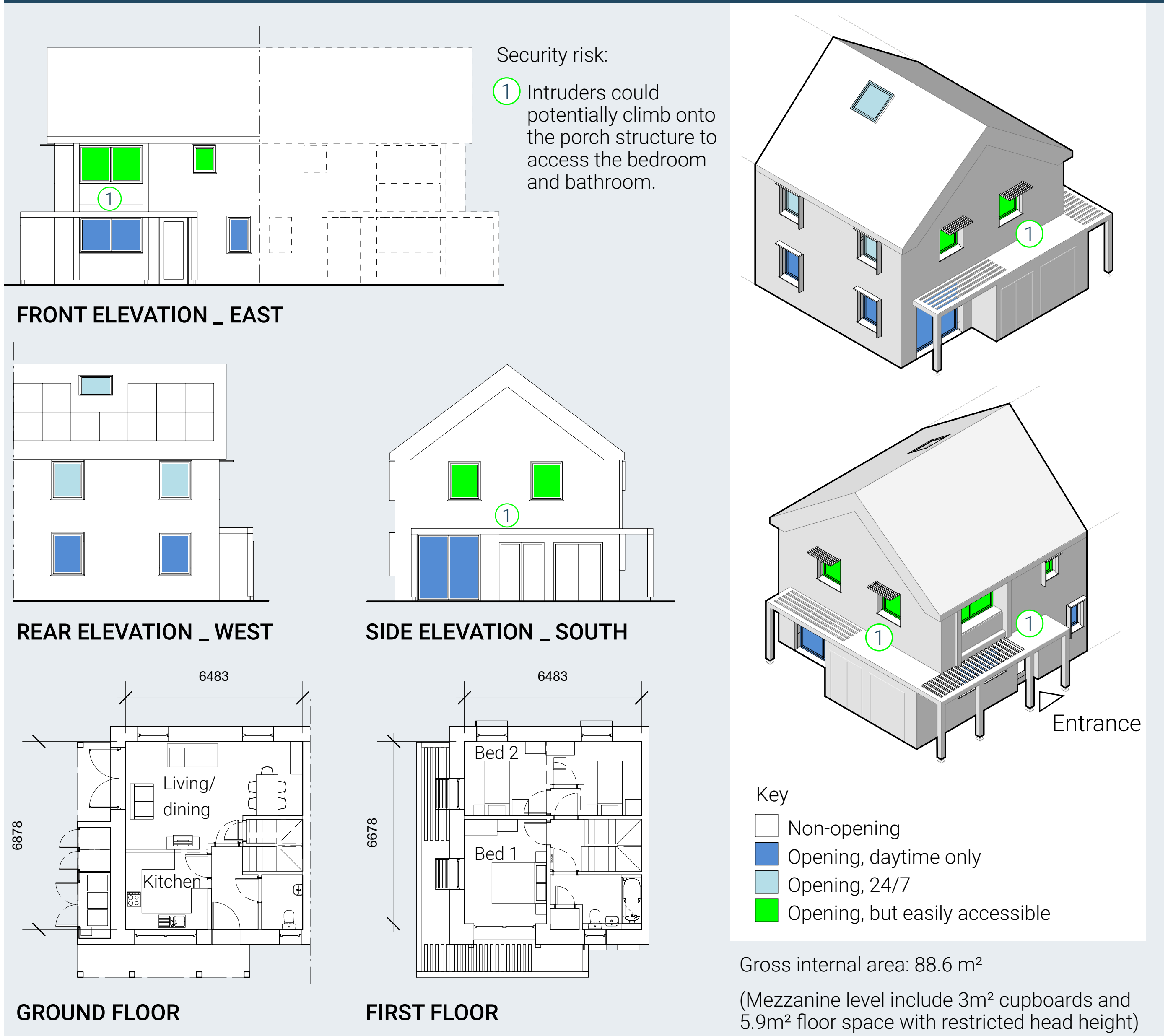


Figure 4. Back to back semi-detached house type - case 1.

This is an example of a semi-detached home in a suburban setting on a constrained site. When a pair of homes was assessed with the ADO Simplified Method the home on the north side passed the limits on glazing area but the house on the south side failed. This was due to the amount of glazing on the south elevation (figure 4) and the accessibility of the bedroom windows above.

Dynamic Thermal Modelling (TM59) was used to explore solutions that keep the basic house design the same for both properties and the same on the opposite side of the street (i.e, front facing east and front facing west). Measures used included shading, external blinds and improved glass g-value.

The large areas of glazing were part of the client brief and to do with internal arrangement and use of the home. For instance, the bedroom on the west side has two windows so that it could potentially be divided to make the home a three-bedroom, four person home for a growing family.

TM59 results

The front (east facing) of the house has a large porch structure which extends across the ground floor kitchen window to provide some shading. This was designed as a fairly substantial timber structure and would be deemed by ADO to compromise the safety of the bedroom window above (ADO, para. 3.6). For the first run of the model, this window was assumed to be closed at night and the bedroom failed the night-time bedroom test by some margin. (Table 2.1)

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen	59	69	N/A	N/A	FAIL
00_Living/dining	59	81	N/A	N/A	FAIL
01_Bedroom 1	110	115	32	187	FAIL
01_Bedroom 2	110	83	32	19	PASS

Table 2.1. Case 1. Base case - Gatwick East facing results.

Removing the porch canopy allowed the bedroom window to extend to the full 650mm opening to comply with ADO, but the unshaded kitchen window is now admitting solar gains. In the second run of the model, the bedroom improved considerably but the living/dining room worsened. The home still failed in three areas. (Table 2.2)

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen	59	75	N/A	N/A	FAIL
00_Living/dining	59	90	N/A	N/A	FAIL
01_Bedroom 1	110	83	32	41	FAIL
01_Bedroom 2	110	84	32	20	PASS

Table 2.2. Case 2. Gatwick East facing with shading to front and side elevations removed.

A further iteration of the model was undertaken to test security shutters on the first floor bedroom windows. This would add some cost but enabled the porch and shading device at the first floor to be retained. The shutters were applied to accessible bedroom windows at night and assumed to be secure in nature, allowing the windows behind to be opened during night hours. The shutters were modelled with a free area of 20% and the windows assumed to have limited outward opening. (Table 2.3)

The use of shutters at night-time has allowed both bedrooms to meet TM59. The retaining of the external shading results in a small decrease in overheating hours in the ground floor spaces, however further measures would still be required to pass TM59.

The house tested has an east facing front door and south facing patio doors to the living room. When the same house, with the same measures was located on the other side of the street with the front door facing west there were still minor fails but in different spaces. By using the Dynamic Thermal Model it is possible to refine the house design for all orientations.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen	59	62	N/A	N/A	FAIL
00_Living/dining	59	80	N/A	N/A	FAIL
01_Bedroom 1	110	74	32	23	PASS
01_Bedroom 2	110	78	32	16	PASS

Table 2.3. Case 3. Gatwick East facing with shutters applied to bedroom windows at night.

TM59 results

The model was then used to find a solution for all orientations and two scenarios were tested that could be applied to the same basic design and window areas. The first test kept the shutter but changed the windows to be inward opening and achieve more free area. The second test was to change the glass g-value to 0.53. Tables 2.4 and 2.5 show the results for the house with porch removed and the front door made entirely opaque.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen	59	50	N/A	N/A	PASS
00_Living/dining	59	59	N/A	N/A	PASS
01_Bedroom 1	110	70	32	26	PASS
01_Bedroom 2	110	73	32	11	PASS

Table 2.4. Case 4. Gatwick West facing with inward opening windows and shutters applied to bedroom windows at night.

Figure 5. 4 houses mirrored on either side of a notional street.

In this example the glazing specification would be looked at in tandem with the thermal model. The g-value could be achieved with triple glazing with benefits to the Target Fabric Energy Efficiency (TFEE), in Approved Document L (ADL). Typical g-value for high performance triple glazing is around 0.5 (50%).

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen	59	44	N/A	N/A	PASS
00_Living/dining	59	50	N/A	N/A	PASS
01_Bedroom 1	110	62	32	23	PASS
01_Bedroom 2	110	60	32	14	PASS

Table 2.5. Case 5. Gatwick East facing with opaque door and centre pane g-value of 0.53.

Explanation of g-value:

The g-value of the glass is a measure of how well the glass transmits heat from the sun. It is expressed as a percentage or simple decimal.

Lessons learnt

Dynamic Thermal Modelling can be used to optimise a design for different orientations. For instance, an identical house on different sides of the street.

Consider security and restrictions caused by porches and single storey structures (covered bin and bike stores).

In this case, a balance was achieved between the need for larger ventilation areas (opening windows) and mitigating solar gains.

Improved g-value or secure inward opening windows achieved compliance.

Example 3: A bespoke design with planning consent

DETACHED BUNGALOW HOUSE TYPE

Figure 6. Detached bungalow house type - case 1.

This bungalow has a simple design and south-west facing glazing for the main living room in a rural setting where orientation for views and garden were fixed. The large areas of glazing are desirable for outlook and daylighting but not in an ideal orientation for overheating. The house had an existing planning consent, based on the footprint of former agricultural buildings, which could not be changed.

TM59 results

The main issue is that the bedroom windows are on the ground floor and are assumed to be closed at night. Only the proportion of openings that can be opened securely can be included in the compliance calculations.* The baseline TM59 results in table 3.1 indicate that the bedrooms fails Criterion 2 as the bedroom ground floor windows are closed all night due to security risk. A security device would be needed combined with inward-opening windows or a calculation based on restricted opening. The security grille or shutter will have an effect on the free ventilation area so this needs to be considered when assessing the ventilation performance of the window and shutter/grille together.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Bedroom 01	110	12	32	49	FAIL
00_Bedroom 02	110	18	32	65	FAIL
00_Kitchen/dining	59	39	N/A	N/A	PASS
00_Living	59	29	N/A	N/A	PASS

Table 3.1. Baseline result for Norwich with large windows facing south west.

Often the design of security grilles is bespoke so there may not be manufacturer's data on ventilation performance and the modeller will have to make cautious assumptions. Alternatively, there are more traditional louvered shutters but to satisfy the security requirements these would need to be made of a robust material and off-the-shelf products tend to have a modern industrial appearance that may not suit the rural setting of a home like this. Adding secure shutters to the openable portions of bedroom windows at night, achieved a pass as indicated in table 3.2 and figure 7.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Bedroom 01	110	7	32	27	PASS
00_Bedroom 02	110	14	32	28	PASS
00_Kitchen/dining	59	35	N/A	N/A	PASS
00_Living	59	31	N/A	N/A	PASS

Table 3.2. Mitigation 1: Results for Norwich with shutters to windows at night.

DETACHED BUNGALOW - MITIGATIONS

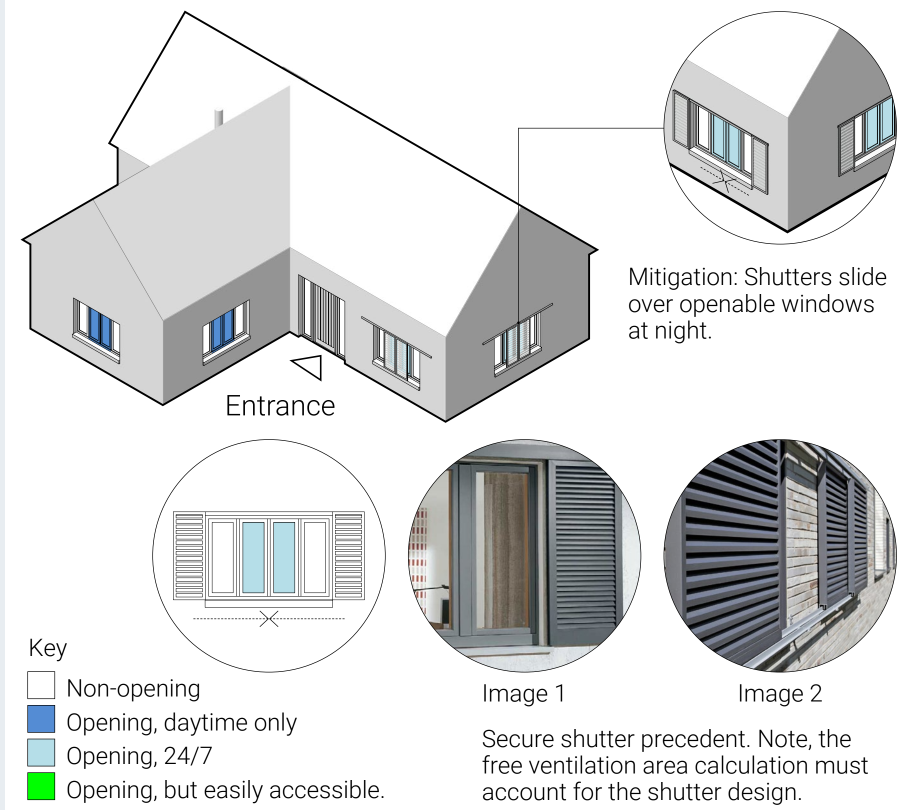


Figure 7. Detached bungalow mitigations.

Image 1: Italian cocif shading systems and internal door kits available in the UK from www.Dooritalia.co.uk

Image 2: EHRET sliding shutter model PARIS MAX-15.

ADO (2021: 3.6 page 12)

'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.'

EXAMPLE 3 RESULTS

Mechanical cooling

Under ADO, mechanical 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.

Mechanical cooling has energy use implications, with associated energy costs and carbon emissions. 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. Mechanical cooling should only be provided once alternatives have been explored, and the reliance on it should be reduced even where it is provided, to minimise its energy impacts and improve the resilience of homes.

Dissipating heat gains: ventilation

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

Large and wide-opening 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 ADO, especially in the Simplified Method, as with them in place it would be very difficult to achieve the required free areas and air flow.
- 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.

Example 3 continued

An alternative to shutters would be to increase the ventilation rate using mechanical ventilation without depending on opening the bedroom windows. This can easily be demonstrated in the model but in practice designers need to be sure that air can be supplied (through trickle or background vents) at the rate required for the extract to mitigate overheating. In this case a ventilation rate of 20L/s was assumed as a sensible rate where noise from the ventilation system would not be a problem and sufficient supply air could be delivered through conventional means (integrated or over-window ventilators). See table 3.3.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Bedroom 01	110	7	32	17	PASS
00_Bedroom 02	110	14	32	28	PASS
00_Kitchen/dining	59	30	N/A	N/A	PASS
00_Living	59	27	N/A	N/A	PASS

Table 3.3. Mitigation 2: Results for Norwich with shutters to windows at night.

A third iteration of the model looked at what mechanical cooling load would be required in each bedroom space if windows were closed at night and just minimum ventilation was applied to the dwelling, as per the requirements of Building Regulations Approved Document F - Ventilation 2021 (ADF). Under this scenario, the following cooling loads would be required to maintain air temperatures in bedrooms no higher than 26°C:

- Bedroom 01: 151 W
- Bedroom 02: 120 W

Lessons learnt

Any dwelling with ground floor bedrooms needs to be carefully designed.

Security measures such as screens or grilles need to maintain air flow.

Improved ventilation rates for mechanical ventilation can be modelled in the Dynamic Thermal Model but specialist advice on acoustics will be required.

Movable devices need to be securely fixed in the closed position (this is not well defined, or explained in ADO).

Example 4: Bespoke home in West Sussex illustrating changes to window configuration

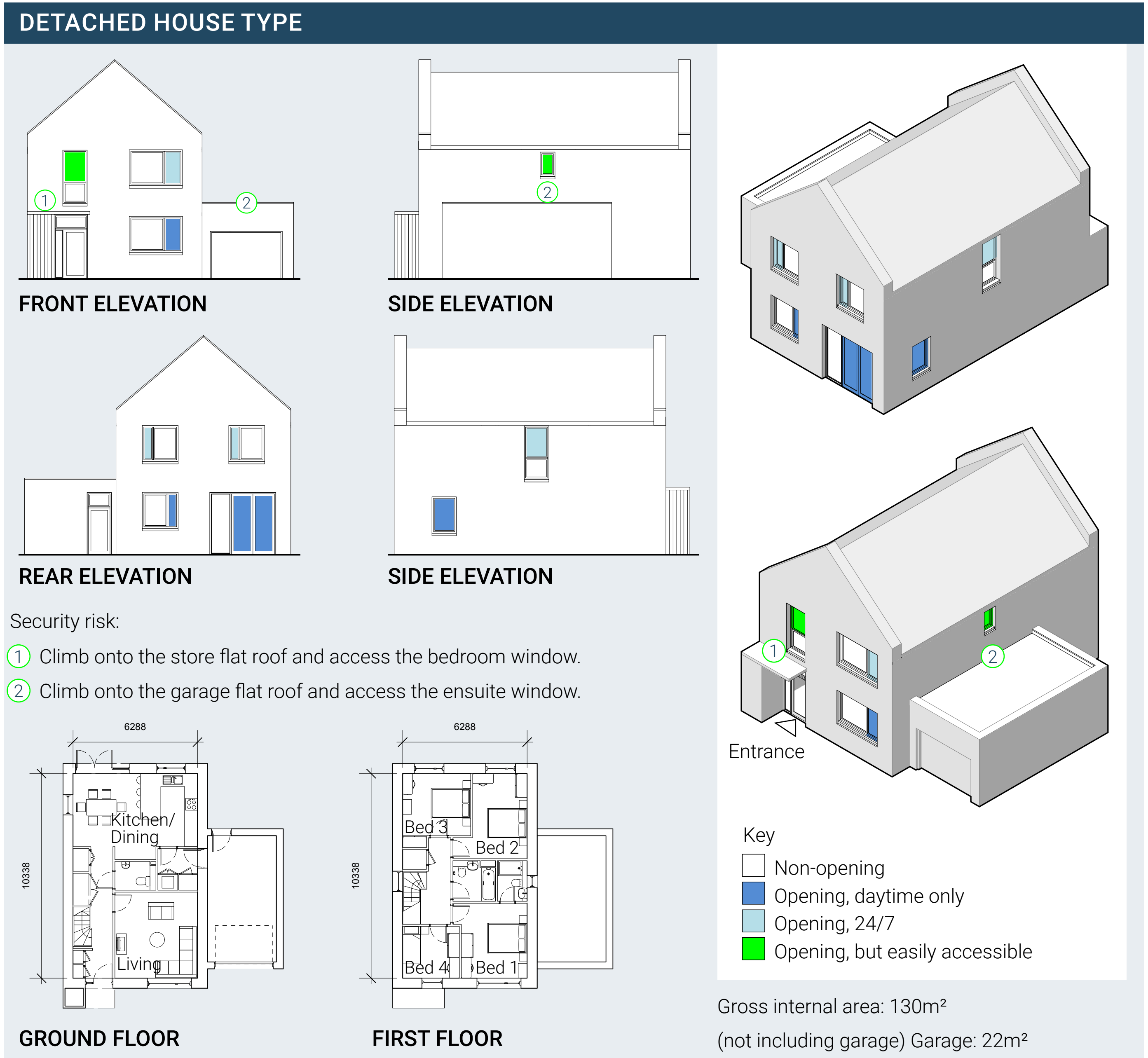


Figure 8. Detached house type - case 1

This example shows the evolution of a house design, using the modelling output to influence decisions about window and opening areas and security. Incremental changes were made to the proportion of the windows and the glazing areas and openings. The first floor windows were adjusted to increase the cill heights and increase the number of subdivisions and opening vents. The changes affect the aspect ratio of the windows and proportions of the house. These changes were necessary as a first test (table 4.2, page 18) using a reduced g-value failed to pass Criterion 2, the number of night hours exceeding 26°C for bedrooms.

Note the house is also illustrated as a case study in the FHH main Part O 2021 Technical Guidance section 9 case study 4 available ***here***.

The house was tested for all orientations of the most glazed façade including south west facing and west facing. The convention in table 4.1, see page 18, is that the orientation stated is for the front entrance. So the worst overheating is for the case with front door facing east (and garden side glazing facing west).

TM59 results

The house design had minor fails when tested for Swindon with a north east entrance orientation. For the Gatwick weather files the home fails both the Criterion 1 whole dwelling and Criterion 2 night-time bedroom conditions, see table 4.1. The house also has opening windows below the 1100mm notional cill height* for the first floor windows as well as one bedroom window that is accessible from an entrance porch.

Zone name	N			NE			E			SE		
	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓
00_Kitchen/dining	110			144			133			92		
00_Living	40			55			66			76		
01_Bedroom 01	47	29		65	49		89	57		83	32	
01_Bedroom 02	74	38		92	37		103	51		73	43	
01_Bedroom 03	91	40		120	50		116	64		84	47	
01_Bedroom 04 (S)	82	139		109	212		175	255		132	206	
Zone name	**S**			**SW**			**W**			**NW**		
	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓	Crit. 1	Crit. 2	✓
00_Kitchen/dining	66			67			88			105		
00_Living	66			87			89			61		
01_Bedroom 01	87	33		117	45		109	41		77	31	
01_Bedroom 02	52	42		59	50		71	54		76	39	
01_Bedroom 03	60	42		73	58		81	69		90	42	
01_Bedroom 04 (S)	115	156		142	165		145	176		108	160	

Table 4.1. Case 1. Results for the Gatwick base case for all orientations.

The result show that the worst results are for the orientation with the entrance facing east. This is because the kitchen/dining room receives high solar gains during the hottest part of the day due to its south and west facing glazing, while bedroom 4 receives early morning solar gains from the east.

Table 4.2 shows the results from changing the glazing g-value to 0.50 (from 0.63). All spaces are now able to meet Criterion 1. There is still night-time overheating in three of the four bedroom spaces, though less than previously and there is still the problem of bedroom 4 window having to be closed.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen/dining	59	41	N/A	N/A	PASS
00_Living	59	59	N/A	N/A	PASS
01_Bedroom 01	110	74	32	32	PASS
01_Bedroom 02	110	43	32	43	FAIL
01_Bedroom 03	110	43	32	50	FAIL
01_Bedroom 4 (S)	110	87	32	129	FAIL

Table 4.2. Case 2. Results with glazing g-value of 0.50.

****** DLUHC FAQ16** *available* ***here***

Some build tolerance is acceptable when building a window that is a means of escape, with an opening at a height of 1100mm above the floor. While it is expected that the 1100mm guarding height in Approved Document O is achieved, a reasonable build tolerance is +0 / - 100mm.

TM59 results

The second set of changes give a far better performance than that with the previous window arrangement. See figure 9 (mitigation illustration showing the subdivision and re-arrangement of the windows). Only the kitchen/dining fails to meet Criterion 1. Two bedrooms fail to meet Criterion 2, one of which is bedroom 4 with the accessible window. Further mitigation could involve reducing the g-value or amount of glazing to the kitchen/dining, while finding a solution to allow night-time ventilation in bedroom 4. See table 4.3.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen/dining	59	63	N/A	N/A	FAIL
00_Living	59	50	N/A	N/A	PASS
01_Bedroom 1	110	62	32	20	PASS
01_Bedroom 2	110	44	32	18	PASS
01_Bedroom 3	110	54	32	39	FAIL
01_Bedroom 4 (S)	110	110	32	119	FAIL

Table 4.3. Case 3. Results with amended window arrangement.

The third change involves the addition of an external security grille in front of the accessible window to bedroom 4. The grille has been assumed in place at all times and have a free area of around 80%. The window behind is now considered openable at night. See table 4.4, which shows a solution for the problem in bedroom 4.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen/dining	59	67	N/A	N/A	FAIL
00_Living	59	83	N/A	N/A	FAIL
01_Bedroom 1	110	108	32	37	FAIL
01_Bedroom 2	110	58	32	50	FAIL
01_Bedroom 3	110	77	32	60	FAIL
01_Bedroom 4 (S)	110	84	32	16	PASS

Table 4.4. Case 4. Results with security grille to bedroom 4.

All of the measures were tested together and the results are shown in table 4.5. The results are showing that all spaces are able to meet TM59, with the exception of the kitchen/dining.

The number of overheating hours in the kitchen/dining have been reduced by around 40% from the original base case, but remain above the limit set. Additional measures are needed to reduce solar gain, as this remains the principal driver of the high internal temperatures being experienced.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen/dining	59	82	N/A	N/A	FAIL
00_Living	59	29	N/A	N/A	PASS
01_Bedroom 1	110	30	32	15	PASS
01_Bedroom 2	110	53	32	12	PASS
01_Bedroom 3	110	62	32	21	PASS
01_Bedroom 4 (S)	110	45	32	17	PASS

Table 4.5. Case 5. Results with the combination of mitigation measures applied.

DETACHED HOUSE TYPE - MITIGATIONS

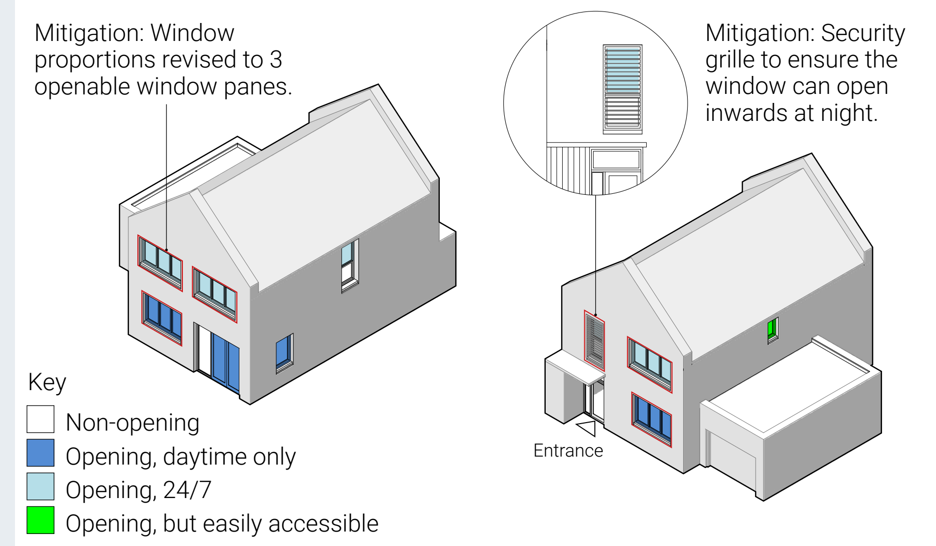


Figure 9. Detached mitigations.

TM59 results

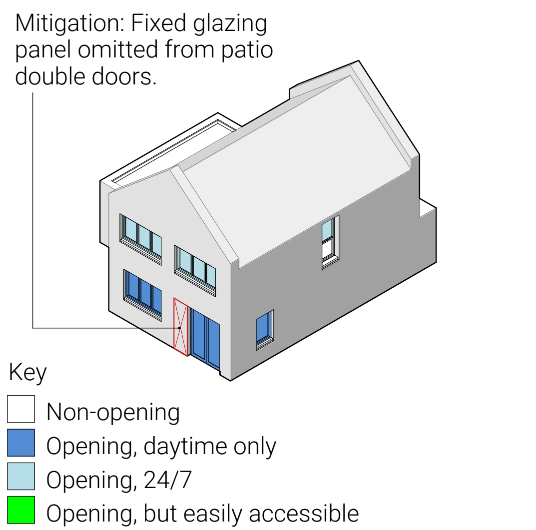
The final adjustment was to remove the fixed glazing panel next to the patio doors to reduce the solar gains in the kitchen/dining space. See table 4.6 and figure 10.

Zone name	Crit. 1: Number of occupied hours exceeding comfort range		Crit. 1: Number of night hours exceeding 26°C for bedrooms		Results
	Target	Result	Target	Result	
00_Kitchen/dining	59	52	N/A	N/A	PASS
00_Living	59	27	N/A	N/A	PASS
01_Bedroom 1	110	30	32	14	PASS
01_Bedroom 2	110	48	32	12	PASS
01_Bedroom 3	110	59	32	21	PASS
01_Bedroom 4 (S)	110	44	32	17	PASS

Table 4.6. Case 6. Results with the omission of fixed glazing panel to the rear patio doors.

The outputs from the model show how the different window types contribute to ventilation through the day and at night, based on the prescribed occupancy profiles, internal gains and window-opening profiles, as well as the information in-putted by the modeller on shading and security devices. The changes to the proportion and subdivision for opening lights change the essential character of the design but these changes can be considered at an appropriate time in the overall process. This example highlights the importance of testing designs for ADO at an early stage, preferably before planning applications are submitted.

DETACHED HOUSE TYPE - ALL MITIGATIONS



Mitigation summary:

- Window proportions revised to 3 openable window panes.
- Security grille to ensure the window can open inwards at night.
- Fixed glazing panel omitted from patio double doors.

Figure 10. Detached all mitigations.

Lessons learnt

A home with generous glazing (for outlook or views) may struggle using the ADO Simplified Method.

A combination of measures (security grilles, g-value, increased opening area) may be needed for a bespoke design in a south-eastern location.

Sub-division of large fixed window areas can help, but changes the appearance of the home.

Dynamic Thermal modelling at an early stage should be used to confirm the detail of shading devices and ensure a planning application includes all of the measures that might affect the appearance of the home.

Window design, glazing and ventilation

A general principle in window design is that large full height windows contribute less to daylighting of internal spaces than the same area window arranged horizontally. The lower portion of a vertical window allows sunlight in, contributing to overheating, but the light does not penetrate very far into the space. In terms of overheating and daylighting a wide aspect ratio is better. This is contrary to the traditional appearance of windows in masonry construction which historically are taller and narrower in proportion to reduce the width of lintels or supporting arched bricks at the window head.

While designers are beginning to understand the interaction between overheating and window design the planning system may take some time to recognise these changes. The reference point for planners will often be the local traditional design based on historical precedents. The possibility that horizontal windows, external blinds, shading and louvres will all become valuable components of a new 'vernacular' of climate resilient homes, may be at odds with current planning preferences.

If the window design cannot be altered one option would be to use a lower g-value glass to reduce solar gains, but the implications for appearance, daylighting and thermal modelling need to be considered.

Another option if the original design is to be preserved may be an increased ventilation rate using mechanical ventilation. However, this needs to be investigated thoroughly by a services or ventilation designer to ensure that sufficient 'make-up' ventilation can be provided through trickle or over-window vents and to make sure that the ventilation runs quietly enough at night.

If the home already has mechanical ventilation with heat recovery (MVHR) then the designers also need to be aware that increased fan speeds or oversized MVHR units may have less efficient heat recovery so the solution for ADO needs to be developed in tandem with the design solutions for ADL and ADF and this co-ordinated thinking must happen at an early stage in the design process.

Conclusions

Dynamic Thermal Modelling can provide a more accurate assessment of overheating risk and a greater number of solutions or combination of solutions to mitigate risk and demonstrate compliance with ADO.

Dynamic Thermal Modelling can illustrate the geographical differences and orientation differences to allow for optimisation and standardisation of house types, even for simple changes such as a house type used on opposite sides of the same street.

The Dynamic Thermal Model can reveal changes in comfort in the different spaces of the home allowing for a room-by-room adjustment of mitigation measures. However, it is good advice to run multiple iterations of the model changing one mitigation measure at a time in order that the contribution of each measure can be quantified individually.

Exercise caution when applying measures that have an interaction with other parts of the Building Regulations. When changing glazing g-values the effect in ADL needs to be considered. Critically when changing ventilation rates the interaction with ADL, ADF and the internal noise environment must be assessed by an experienced ventilation and/or services designer.

Ensure that assumptions about security grilles and shutters allow for convenient operation for the occupiers and assess the impact on ventilation rates and free areas through the protected openings.

Use the skills of the modeller to provide timely design advice during the evolution of house or site layout. The outcomes of the modelling are likely to be more valuable during the design stage, than when the model is only seen as a route to 'compliance' at the building regulations stage.

Brief the modeller carefully and allow for several iterations of the model, all described in a summary report with analysis of the results.

Appendix - Results from the FHH ADO Simplified Method calculator

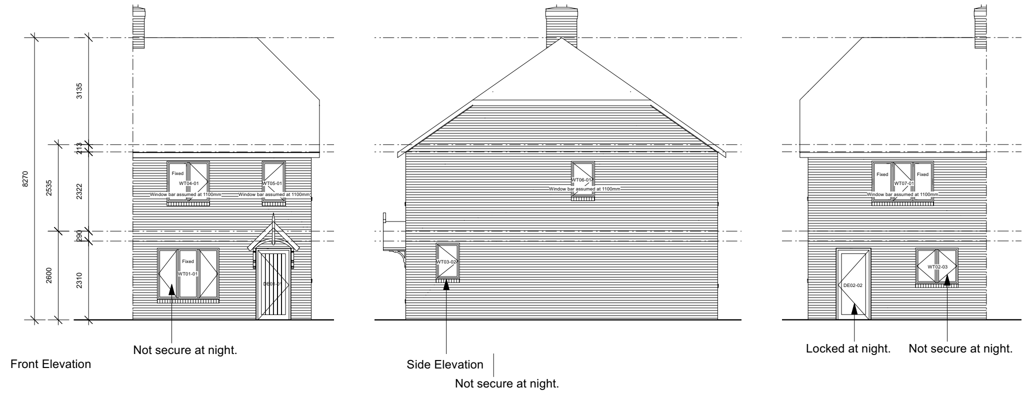
Tabulated modelling outputs for all four house types presented to show clearly geographical variation and orientation FOR SIMPLIFIED METHOD.

Example 1: A typical house tested in various locations _ Base case

High-risk location

Failed all orientations:

- Failed: removal of excess heat in bedrooms 1 and 2.



Building Regulations Part O 2021 (England), Simplified Method - Summary results for all orientations

Future Homes Hub spreadsheet tool version: FHH-SM-V1

A Site data	
Company	Error! Enter information on RESULTS sheet
Site	Error! Enter information on RESULTS sheet
House type	Croudace House type
Plot number	Error! Enter information on RESULTS sheet
B Home data	
Location risk category	High Risk
Shading provided?	Provided
Cross ventilation?	Yes
Total GIA of home (m^2)	79.354
Direction of most glazed façade on house type plan	**'Clock face' 12**

Glazed area information

'Clock face'	Total glazed area (m^2)	% of total
12	3.712	45%
3	0.992	12%
6	3.613	43%
9	0	0%

C Results

	Value	Percentage	Largest glazed façade orientation: North – Target	North – RESULT	✓×	Largest glazed façade orientation: East – Target	East – RESULT	✓×	Largest glazed façade orientation: South – Target	South – RESULT	✓×	Largest glazed façade orientation: West – Target	West – RESULT	✓×
Limiting solar gains:														
Total glazing area for home	8.32 m²	10.48 %	15 %	Target met	✓	18 %	Target met	✓	15 %	Target met	✓	18 %	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	2.17 m²	12.74 %	37 %	Target met	✓	37 %	Target met	✓	22 %	Target met	✓	37 %	Target met	✓
Shading	Provided		Required		✓	Required		✓	Required		✓	Required		✓
Removal of excess heat:														
Total equivalent area (% of floor area)	6.25 m²	7.88 %	6 %	Target met	✓	6 %	Target met	✓	6 %	Target met	✓	6 %	Target met	✓
Total equivalent area (% of glazed area)	6.25 m²	75.19 %	70 %	Target met	✓	70 %	Target met	✓	70 %	Target met	✓	70 %	Target met	✓
Bedroom 1 equivalent area	0.49 m²	3.50 %	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×
Bedroom 2 equivalent area	1.07 m²	8.05 %	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×
Bedroom 3 equivalent area	m²	%	%			%			%			%		
Bedroom 4 equivalent area	m²	%	%			%			%			%		
Bedroom 5 equivalent area	m²	%	%			%			%			%		

Appendix - Results from the FHH ADO Simplified Method calculator

Moderate-risk location

Failed all orientations:

- Removal of excess heat from total equivalent area (% of floor area).
- Removal of excess heat from bedroom 1.

Findings

In both high and moderate risk locations, the house type passed in limiting solar gains, however the house failed in removing excess heat in different categories.

In high-risk locations, the house failed the removal of excess heat from bedrooms 1 and 2. However, in moderate-risk locations it failed on removing excess heat from bedroom 1 and removing excess heat from the whole house according to the % of floor area.

Overall, the property passed in all risk scenarios for limiting solar gains. However, there are not enough openable windows to remove excess heat from the whole house and bedroom 1.

B Home data

Location risk category	Moderate Risk
Shading provided?	None
Cross ventilation?	Yes
Total GIA of home (m^2)	79.354
Direction of most glazed façade on house type plan	**'Clock face' 12**

Glazed area information

'Clock face'	Total glazed area (m^2)	% of total
12	3.712	45%
3	0.992	12%
6	3.613	43%
9	0	0%

C Results

	Value		Percentage	
Limiting solar gains:				
Total glazing area for home	8.32	m²	10.48	%
Glazing area for most glazed room: **Kitchen/ Dining**	2.17	m²	12.74	%
Shading	None			
Removal of excess heat:				
Total equivalent area (% of floor area)	6.25	m²	7.88	%
Total equivalent area (% of glazed area)	6.25	m²	75.19	%
Bedroom 1 equivalent area	0.49	m²	3.50	%
Bedroom 2 equivalent area	1.07	m²	8.05	%
Bedroom 3 equivalent area		m²		%
Bedroom 4 equivalent area		m²		%
Bedroom 5 equivalent area		m²		%

Largest glazed façade orientation: **North**

	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	18	%	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	37	%	Target met	✓
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target not met	×
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target not met	×
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area		%		
Bedroom 4 equivalent area		%		
Bedroom 5 equivalent area		%		

Largest glazed façade orientation: **East**

	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	18	%	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	37	%	Target met	✓
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target not met	×
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target not met	×
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area		%		
Bedroom 4 equivalent area		%		
Bedroom 5 equivalent area		%		

Largest glazed façade orientation: **South**

	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	15	%	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	30	%	Target met	✓
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target not met	×
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target not met	×
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area		%		
Bedroom 4 equivalent area		%		
Bedroom 5 equivalent area		%		

Largest glazed façade orientation: **West**

	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	11	%	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	22	%	Target met	✓
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target not met	×
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target not met	×
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area		%		
Bedroom 4 equivalent area		%		
Bedroom 5 equivalent area		%		

Appendix

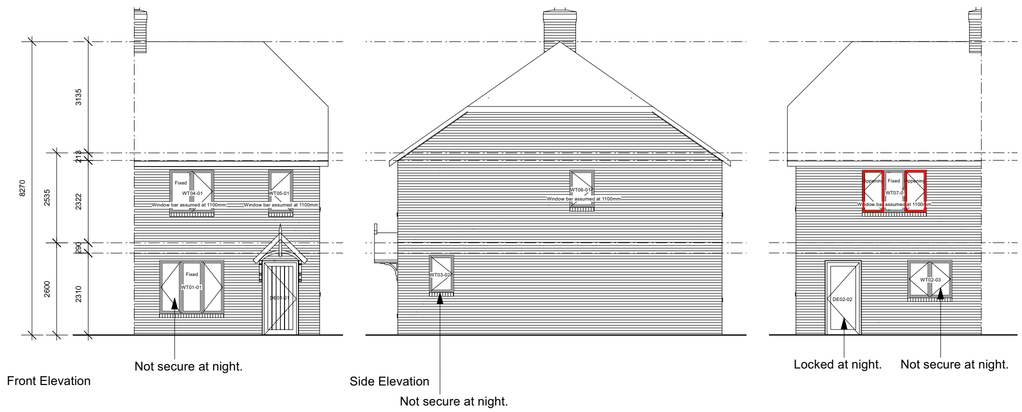
Example 1: A typical house tested in various locations _ Mitigation

2 x openings added in place of 2 x fixed panes. WT07-01 modified. Aim to pass the removal of excess heat.

High-risk location

Failed all orientations:

- Failed: removal of excess heat to bedrooms 1 and 2.



Building Regulations Part O 2021 (England), Simplified Method - Summary results for all orientations

Future Homes Hub spreadsheet tool version:	FHH-SM-V1
A Site data	
Company	Error! Enter information on RESULTS sheet
Site	Error! Enter information on RESULTS sheet
House type	Croudace House type
Plot number	Error! Enter information on RESULTS sheet
B Home data	
Location risk category	High Risk
Shading provided?	Provided
Cross ventilation?	Yes
Total GIA of home (m^2)	79.354
Direction of most glazed façade on house type plan	**'Clock face' 12**

Glazed area information

'Clock face'	Total glazed area (m^2)	% of total
12	3.712	45%
3	0.992	12%
6	3.613	43%
9	0	0%

C Results

			Largest glazed façade orientation North			Largest glazed façade orientation East			Largest glazed façade orientation South			Largest glazed façade orientation West		
	Value	Percentage	Target	RESULT	✓×	Target	RESULT	✓×	Target	RESULT	✓×	Target	RESULT	✓×
Limiting solar gains:														
Total glazing area for home	8.32 m^2	10.48 %	15 %	Target met	✓	18 %	Target met	✓	15 %	Target met	✓	18 %	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	2.17 m^2	12.74 %	37 %	Target met	✓	37 %	Target met	✓	22 %	Target met	✓	37 %	Target met	✓
Shading	Provided		Required		✓	Required		✓	Required		✓	Required		✓
Removal of excess heat:														
Total equivalent area (% of floor area)	6.75 m^2	8.50 %	6 %	Target met	✓	6 %	Target met	✓	6 %	Target met	✓	6 %	Target met	✓
Total equivalent area (% of glazed area)	6.75 m^2	81.13 %	70 %	Target met	✓	70 %	Target met	✓	70 %	Target met	✓	70 %	Target met	✓
Bedroom 1 equivalent area	0.99 m^2	7.00 %	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×
Bedroom 2 equivalent area	1.07 m^2	8.05 %	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×	13 %	Target not met	×
Bedroom 3 equivalent area	m^2	%	%			%			%			%		
Bedroom 4 equivalent area	m^2	%	%			%			%			%		
Bedroom 5 equivalent area	m^2	%	%			%			%			%		

Appendix

Moderate-risk location

Failed all orientations:

- Failed: removal of excess heat from total equivalent area (% of floor area).

Findings

By making the modification of replacing 2 fixed panes with 2 openings in Bedroom 1, this has enabled the moderate-risk location house type to pass removing excess heat from the Bedroom 1. However, it failed in all orientations on removing excess heat from the total equivalent area according to % of floor area.

The ADO Simplified Method results indicate that when you add more openings to windows, rather than fixed panes, this helps to pass the removal of excess heat.

B Home data

Location risk category	Moderate Risk
Shading provided?	None
Cross ventilation?	Yes
Total GIA of home (m^2)	79.354
Direction of most glazed façade on house type plan	**'Clock face' 12**

Glazed area information

'Clock face'	Total glazed area (m^2)	% of total
12	3.712	45%
3	0.992	12%
6	3.613	43%
9	0	0%

C Results

			Largest glazed façade orientation North			Largest glazed façade orientation East			Largest glazed façade orientation South			Largest glazed façade orientation West		
	Value	Percentage	Target	RESULT	✓×	Target	RESULT	✓×	Target	RESULT	✓×	Target	RESULT	✓×
Limiting solar gains:														
Total glazing area for home	8.32 m^2	10.48 %	18 %	Target met	✓	18 %	Target met	✓	15 %	Target met	✓	11 %	Target met	✓
Glazing area for most glazed room: **Kitchen/ Dining**	2.17 m^2	12.74 %	37 %	Target met	✓	37 %	Target met	✓	30 %	Target met	✓	22 %	Target met	✓
Shading	None		Not required		✓	Not required		✓	Not required		✓	Not required		✓
Removal of excess heat:														
Total equivalent area (% of floor area)	6.75 m^2	8.50 %	9 %	Target not met	×	9 %	Target not met	×	9 %	Target not met	×	9 %	Target not met	×
Total equivalent area (% of glazed area)	6.75 m^2	81.13 %	55 %	Target met	✓	55 %	Target met	✓	55 %	Target met	✓	55 %	Target met	✓
Bedroom 1 equivalent area	0.99 m^2	7.00 %	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓
Bedroom 2 equivalent area	1.07 m^2	8.05 %	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓
Bedroom 3 equivalent area	m^2	%	%			%			%			%		
Bedroom 4 equivalent area	m^2	%	%			%			%			%		
Bedroom 5 equivalent area	m^2	%	%			%			%			%		

Appendix

Example 4: Bespoke homes in West Sussex illustrating changes to window configuration _ Mitigations

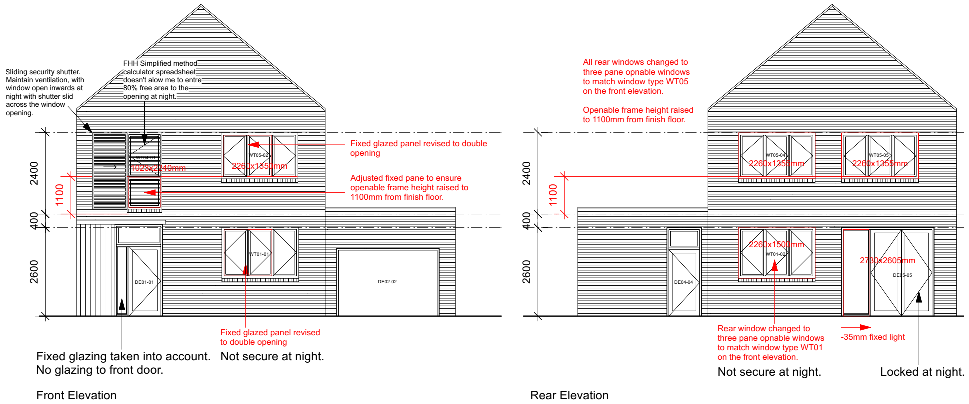
All mitigations applied:

- All windows openable
- Set the window frame at 1100mm from FFL for windows on the first floor.
- Security grille added to the window over the entrance store flat roof.

Moderate-risk location, without shading

Failed South and West orientations:

- Failed: limiting solar gains - total glazing area for home and glazing area for most glazed room (kitchen/dining).



Building Regulations Part O 2021 (England), Simplified Method - Summary results for all orientations

B Home data

Location risk category	Moderate Risk
Shading provided?	None
Cross ventilation?	Yes
Total GIA of home (m^2)	129.994
Direction of most glazed façade on house type plan	**'Clock face' 12**

Glazed area information

'Clock face'	Total glazed area (m^2)	% of total
12	11.121	53%
3	0.306	1%
6	6.81	33%
9	2.58	12%

C Results

	Value	Percentage	North Target	North RESULT	North ✓✗	East Target	East RESULT	East ✓✗	South Target	South RESULT	South ✓✗	West Target	West RESULT	West ✓✗
			Largest glazed façade orientation North			Largest glazed façade orientation East			Largest glazed façade orientation South			Largest glazed façade orientation West		
Limiting solar gains:														
Total glazing area for home	20.82 m^2	16.01 %	18 %	Target met	✓	18 %	Target met	✓	15 %	Target not met	✗	11 %	Target not met	✗
Glazing area for most glazed room: **Kitchen/ Dining**	8.21 m^2	33.44 %	37 %	Target met	✓	37 %	Target met	✓	30 %	Target not met	✗	22 %	Target not met	✗
Shading	None		Not required		✓	Not required		✓	Not required		✓	Not required		✓
Removal of excess heat:														
Total equivalent area (% of floor area)	17.26 m^2	13.27 %	9 %	Target met	✓	9 %	Target met	✓	9 %	Target met	✓	9 %	Target met	✓
Total equivalent area (% of glazed area)	17.26 m^2	82.89 %	55 %	Target met	✓	55 %	Target met	✓	55 %	Target met	✓	55 %	Target met	✓
Bedroom 1 equivalent area	1.98 m^2	15.17 %	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓
Bedroom 2 equivalent area	2.08 m^2	16.13 %	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓
Bedroom 3 equivalent area	2.18 m^2	20.19 %	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓
Bedroom 4 equivalent area	1.01 m^2	13.41 %	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓	4 %	Target met	✓
Bedroom 5 equivalent area	m^2	%	%			%			%			%		

Appendix

Moderate-risk location with shading

Failed South orientation:

- South FAILED: limiting solar gains - total glazing area for home and glazing area for most glazed room (kitchen/dining).

Findings

In both high and moderate risk locations, the house type passed ADO Simplified Method on the removal of excess heat from the house.

In moderate-risk locations without shading, the house passed in orientations North and East, however it failed in orientations South and West on limiting solar gains to the total glazing area for the home and glazing area for the most glazed room (kitchen/dining).

In comparison, moderate-risk locations with shading (grille to the front window), the house passed in all orientations apart from the South. For the South orientation, it failed on limiting solar gains to the total glazing area for the home and glazing area for the most glazed room (kitchen/dining).

Overall, in high-risk locations the house type with all the mitigations to the window proportions and openings along with the security grille, the house type passed in all orientations apart from the South. When the rear of the house, with the largest glazing facing South, it fails in limiting solar gains, due to the amount of glazing.

In all risk scenarios, the house passed in removing excess heat from the building, as all the windows have openable pains, apart from the living room patio door, that has a fixed light. If this is omitted, this might help reduce solar gains.

B Home data

Location risk category	Moderate Risk
Shading provided?	Provided
Cross ventilation?	Yes
Total GIA of home (m^2)	129.994
Direction of most glazed façade on house type plan	**'Clock face' 12**

Glazed area information

'Clock face'	Total glazed area (m^2)	% of total
12	11.121	53%
3	0.306	1%
6	6.81	33%
9	2.58	12%

C Results

	Value		Percentage	
Limiting solar gains:				
Total glazing area for home	20.82	m²	16.01	%
Glazing area for most glazed room: **Kitchen/ Dining**	8.21	m²	33.44	%
Shading	Provided			
Removal of excess heat:				
Total equivalent area (% of floor area)	17.26	m²	13.27	%
Total equivalent area (% of glazed area)	17.26	m²	82.89	%
Bedroom 1 equivalent area	1.98	m²	15.17	%
Bedroom 2 equivalent area	2.08	m²	16.13	%
Bedroom 3 equivalent area	2.18	m²	20.19	%
Bedroom 4 equivalent area	1.01	m²	13.41	%
Bedroom 5 equivalent area		m²		%

Largest glazed façade orientation: North	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	18	%	Target met	✓
Glazing area for most glazed room: Kitchen/ Dining	37	%	Target met	✓
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target met	✓
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target met	✓
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area	4	%	Target met	✓
Bedroom 4 equivalent area	4	%	Target met	✓
Bedroom 5 equivalent area		%		

Largest glazed façade orientation: East	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	18	%	Target met	✓
Glazing area for most glazed room: Kitchen/ Dining	37	%	Target met	✓
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target met	✓
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target met	✓
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area	4	%	Target met	✓
Bedroom 4 equivalent area	4	%	Target met	✓
Bedroom 5 equivalent area		%		

Largest glazed façade orientation: South	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	15	%	Target not met	×
Glazing area for most glazed room: Kitchen/ Dining	30	%	Target not met	×
Shading	Not required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target met	✓
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target met	✓
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area	4	%	Target met	✓
Bedroom 4 equivalent area	4	%	Target met	✓
Bedroom 5 equivalent area		%		

Largest glazed façade orientation: West	Target		RESULT	✓×
Limiting solar gains:				
Total glazing area for home	18	%	Target met	✓
Glazing area for most glazed room: Kitchen/ Dining	37	%	Target met	✓
Shading	Required			✓
Removal of excess heat:				
Total equivalent area (% of floor area)	9	%	Target met	✓
Total equivalent area (% of glazed area)	55	%	Target met	✓
Bedroom 1 equivalent area	4	%	Target met	✓
Bedroom 2 equivalent area	4	%	Target met	✓
Bedroom 3 equivalent area	4	%	Target met	✓
Bedroom 4 equivalent area	4	%	Target met	✓
Bedroom 5 equivalent area		%		

Glossary

Background ventilation – low level ventilation rate provided 24/7 (as required by ADF) 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 ADO as when a home that has openings on opposite façades. 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 ADO 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.

Dual Aspect home – a home with windows or openings on more than one façade. Note that the ADO definition of cross-ventilation requires openings on opposite façades 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 ADO 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 ADO, this is the centre pane value.

High risk location – most areas of London, with list of postcodes defined in ADO 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 ADO 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 ADO 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. ADF states requirements for purge ventilation. Higher ventilation rates may be required to meet overheating mitigation under ADO.

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.

Target Fabric Energy Efficiency (TFEE) rate: The target fabric energy efficiency rate as calculated by SAP for a particular home and is expressed as kWh/(m^2.yr). The calculation is based on a concurrent notional dwelling of the same size and shape as the proposed dwelling, using the reference values in SAP Appendix R.

TM59 – in this Guide 'TM59' is used as shorthand for Dynamic Thermal Modelling to assess overheating, following the CIBSE TM59 guidance supplemented by the requirements of ADO.

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.

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