Research report on Overheating risk in dwellings

Sustainable Energy Authority of Ireland

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Prepared for:

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1. Introduction

The Sustainable Energy Authority of Ireland (SEAI) appointed AECOM to carry out an assessment of the overheating risk in dwellings using CIBSE TM59 methodology, and to review the available risk assessment tools to avoid/minimise cooling being retrofitted in new homes.

One tool considered was Appendix P of the Dwelling Energy Assessment Procedure[1] (DEAP) which sets out the methodology for assessing the tendency of a dwelling to have high internal temperature in hot weather. The objective of the review is to optimise the assessment methodology in DEAP, where relevant, to ensure that the risk of overheating in dwellings is minimised. The findings from the review will in turn be used to develop guidance for designers.

To understand the risk of overheating and to inform the review of available tools, a range of typical dwellings with different fabric specifications and mitigation measures are modelled using CIBSE TM59 methodology. Weather data for the 2020s[2] has been used as recommended by CIBSE, to account for future changes in temperature and weather patterns due to climate change.

2. Methodology and modelling parameters

2.1 Definition of overheating

For this study the CIBSE TM59 definition[3] has been used to identify overheating risk in new dwellings. The CIBSE TM59 provides a standardised approach for assessing overheating risk in residential buildings and has been developed through industry consultation in the UK. TM59 sets out two compliance criteria for dwellings that are predominantly naturally ventilated.

- Criterion A for living rooms, kitchens and bedrooms. It requires that the internal temperature in these rooms does not exceed a defined comfort temperature by 1 °C or more for more than 3% of occupied hours over the summer period (1 May to 30 September).
- Criterion B for bedrooms only. It requires that the internal temperature between 10 pm and 7 am does not exceed 26 °C for more than 1% of annual hours.

The threshold comfort temperature under Criterion A is based on an adaptive model that takes into account the variations in external temperature.

The dwelling is deemed to have an acceptable risk of overheating if both TM59 criteria are met. If one or both of the criteria are not met, the implication is that mitigation measures are necessary to reduce the risk to an acceptable level.

2.2 Assessing overheating risk

The overheating risk has been assessed using Dynamic Thermal Simulation modelling. IES Virtual Environment version 2016 has been used, which is a commercially available software package. Assessment of overheating risk has been based on Category II buildings (i.e. new buildings with normal occupancy as per EN15251).

The sub-sections below set out the modelling parameters and the dwelling typologies assessed.

2.2.1 Dwelling typologies

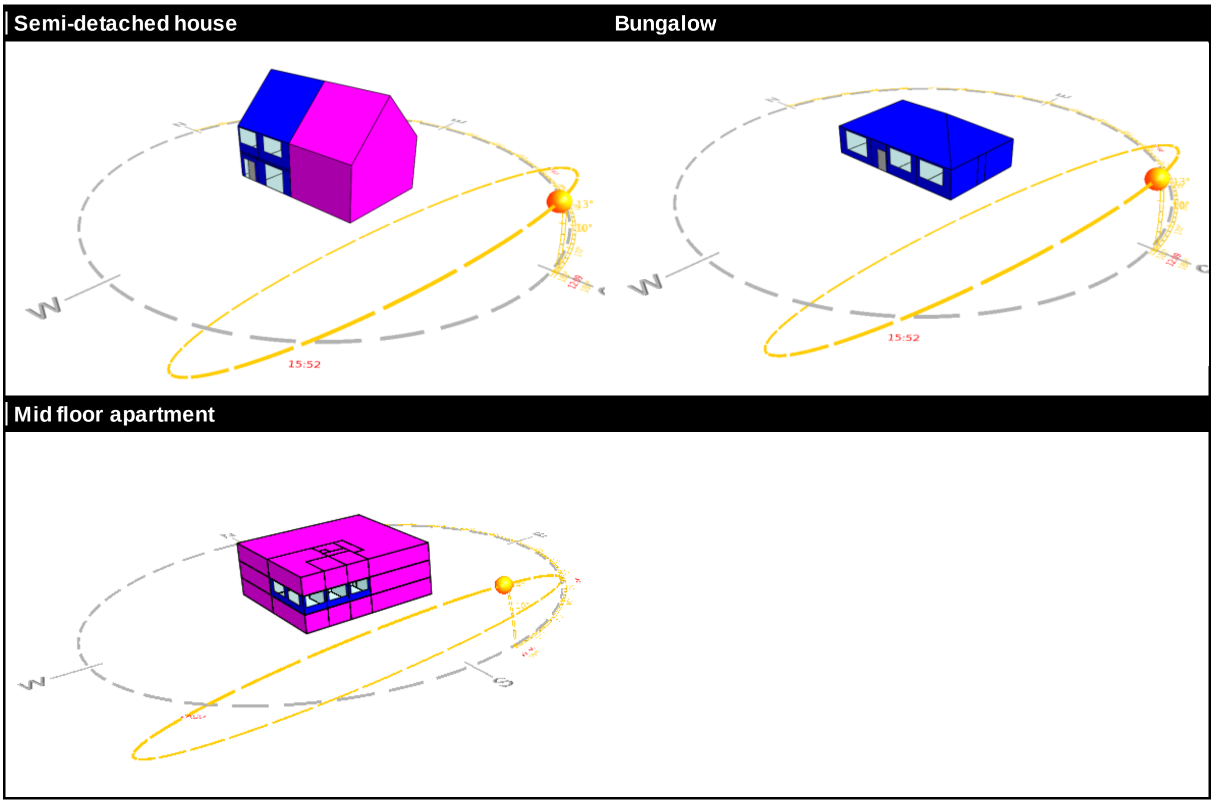
The overheating risk has been assessed for the following dwelling typologies:

[1] DEAP is Republic of Ireland's official method for calculating the Building Energy Rating of new and existing dwellings. Details available on www.seai.ie/energy-in-business/ber-assessor-support/deap/
[2] The 2020s weather file is representative of the time period 2011-2040.
[3] CIBSE; TM59 Design methodology for the assessment of overheating risk in homes; May 2017

- Bungalow
- Semi Detached
- Mid Floor Apartment

The dwelling layouts and geometry for the base case are the same as used for the Part L regulatory impact assessment.

Figure 1: Dwelling typologies showing building orientation for the base-case scenario



2.2.2 Base modelling parameters and assumptions

The modelling parameters and assumptions are tabulated below.

Note that the TM59 methodology recommends using weather data for the 2020s for the overheating risk analysis to account for future changes in temperature and weather patterns due to climate change. The weather files, developed by CIBSE and the University of Exeter are only available for 14 locations in the UK, with Belfast being the only location in Ireland for which future weather data is available. In the absence of future weather data for Dublin, Belfast weather data has been used for the base case. This is based on advice from Met Eireann that Belfast data is more representative of Ireland climate. The overheating results were also analysed with other weather data (including historic Dublin data, 2020s data for Manchester and alternative future weather data for Belfast), as set out in Section 2.3. Manchester data has only been included for comparison only as this location was used to assess overheating risk as part of the Regulatory Impact Assessment for Part L 2019.

Table 1: Base modelling parameters and assumptions

Weather file	Belfast DSY1 (Design Summer Year 1) data for 2020s[4] (high emissions 50% percentile scenario in line with TM59 methodology)

[4] The 2020s weather file is representative of the time period 2011-2040. DSY1 represents a moderately warm summer.

Dwelling occupancy	Based on the size of the bedrooms in the drawings, the following design occupancy has been assumed: Semi-detached house: 3 bed 5 persons Bungalow: 3 bed 6 persons Apartments: 2 bed 4 persons TM59 requires that bedrooms are modelled as being occupied 24 hrs a day, with relatively lower occupancy levels during the day compared to night. Living rooms and kitchens are modelled to be occupied between 9am in the morning to 10pm in the night. Maximum occupancy in a dwelling has been limited to the design occupancy.
Fabric thermal performance standards	As per TGD Part L 2019. External Wall U-value – 0.13 W/m².K Floor U-value – 0.14 W/m².K Roof U-value – 0.11 W/m².K Party wall U-value – 0.0 W/m².K Windows and glazed doors – 0.9 W/m².K (triple glazed, low E, soft coat) External door U-value – 1.5 W/m².K
Orientation and solar gains	Living rooms in all dwelling types have been assumed to face west, which is expected to be the worst-case orientation for summer overheating. Apartments have been assumed to be west and south facing. No external shading or internal blinds/ curtains has been assumed for the base-case scenario.
Thermal mass parameter (TMP)	Medium. TMP calculated based on the following construction: solid concrete slab over PIR insulation; masonry external walls with cavity fill insulation, internal insulation and wet plaster; solid masonry party walls with wet plaster; concrete deck party floors in apartments; steel stud internal partitions; pitched timber frame roof for houses.
Ventilation strategy	Purge ventilation through openable windows.
Openable window and door area (excluding front door)	Total window and door openable area has been assumed to be 1/20th of the floor area of each habitable room (as per TGD Part F requirements)
Glazing/ window type	Side hung, assumed 90° open when fully open
Window g-value	0.6
Percentage of window that is frame	Houses – 35% Apartments – 25%
Window opening regime	Windows, patio and balcony doors have been modelled to start to open in occupied rooms when indoor operative temperature exceeds 22°C and are fully open when temperature exceeds 26°C. Similarly, window and door openings have been modelled to start closing as internal temperature drop below 26°C and are fully closed when internal temperature drops below 22°C. The windows in unoccupied rooms (bathrooms, toilets, cloak room, utility room, etc.) have been assumed to be closed.
Internal doors	Internal doors have been assumed to be open all the time, with the exception of bedroom doors which are closed 22:00 – 9:00.

<table>
<tr><td></td><td>Bedrooms doors modelled with 10mm undercut in line with Part F requirements (clause 1.2.1.2).</td></tr>
<tr><td>External doors</td><td>The external entrance doors have been assumed shut at all times.</td></tr>
<tr><td>Air infiltration</td><td>Air infiltration rates have been assumed to be continuous and calculated based on CIBSE Guide A empirical values for normally exposed sites (Table 4.24) and an air permeability rate of 5 m³/hm² @ 50Pa (in line with TGD Part L 2018).

Unheated loft spaces in houses have been assumed to have infiltration rate of 1.0 ach (air change per hour).</td></tr>
<tr><td>Building services and percentage low energy lighting</td><td>As per TGD Part L 2019.</td></tr>
<tr><td>Heating regime</td><td>Temperature set point of 18°C modelled for heating throughout the year with the exception of June, July and August.</td></tr>
<tr><td>Lighting and equipment gains</td><td>In line with TM59 guidelines. Equipment and lighting gains vary with occupancy and time of the day.
<table>
<tr><th>Room types</th><th>Max. no. of people</th><th>Occupancy* (Sensible) - W</th><th>Lighting – W/m²</th><th>Equipment – W</th></tr>
<tr><td>Bedrooms - Double</td><td>2</td><td>150</td><td>2</td><td>80</td></tr>
<tr><td>Bedrooms - Single</td><td>1</td><td>75</td><td>2</td><td>80</td></tr>
<tr><td>Living room – 2b4p</td><td>2</td><td>150</td><td>2</td><td>150</td></tr>
<tr><td>Living room – 3b5p</td><td>2</td><td>150</td><td>2</td><td>150</td></tr>
<tr><td>Living room – 3b6p</td><td>3</td><td>150</td><td>2</td><td>150</td></tr>
<tr><td>Kitchen – 2b4p</td><td>2</td><td>150</td><td>2</td><td>300</td></tr>
<tr><td>Kitchen – 3b5p</td><td>2</td><td>150</td><td>2</td><td>300</td></tr>
<tr><td>Kitchen – 3b6p</td><td>3</td><td>150</td><td>2</td><td>300</td></tr>
<tr><td>Kitchen/ dining</td><td>as per kitchen</td><td></td><td></td><td></td></tr>
<tr><td>Hallway</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Bathroom, cloakroom</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Toilet</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Utility room</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>
*Note: Occupancy gains assumed to be 75 W/person sensible and 55 W/person latent. During sleeping hours these gains are reduced by 30%.</td></tr>
<tr><td>Heat gains from hot water storage</td><td>Hot water storage of 120 litres assumed for all dwelling typologies, with continuous standing loss of 50W.</td></tr>
</table>

2.3 Modelling scenarios

The modelling scenarios cover a mix of dwelling design features and other parameters such as weather data and internal gains though exclude specific occupant behavioural aspects. The various parameters have been modelled individually for each of the dwellings typologies to understand how these affect overheating risk. Certain parameters have then been combined to understand the scale of the cumulative impact on overheating risk.

The scenarios modelled are tabulated below.

Table 2: Modelling scenarios

Weather data	Belfast DSY1 data for 2050s (high emissions 50% percentile scenario)[5]
	Belfast DSY2 data for 2020s (high emissions 50% percentile scenario)[6]
	Dublin 89 weather data tape (represents a historic warm summer)
	Manchester DSY1 data for 2020s (high emissions 50% percentile scenario)
Glazing areas and specification	Double glazing, U-value of 1.4 W/m^{2}K, g-value 0.65
	Triple glazing as per base case specification with window to floor area ratio increased to 35%
	Triple glazing as per base case specification with window to floor area ratio increased to 40%
	Triple glazing with window to floor area ratio increased to 40% and g-value of 0.4
	Roof window (500 mm X 900 mm) assumed above the landing in the semi-detached house and above the hall in the bungalow. Rooflights start opening when the indoor operative temperature exceeds 22°C and are fully open when the temperature exceeds 26°C between 09:00 and 22:00 (same profile as for living rooms). The roof window is modelled to have a U value of 0.9 W/m^{2}K, g-value of 0.6, framing ratio of 35% and an openable area of 0.2 m^2.
Ventilation Strategy	The window openable area to floor area ratio reduced to 3.5% in the habitable rooms.
	The window openable area to floor area ratio reduced to 2% in the habitable rooms. This reflects a scenario where a window is restricted from opening, for example due to noise, safety concerns, etc. The intention of modelling this scenario is to flag to designers the impact of restricting the window openings on overheating risk, and to highlight the need to consider alternative strategies where needed (such as external louvered shutters)
	Mechanical ventilation (cMEV) delivering 2.5ach in boost mode for the dwelling combined with 5% of window openable area to floor area ratio. The cMEV starts to operate when the air temperature in the living room is above 24°C. The external air is supplied to bedrooms and living rooms, and extracted from kitchens/dining rooms, bathrooms and WCs
Ceiling Height	Floor to ceiling height reduced to 2.3 m.
	Floor to ceiling height increased to 2.7 m.
Internal gains	50% increase in internal gains including equipment gains, and heat gains from lighting and hot water storage.
Dwelling orientation and solar gains	Living Room assumed to face south
	Fixed external shading modelled as horizontal overhangs on the south façade (50° altitude cut-off), and 300m vertical fins on the east and west façade. No shading assumed on the north façade.

[5] The 2050s weather data is representative of the time period 2041-2070.
[6] Note that DSY1 is representative of a moderately warm summer, DSY2 has a short intense warm period, and DSY3 has a long less intense warm period. For more details refer CIBSE Weather Files 2016 release: Technical briefing and testing.

	Fixed external shading modelled as 120mm deep window reveals on all facades.
	Fixed external shading modelled as 220mm deep window reveals on all facades.
	Fixed external shading modelled as manual movable shading devices (e.g. external blinds) on east, west and south facades. The shading is assumed to have a transmission factor of 50%. It is assumed to be lowered when incident radiation is above 200 W/m^2 and raised when incident radiation is less than 150 W/m^2.
	Internal Blinds with a shading coefficient of 0.4 and a short-wave radiant fraction of 0.3. The internal blinds are assumed to be lowered when incident radiation is above 200 W/m^2 and raised when incident radiation is less than 150 W/m^2.
Thermal Mass	Low TMP calculated based on the following construction: solid concrete floor, insulation and screed; masonry external walls with cavity fill insulation, internal insulation and wet plaster for houses; timber frame external walls with brick cladding in apartments; lightweight blockwork party walls in houses; steel /timber stud party walls in apartments; timber party floors (with floating floor) in apartments; steel /timber stud internal partitions in both houses and flats; pitched timber frame roof for houses
Internal doors	Internal doors assumed closed at all times. Doors modelled with 10mm undercut.
Combined modelling scenarios	Belfast DSY2 data for 2020s Lower fabric thermal performance – U-value of 0.18 W/m^{2}K for external walls – U-value of 0.16 W/m^{2}K for roofs – U-value of 0.18 W/m^{2}K for ground floors Internal doors closed in apartments (modelled with 10mm undercut)
	Belfast DSY2 data for 2020s Triple Glazing as per base case specification with window to floor area ratio increased to 40% Internal doors closed in apartments (modelled with 10mm undercut)
	Belfast DSY2 data for 2020s Window openable area to floor area ratio reduced to 2% in habitable rooms. Internal doors closed in apartments (modelled with 10mm undercut)
	Belfast DSY2 data for 2020s Triple Glazing as per base case specification with window to floor area ratio increased to 40% Internal Blinds with a shading coefficient of 0.4 and a short-wave radiant fraction of 0.3. Internal blinds are assumed to be lowered when incident radiation is > 200 W/m^2 and raised when incident radiation is <150 W/m^2. Internal doors closed in apartments (modelled with 10mm undercut)
	Belfast DSY2 data for 2020s Triple Glazing as per base case specification with window to floor area ratio increased to 40%

	Fixed external shading modelled as horizontal overhangs on the south façade (50° altitude cut-off), and 300m vertical fins on the east and west façade. Internal doors closed in apartments (modelled with 10mm undercut)

3. Modelling results

The modelling results for each of the scenarios described in Section 2.3 are presented in Figure 2 - Figure 15. These show the percentage of occupied hours that exceed the threshold temperature under Criterion A and Criterion B for each room in the dwelling.

The broad trends in terms of overheating risk are summarised below.

Table 3: Summary of modelling results

Category	**Modelling scenario**		**TM59 compliance**		
			Bungalow	**Mid floor flat**	**Semi-detached house**
Base case			✓	✓	✓
Weather data	Belfast DSY1 2050s		✓	✓	✓
	Belfast DSY2 2020s		✓	✓	✓
	Dublin 89		✓	✓	✓
	Manchester DSY1 2020s		✗	✗	✗
Glazing areas and specification	Double glazing, U-value 1.4 W/m^{2}K, g-value 0.65		✓	✓	✓
	Triple glazing; 35% window to floor area ratio		✓	✓	✓
	Triple glazing; 40% window to floor area ratio		✓	✓	✓
	Triple glazing; 40% window to floor area ratio; g-value 0.4		✓	✓	✓
	Roof window		✓	✓	✓
Ventilation strategy	3.5% window openable area to floor area ratio		✓	✓	✓
	2% window openable area to floor area ratio		✓	✗	✓
	cMEV delivering 2.5ach in boost mode		✓	✓	✓
Internal doors	Internal doors closed		✓	✓	✓
Ceiling height	2.3m floor to ceiling height		✓	✓	✓
	2.7m floor to ceiling height		✓	✓	✓
Orientation	South facing living room		✓	✓	✓
Thermal Mass	Low		✓	✓	✓
Internal gains	50% increase in internal gains		✓	✓	✓
Shading devices	Fixed external shading.		✓	✓	✓
	120mm deep window reveals		✓	✓	✓
	220mm deep window reveals		✓	✓	✓
	Movable external shading		✓	✓	✓
	Internal Blinds		✓	✓	✓
Combined scenarios	Belfast DSY2 2020s Internal doors closed in apartments	Lower fabric thermal performance	✓	✓	✓
		Triple glazing; 40% window to floor area ratio	✗	✗	✗
		2% window openable area to floor area ratio	✗	✗	✗
		Triple glazing; 40% window to floor area ratio Internal Blinds	✓	✓	✓

Category	Modelling scenario		TM59 compliance		
			Bungalow	Mid floor flat	Semi-detached house
		Triple glazing; 40% window to floor area ratio Fixed external shading	✘	✔	✔

Base case scenario: All base case dwelling typologies comply with both Criterion A and B when modelled with the Belfast DSY1 file for the 2020s. It is however worth highlighting that the choice of weather file is a key consideration as indicated by the relative increase in overheating hours using the historic Dublin 89 weather data (see Figure 2)

Weather data: The dwellings have been modelled with Belfast weather data for the 2020s and 2050s, historic weather data for Dublin and 2020s weather data for Manchester. The Belfast 2020s weather data includes both DSY1 and DSY2 weather data for 2020s; the former represents a moderately warm summer while DSY2 has a short intense warm period.

For criterion A, the dwellings have a marginally higher number of overheating hours relative to the base-case when modelled with the Belfast DSY1 weather data for 2050s. The overheating hours are even higher when modelled with Belfast DSY2 weather data for the 2020s. With the Dublin 89 weather data, which represents a historically warmer than average summer, the overheating hours are broadly comparable to the Belfast DSY2 weather data for the 2020s (though vary by room and dwelling type), with one of the west facing bedrooms in the semi-detached house just under the 3% compliance threshold. When modelled with DSY1 2020s weather data for Manchester, which is roughly the same latitude as Dublin, the overheating hours in at least one of the rooms in each for the dwelling typologies are in excess of the compliance limit for Criterion A.

For criterion B, the overheating hours are well below the compliance threshold in all instances. The broad trend in terms of the frequency of overheating hours is similar as for criterion A.

Glazing areas and specification: As would be expected the overheating risk goes up as glazing area (and therefore solar gains) increases when assessing compliance under criterion A though this is counteracted by lower g-values. Increasing the window to floor area ratio to 40% with a g-value of 0.4 does not substantially add to the overheating risk relative to the base case. It is however worth noting that an overheating risk mitigation strategy based on lower g-value glazing comes at the expenses of reduced winter gains.

The addition of roof window does not appear to make a significant impact on the results. There is inevitably a trade-off between additional solar gains versus the cooling effect due to increased ventilation rates.

Criterion B results, which reflect night time overheating risk in bedrooms, are largely unaffected by changes to glazing areas and g-values. This would hold true for dwellings where heat build is minimised through effective ventilation during the day and in the late evenings.

Ventilation strategy: There are two main parameters that affect overheating risk in the context of ventilation strategies in dwellings.

- Window openable area, with overheating risk going up significantly when window openable area to floor area ratio is reduced to 2%. Notably the mid-floor flat does not comply with the compliance threshold for criterion A, and is just under the threshold for criterion B
- Ability to cross-ventilate, thereby indicating that single-sided flats may be more at risk than say other dwelling types.

The broad trends for the different ventilation scenarios are similar for both criterion A and B.

Design features: This includes design features such as dwelling volume, orientation and thermal mass. Dwelling volume has a minimal impact relative to the base case. South orientation works more favourably than west orientation, which is also more challenging to shade because of the low angle sun. Switching from medium to low thermal mass marginally increases the overheating risk though this is well below the compliance threshold. Again, the broad trends are similar for both criterion A and B.

Internal gains: Increasing the internal gains by 50% does not have a significant impact on overheating risk.

Shading devices: Shading devices where appropriately designed for the window orientation considerably reduce the risk of overheating under criterion A (as is also demonstrated by the combined scenarios discussed below). Window reveals have a positive impact, although small, for south, east and west facing windows. Fixed external shading works well on south façade but may be problematic for wide areas of west facing glazing. Repeating fixed vertical fins will perform better for west facing windows. Such fixed shading will however obstruct external views and impact daylighting levels throughout the year and may therefore be less desirable for domestic buildings. Movable external shading performs the best, though both this and internal blinds are reliant on occupants using them optimally.

Criterion B results are largely unaffected by the presence of shading devices. As with glazed areas, this would hold true for dwellings where heat build is minimised through effective ventilation during the day and in the late evenings.

Combined parameters: The cumulative impact of parameters that either increase solar gains (such as larger glazed areas) and/or reduce ventilation rates (such as reduced openable window areas and single-sided ventilation) combined with warmer summers significantly increases the overheating risk, well in excess of the compliance thresholds for both criterion A and B. All three dwellings fails to meet criterion A where modelled with Belfast DSY2 weather data for 2020s, single sided ventilation in the flat, and window openable area to floor area ratio of 2%. In the mid floor flat, the overheating hours exceed the compliance threshold by as much as four times. The flat also exceeds the compliance threshold for criterion B by nearly three times.

All three dwellings also fail to meet criterion A where modelled with Belfast DSY2 weather data for 2020s, single sided ventilation in the flat, and 40% window to floor area ratio. Suitably designed internal or external shading can bring the overheating risk down to an acceptable level.

Figure 2: Percentage overheating hours – Criterion A – Weather data

Figure 3: Percentage overheating hours – Criterion B – Weather data

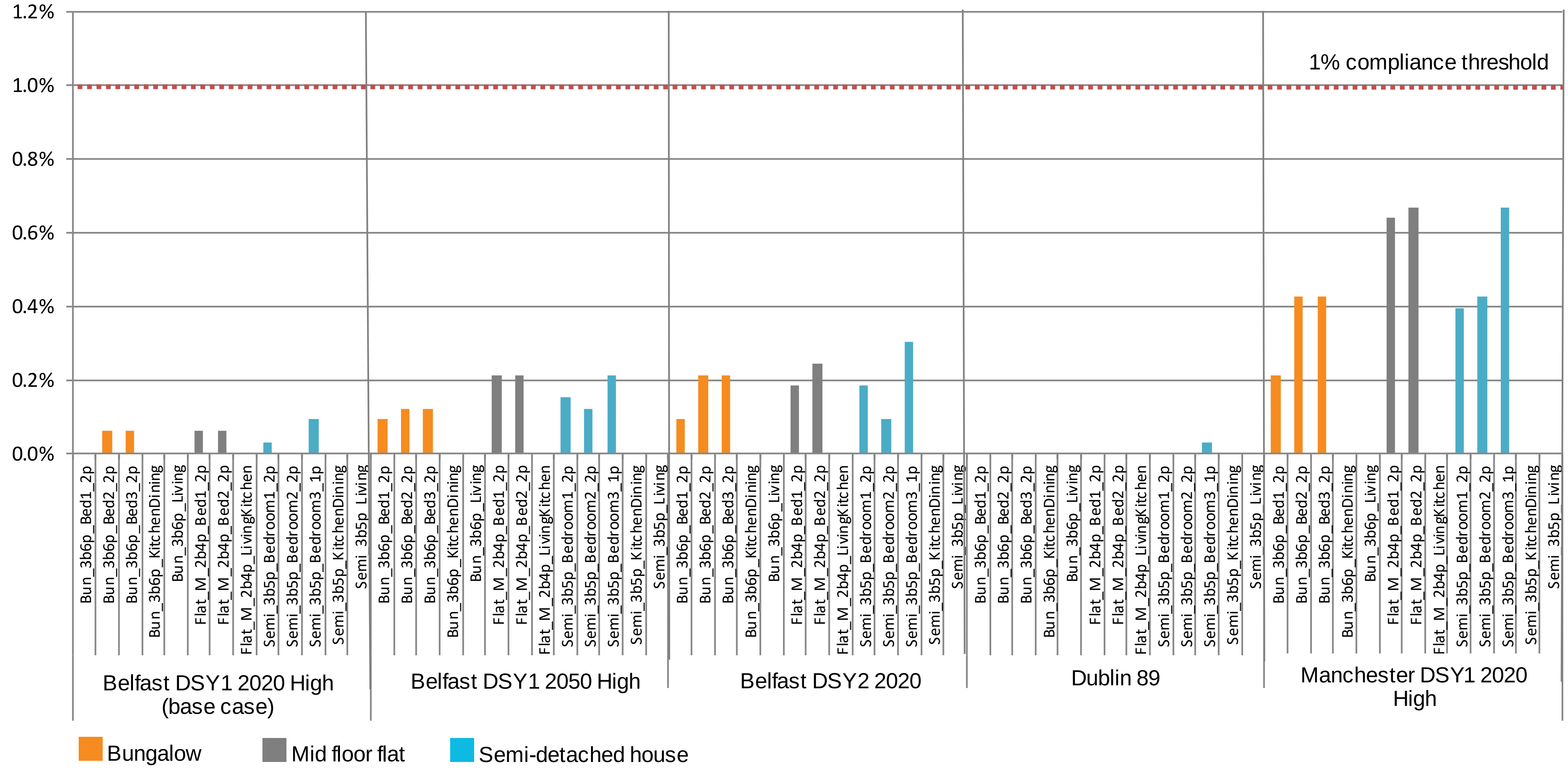


Figure 4: Percentage overheating hours – Criterion A – Glazing areas and specification

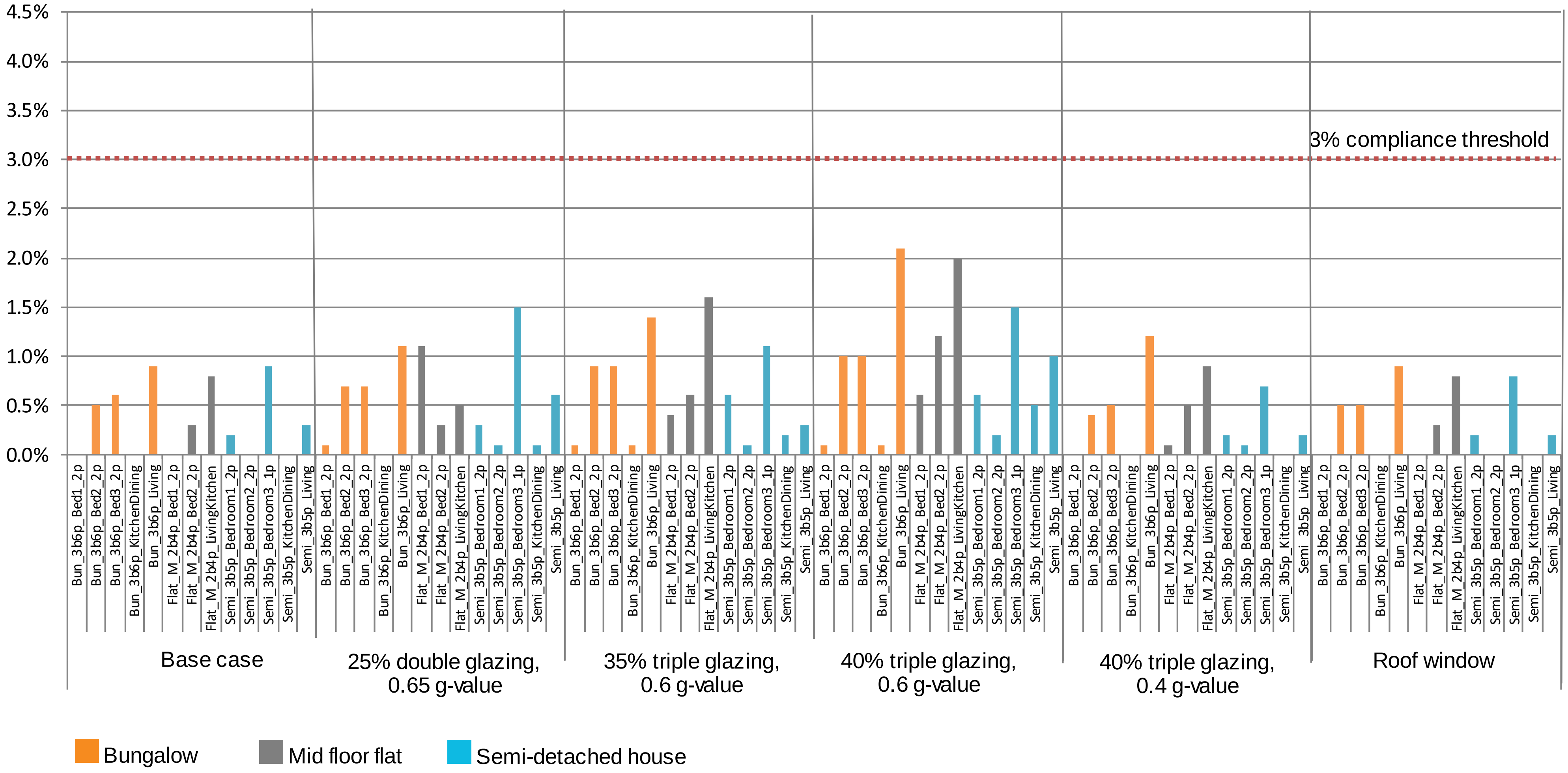


Figure 5: Percentage overheating hours – Criterion B – Glazing areas and specification

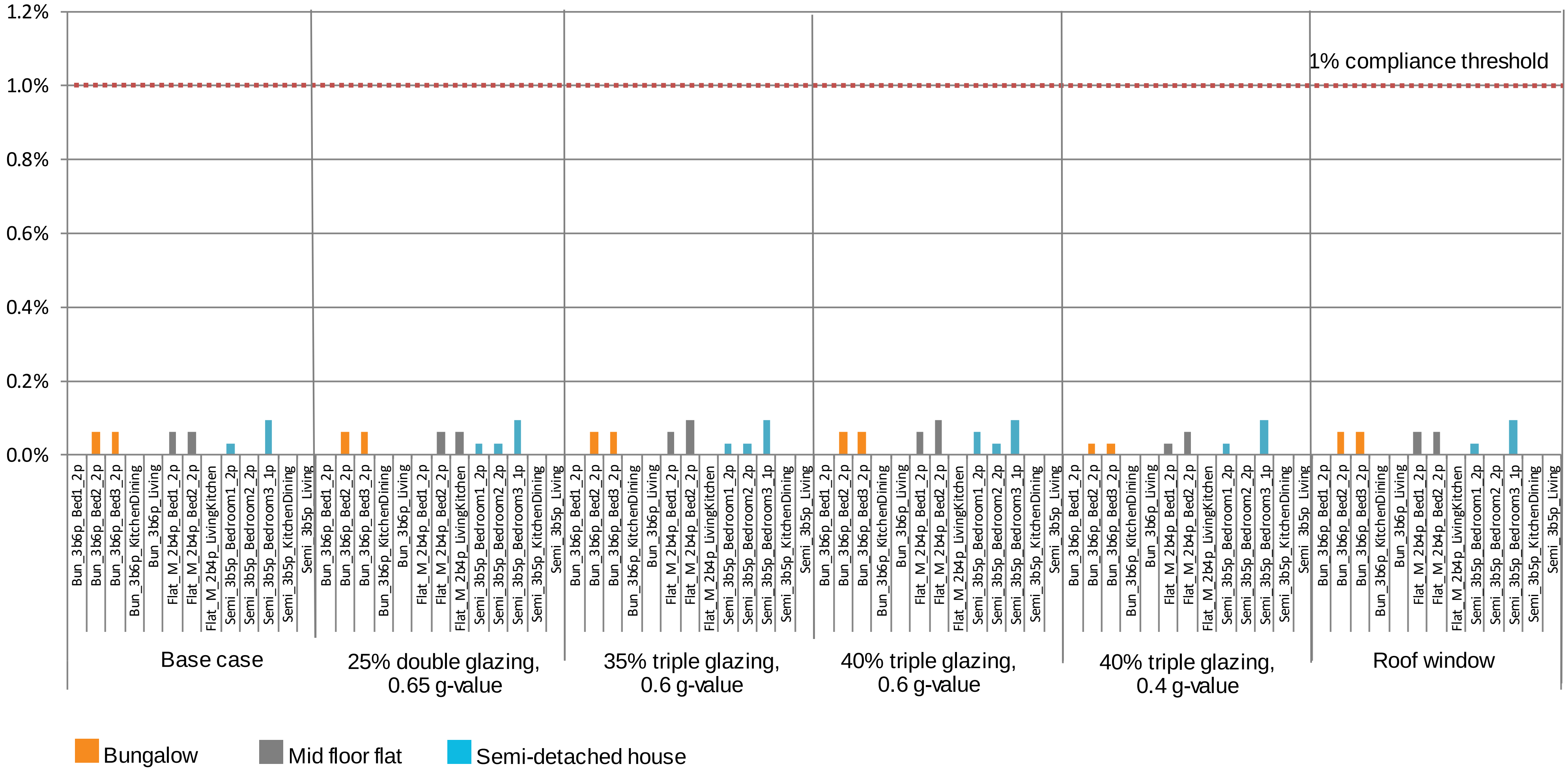


Figure 6: Percentage overheating hours – Criterion A –Ventilation strategy

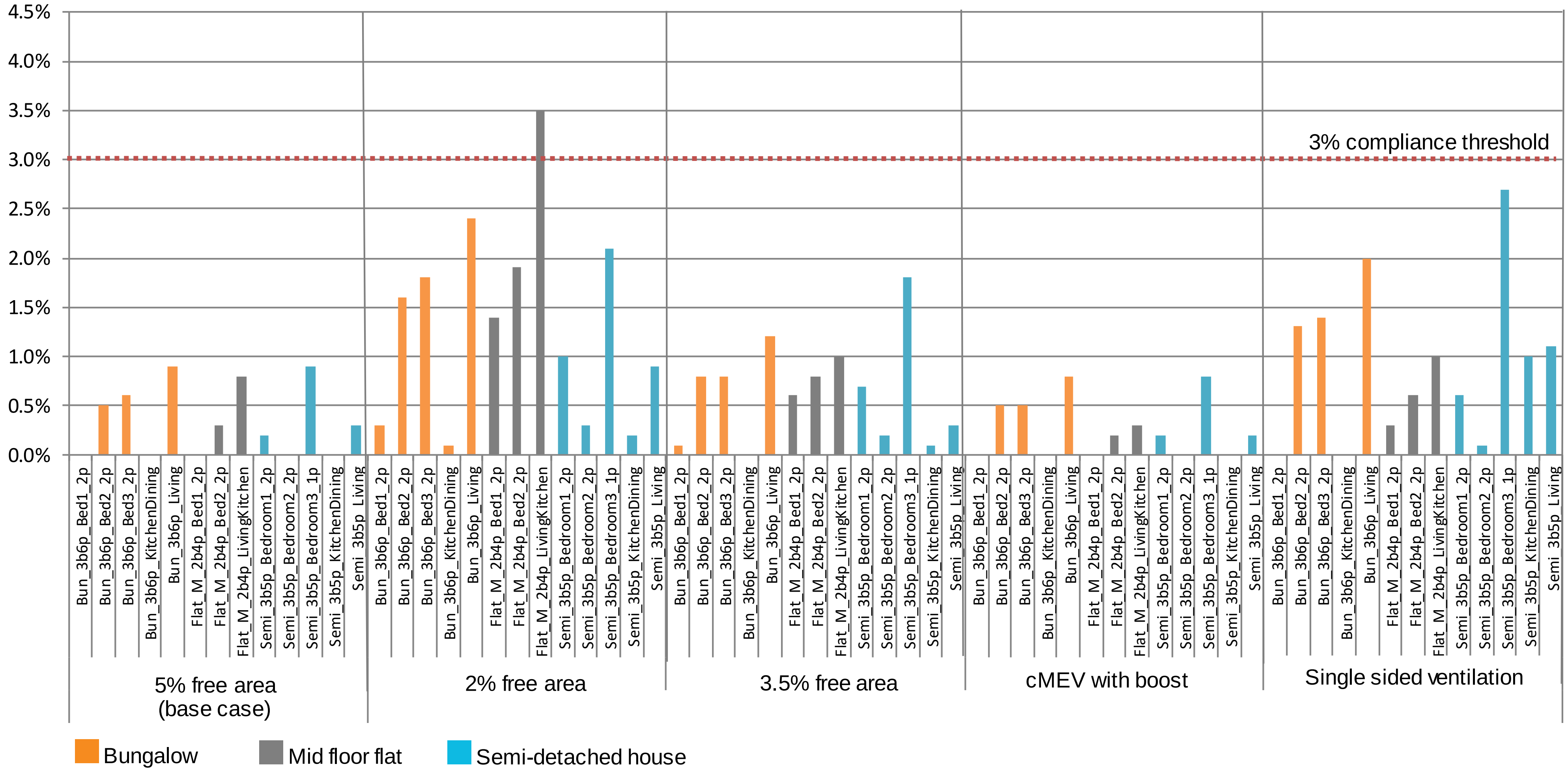


Figure 7: Percentage overheating hours – Criterion B –Ventilation strategy

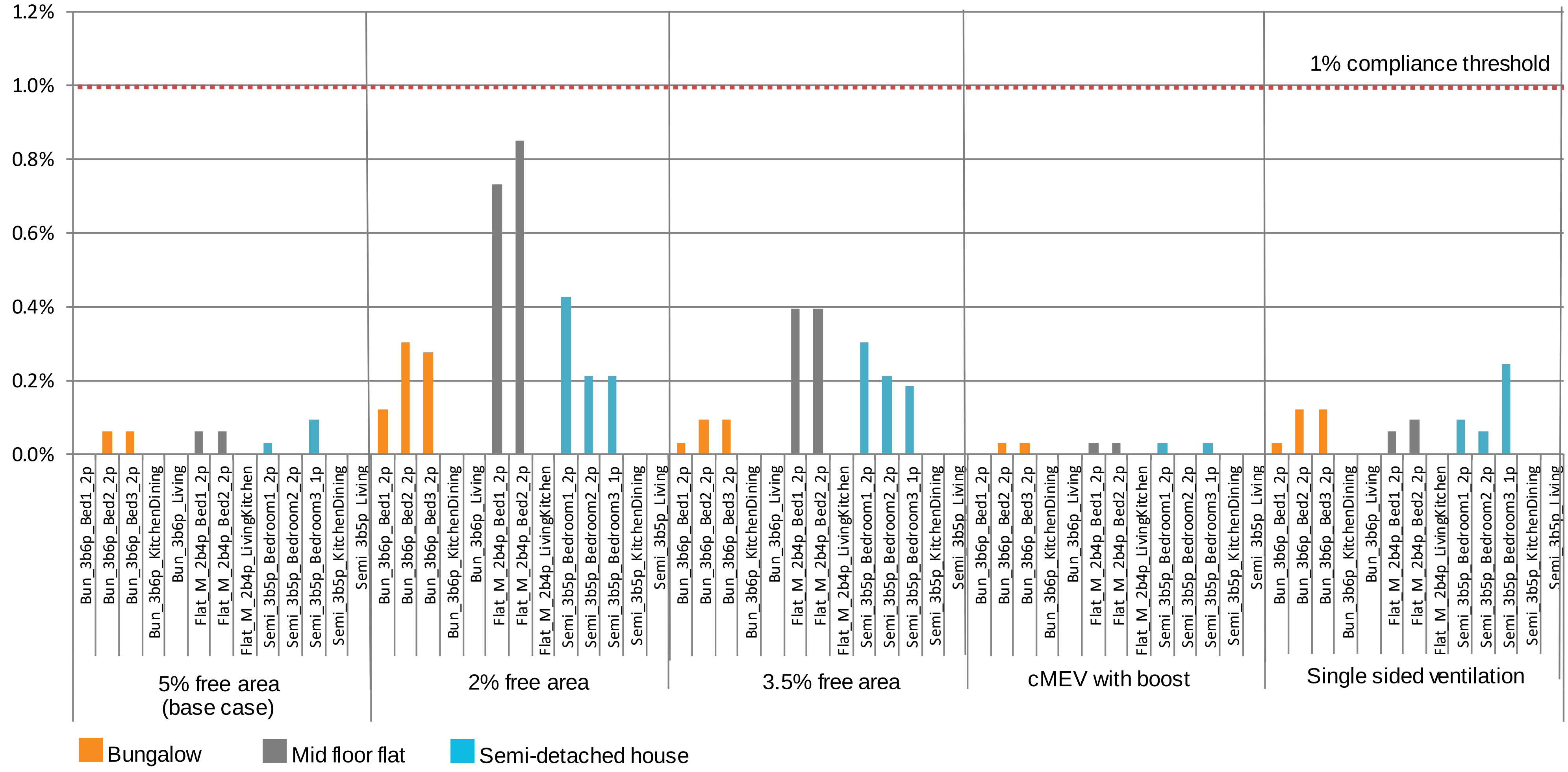


Figure 8: Percentage overheating hours – Criterion A – Design features

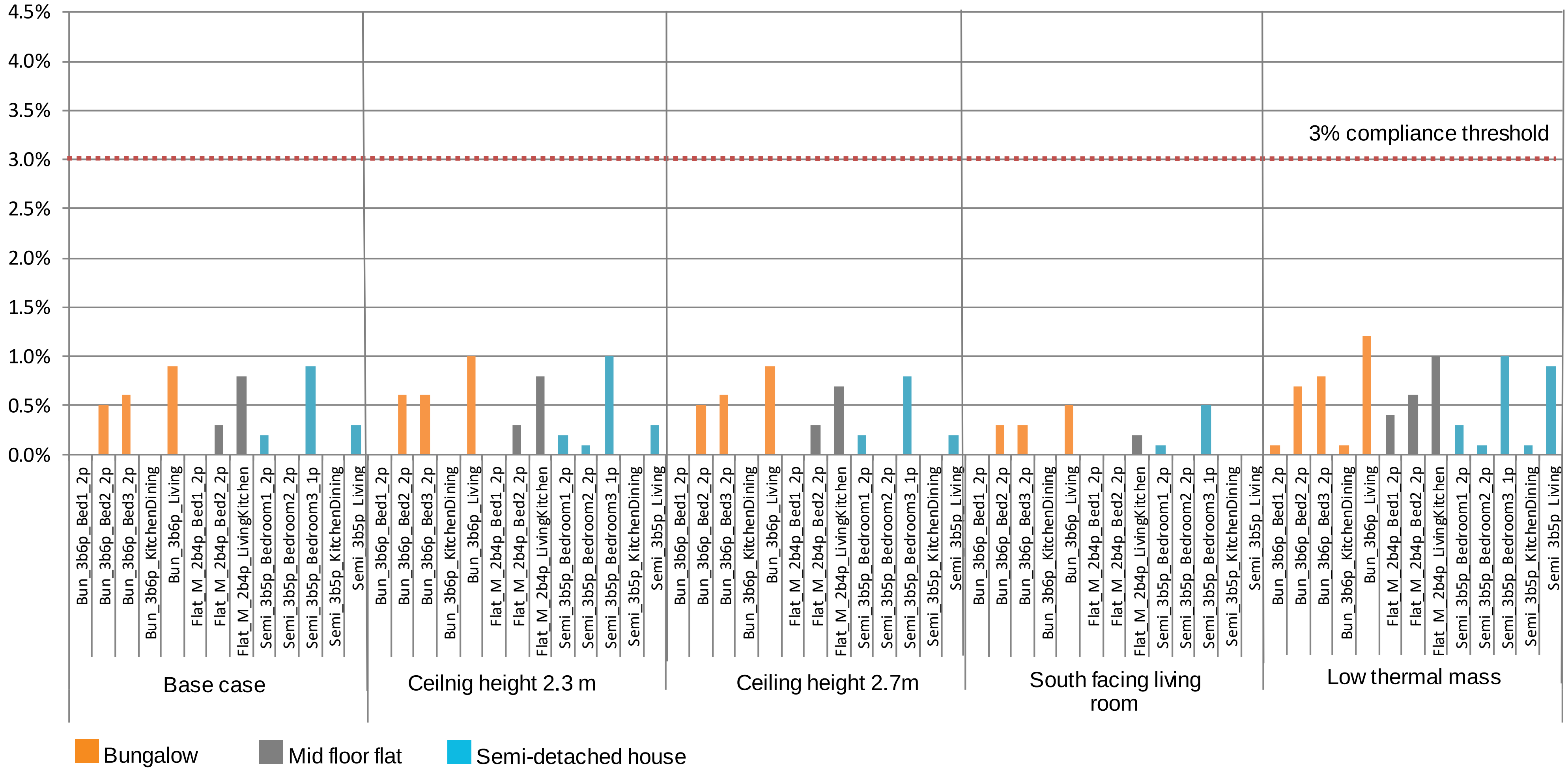


Figure 9: Percentage overheating hours – Criterion B – Design features

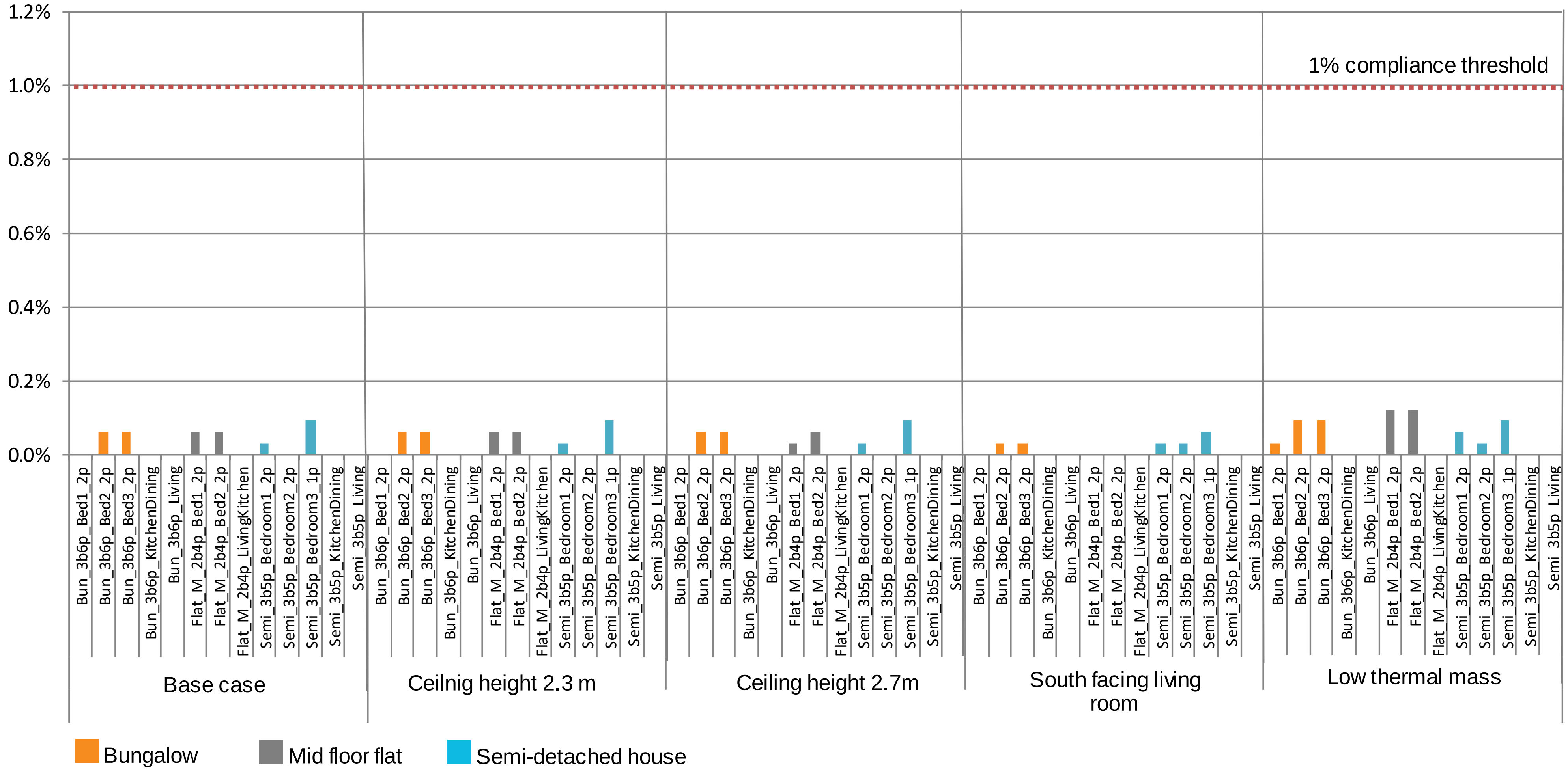


Figure 10: Percentage overheating hours – Criterion A –Internal gains

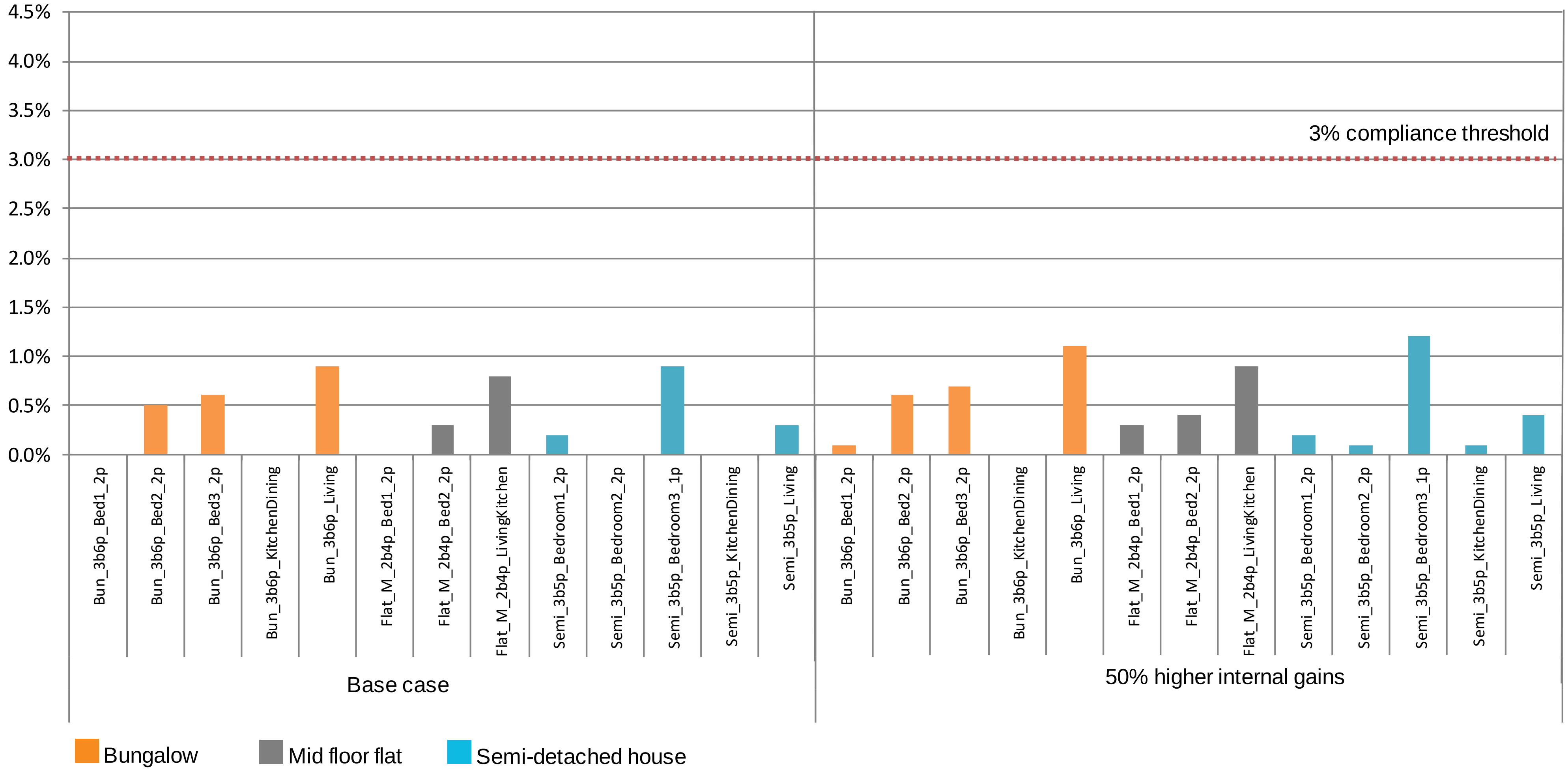


Figure 11: Percentage overheating hours – Criterion B –Internal gains

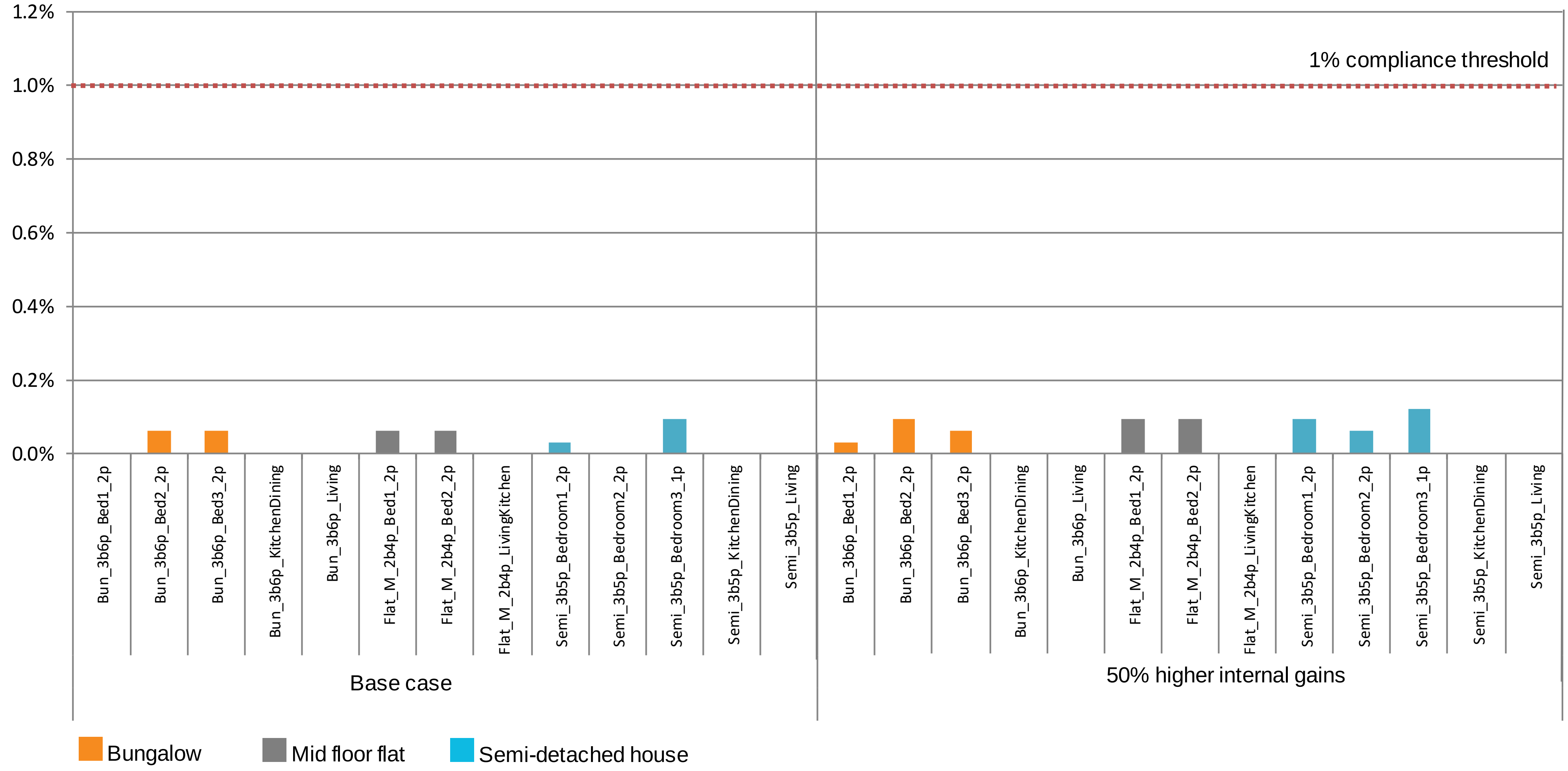


Figure 12: Percentage overheating hours – Criterion A – Shading devices

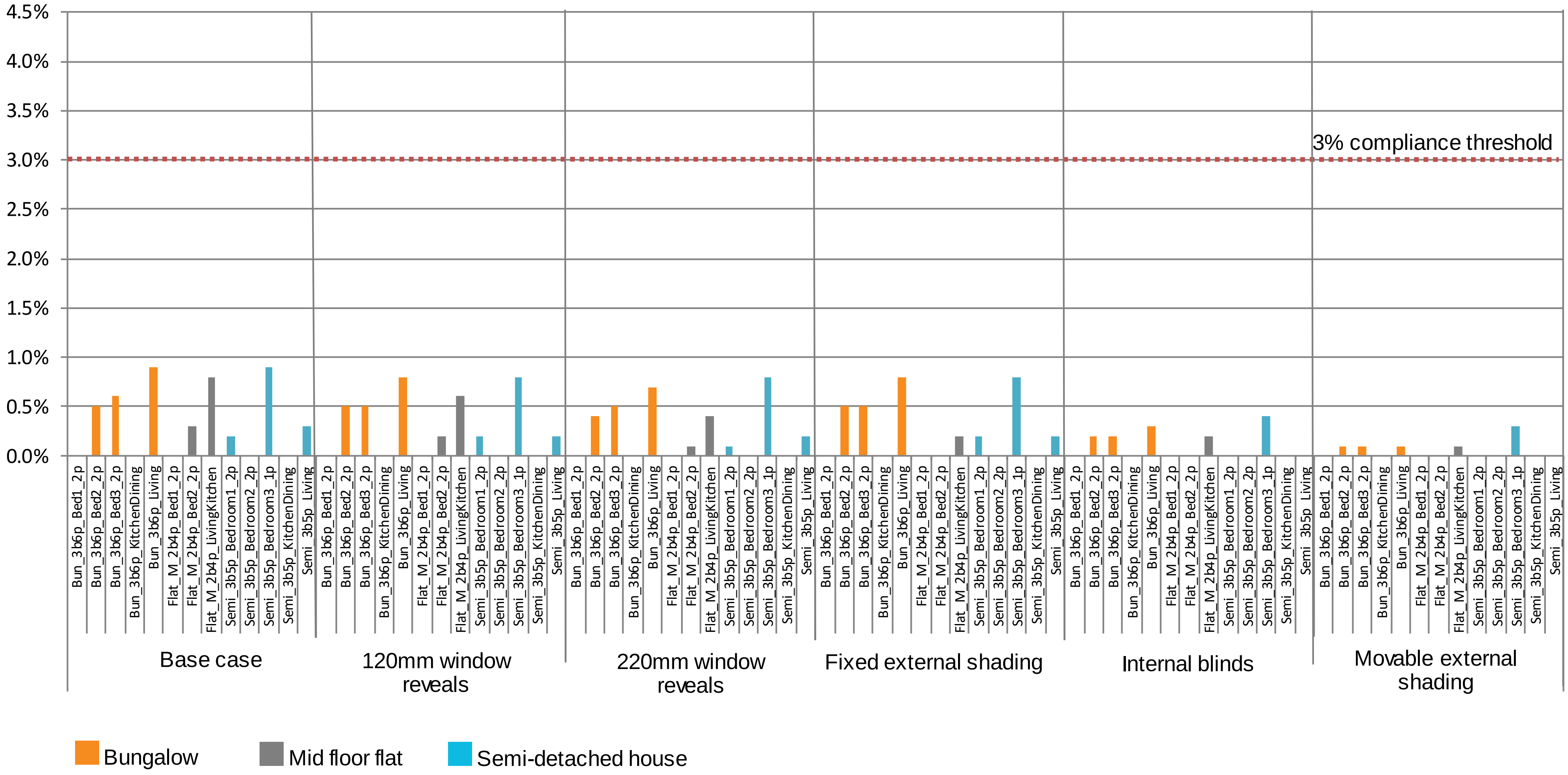


Figure 13: Percentage overheating hours – Criterion B – Shading devices

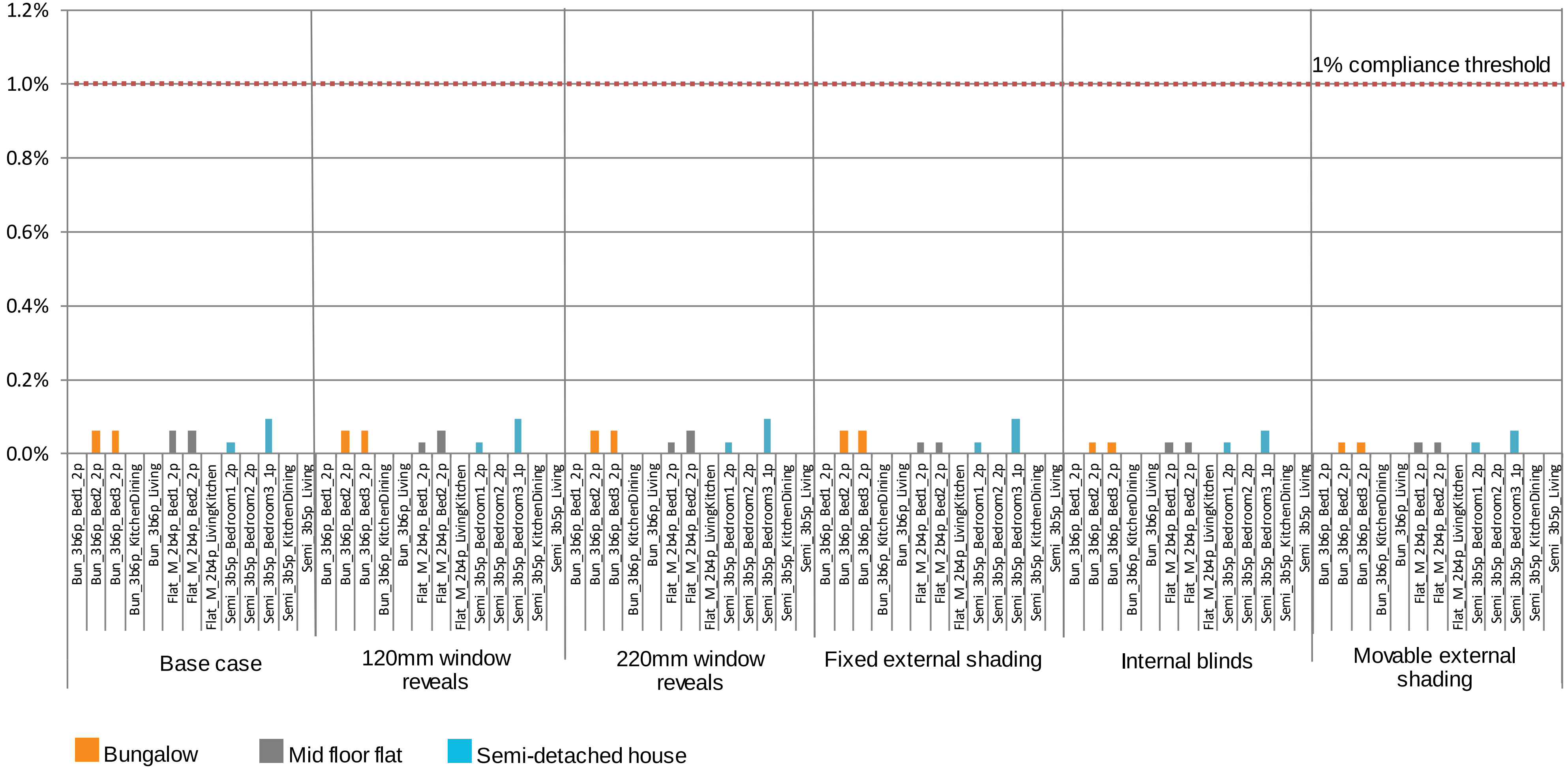


Figure 14: Percentage overheating hours – Criterion A – Combined scenarios

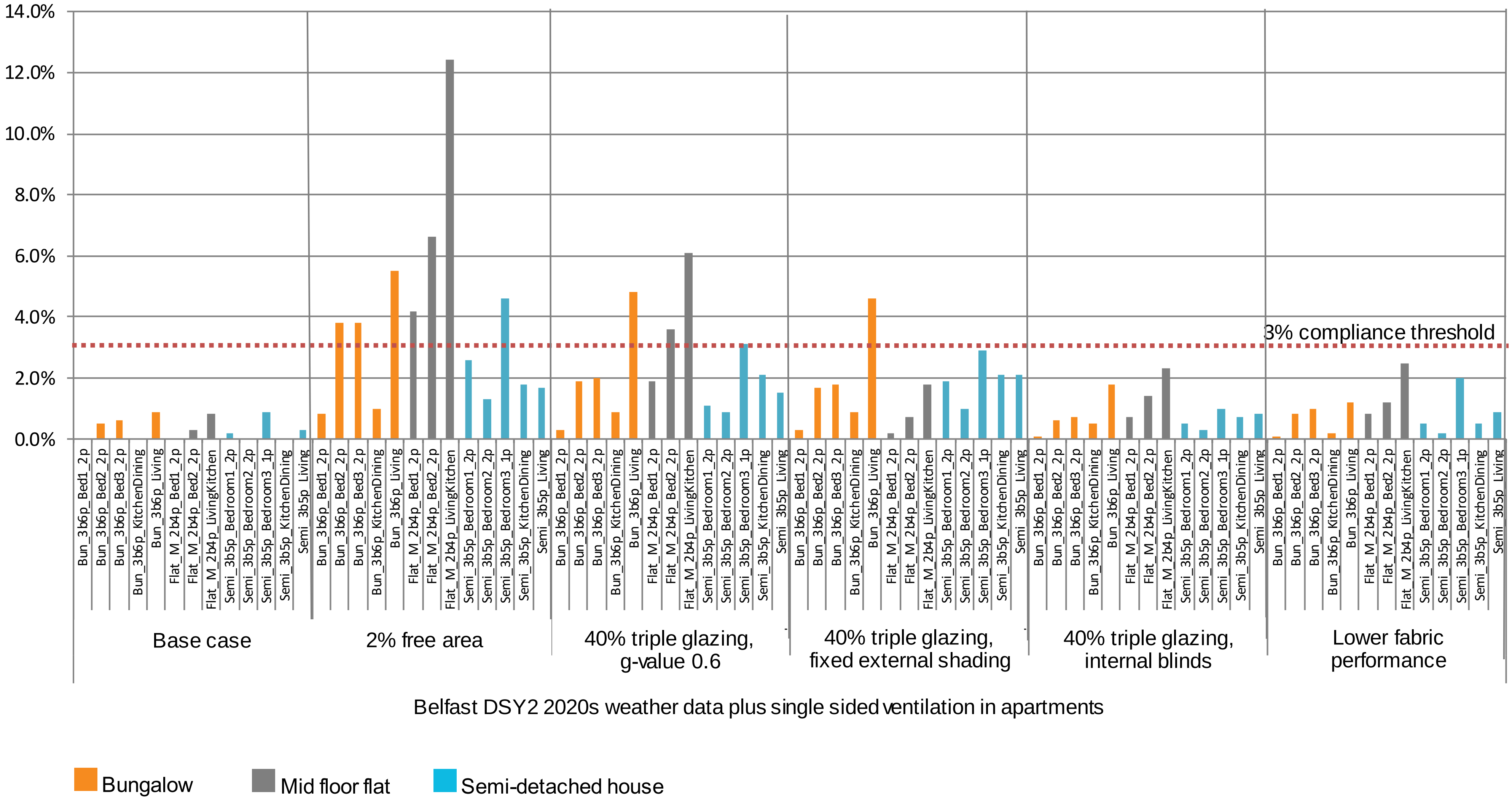
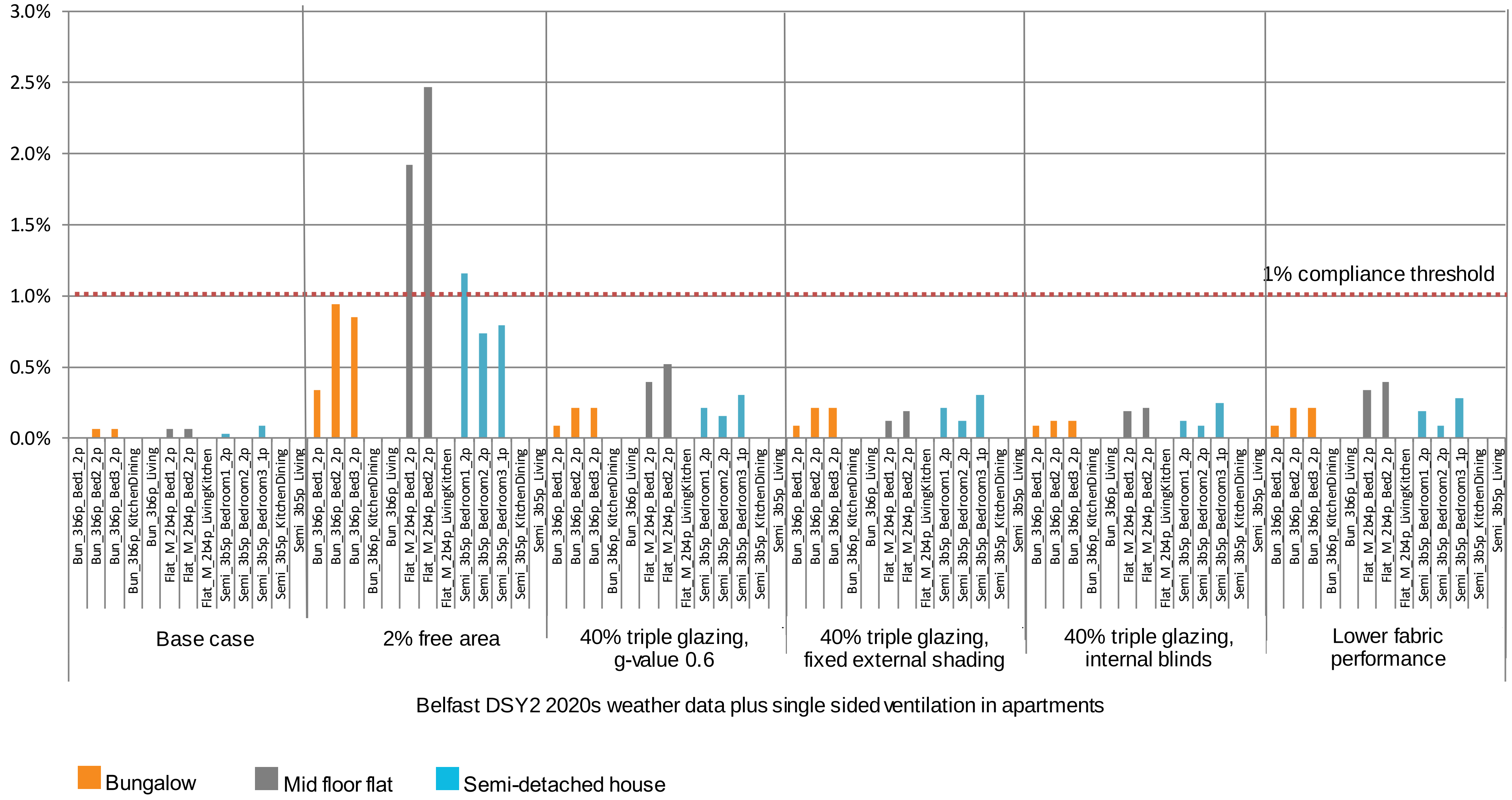


Figure 15: Percentage overheating hours – Criterion B – Combined scenarios



4. Review of overheating risk assessment methodology in Part L, England

The Standard Assessment Procedure (SAP) is the UK methodology for calculating the energy performance of dwellings to demonstrate compliance with Part L of the Building Regulations. The current version is SAP 2012. Appendix P in SAP 2012 provides a method for assessing the tendency of a dwelling to have high internal temperatures in summer. While this assessment is not integral to the energy and/or CO_2 rating calculated for dwellings as part of the SAP methodology, Part L of the Building Regulations require that dwellings should not have "high" likelihood of high internal temperatures during hot weather to demonstrate compliance with Criterion 3 (Limiting the effects of heat gains in summer).

The procedure set out in SAP 2012 Appendix P is the same as in DEAP. Figure 16 below provides an overview of the SAP 2012 methodology and the key design and locational factors that are taken into consideration to assess the tendency of a dwelling to overheat.

The Building Research Establishment (BRE) published the SAP 10 version in 2018, which is intended to supersede SAP 2012. It is worth noting that SAP10 is not yet being used for any official purpose and is meant for information only at this stage. Some refinements have been incorporated to the assessment of summer internal temperatures in this version, which may also be relevant to DEAP. They are intended to better capture any dwelling or site-specific constraints that may impact on the likelihood of higher internal temperatures as well as make some allowance for user behaviour aspects. The changes to Appendix P in SAP 10 include:

- Specific questions around noise and security risk that may impact on the ability to open windows for extended period of time.

  Where the dwelling is in close proximity (<20m) and line of sight of a source of noise (such as a main road, railway, industrial site or within 6km of an airport), then this is assumed to prevent occupants from opening windows for extended period of time. Again, where any window or door is classed as 'easily-accessible' as per Approved Document Q of the Building Regulations, it cannot be left open unattended unless fitted with certified secure night time ventilation. In such instances, effective air change rate for calculating overheating risk is to be based on trickle vents only (unless mechanical ventilation is present)

- Reduced air change rates where windows assumed to be fully open (the reduced values are the same as currently for windows open half the time as per Table P1 of SAP 2012 and DEAP)
- Blinds or curtains are assumed closed 75% of the time during daylight hours (as opposed to 100% of the time currently in SAP 2012 and DEAP)
- Revisions to shading factors for blinds, curtain and external shutters (Table P3 in SAP 2012, Table P4 in DEAP)

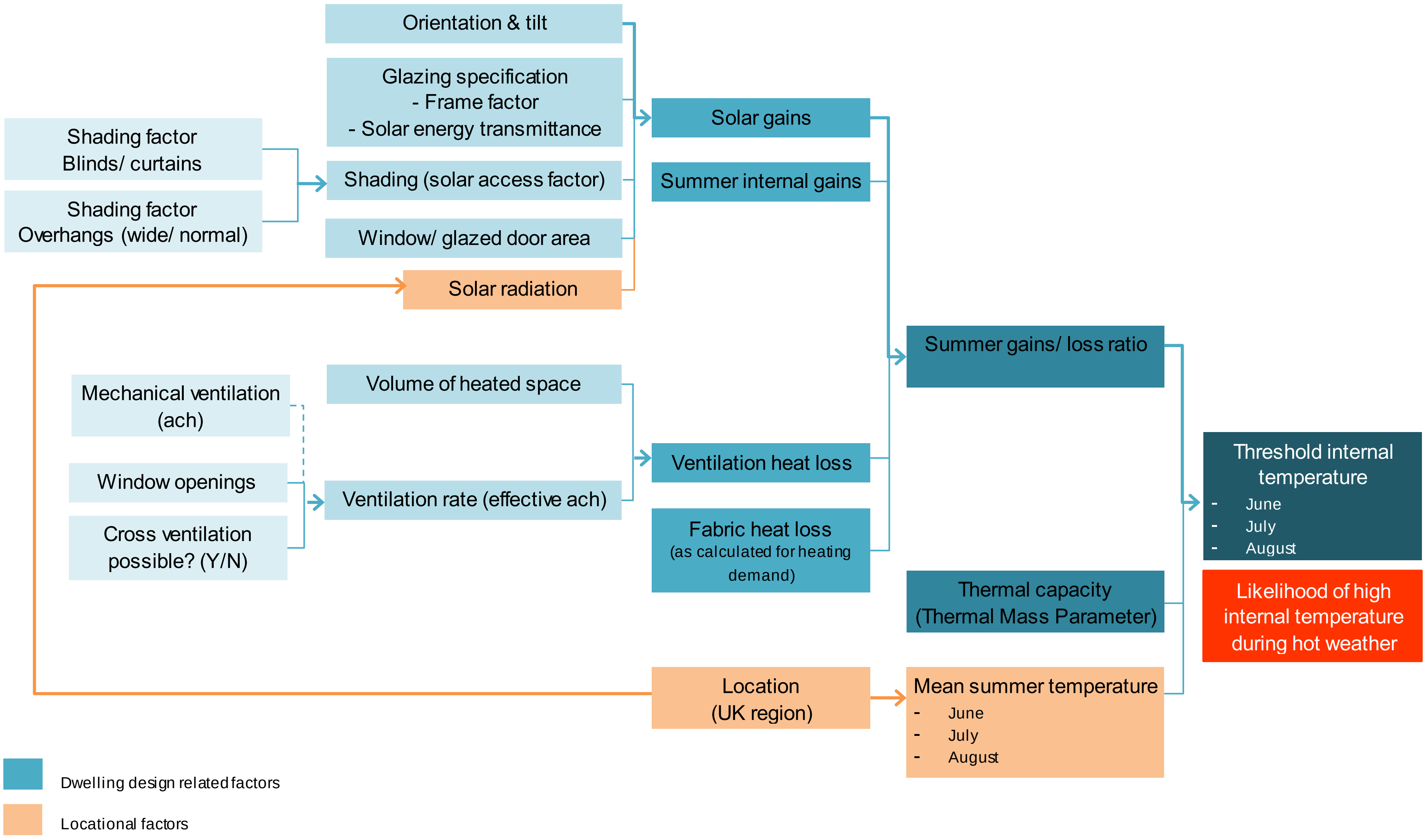
These changes provide better guidance and accountability for assumptions made around window openings and effective air change rates. It is however worth highlighting, that both DEAP and SAP are intended to be simplistic models and therefore have some key limitations in terms of predicting the frequency and intensity of overheating risk in dwellings.

- SAP and DEAP is a whole dwelling model that assesses the risk of high internal temperatures using monthly mean external temperatures (for June, July and August) and therefore does not capture the risk of overheating by room or time of the day (such as in bedrooms at night). In addition, the use of monthly average weather data cannot deliver the same accuracy as hourly data, which is an inevitable trade-off of the simplification process.

- The assessment is based on current weather data and does not take into account the impact of future climate change.

- The assumptions on effective air change rates do not take into account the window openable areas, both for the baseline assessment and as a mitigation measure. Dynamic thermal simulation modelling results discussed in the preceding section have highlighted that this is a key variable affecting overheating risk along with net solar gains.

Figure 16: SAP 2012 methodology for assessing likelihood of high internal temperature during summer



5. Conclusions

5.1 Key parameters affecting overheating risk

Dynamic thermal modelling of dwellings designed to Part L 2019 fabric standards using historic or future weather data highlights the need to consider overheating risk in new build design. The modelling results indicate that while standard design does not present a high risk of summer overheating, aggregated impacts of certain design parameters can significantly increase that risk. There are two key parameters to consider:

- Net solar gains in the dwelling, which are a function of glazed areas, orientation, window g-values and shading.
- Ventilation rates, which in case of naturally ventilated dwellings are a function of window opening areas and ability to cross ventilate.

For instance, single aspect dwellings with large areas of west facing glazed areas that are unshaded and small window openable areas will inevitably require consideration of appropriate mitigation measures or a design review. While advanced fabric performance is one of the factors that may contribute to overheating risk, it is not the dominant factor.

Additionally, the choice of weather data when assessing overheating risk is extremely important. Locational differences including differences in external temperatures, diurnal range, wind speed and solar radiation among others will impact on overheating risk. The weather data used to assess compliance should help ensure that dwellings are designed to be fit for purpose over significant proportion of the building life and are resilient to the future impacts of climate change. The study therefore highlights the need to develop future weather datasets for major cities in Ireland. These can not only be used to inform the weather inputs in DEAP but the detailed weather datasets can also be used by design teams for more detailed analysis (e.g. using dynamic thermal simulation modelling) should they choose/ opt to do so. . It is worth highlighting that different sets of weather data could be used for producing asset energy ratings and for assessing summer overheating risk in DEAP.

5.2 Recommendations

It is acknowledged that adding complexity to the DEAP software may result in it being more resource intensive for the design team. Future versions of DEAP could however consider the following aspects when assessing the overheating risk in dwellings:

- Reflect future weather data in Appendix P calculations, such as increase in mean external temperature or solar radiation.
- The changes to the Appendix P procedure in SAP 10 takes into consideration the impact of noise, security risk and other site constraints that may limit the ability to open windows for extended period of time. These should also be considered for DEAP. In addition, window restrictors should be assumed when calculating effective air change rates for dwellings with windows on first floor and above.
- Given the limitation of simplified models, allowances should be built in the calculation for user behaviour (e.g. user control of shading devices) as a means to stress test the dwelling design. For instance, SAP 10 assumes that blinds or curtains are used only 75% of the time during daylight hours. Similar allowances could be made, for instance, around assumptions for internal doors (for instance bedroom doors closed at night would limit the ability to cross-ventilate the dwelling) and the impact on effective air change rates achieved. In-use factors could also be included for mechanical ventilation systems to account for reduced flow rates due to duct configuration or unclean filters[7].

[7] Monitoring of MVHR systems has highlighted the performance gap relative to design stage predictions. A meta study of MVHR systems used in the Innovate UK Building Performance Evaluation Programme indicated that measured air flow in 88% of systems utilising rigid ducting were equal to or greater than their design air flow values, whereas between only 40 and 44% of systems utilising flexible ducting met their respective design values. A

- Investigate the option to factor in window openable areas (say as a function of dwelling floor area) when estimating effective air change rates that can be achieved. This will also encourage designers to incorporate this as a mitigation measure, where relevant.
- Consider flagging up the following dwelling types as high risk, thereby requiring more comprehensive analysis of overheating risk using dynamic thermal simulation models. This will require detailed guidance to be produced to ensure consistency of baseline assumptions or alternatively reference could be made to existing methodologies such as CIBSE TM59.
    - Those in close proximity to sources or noise or pollution and therefore limited ability to open windows.
    - Limited free area/ restricted windows (e.g. due to security concerns).
    - West or south facing single aspect flats.
    - Dwellings that are predominantly west or south facing, offer limited ability to cross-ventilate, and have window to floor area ratio greater than a certain percentage.

Further analysis is required to derive the threshold percentages. It is acknowledged that large unshaded areas of glazing are the concern rather than total glazed areas as such. More detailed analysis of such high-risk properties would be helpful in ensuring overheating risk is adequately mitigated.