

Summer Overheating Analysis

Titan Property Developments

29-35 Station Road, Reading

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1 Executive Summary

- 1.1 Titan Property Developments have commissioned AES Sustainability Consultants Ltd to undertake calculations to identify whether selected apartments at 29-35 Station road will be at significant risk of overheating using the base specification. Apartments 84, 105 and 106 have been selected as their orientation and glazing areas mean they represent a worst case sample of the apartments within the development.
- 1.2 There is not a widely established definition of overheating risk within the domestic environment. However, this report uses internal temperature profiles assessed against CIBSE benchmarks outlined in TM52:2013 for the analysis of the risk of overheating.
- 1.3 CIBSE TM52:2013 The limits of thermal comfort: Avoiding overheating in European buildings outlines the following 3 assessment criteria:
- Criterion 1: Hours of exceedance
 - Criterion 2: Daily weighted exceedance
 - Criterion 3: Upper limit temperature
- 1.4 The results of the modelling using the base specification have shown that there is a significant risk of summer overheating compared to CIBSE benchmarks as outlined in TM52:2013. The analysis has shown that lowering the G-value (of the glass) from 0.63 to 0.50 on the North and Eastern elevations will reduce the risk to within acceptable levels for all apartments tested.

Table 1: Thermal modelling results

Apartment	Option 1 G-value* of 0.63 / 0.35	Option 2 G-value* of 0.50 / 0.35	Option 3 G-value* of 0.50 / 0.40
84	Pass	Pass	Pass
105	Fail	Pass	Pass
106	Pass	Pass	Pass

**Solar factor of the glass.*

2 Aims and Objectives

- 2.1 Part L1A – Building Regulations 2013 Criterion 3 – Limiting the effects of solar gains during the summer states that reasonable provision should be made to limit solar gains. This can be achieved by an appropriate combination of window size and orientation, solar protection through shading and other solar control measures, ventilation (day and night) and high thermal capacity. This is assessed within SAP in terms of regulatory compliance, however, this is not a particularly sensitive analysis. Assessing the risk in accordance with CIBSE guidance provides a more in-depth analysis.
- 2.2 Living areas and bedrooms are the rooms that should be considered most closely as it is envisaged that these will be the rooms occupied for significant periods of time. Bedroom temperatures are likely to be most critical as people find sleeping difficult in the heat. Rooms such as bathrooms, circulation spaces, store rooms and kitchens do not have overheating criteria or a suggested maximum temperature as it is envisaged that no one will occupy these rooms for a significant period of time.
- 2.3 The purpose of this report is to ascertain whether internal temperatures are likely to exceed the criterion recommended in CIBSE TM52:2013.
- 2.4 CIBSE TM52:2013 sets out the following three criteria, which, taken together provide a robust yet balanced assessment of the risk of overheating of buildings in the UK and Europe:
- 1) The first criterion sets a limit for the number of hours that the operative temperature can exceed the threshold comfort temperature (upper limit of the range of comfort temperature) by 1 Kelvin or more during the occupied hours of a typical non-heating season (1 May to 30 September).
 - 2) The second criterion deals with the severity of overheating within any one day, which can be as important as its frequency, the level of which is a function of both temperature rise and its duration. This criterion sets a daily limit for acceptability.
 - 3) The third criterion sets an absolute maximum daily temperature for a room, beyond which the level of overheating is unacceptable.
- 2.5 A room or building that fails any two of the three criteria is potentially at risk of overheating.
- 2.6 If a dwelling fails CIBSE TM52:2013 thresholds, measures should be investigated to reduce internal temperatures and, therefore, reduce the likelihood of overheating.
- 2.7 To ensure that the CIBSE standards are met it is necessary to use appropriate simulation software in the design process and introduce adequate measures to ensure it is maintained within the completed dwellings. In order to assess the overheating risk IES Virtual Environment has been used. IES Virtual Environment is a state-of-the-art dynamic modelling software tool for checking building energy, carbon, lighting and thermal comfort.

3 Introduction to Overheating in Modern Dwellings

- 3.1 The project team should consider the risk of overheating in their building designs very early in the design process as it has the potential to not only cause discomfort for building occupants, but also cause potentially harmful medical conditions such as dehydration or heat exhaustion.
- 3.2 People may feel hot, uncomfortable and show lower productivity when temperatures reach between 25-28°C. Indoor operative temperatures that stay at or over 28°C for long periods of the day will result in dissatisfaction for many occupants. This can be expressed as the occupant experiencing thermal discomfort and in some cases thermal stress. Thermal discomfort is where occupants feel uncomfortable as they are too hot (or cold). Thermal stress is where the thermal environment will cause potentially harmful medical conditions such as dehydration or heat exhaustion. Vulnerable people, such as the elderly are particularly susceptible to health problems due to overheating.
- 3.3 Homes in the UK have not historically been associated with overheating. This is most likely due to a combination of the heavyweight materials from which they were constructed, a low level of thermal insulation and high levels of uncontrolled ventilation through minor gaps in the fabric.
- 3.4 The use of heavyweight materials provides high thermal mass within the building envelope. This ensures that external daily temperature variations are not reproduced as quickly inside the building because the fabric will absorb heat during the day and release it slowly when temperatures drop at night. In this way, the impact of maximum heat levels reached during the day is delayed by the thermal mass of the building and can be counter-balanced by strategies that make use of the cool of the night.
- 3.5 Modern homes are usually constructed from lightweight materials, are highly insulated, have been built to high standards of air tightness and have double-glazed windows that have coatings specifically designed to trap the sun's heat. This results in more heat being retained within the homes which is not able to be absorbed by the lightweight fabric.
- 3.6 Rooms with large glazing areas to their South and West facades are likely to be those at highest risk of overheating. South facades receive the highest amount of direct sunlight when the sun is highest, whilst West facades experience unwanted solar gains from low-level sun in the evenings. Proposed mitigation measures need to take account of the difference in the position of the sun during the day as some measures will work on certain facades but not on others. For example, overhangs can block out the sun when it is high in the sky but will have little effect if installed on West facing elevations when the sun is low in the sky.

- 3.7 Overheating in apartments is a greater risk where apartments are designed with a single-aspect and where communal heating pipework is routed through corridors and common spaces. In these situations, high internal temperatures are often caused by a combination of inadequate ventilation and excessive heat discharged by heating pipework.

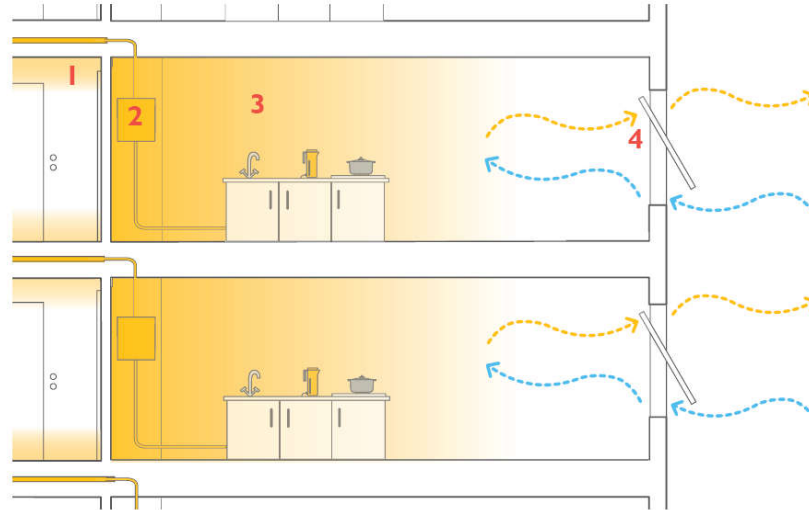


Figure 1: Service design in apartments, cumulative effects of individual heat gains

4 Methodology and Key Assumptions

Methodology

- 4.1 In CIBSE has undertaken considerable consultation and research on the impact of climate change on the indoor environment and weather data. TM52:2013, CIBSE Guide A 2015, AD Part L1A 2013, AD Part F 2013 and SAP 2012 provide data on maximum average temperatures, ventilation rates and overheating criteria for areas of dwellings as illustrated below. We have used this data as the basis for our analysis and the recommendations presented in this report.
- 4.2 Building Regulations Part F 2013 states that for new dwellings the whole dwelling ventilation rate for the supply of air to the habitable rooms should be no less than the rates detailed in the Table 2 below.

Table 2: Part F minimum standards for new dwellings

	Number of bedrooms in dwelling				
	1	2	3	4	5
Whole dwelling ventilation rate ^{a,b} (l/s)	13	17	21	25	29

- a. In addition, the minimum ventilation rate should be not less than 0.3 l/s per m² of internal floor area
- b. This is based on two occupants in the main bedroom and a single occupancy in all other bedrooms. If a greater level of occupancy is expected add 4 l/s per occupant.

- 4.3 The proposed mechanical ventilation for this development is centralised Mechanical Ventilation with Heat Recovery (MVHR). This system is a whole house ventilation system that supplies air to habitable rooms, such as bedrooms and living rooms and extracts air from wet rooms, such as bathrooms and kitchens. It offers a balanced low energy ventilation solution and re-uses up to 95% of the heat that would have otherwise have been lost.

Software

- 4.4 IES version 2015 'Apache Sim' has been used to carry out dynamic simulation to analyse the thermal comfort likely to be experienced within the apartments.
- 4.5 The full dynamic simulation in accordance with CIBSE TM52:2013 combines the effects of:
- Annual Design Summer Year (DSY) weather data as produced by CIBSE;
 - Casual, lighting and people heat gains;
 - Thermal mass of the building;
 - Solar heat gain.
- 4.6 The results give an indication of the predicted environmental conditions based on weather data and the anticipated operation strategy of the building.

- 4.7 The predicted simulated internal temperatures generated by the software may not match the actual internal air temperatures due to several reasons, for example, change in space function, use of equipment, natural wear and tear of building elements, global climate change and metrological changes, change in operation management of apertures etc.
- 4.8 The proper use of spaces by occupants should be emphasised as failure to do so may result in the internal operative temperatures within occupied spaces rising above the predicted simulated operative temperatures.

Weather data

- 4.9 Our analysis has been carried out using average weather data appropriate to the location of the development. CIBSE recommends using the nearest available Design Summer Year (DSY) weather data. The DSY represents warmer than typical year and is used to evaluate overheating risk within buildings.
- 4.10 Therefore, Swindon DSY weather file has been used. CIBSE Guide A has the following recommendation regarding the weather data used within the model.

“The CIBSE recommend the use of an appropriate Design Summer Year (DSY) for the purpose of assessing overheating risk. Suitable years are available for 14 sites in the UK.” (CIBSE Guide A, 2015).”

- 4.11 The following chart shows a typical metrological year for Swindon. During a 23 year period summer temperatures exceed 25°C and can reach peak values of up to 27 °C in July. However, the summer comfort zone between 24°C and 27°C, as shown on the graph, is not regularly exceeded.

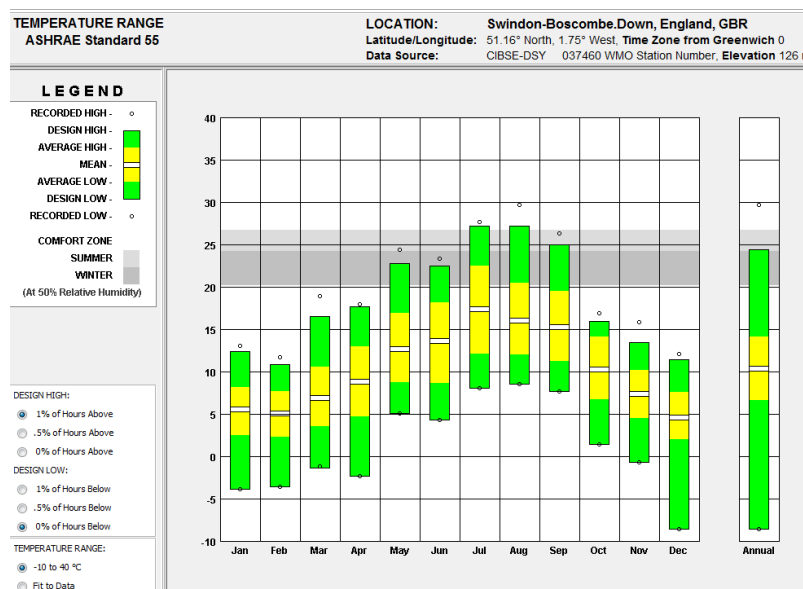


Figure 2: Temperature range for Swindon [screenshot - Climate consultant v5.5]

4.12 Recently probabilistic DSY data has been developed for all 14 locations across the UK. The probabilistic design summer years consider overheating events with three characteristics as follows.

- Swindon DSY 1 – moderately warm summer
- Swindon DSY 2 – short intense warm spell
- Swindon DSY 3 – long, less intense warm spell

4.13 Use of a Swindon DSY 3 file, which represents a summer with a long heat event results in the highest level of overheating and will therefore be used as a worst case scenario at the Station Road development¹.

Development design

4.14 The modelling has been based upon the WCEC floor plans below.



Figure 3: Level 13 & 22 floor plan showing apartment 84, 105 & 106 at Station Road

4.15 The following design criteria have been used in the modelling software to perform the calculations and modelling to assess the risk of summertime overheating.

¹ CIBSE Weather Files 2016 release: Technical Briefing and Testing

Building Fabric

- 4.16 The building elements were modelled according to the construction specification detailed in the table below, with derivation of an overall U-value calculated using the BRE U-value calculator, or by the software used for the overheating analysis. The proposed specification achieves Building Regulations compliance – AD Part L1A 2013 or better.

Table 3: Baseline Building Fabric

Construction Elements	Construction specification	U-value in [W/m ² K]	Kappa in (kJ/m ² K)
Ext. Wall	N/A	0.14	15
Main Roofs	N/A	0.11	84
Exposed Floor	N/A	N/A	N/A
Int. Ceiling & Floor	N/A	N/A	140
Party Wall	N/A	N/A	140
Internal Partitions	N/A	N/A	76
Windows	Double glazed	U=1.20	g=0.63 N/E g=0.35 S/W
Infiltration	CIBSE A - Table 4.24		0.25 ACH

Building Services

- 4.17 The building services outlined below form part of the base specification.

Table 4: Building Services

Building Services	Notes
Ventilation	MVHR
Lighting	100% low energy lighting throughout

Ventilation

- 4.18 One of the most effective ways of addressing the risk of overheating in homes is to have a well thought out strategy for purge ventilation (supply of large amounts of fresh air in a short period of time). This can be achieved by providing means for cross-ventilation, circulating large amounts of air through the home. Where mechanical ventilation is used, occupants should still be able to open windows adequately and in a secure manner, even if only for a short period of time.

Table 5: Thermal Data

Thermal Data	Notes
Ventilation Strategy	Calculated natural and mechanical ventilation
Shading Strategy	No internal blinds or curtains
	No external overhangs

- 4.19 It has been assumed that occupants will open windows when the building is occupied, at times when the internal air temperature exceeds a comfortable level. The occupied times have been modelled according to variation profiles (see Figure 4 below).

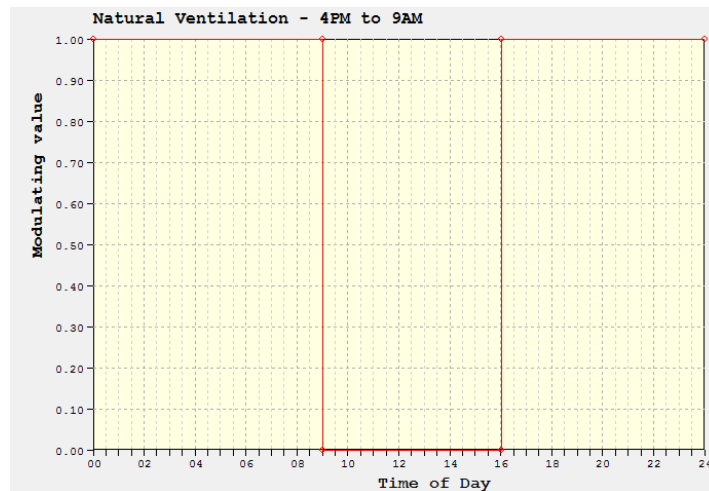


Figure 4: Variation profile for natural ventilation between 4pm and 9am

- 4.20 Natural ventilation via openable windows has been allowed during times the apartment is occupied. This has been assumed to be between 16:00 and 09:00 in line with the NCM, when the internal air temperature exceeds a comfortable level of 22°C.

- 4.21 For the assessed apartments it has been assumed that doors and windows being open during the night would not pose security issues.
- 4.22 For a model using calculated natural ventilation, air change rates can be much higher than those for scheduled natural ventilation. Although ventilation rates greater than 10 air changes per hour can be achieved, this can also cause discomfort due to the excessive draft. Furthermore, the effectiveness of ventilation as a cooling mechanism is reduced as the air change rate increases. Plots 84, 105 and 106 have been reviewed to ensure that there are no unusually high air change rates which could result in discomfort for the occupants.
- 4.23 The MVHR will provide a small amount of fresh air in addition to natural ventilation. Boosted rates have been calculated based on the number of wet rooms within the dwelling and the intermittent extract minimum rate from Table 5.1a in Part F.

Occupancy gains

- 4.24 Occupancy gain assumptions are based on NCM standard figures for a dwelling. See Appendix A for full occupancy profiles.
- The living area has been assumed to be occupied by 3 people at 67.1 W per person
 - Bedrooms have been assumed to be occupied by 2 people in the master bedroom and 1 person in the second bedroom at 67.5 W per person

Equipment gains

- 4.25 The following equipment gains have been assumed for the rooms being assessed. Equipment gains for the living room are based on NCM standard figures for a dwelling.

Table 6: Equipment gains

Room	Equipment gains (W/m ²)
Bedroom	none
Living Room	3.9

5 Results – Summertime Overheating Modelling

5.1 The following tables illustrate the results using the design specification, mechanical and natural ventilation. The results are compared with the recommendations from TM52:2013 as stated earlier in this report.

Items within the table:

- Items in **Red** DO NOT comply with the CIBSE recommendations
- Items in **Green** DO comply with the CIBSE recommendations

5.2 Natural ventilation via openable windows has been allowed once the internal air temperature exceeds a comfortable temperature, which is modelled as 24°C, and fresh air due to the MVHR in accordance with Part F (see Figure 5 below).

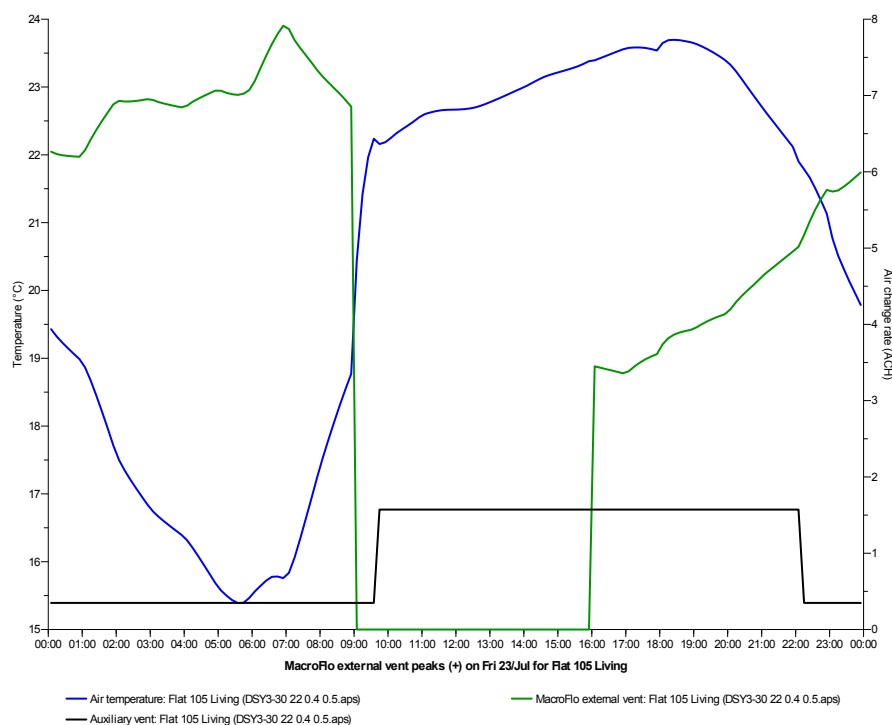


Figure 5: Typical variation profile for natural and mechanical ventilation

5.3 The graph above shows that natural ventilation is more effective in the morning because external temperatures are lower resulting in cooler air entering the building. In the evening natural ventilation is less effective due to higher external temperatures and the apartment having no fresh air, other than the boost ventilation from the MVHR during the day when unoccupied. The most effective way of preventing the apartments from overheating would be to limit solar gains (e.g. low window g-value).

Apartment 84

Table 7: Modelling results for Apartment 84

		Overall	CIBSE TM 52:2013					Overall	CIBSE TM 52:2013		
			Criteria 1	Criteria 2	Criteria 3				Criteria 1	Criteria 2	Criteria 3
FLAT 84						Flat 64					
g- values = N/E: 0.63 S/W: 0.35						g- values = N/E: 0.5 S/W: 0.35					
FLAT 84	Bath	Pass	Pass	Pass	Pass	FLAT 84	Bath	Pass	Pass	Pass	Pass
FLAT 84	Bed 1	Pass	Pass	Pass	Pass	FLAT 84	Bed 1	Pass	Pass	Pass	Pass
FLAT 84	Bed 2	Pass	Pass	Pass	Pass	FLAT 84	Bed 2	Pass	Pass	Pass	Pass
FLAT 84	Hallway	Pass	Pass	Pass	Pass	FLAT 84	Hallway	Pass	Pass	Pass	Pass
FLAT 84	Kitchen	Pass	Pass	Pass	Pass	FLAT 84	Kitchen	Pass	Pass	Pass	Pass
FLAT 84	Living	Pass	Pass	Fail	Pass	FLAT 84	Living	Pass	Pass	Fail	Pass

- 5.4 The results show there is no significant risk of overheating within the occupied rooms of apartment 84 compared with CIBSE TM52.

Apartment 105

Table 8: Modelling results for Apartment 105

		Overall	CIBSE TM 52:2013					Overall	CIBSE TM 52:2013		
			Criteria 1	Criteria 2	Criteria 3				Criteria 1	Criteria 2	Criteria 3
FLAT 105						Flat 105					
g- values = N/E: 0.63 S/W: 0.35						g- values = N/E: 0.5 S/W: 0.35					
FLAT 105	Bed 1	Fail	Fail	Fail	Pass	FLAT 105	Bed 1	Pass	Pass	Fail	Pass
FLAT 105	Bed 2	Pass	Pass	Pass	Pass	FLAT 105	Bed 2	Pass	Pass	Pass	Pass
FLAT 105	Kitchen/Dining	Fail	Fail	Fail	Pass	FLAT 105	Kitchen/Dining	Pass	Pass	Fail	Pass
FLAT 105	Living	Fail	Fail	Fail	Pass	FLAT 105	Living	Pass	Pass	Fail	Pass
FLAT 105	Bathroom	Pass	Pass	Pass	Pass	FLAT 105	Bathroom	Pass	Pass	Pass	Pass

- 5.5 The results show a significant risk of overheating within the living room, kitchen diner and bedroom 1 of apartment 105 compared with CIBSE TM52. However, the analysis indicates that by reducing the G-value (of the glass) for the North and East elevations to 0.50 reduces this risk to within acceptable levels.

Apartment 106

Table 9: Modelling results for Apartment 106

		Overall	CIBSE TM 52:2013					Overall	CIBSE TM 52:2013		
			Criteria 1	Criteria 2	Criteria 3				Criteria 1	Criteria 2	Criteria 3
Flat 106						Flat 106					
g- values = N/E: 0.63 S/W: 0.35						g- values = N/E: 0.5 S/W: 0.35					
Flat 106	Bed 1	Pass	Pass	Pass	Pass	Flat 106	Bed 1	Pass	Pass	Pass	Pass
Flat 106	Bed 2	Pass	Pass	Pass	Pass	Flat 106	Bed 2	Pass	Pass	Pass	Pass
Flat 106	Bed 3	Pass	Pass	Pass	Pass	Flat 106	Bed 3	Pass	Pass	Pass	Pass
Flat 106	Living Room	Pass	Pass	Fail	Pass	Flat 106	Living Room	Pass	Pass	Pass	Pass
Flat 106	Kitchen	Pass	Pass	Pass	Pass	Flat 106	Kitchen	Pass	Pass	Pass	Pass
Flat 106	Bathroom	Pass	Pass	Pass	Pass	Flat 106	Bathroom	Pass	Pass	Pass	Pass

- 5.6 The results show there is no significant risk of overheating within the occupied rooms of apartment 84 compared with CIBSE TM52.
- 5.7 By reducing the G-value to 0.5 on the North and East elevations we are able to mitigate any risk of overheating within the modelled apartments.
- 5.8 Further analysis also showed that the g-value of the glazing on the South and West elevations can be raised to 0.4 whilst maintaining the risk of overheating within acceptable levels.

6 Conclusion

- 6.1 AES Sustainability Consultants have carried out summer overheating calculations for the Titan Property Developments development at 29-35 Station Road development, Reading to plots 84, 105 and 106 to assess compliance with CIBSE TM52:2013 design standards
- 6.2 The modelling has been based upon WCEC Planning Issue drawings, issued July 2016.
- 6.3 The results of the modelling have shown that there is a significant risk of summer overheating using the base specification compared to CIBSE benchmarks as outlined in TM52. The analysis to apartment 105 shows that lowering the G-value (of the glass) from 0.63 to 0.50 on the North and East elevations will reduce the risk to within acceptable levels.
- 6.4 It was also established that the g-value of the South and East elevations could be raised to 0.4, without having detrimental effect on the overheating risk.

Table 10: Thermal modelling results

Apartment	Option 1 G-value* of 0.63 / 0.35	Option 2 G-value* of 0.50 / 0.35	Option 3 G-value* of 0.50 / 0.40
84	Pass	Pass	Pass
105	Fail	Pass	Pass
106	Pass	Pass	Pass

**Solar factor of the glass.*

7 References

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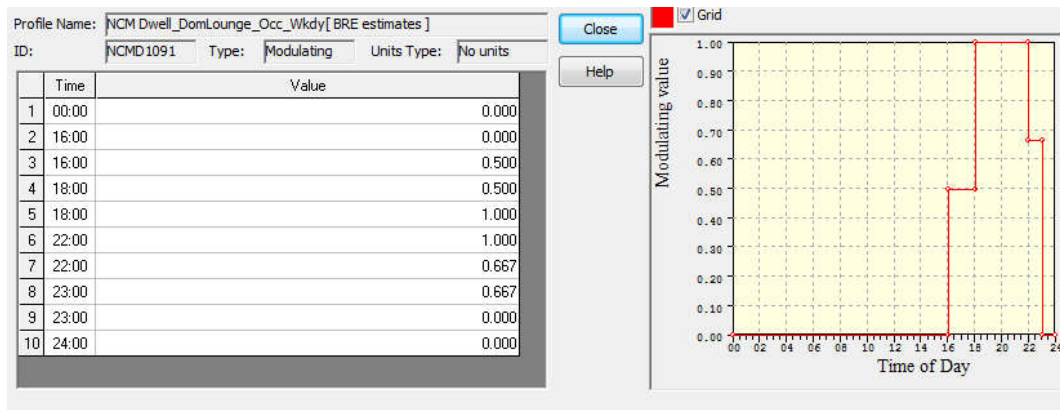
Weather file: CIBSE, in collaboration with UK Climate Impacts Programme (UKCIP). - <http://www.cibse.org/index.cfm?go=page.view&item=1300>

Graphic output weather files: Climate consultant v5.5 (3rd September 2014) – <http://www.energy-design-tools.aud.ucla.edu/>

Appendix A - Occupation Profiles – NCM Standards

The following occupation profiles have been used in the different room types.

Living Room



Bedroom

