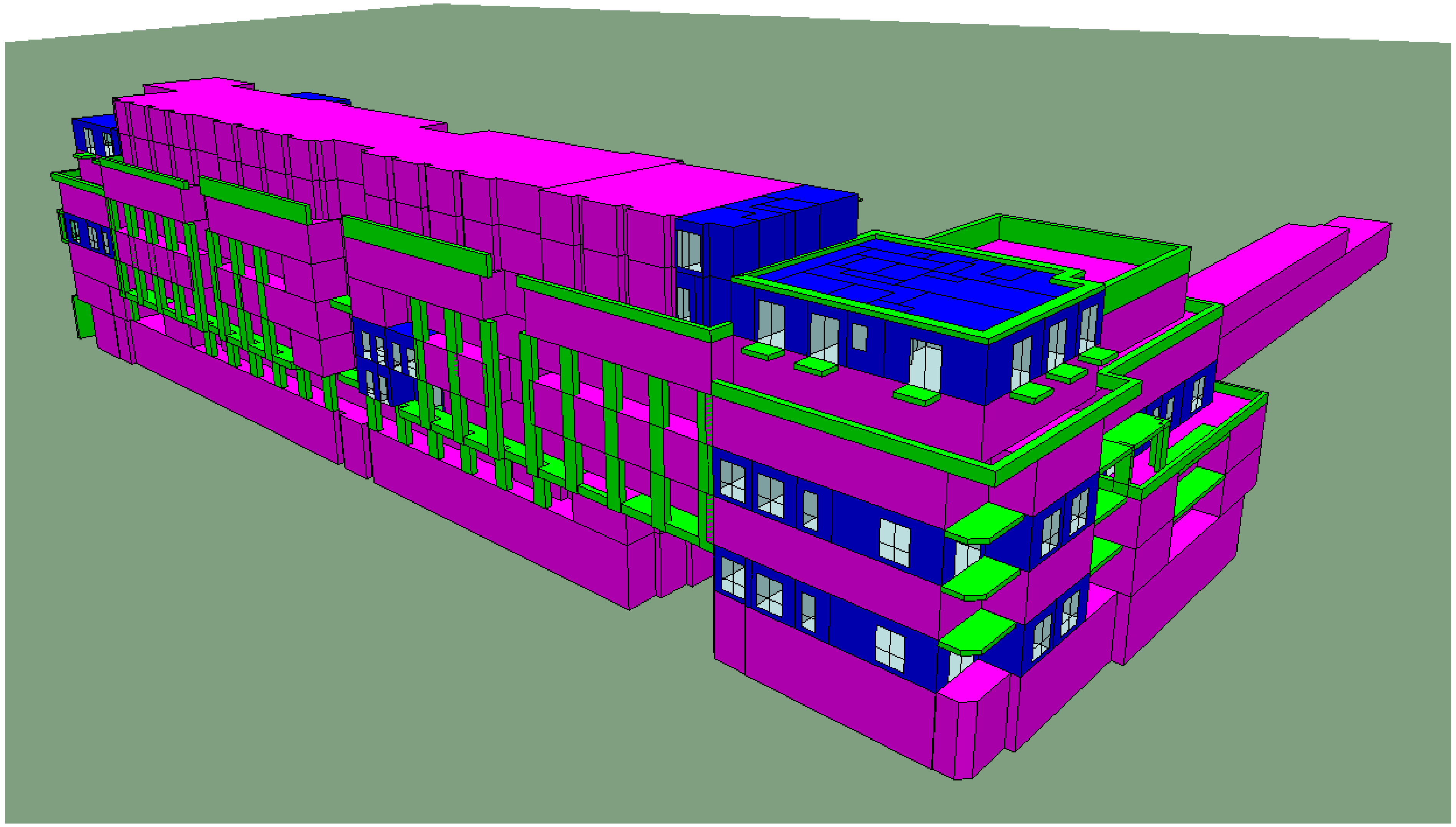

November 2023

Welling United FC

Overheating Analysis Report

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Contents

1 Executive Summary

This report has been produced for the Welling United FC development, in the Borough of Bexley, in Welling.

The Welling United FC development consists of a total of 104 flats and duplexes. The report analyses the solar internal gains for a sample of the residential areas, in representative floors, under current climate scenario.

The report demonstrates that a mechanical ventilation with heat recovery (MVHR) system along with a decreased G-value of 40% in some rooms, and MVHR with cooling in other dwellings, is required to pass the CIBSE TM59 overheating criteria, considering that passive ventilation via openable windows is not possible as per produced noise impact assessment report to achieve compliance with AVO and Part O guidelines.

The following results are achieved:

- **100%** of rooms (56) **pass** the CIBSE TM59 overheating Criterion A and **100%** of bedrooms (37) **pass** Criterion B for the **current climate**, considering a G-value of 45%.

Additional testing has been undertaken in accordance with current GLA guidance using the 2020 versions of the extreme year weather files: DSY2-2003 a year with a very intense single warm spell; and DSY3-1976 a year with a prolonged period of sustained warmth. The risk of overheating in these scenarios could be reduced by using internal blinds and small power electric fans.

2 Introduction

This report has been produced for Welling United FC, which consists of a total of 104 flats and duplexes.

The site is located in the west of Bexley, near Danson Park. The site is bordered by Park View Road to the north, Bexleyheath Cricket Club to the east, Danson Park to the south and Roseacre Road to the west (see Figure 1). The area comprises of low-density terraced and semi-detached houses.

Figure 1. The Welling United FC development; source Google maps

This report considers all the residential areas and seeks to investigate the overheating potential and propose an alternative solution to improve the thermal comfort of areas identified with a risk of overheating, if there is any, for the habitable spaces, kitchen/dining/living rooms and bedrooms.

3 Requirements

CIBSE TM59: 2017

The overheating criteria for buildings that are not mechanically cooled, during summer period, are defined in CIBSE TM59: 2017 'Design Methodology for the Assessment of Overheating Risk in Homes' which is directly associated with CIBSE TM52: 2013 'The Limits of Thermal Comfort: Avoiding Overheating in European Buildings' as follows:

Criterion A: For Kitchens, Living rooms and Bedrooms
CIBSE TM52 criterion 1: *Hours of Exceedance* The number of hours (He) that delta T is greater than or equal to one degree (K) during the period between May and September, shall not be more than 3% of occupied hours

Criterion B: For Bedrooms Only
To guarantee comfort during the sleeping hours the operative temperature in the bedroom from 10pm to 7am shall not exceed 26 °C for more than 1% of annual hours (Note: 1% of the annual hours between 22:00 and 07:00 for bedrooms is 32 hours, so 33 or more hours above 26 °C will be recorded as a fail)

In order to demonstrate the proposed units are not at risk of overheating, these two criteria must be met.

For **communal corridors**, where heating pipework runs through, the overheating test should be based on the number of annual hours for which an operative temperature of 28°C is exceeded for more than 3% of the total annual hours.

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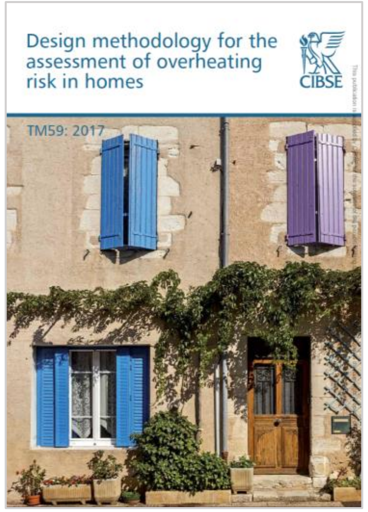
CIBSE TM59:



CIBSE TM52:

Requirement O1 of Schedule 1 to the Building Regulations 2010

The aim of requirement O1, which will take effect on 15 June 2022, is to protect the health and welfare of occupants of the building by reducing the occurrence of high indoor temperatures. In the Secretary of State's view, requirement O1 is met by designing and constructing the building to achieve both of the following:

a. Limiting unwanted solar gains in summer.
b. Providing an adequate means of removing excess heat from the indoor environment.

Requirement: O1 Overheating mitigation
(1) Reasonable provision must be made in respect of a dwelling, institution or any other building containing one or more rooms for residential purposes, other than a room in a hotel ("residences") to— (a) limit unwanted solar gains in summer. (b) provide an adequate means to remove heat from the indoor environment. (2) In meeting the obligations in paragraph (1)— (a) account must be taken of the safety of any occupant, and their reasonable enjoyment of the residence; and (b) mechanical cooling may only be used where insufficient heat is capable of being removed from the indoor environment without it.

Acoustics Ventilation and Overheating (AVO) Residential Design Guide

The Association of Noise Consultants published the AVO Guidance in January 2020. This guidance is for acoustic practitioners and others involved in planning, developing, designing, and commissioning new dwellings to achieve an appropriate balance of internal noise levels, ventilation and overheating control concerning external transportation noise.

It seeks to encourage an assessment of these issues at the planning stage. It is not mandatory guidance but represents current best practices for assessment. In particular, AVO guidance advises assessing when noise levels are such that it is reasonable to control overheating with openable windows and when it may be too noisy to do so.

4 CIBSE methodology

CIBSE Identification of Risk

This methodology is based on the use of dynamic thermal modelling for the treatment and assessment of overheating risk in residential buildings. This methodology is proposed for all residences and should especially be considered for:

- Large developments
- Developments in urban areas, particularly in southern England
- Blocks of flats
- Dwellings with high levels of insulation and airtightness
- Single aspect flats

Individual houses and developments with a low risk of overheating may not require the use of dynamic thermal modelling. Professional judgement must be used when taking the decision to omit dynamic thermal modelling to test overheating. The risk must be considered in the context of the project and the decision should be taken jointly with the client, design team and planners. A list of risk factors for identifying properties at high risk of overheating is provided in Energy Planning – Greater London Authority guidance on preparing energy assessments (GLA, 2018) and in BRE's Home Quality Mark (BRE, 2015).

CIBSE Methodology Overview

The assessment should follow the following steps:

1. A suitable sample of units within a development should be selected.
2. Zoning: all sample units should be zoned into the separate rooms including kitchens, living rooms, bedrooms, bathrooms and halls.
3. Building constructions should be modelled as proposed, accurately reflecting thermal properties such as thermal mass, insulation and solar transmittance for glazing.
4. Standard profiles should be applied for occupancy, lighting and equipment gains.
5. Guidance on the treatment of communal corridors.
6. Pipework and equipment, e.g., heat interface unit gains from community heating systems.
7. Openable windows should be included in the model.
8. Any internal or external shading provision should be included in the model.
9. Additional mechanical ventilation including mechanical ventilation with heat recovery (MVHR) or extract systems should be included in the model.
10. Air speed assumptions should be based on the guidance.
11. The weather file used for the methodology should be the DSY1 (current design summer year) file most appropriate for the site location for the 2020s high emissions, 50% percentile scenario.
12. The assessment should be undertaken using hourly dynamic simulation modelling, which includes all the relevant features of the building.

Internal Conditions

Internal conditions, (room gains from lights, equipment, occupants, infiltration rates and plant) are grouped together in profiles which are applied to the modelled zones.

All internal gains for occupancy, lighting and equipment are modelled in accordance with CIBSE TM59:2017, Table 1, Table 2 and Figure 1.

Sample Size

The assessment should try to identify if there is any space that is at risk of overheating. This is likely to be those:

- With large glazing areas
- On the topmost floor
- Having less shading
- Having large, sun-facing windows
- Having a single aspect, or
- Having limited opening windows

At least one corridor should be included in the assessment if the corridors contain community heating distribution pipework.

Flats Modelled

A sample of 19 flats have been modelled for overheating risk using the IES VE software, representing several flat types over several floors.

Weather Data

CIBSE Hourly Weather Data for Test Reference Years (TRYs) and Design Summer Years (DSYs) are available for 14 locations across the UK.

The Design Summer Year (DSY) consists of a 1-year sequence of hourly data, selected from data sets that represent a year with a hot summer. The selection is based on dry bulb temperatures during the period May-September. The year selected is the mid-year of the upper quartile. This enables designers to simulate building performance during a year with a hot, but not extreme, summer.

The analysis is based on CIBSE TM59 requirements and has been conducted using the CIBSE London DSY1 (Design Summer Year) weather file for the 2020s, high emissions, 50% percentile scenario.

5 Analysis

Software

Dynamic thermal analysis has been performed across the residential units to assess the conditions during annual period. The analysis accounts for the characteristics of each space (kitchen/dining/living rooms & bedrooms) including the internal gains, building fabric details, building orientation and external weather conditions.

The thermal model of the West Byfleet development was constructed using the Integrated Environmental Solutions (IES-VE) 2023 version, which complies with CIBSE Applications Guide AM11 'Building Energy and Environmental Modelling'.

The following IES software tools were used:

ModelIT	Model the geometry of the building
Apache	Assign constructions, material properties, internal conditions, and occupancy patterns
SunCast	Calculate solar shading and provide data for thermal calculations
MacroFlo	Assign ventilation templates for openable windows and doors
Apache Sim	Simulate internal conditions

Building Geometry

The model's geometry and analysed spaces are based on the received drawings, as follows:

- 694-CDA-ZZ-00-DR-A-05-0100-REV -SITE_GROUND FLOOR PLAN
- 694-CDA-ZZ-01-DR-A-05-0101-REV -FIRST FLOOR PLAN
- 694-CDA-ZZ-ZZ-DR-A-05-0102-REV -SECOND & THIRD FLOOR PLANS
- 694-CDA-ZZ-ZZ-DR-A-05-0103-REV -FOURTH & FIFTH FLOOR PLANS
- 694-CDA-ZZ-ZZ-DR-A-05-0104-REV -SIXTH & SEVENTH FLOOR PLANS
- 694-CDA-ZZ-B1-DR-A-05-0099-REV -BASEMENT PLAN
- 694-CDA-ZZ-08-DR-A-05-0105-REV -ROOF PLAN
- 694-CDA-ZZ-ZZ-DR-A-05-0300-REV -FRONT & REAR ELEVATIONS
- 694-CDA-ZZ-ZZ-DR-A-05-0301-REV -SIDE ELEVATIONS
- 694-CDA-ZZ-ZZ-DR-A-05-0313-REV -EAST & WEST WING PITCH SIDE ELEVATIONS
- 694-CDA-ZZ-ZZ-DR-A-05-0400-REV -CROSS SECTION

Building Fabric

The following construction details have been used in the analysis:

Element	Value
External Wall U-value	0.16 W/m².K
Roof U-value (varies per block)	0.1 W/m².K
Ground Floor U-value	0.1 W/m².K
Window U-value/G-value	1.2 W/m².K /45%
Doors U-value	1.2 W/m².K
Air Permeability	3 m³/m².h @ 50Pa

Internal Conditions

Internal conditions (room gains from lights, equipment, occupants, infiltration rates and plant) are grouped together in profiles which are applied to the modelled zones.

All internal gains are based on Table 1, Table 2 and Figure 1 of CIBSE TM59:2017, also summarised below.

Gains are modelled by resolving them into radiant and convective portions. The convective portion is injected into the zone air, whilst the radiant gains are distributed amongst the zone's surfaces.

Infiltration, ventilation and air movement between the various zones of the building cause a transfer of heat between the appropriate air masses, which is represented by terms involving the mass flow, the temperature difference and the specific heat capacity of air.

Solar radiation entering a zone through transparent building components falls on internal surfaces, where it may be absorbed, reflected or transmitted depending on the surfaces' properties. Distribution of reflected and transmitted solar radiation continues until all the radiation has been accounted for.

The following design conditions, which are provided by TM59, have been included in the modelling analysis:

Location	Occupancy	Occupancy sensible/ latent (W/person)	Lighting (W/m²)	Equipment (W)
1 bed Bedroom	1	75 / 55	2	80
2 beds Bedroom	2	75 / 55	2	80
Living Room/Kitchen	1-2	75 / 45	2	450

Occupancy Patterns

Occupancy patterns are as follows:

Habitable space	Occupancy (Weekdays)	Occupancy (Weekends)
Bedroom	Full day	Full day
Living Room/Kitchen	9am to 10pm*	9am to 10pm

* CIBSE TM59:2017, Table 2, Page 7.

Determining *'occupied hours'* is critical to the results of the analysis. In a domestic situation, the occupation of rooms cannot easily be determined and varies widely.

Mechanical Ventilation and Natural Ventilation Openings

Considering that the proposed development needs to comply with both Approved Document O (Part O) and the Acoustic Ventilation and Overheating Guide (AVO), due to high internal ambient noise levels in all habitable spaces all window on all facades are considered closed, as per produced Noise Assessment Report (October 2023).

Therefore the proposed development will rely on mechanical ventilation with heat recovery to eliminate the build up of internal gains. The supply flow rate will be 2ach in each habitable room.

6 Discussions and Results

The overheating results for occupied areas of the dwellings are summarised in the following sections.

Compliance with the following criteria is addressed:

- **Criterion A:** For occupied rooms (kitchen/dining/living rooms and bedrooms), the number of hours (He) that delta T is greater than or equal to one degree (K) during the period between May and September, shall not be more than 3% of occupied hours.
- **Criterion B:** The operative temperature in the bedroom from 10pm to 7am shall not exceed 26°C for more than 1% of annual hours (>32 total hours).

Sample Size:

The assessment considered a sample of 19 flats located on the first, second, third, sixth and seventh floors (Figure 2).

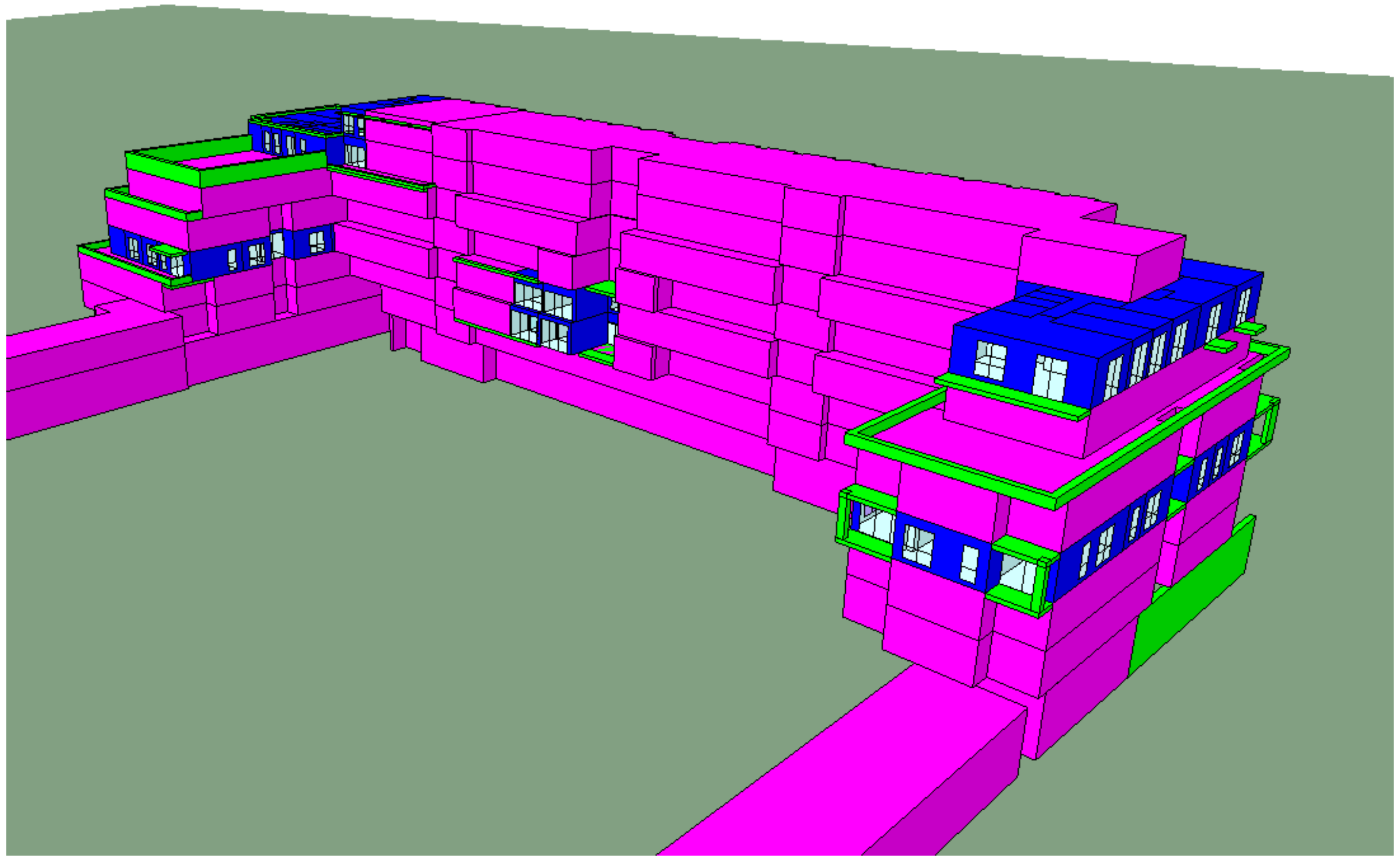


Figure 2. Thermal modelling design for the overheating study; studied flats (blue), local shade (green) and adjacent buildings (magenta).

Current Climate Scenario (DSY01)

The results of the current climate overheating analysis, along with the followed strategy are summarised thereafter:

Strategy

- Solar Energy Transmittance (G-Value) 45%.
- MVHR Ventilation (2ach).
- Closed windows and balcony doors all day, as per noise impact assessment report.

Results

The overheating analysis shows that based on the above proposed strategy, **87.5%** of the rooms **pass** (49 out of 56) Criterion A, and **21.6%** (8 out of 37) of bedrooms **pass** CIBSE TM 59 Criterion B.

Location	No. Rooms Tested	Criterion A - No. Rooms with overheating issues	Criterion B - No. Rooms with overheating issues
K/D/Ls	19	2	
Bedrooms	37	5	29
TOTAL	56	7	29

In this analysis, the rooms that failed are located on all façades of the development with large glazing areas, experiencing solar gains, which exceed CIBSE Criterion A and B.

The failing bedrooms are liable to solar gain overheating since the option of opening the windows to enable purge ventilation is limited constantly due to noise nuisance.

Failing Rooms		
01_A01.01-doublebedroom1	03_A03.03-doublebedroom2	03_D03.02-doublebedroom
01_A01.01-doublebedroom2	03_A03.03-singlebedroom	03_D03.03-doublebedroom
01_A01.01-singlebedroom	03_A03.04-doublebedroom1	03_D03.04-doublebedroom
01_A01.02-doublebedroom1	03_A03.04-doublebedroom2	03_D03.04-singlebedroom
01_A01.02-doublebedroom2	03_B02.07-doublebedroom1	06_A06.01-doublebedroom
03_A03.02-doublebedroom1	03_B02.07-doublebedroom2	06_A06.01-singlebedroom
03_A03.02-doublebedroom2	03_B02.08-doublebedroom1	06_A06.02-doublebedroom
03_A03.03-doublebedroom1	03_B02.08-doublebedroom2	06_A06.02-kdl1B2P
06_D06.01-doublebedroom	06_D06.02-kdl3B5P	07_B06.01-singlebedroom
06_D06.02-doublebedroom1	06_D06.02-singlebedroom	
06_D06.02-doublebedroom2	07_B06.01-doublebedroom	

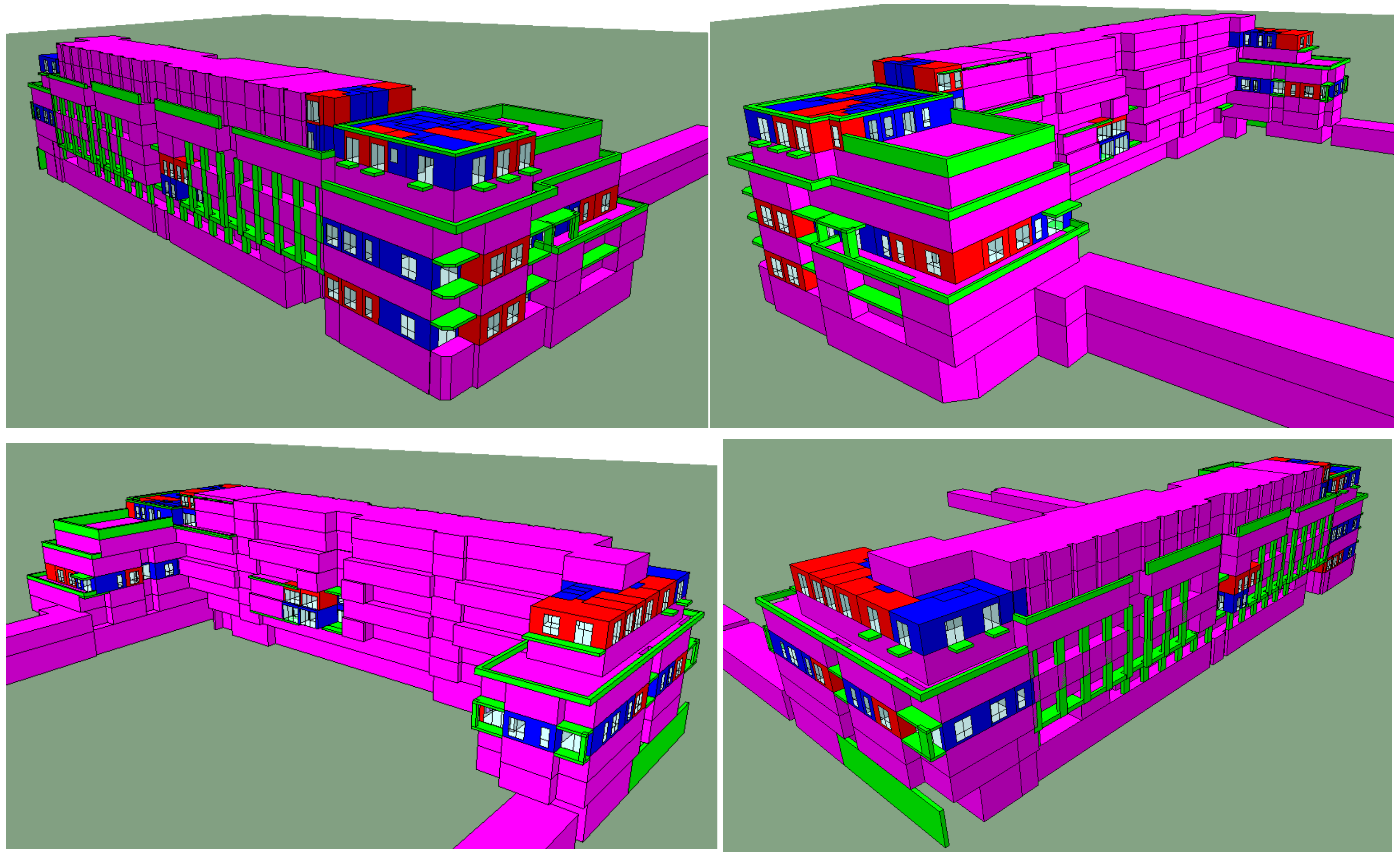


Figure 3. Illustration of overheating results for DSY01, failing rooms (red), passing rooms(blue), adjacent space(magenta), and local shade(green).

For the rooms that failed to comply, a lower G-value of 40% will be applied as a mitigation measure.

Mitigation Strategy 1 – Reduced G-Value 0.40

The proposed mitigation strategy considers a reduced G-value in the rooms that failed to meet the CIBSE TM59 Criterion A and B.

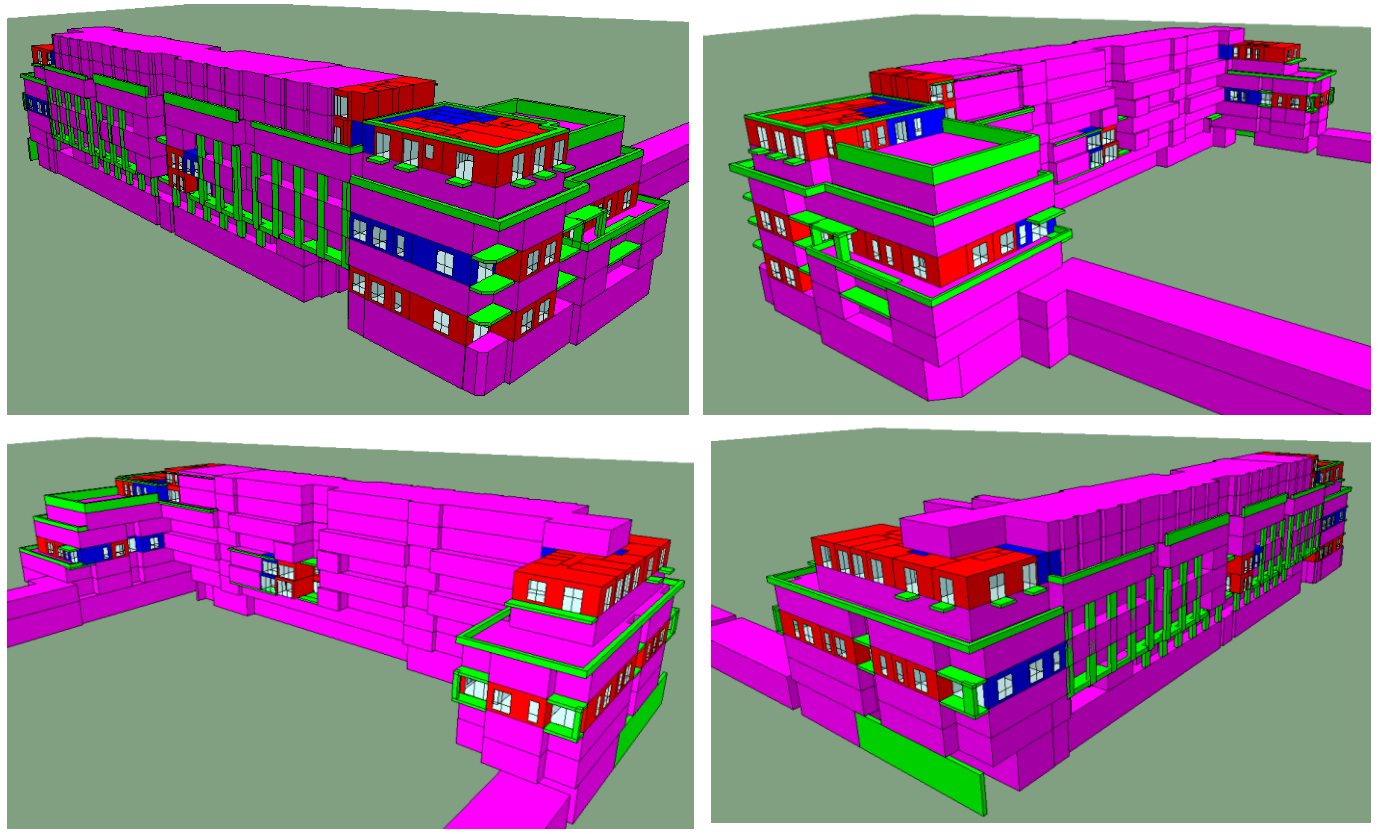
Strategy

- Solar Energy Transmittance (G-Value) 45%.
- Solar Energy Transmittance (G-Value) 40% to failing rooms.
- MVHR Ventilation (2ach).
- Closed windows and balcony doors, as per noise impact assessment report.

The overheating analysis shows that based on the above proposed strategy, **89.28%** of the rooms **pass** (50 out of 56) Criterion A, and **27.02%** (10 out of 37) of bedrooms **pass** CIBSE TM 59 Criterion B.

Site B	No. Rooms Tested	Criterion A - No. Rooms with overheating issues	Criterion B - No. Rooms with overheating issues
K/D/Ls	19	2	
Bedrooms	37	4	27
TOTAL	56	6	27

Failing Rooms		
01_A01.01-doublebedroom1	03_A03.03-doublebedroom2	03_D03.04-doublebedroom
01_A01.01-doublebedroom2	03_A03.03-singlebedroom	03_D03.04-singlebedroom
01_A01.01-singlebedroom	03_A03.04-doublebedroom1	06_A06.01-doublebedroom
01_A01.02-doublebedroom1	03_A03.04-doublebedroom2	06_A06.01-singlebedroom
01_A01.02-doublebedroom2	03_B02.08-doublebedroom1	06_A06.02-doublebedroom
03_A03.02-doublebedroom1	03_B02.08-doublebedroom2	06_A06.02-kdl1B2P
03_A03.02-doublebedroom2	06_D06.02-kdl3B5P	07_B06.01-singlebedroom
03_A03.03-doublebedroom1	06_D06.02-singlebedroom	
06_D06.01-doublebedroom	07_B06.01-doublebedroom	
06_D06.02-doublebedroom1	03_D03.02-doublebedroom	
06_D06.02-doublebedroom2	03_D03.03-doublebedroom	



To the flats with failing rooms, an MVHR system with cooling is proposed to mitigate the overheating.

Flats with Failing Rooms	
A01.01	D03.02
A01.02	D03.03
A03.02	D03.04
A03.03	A06.01
A03.04	A06.02
B02.07	D06.01
B02.08	D06.02

Mitigation Strategy 2 – MVHR with Cooling System

The proposed mitigation strategy considers MVHR with a cooling system in the flats with rooms that failed to meet the CIBSE TM59 Criterion A and B with the previous mitigation strategy.

Strategy

- Solar Energy Transmittance (G-Value) 45%.
- Solar Energy Transmittance (G-Value) 40% to initially failing rooms.
- MVHR Ventilation (2ach).
- MVHR Ventilation (2ach) with a cooling system to flats with rooms that fail mitigation strategy 1.
- Closed windows and balcony doors, as per noise impact assessment report.

The overheating analysis shows that based on the above proposed strategy, **100%** of the rooms **pass** (56 out of 56) Criterion A, and **100%** (37 out of 37) of bedrooms **pass** CIBSE TM 59 Criterion B.

Site B	No. Rooms Tested	Criterion A - No. Rooms with overheating issues	Criterion B - No. Rooms with overheating issues
K/D/Ls	19	0	
Bedrooms	37	0	0
TOTAL	56	0	0

The full set of results is provided in Appendix C and D.

6.1 Prorated Data

The overheating results have been prorated to the whole Welling United FC development, to identify the dwellings that will require MVHR with 2ach in each habitable room, decreased G-value of 0.4, and an MVHR system with cooling unit.

According to the following table, in order to ensure thermal comfort conditions for the users, 17 dwellings should be equipped with MVHR system with flow rates of 2ach to each habitable room, 28 dwellings with a decreased G-value of 0.4, and 59 dwellings with a MVHR system with cooling unit.

	Block A	Block B	Block C	Block D	TOTAL
Strategy 1 – Standard MVHR	10	0	0	7	17
Strategy 2 – G-value 0.4	0	14	14	0	28
Strategy 3 - MVHR with cooling	18	12	12	17	59
TOTAL	28	26	26	24	104

Detailed set of results is presented in Appendix E.

6.2 Typical Room Analysis

This section of the report discusses the results for some examples of the assessed rooms. The analysis and tables below are presented based on the simulation.

Kitchen/Dining/Living Room MVHR with Cooling

The 2-bedroom Kitchen/Dining/Living room (KDL) located on the third floor in A03.02 (2B4P) is reviewed in detail. This room features two west facing balcony windows.

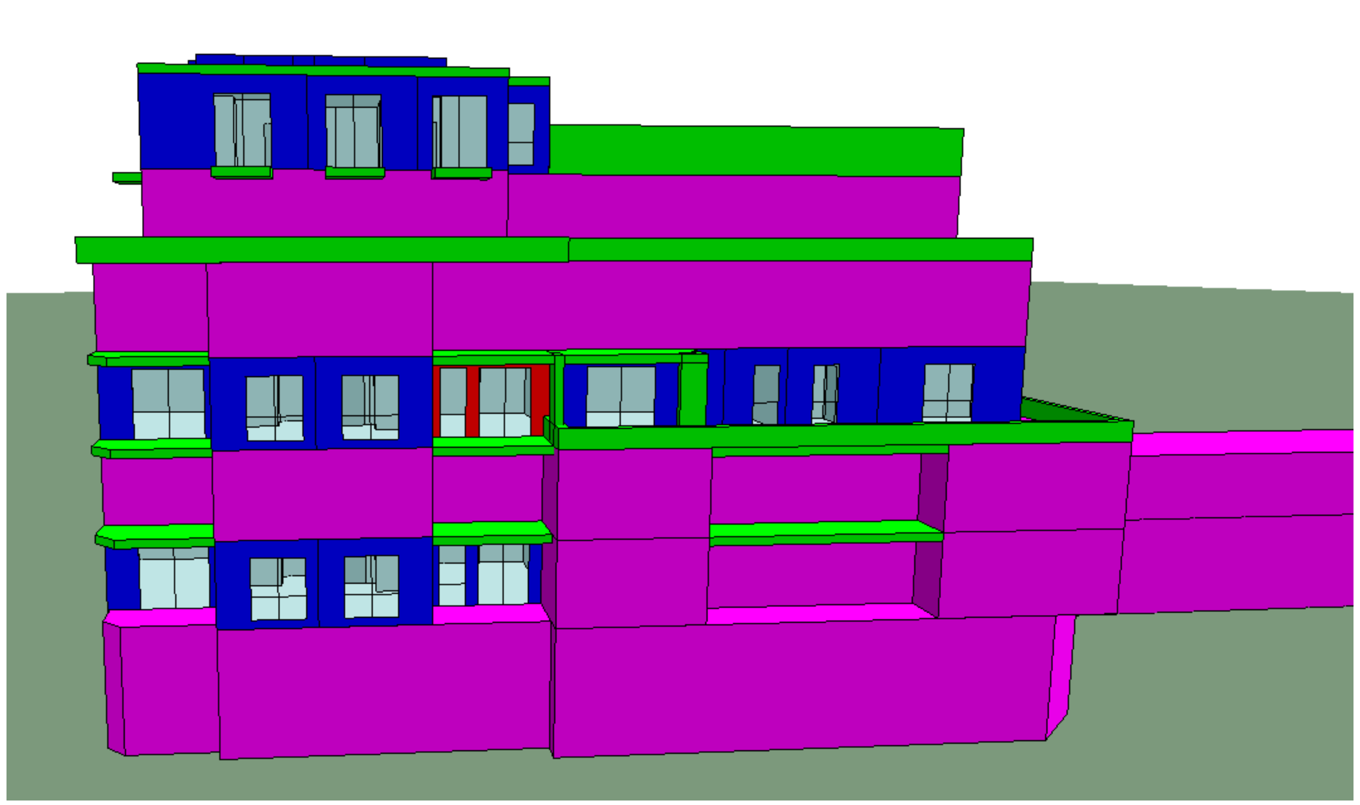


Figure 4: K/D/L in flat A03.02

The room is analysed on the hottest summer day (22nd of July) with a G-value of 45. As illustrated in Figure 5, solar gains reach a peak of 0.419 kWh at 18:28. The internal gains from people, lighting and equipment hit a maximum of 0.6585 kWh in the evening. The operative temperature can be seen to rise throughout the day following this, reaching a peak temperature of 24°C at 18:33.

For low thermal mass or low conductivity (i.e.: highly insulating) elements, very little of the surface heat is conducted away internally. This means that the rise in temperature at the surface is much higher, leading to most heat being lost immediately by radiation and convection to the room. This has an impact on both air and mean radiant temperatures within a space. In the same way, the absorbed and radiated solar heat gains through glazing will be absorbed by the internal surfaces and is released into the room with a time-lag, which explains the time shift of the peak solar heat gains and indoor operative temperature in the chart below.

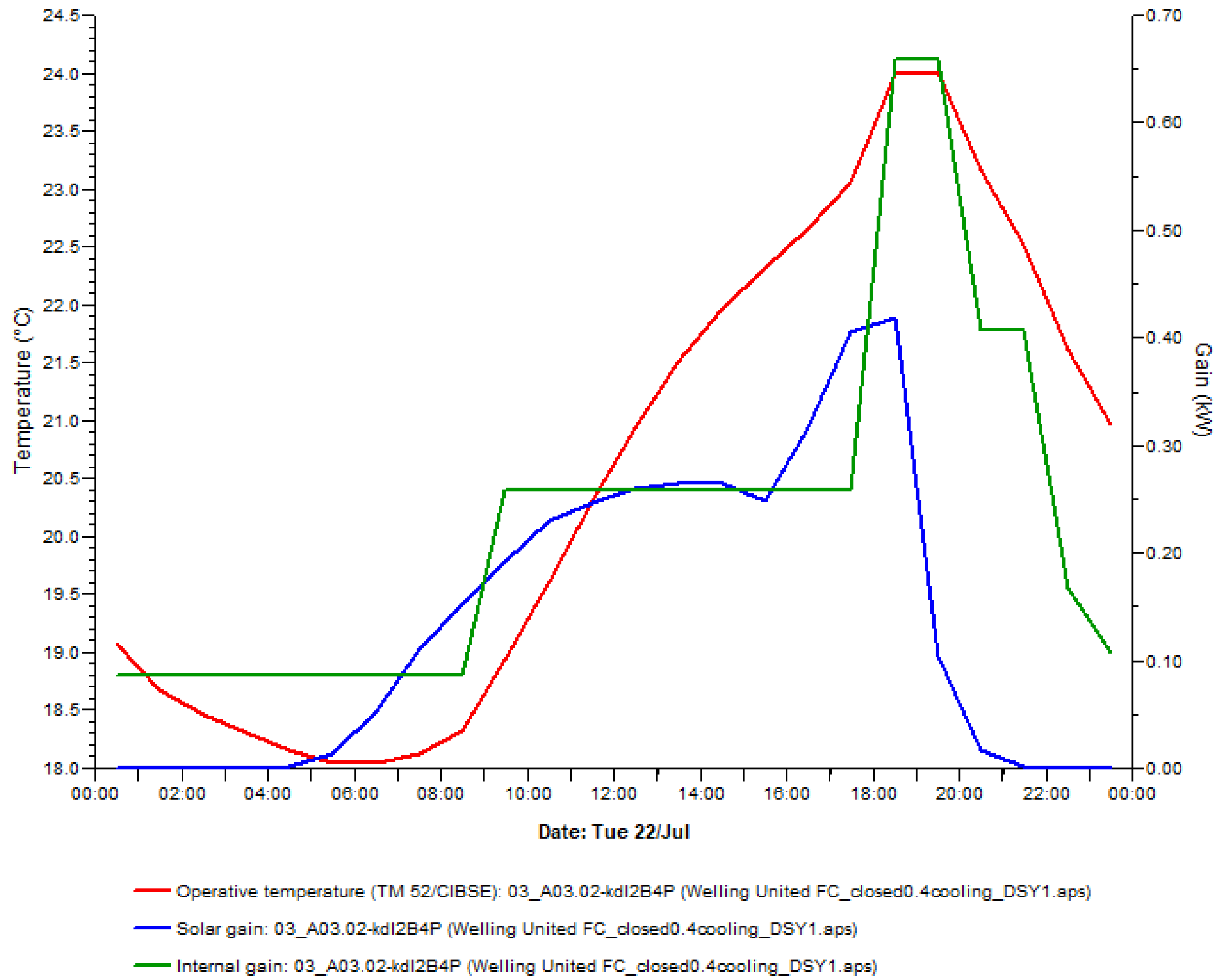


Figure 5: Weather data chart of operative temperature, internal and solar gains for the KDL in flat A03.02 on the 22nd of July

Typical Double Bedroom - MVHR with cooling

An example double bedroom located on the sixth floor in flat D06.01 (1B2P) is reviewed in detail. The room features one balcony window facing east. The room is highlighted in red below.

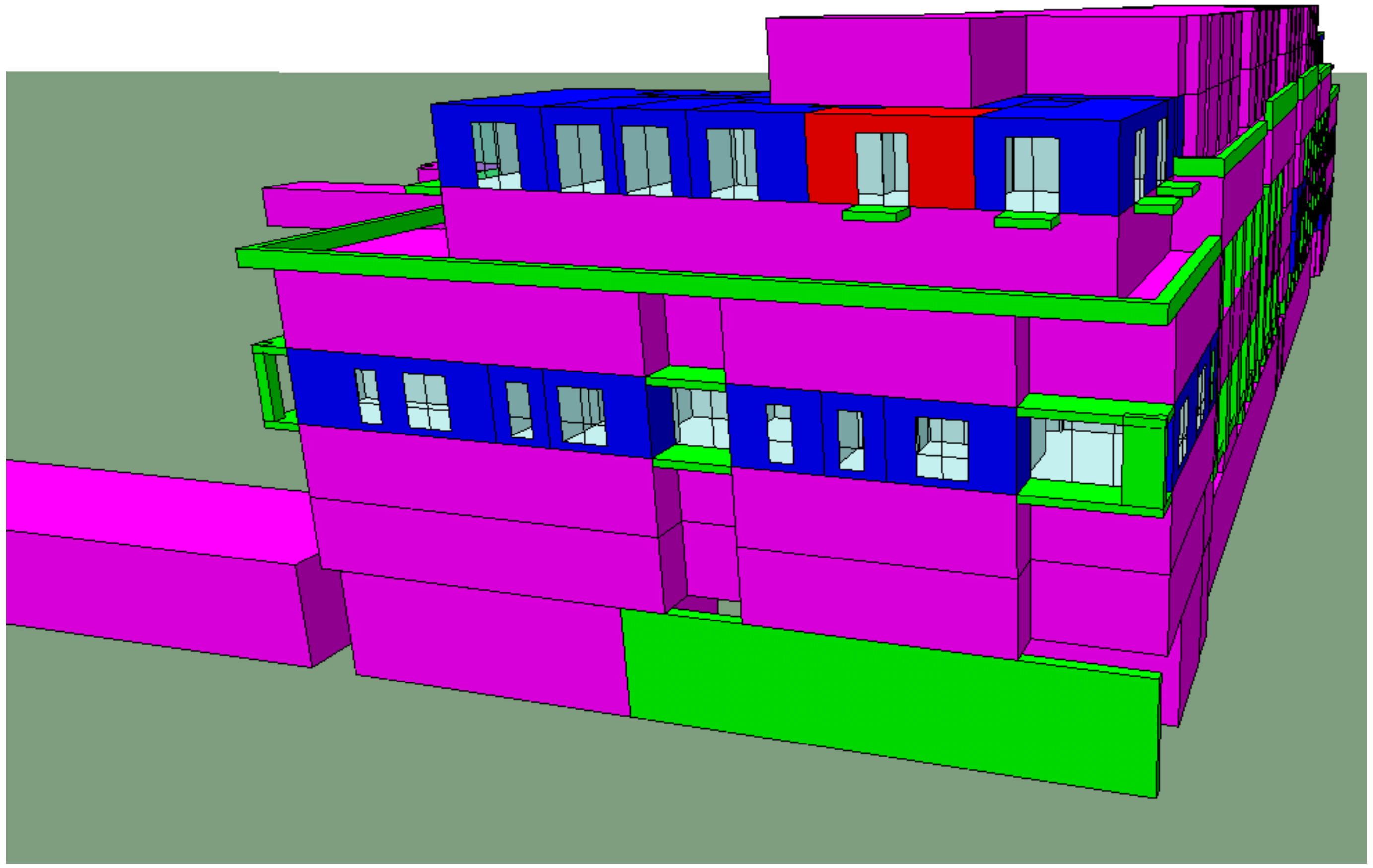


Figure 6: Example double bedroom in flat D06.01

In the analysed room on the hottest summer day (22nd of July), the solar gains appear to reach a peak of 0.8246 kWh at 09.31. As illustrated in Figure 7, the operative temperature can be seen to rise throughout the day with a peak of 23.45ºC in the evening. During sleeping hours, the windows remain closed as per AVO requirements.

To comply with Criterion B and guarantee comfort during sleeping hours, sleeping hours must not exceed 26ºC for more than 1% of annual hours (or 32 hours) between 22.00 and 07.00. The room is predicted to exceed 26 C between 22.00 and 07.00 for 0 hours per year, which complies with the requirements of Criterion B (full results in Appendix B).

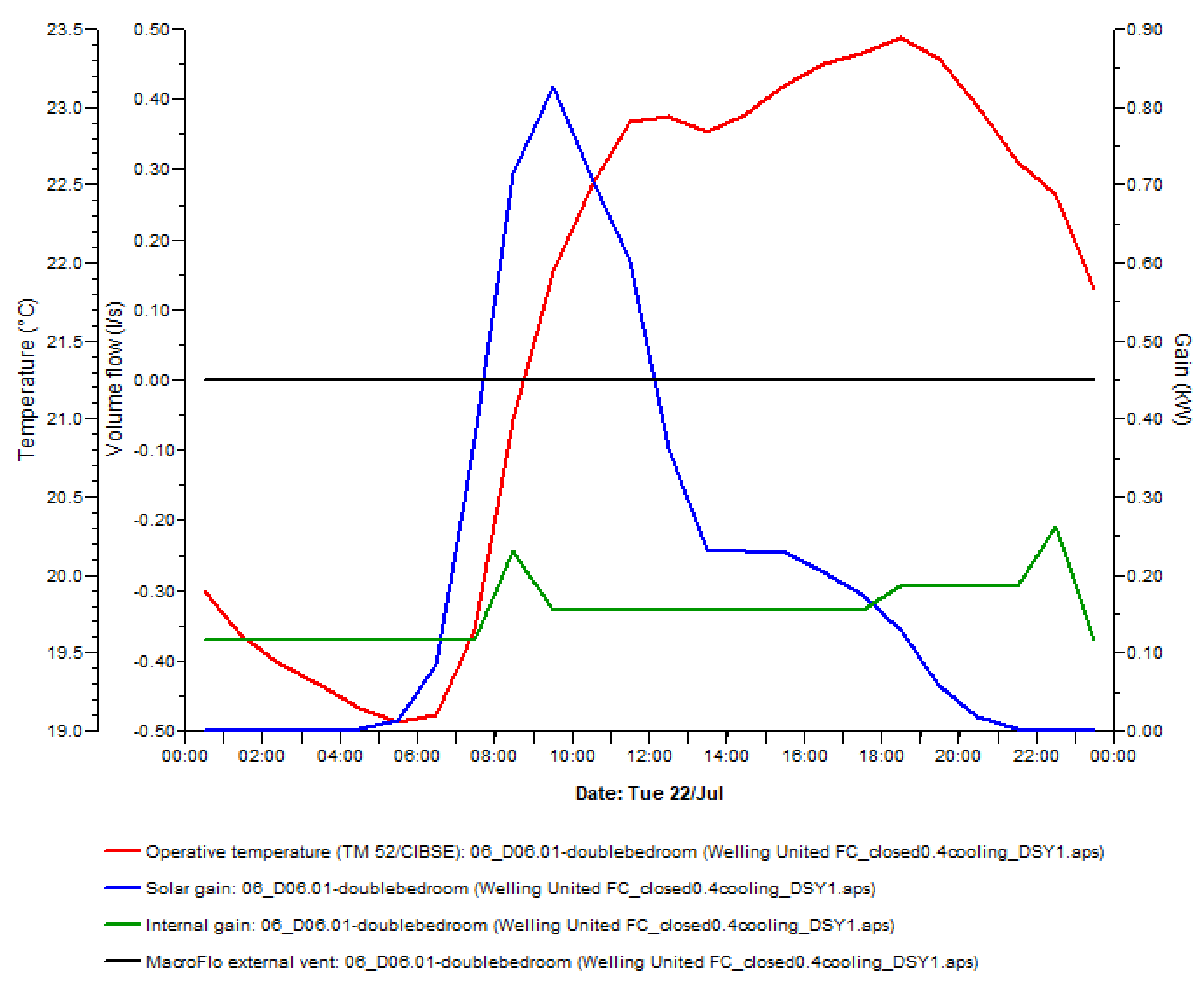


Figure 7: Weather data chart of operative temperature, internal, solar gains and airflow volume through openable windows for the example Double Bedroom in flat D06.01 on the 22rd of July

7 Additional Analysis

In accordance with GLA guidelines, additional testing has been undertaken using the 2020 versions of the more extreme design weather years, DSY2 & DSY3.

The proposed strategy is the same as the Current Climate Scenario, incorporating low solar energy transmittance glazing with a G-Value of 45%, mechanical ventilation with heat recovery with standard flow rates, with a decreased G-value of 40%, and mechanical ventilation with heat recovery with cooling units, and no purge ventilation via openable windows as per AVO noise impact assessment.

GLA guidance acknowledges that meeting the CIBSE compliance criteria is challenging for the DSY2 and DSY3 weather files, therefore full compliance is not mandatory.

DSY2-2003 (a year with a very intense single warm spell):

Based on this strategy for the DSY2-2003 climate scenario, **100%** of assessed rooms **pass** Criterion A. **100%** of the assessed Bedrooms **pass** Criterion B for night-time hours over 26°C.

DSY 2 – 2003		Number of with overheating issues	
Room Type	No. rooms tested	Criterion A	Criterion B
Bedrooms	37	0	0
Kitchen/Dining/Living Rooms	19	0	
TOTAL	56	0	0

DSY3-1976 (a year with a prolonged period of sustained warmth):

Due to the nature of the CIBSE overheating criteria, which are based on hours of compliance, the targets for a year with a prolonged period of sustained warmth are very challenging to meet. This is acknowledged by GLA guidance, which states compliance is not mandatory, but the developer must reduce the risk of overheating as far as practical and ensure all passive measures have been explored.

Based on this strategy for the DSY3-1976 climate scenario, **100%** of assessed rooms **pass** Criterion A. **94.6%** of the assessed Bedrooms **pass** Criterion B for night-time hours over 26°C.

DSY 3 – 1976		Number of with overheating issues	
Room Type	No. rooms tested	Criterion A	Criterion B
Bedrooms	37	0	2
Kitchen/Dining/Living Rooms	19	0	
TOTAL	56	0	2

DSY2 & DSY3 mitigation measures:

In order to mitigate potential future overheating risk, the occupants may proceed with the installation of internal blinds that are user-controlled and can significantly improve the results for the DSY2 & DSY3 weather files.

Occupants will be able to further increase indoor comfort levels by use of small power electric fans at night during extreme weather events to provide additional air circulation directed to the specific affected areas.

The full set of results is provided in Appendix C and D.

8 Conclusion

An overheating analysis has been undertaken for the Welling United FC development, in accordance with CIBSE TM59 and has been conducted using the CIBSE London DSY1 (Design Summer Year) weather file for the 2020s, high emissions, 50% percentile scenario.

The overheating risk for kitchen/dining/living rooms and bedrooms has been analysed on a sample of 19 flats and duplexes in the Welling United FC development.

The following strategy is proposed to limit the risk of overheating:

- Low Solar Energy Transmittance glazing with a G-Value of 45% to all windows.
- Mechanical Ventilation with Heat Recovery in all flats (2ach).
- Closed openings as per noise impact assessment report to achieve compliance with AVO and Part O guidelines.
- G-value of 40% to failing rooms.
- MVHR with cooling to dwellings with rooms that fail after mitigation strategy 1.

The simulation confirms that, based on the above strategy:

100% of rooms (56 out of 56) **pass** the CIBSE TM59 overheating Criterion A and **100%** of bedrooms (37 out of 37) **pass** Criterion B for the **current climate**, considering a G-value of 45%.

Additional testing has been undertaken in accordance with current GLA guidance using the 2020 versions of the extreme year weather files: DSY2-2003 a year with a very intense single warm spell; and DSY3-1976 a year with a prolonged period of sustained warmth. The risk of overheating in these scenarios could be reduced by using internal blinds and small power electric fans.

Appendix A - Thermal Comfort & Operative Temperature

Thermal Comfort and Operative Temperatures

The provision of thermal comfort for building occupants involves designing the internal conditions so that the heat loss and heat gain from occupants lie within the bounds that are generally accepted as comfortable. Thermal comfort is defined in the ISO 7730 as *"That condition of mind which expresses satisfaction with the thermal environment".* This is a definition most people can agree on but also a definition that is not easily converted into physical parameters.

The human body can be crudely regarded as a heat engine that converts fuel (food) into energy for its function and creates waste heat that must be dissipated by the body to ensure proper "thermoregulation". The greater the amount of activity, the greater the amount of heat to be dissipated. Typical office work generates up to 110-130W of heat. Heat dissipation from the body takes place by several modes of heat transfer — radiation and convection from the outer surface, evaporation from both the surface and inner parts of the body and respiration involving both sensible and latent heat transfer. To maintain thermal equilibrium, the amount of heat produced or absorbed must equal the heat dissipated. The perception of thermal comfort is based on a range of variables:

Dry bulb air temperature

Is the most commonly quoted factor in relation to thermal comfort. In a 'traditional" building, if the air temperature is within reasonable limits, it is likely that there is a reasonable degree of thermal comfort. This simple relationship between air temperature and comfort is less reliable in lighter weight modern buildings.

Moisture content

Humans will experience discomfort if the moisture content of the air in the room is either too dry, causing drying of the respiratory tract and eyes or too moist so that the body is unable to lose heat through evaporation (sweating) from the skin.

Air movement

The movement of air across the surface of the body affects the convective heat transfer from both the bare and clothed parts; over the exposed skin surfaces the flow of air is a factor in determining the transmission rate of moisture from the surface. If the combined effect of temperature and movement is too great, then too much heat is removed and a subjective feeling of chill or draught results. Conversely, a high air temperature with little air movement will produce a subjective sensation of warmth that, although acceptable locally near a heating unit, is not tolerable throughout the general area of a room.

Surface temperatures

Experiments with test subjects in rooms with different air and surface temperatures have shown that, for optimum thermal comfort occupants prefer that the perceived surface temperatures (the mean radiant temperature) should be close to the air temperature. In real buildings, the inside surface temperatures can vary widely between surfaces. The human body is directionally sensitive to the radiation pattern — it cannot average multiple adverse effects to reach an acceptable condition therefore an imbalance can be conceived as uncomfortable.

Direct solar radiation -

If the occupants find themselves in the direct path of solar radiation transmitted through a glazed area, they may experience serious thermal discomfort. This will occur no matter how adequately the environmental systems are designed to cope with the solar and other loads.

PMV & PPD

The PMV represents the predicted mean vote of a large population of people exposed to a certain environment. It predicts the mean value of the votes of a large group of people on a seven-point scale from hot (+3) to cold (-3). PMV takes into account the environmental parameters (air temperature, mean radiant temperature, air velocity and relative humidity) together with heat production due to activity level and thermal resistance due to clothing.

PPD is the predicted percentage of dissatisfied people at each PMV. As PMV changes away from zero in either the positive or the negative direction, PPD increases. Unlike PMV, which gives the average response of a large group of people, PPD is indicative of the range of individual responses.

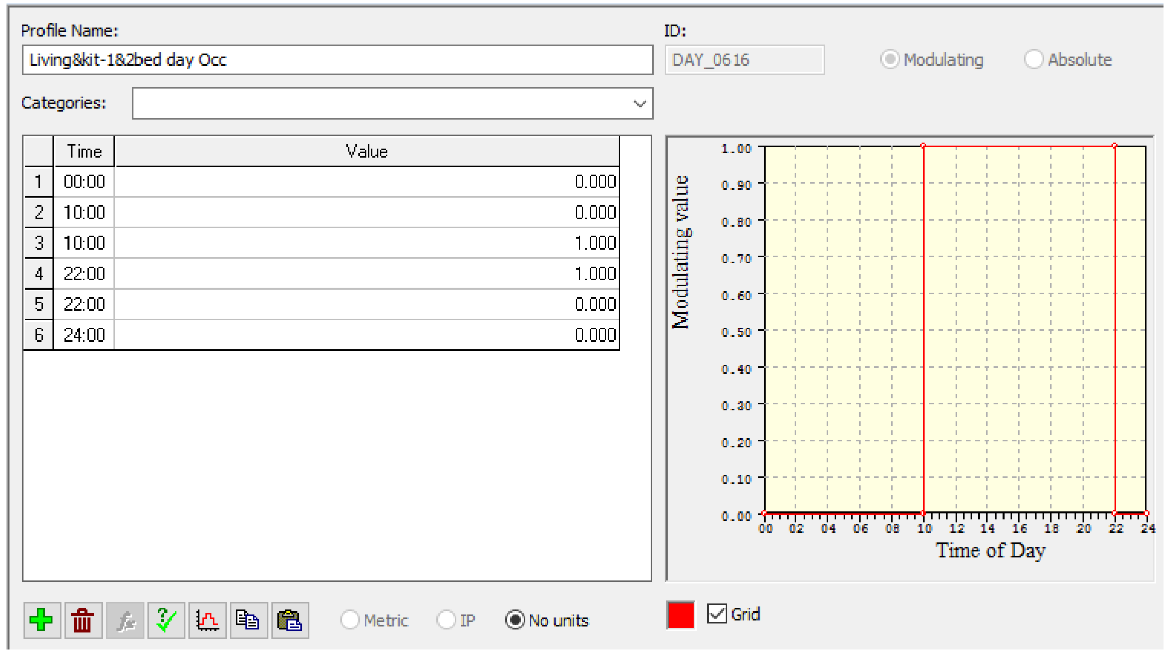
Operative Temperatures

The CIBSE standard adopted in the UK for the assessment of comfort in an internal space is known as operative temperature (formerly known as dry resultant temperature);

$T_{operative} = (0.5xT_{air}) + (0.5x\ T_{radiant})$

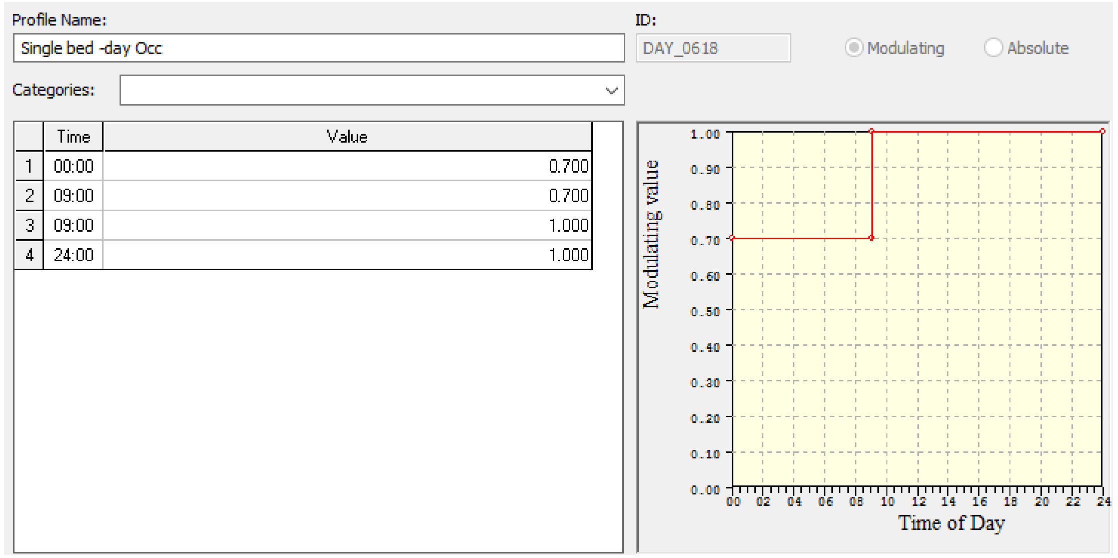
This is in effect a simple average and so an increasing air temperature requires a corresponding reduction in radiant temperature if comfort is to be maintained. This can be achieved through reduced areas of glass, external shading, exposed concrete soffits and radiant cooling systems.

Appendix B - Occupancy and other usage profiles



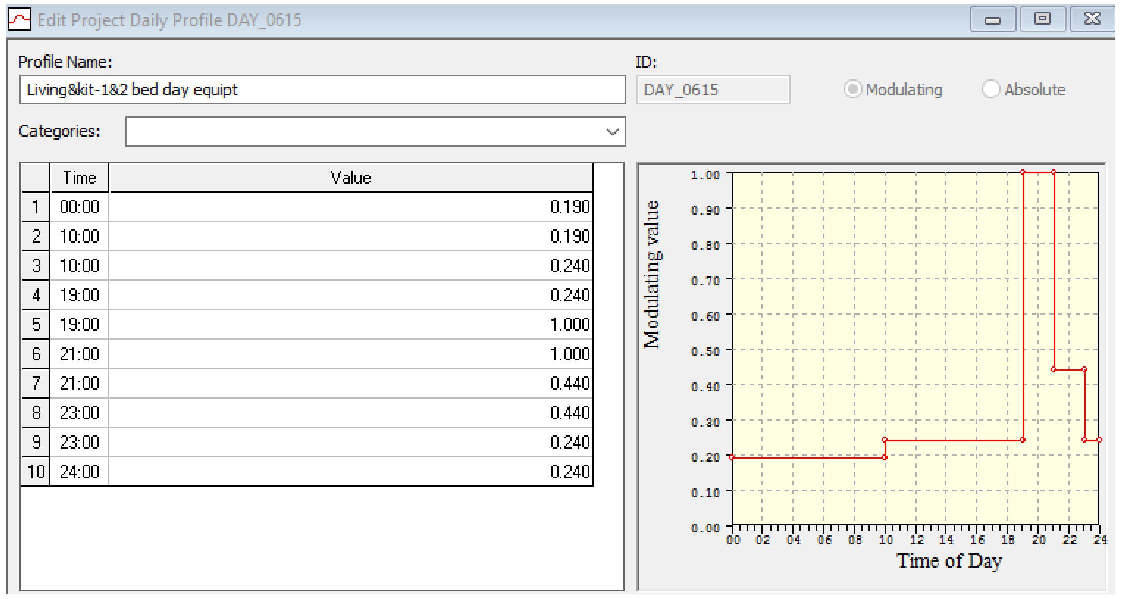
	Time	Value
1	00:00	0.000
2	10:00	0.000
3	10:00	1.000
4	22:00	1.000
5	22:00	0.000
6	24:00	0.000

Living & kit – 1 & 2 beds Occupancy profile



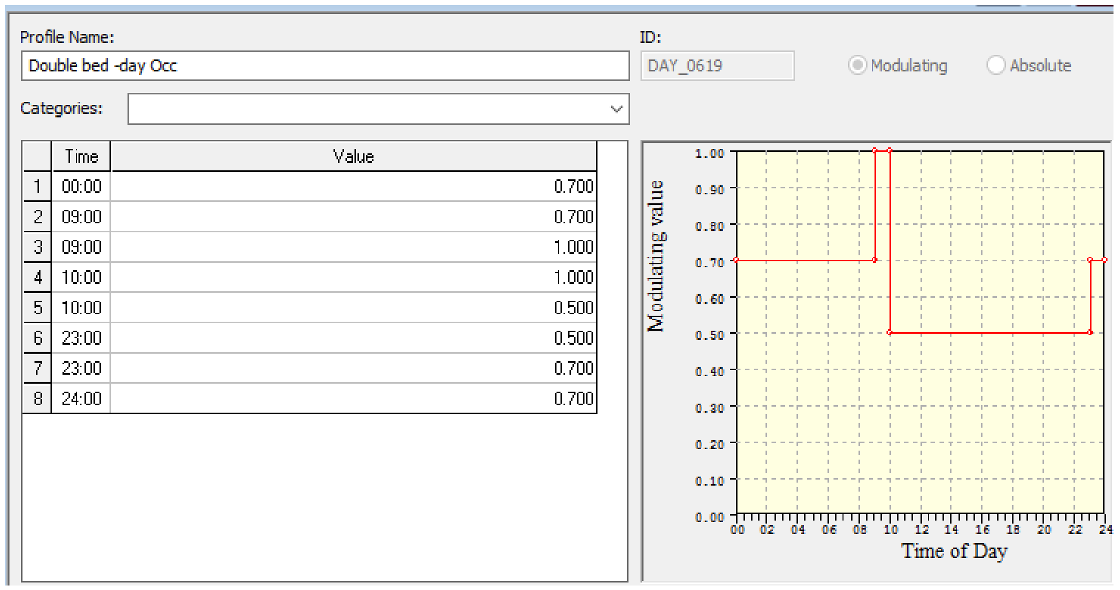
	Time	Value
1	00:00	0.700
2	09:00	0.700
3	09:00	1.000
4	24:00	1.000

Bedrooms – single bed occupancy profile



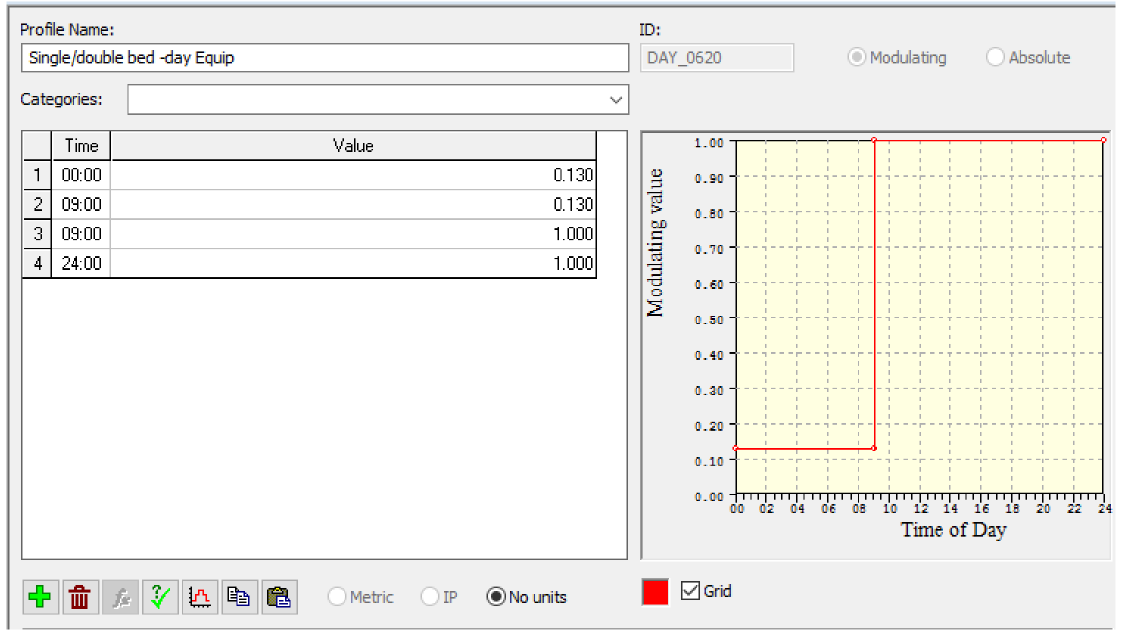
	Time	Value
1	00:00	0.190
2	10:00	0.190
3	10:00	0.240
4	19:00	0.240
5	19:00	1.000
6	21:00	1.000
7	21:00	0.440
8	23:00	0.440
9	23:00	0.240
10	24:00	0.240

Living & kit – 1 & 2 beds Equipment profile

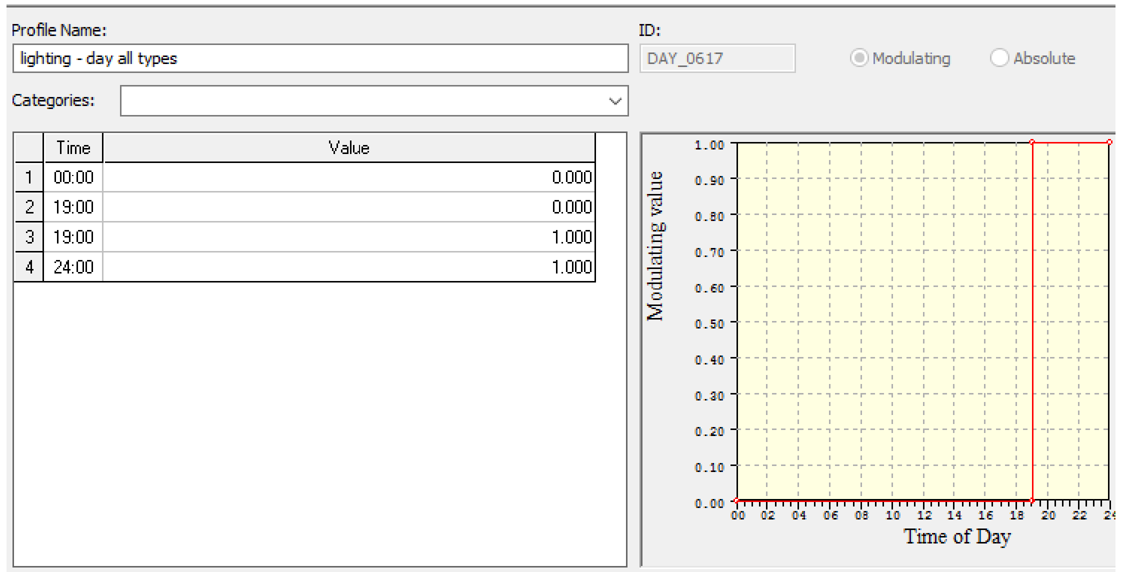


	Time	Value
1	00:00	0.700
2	09:00	0.700
3	09:00	1.000
4	10:00	1.000
5	10:00	0.500
6	23:00	0.500
7	23:00	0.700
8	24:00	0.700

Bedrooms – double bed occupancy profile



Bedrooms – single/double bed equipment profile



Lighting profile

Appendix C – Criterion A Results

WEATHER FILE: DSY 1 – MVHR

Room	Criteria 1 (%Hrs Top-Tmax>=1K)
01_A01.01-doublebedroom1	0.5
01_A01.01-doublebedroom2	0.3
01_A01.01-kdl3B5P	1.5
01_A01.01-singlebedroom	0.4
01_A01.02-doublebedroom1	1
01_A01.02-doublebedroom2	1
01_A01.02-kdl2B4P	1
02_B02.07-kdl2B4P	1.4
02_B02.08-kdl3B5P	1.8
03_A03.01-doublebedroom1	0
03_A03.01-doublebedroom2	0
03_A03.01-kdl3B5P	0.4
03_A03.01-singlebedroom	0
03_A03.02-doublebedroom1	0.6
03_A03.02-doublebedroom2	0.5
03_A03.02-kdl2B4P	1.1
03_A03.03-doublebedroom1	0.9
03_A03.03-doublebedroom2	1.2
03_A03.03-kdl3B5P	0.8
03_A03.03-singlebedroom	0.8
03_A03.04-doublebedroom1	1
03_A03.04-doublebedroom2	0.3
03_A03.04-kdl2B4P	0.8
03_A03.05-doublebedroom	0.6
03_A03.05-kdl1B2P	0
03_B02.07-doublebedroom1	0.1
03_B02.07-doublebedroom2	1.7
03_B02.08-doublebedroom1	0.1
03_B02.08-doublebedroom2	2.3
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	0
03_D03.01-kdl2B3P	0.4
03_D03.01-singlebedroom	0
03_D03.02-doublebedroom	0.1
03_D03.02-kdl1B2P	0.2
03_D03.03-doublebedroom	0.5
03_D03.03-kdl1B2P	1.2
03_D03.04-doublebedroom	3.2
03_D03.04-kdl2B3P	2.2
03_D03.04-singlebedroom	0.7
03_D03.05-doublebedroom	0.4
03_D03.05-kdl1B2P	0.9
06_A06.01-doublebedroom	0.7
06_A06.01-kdl2B3P	2.5
06_A06.01-singlebedroom	1.1
06_A06.02-doublebedroom	5.1
06_A06.02-kdl1B2P	5.3
06_B06.01-kdl2B3P	0.7
06_D06.01-doublebedroom	0.6
06_D06.01-kdl1B2P	1.5
06_D06.02-doublebedroom1	12.2
06_D06.02-doublebedroom2	12.8
06_D06.02-kdl3B5P	17.8
06_D06.02-singlebedroom	8.6
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

WEATHER FILE: DSY 1 – MVHR + g-0.4

Room	Criteria 1 (%Hrs Top-Tmax>=1K)
01_A01.01-doublebedroom1	0.3
01_A01.01-doublebedroom2	0.1
01_A01.01-kdl3B5P	1.3
01_A01.01-singlebedroom	0.2
01_A01.02-doublebedroom1	0.7
01_A01.02-doublebedroom2	0.7
01_A01.02-kdl2B4P	0.8
02_B02.07-kdl2B4P	1.2
02_B02.08-kdl3B5P	1.6
03_A03.01-doublebedroom1	0
03_A03.01-doublebedroom2	0
03_A03.01-kdl3B5P	0.3
03_A03.01-singlebedroom	0
03_A03.02-doublebedroom1	0.4
03_A03.02-doublebedroom2	0.3
03_A03.02-kdl2B4P	0.9
03_A03.03-doublebedroom1	0.5
03_A03.03-doublebedroom2	0.8
03_A03.03-kdl3B5P	0.6
03_A03.03-singlebedroom	0.5
03_A03.04-doublebedroom1	0.6
03_A03.04-doublebedroom2	0.2
03_A03.04-kdl2B4P	0.8
03_A03.05-doublebedroom	0.5
03_A03.05-kdl1B2P	0
03_B02.07-doublebedroom1	0
03_B02.07-doublebedroom2	1
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	1.5
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	0
03_D03.01-kdl2B3P	0.4
03_D03.01-singlebedroom	0
03_D03.02-doublebedroom	0
03_D03.02-kdl1B2P	0.1
03_D03.03-doublebedroom	0.2
03_D03.03-kdl1B2P	1.1
03_D03.04-doublebedroom	2.2
03_D03.04-kdl2B3P	1.5
03_D03.04-singlebedroom	0.6
03_D03.05-doublebedroom	0.4
03_D03.05-kdl1B2P	0.9
06_A06.01-doublebedroom	0.4
06_A06.01-kdl2B3P	2
06_A06.01-singlebedroom	0.9
06_A06.02-doublebedroom	4
06_A06.02-kdl1B2P	3.7
06_B06.01-kdl2B3P	0.6
06_D06.01-doublebedroom	0.4
06_D06.01-kdl1B2P	1.2
06_D06.02-doublebedroom1	8.2
06_D06.02-doublebedroom2	8.4
06_D06.02-kdl3B5P	12.1
06_D06.02-singlebedroom	5.4
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

WEATHER FILE: DSY 1 – MVHR + g-0.4+ MVHR with Cooling

Room	Criteria 1 (%Hrs Top-Tmax>=1K)
01_A01.01-doublebedroom1	0
01_A01.01-doublebedroom2	0
01_A01.01-kdl3B5P	0
01_A01.01-singlebedroom	0
01_A01.02-doublebedroom1	0
01_A01.02-doublebedroom2	0
01_A01.02-kdl2B4P	0
02_B02.07-kdl2B4P	0
02_B02.08-kdl3B5P	0
03_A03.01-doublebedroom1	0
03_A03.01-doublebedroom2	0
03_A03.01-kdl3B5P	0
03_A03.01-singlebedroom	0
03_A03.02-doublebedroom1	0
03_A03.02-doublebedroom2	0
03_A03.02-kdl2B4P	0
03_A03.03-doublebedroom1	0
03_A03.03-doublebedroom2	0
03_A03.03-kdl3B5P	0
03_A03.03-singlebedroom	0
03_A03.04-doublebedroom1	0
03_A03.04-doublebedroom2	0
03_A03.04-kdl2B4P	0
03_A03.05-doublebedroom	0
03_A03.05-kdl1B2P	0
03_B02.07-doublebedroom1	0
03_B02.07-doublebedroom2	0
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	0
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	0
03_D03.01-kdl2B3P	0
03_D03.01-singlebedroom	0
03_D03.02-doublebedroom	0
03_D03.02-kdl1B2P	0
03_D03.03-doublebedroom	0
03_D03.03-kdl1B2P	0
03_D03.04-doublebedroom	0
03_D03.04-kdl2B3P	0
03_D03.04-singlebedroom	0
03_D03.05-doublebedroom	0
03_D03.05-kdl1B2P	0
06_A06.01-doublebedroom	0
06_A06.01-kdl2B3P	0
06_A06.01-singlebedroom	0
06_A06.02-doublebedroom	0
06_A06.02-kdl1B2P	0
06_B06.01-kdl2B3P	0
06_D06.01-doublebedroom	0
06_D06.01-kdl1B2P	0
06_D06.02-doublebedroom1	0
06_D06.02-doublebedroom2	0
06_D06.02-kdl3B5P	0
06_D06.02-singlebedroom	0
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

WEATHER FILE: DSY 2 – MVHR + g-0.4+ MVHR with Cooling

Room	Criteria 1 (%Hrs Top-Tmax>=1K)
01_A01.01-doublebedroom1	0
01_A01.01-doublebedroom2	0
01_A01.01-kdl3B5P	0
01_A01.01-singlebedroom	0
01_A01.02-doublebedroom1	0
01_A01.02-doublebedroom2	0
01_A01.02-kdl2B4P	0
02_B02.07-kdl2B4P	0.2
02_B02.08-kdl3B5P	0
03_A03.01-doublebedroom1	0
03_A03.01-doublebedroom2	0
03_A03.01-kdl3B5P	0
03_A03.01-singlebedroom	0
03_A03.02-doublebedroom1	0
03_A03.02-doublebedroom2	0
03_A03.02-kdl2B4P	0
03_A03.03-doublebedroom1	0
03_A03.03-doublebedroom2	0
03_A03.03-kdl3B5P	0
03_A03.03-singlebedroom	0
03_A03.04-doublebedroom1	0
03_A03.04-doublebedroom2	0
03_A03.04-kdl2B4P	0
03_A03.05-doublebedroom	0.1
03_A03.05-kdl1B2P	0
03_B02.07-doublebedroom1	0
03_B02.07-doublebedroom2	0.3
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	0
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	0
03_D03.01-kdl2B3P	0.2
03_D03.01-singlebedroom	0
03_D03.02-doublebedroom	0
03_D03.02-kdl1B2P	0
03_D03.03-doublebedroom	0
03_D03.03-kdl1B2P	0
03_D03.04-doublebedroom	0
03_D03.04-kdl2B3P	0
03_D03.04-singlebedroom	0
03_D03.05-doublebedroom	0
03_D03.05-kdl1B2P	0.1
06_A06.01-doublebedroom	0
06_A06.01-kdl2B3P	0
06_A06.01-singlebedroom	0
06_A06.02-doublebedroom	0
06_A06.02-kdl1B2P	0
06_B06.01-kdl2B3P	0
06_D06.01-doublebedroom	0
06_D06.01-kdl1B2P	0
06_D06.02-doublebedroom1	0
06_D06.02-doublebedroom2	0
06_D06.02-kdl3B5P	0
06_D06.02-singlebedroom	0
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

WEATHER FILE: DSY 3 – MVHR + g-0.4+ MVHR with Cooling

Room	Criteria 1 (%Hrs Top-Tmax>=1K)
01_A01.01-doublebedroom1	0
01_A01.01-doublebedroom2	0
01_A01.01-kdl3B5P	0
01_A01.01-singlebedroom	0
01_A01.02-doublebedroom1	0
01_A01.02-doublebedroom2	0
01_A01.02-kdl2B4P	0
02_B02.07-kdl2B4P	0
02_B02.08-kdl3B5P	0
03_A03.01-doublebedroom1	0
03_A03.01-doublebedroom2	0
03_A03.01-kdl3B5P	0
03_A03.01-singlebedroom	0
03_A03.02-doublebedroom1	0
03_A03.02-doublebedroom2	0
03_A03.02-kdl2B4P	0
03_A03.03-doublebedroom1	0
03_A03.03-doublebedroom2	0
03_A03.03-kdl3B5P	0
03_A03.03-singlebedroom	0
03_A03.04-doublebedroom1	0
03_A03.04-doublebedroom2	0
03_A03.04-kdl2B4P	0
03_A03.05-doublebedroom	0
03_A03.05-kdl1B2P	0
03_B02.07-doublebedroom1	0
03_B02.07-doublebedroom2	0
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	0
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	0
03_D03.01-kdl2B3P	0
03_D03.01-singlebedroom	0
03_D03.02-doublebedroom	0
03_D03.02-kdl1B2P	0
03_D03.03-doublebedroom	0
03_D03.03-kdl1B2P	0
03_D03.04-doublebedroom	0
03_D03.04-kdl2B3P	0
03_D03.04-singlebedroom	0
03_D03.05-doublebedroom	0.1
03_D03.05-kdl1B2P	0.2
06_A06.01-doublebedroom	0
06_A06.01-kdl2B3P	0
06_A06.01-singlebedroom	0
06_A06.02-doublebedroom	0
06_A06.02-kdl1B2P	0
06_B06.01-kdl2B3P	0
06_D06.01-doublebedroom	0
06_D06.01-kdl1B2P	0
06_D06.02-doublebedroom1	0
06_D06.02-doublebedroom2	0
06_D06.02-kdl3B5P	0
06_D06.02-singlebedroom	0
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

Appendix D – Criterion B Results

WEATHER FILE: DSY 1 – MVHR

Room	Night-time hours >26°C per annum
01_A01.01-doublebedroom1	69
01_A01.01-doublebedroom2	73
01_A01.01-singlebedroom	67
01_A01.02-doublebedroom1	72
01_A01.02-doublebedroom2	74
03_A03.01-doublebedroom1	27
03_A03.01-doublebedroom2	21
03_A03.01-singlebedroom	26
03_A03.02-doublebedroom1	44
03_A03.02-doublebedroom2	43
03_A03.03-doublebedroom1	72
03_A03.03-doublebedroom2	59
03_A03.03-singlebedroom	62
03_A03.04-doublebedroom1	48
03_A03.04-doublebedroom2	50
03_A03.05-doublebedroom	28
03_B02.07-doublebedroom1	38
03_B02.07-doublebedroom2	36
03_B02.08-doublebedroom1	52
03_B02.08-doublebedroom2	66
03_B02.08-singlebedroom	32
03_D03.01-doublebedroom	25
03_D03.01-singlebedroom	16
03_D03.02-doublebedroom	37
03_D03.03-doublebedroom	53
03_D03.04-doublebedroom	53
03_D03.04-singlebedroom	56
03_D03.05-doublebedroom	23
06_A06.01-doublebedroom	68
06_A06.01-singlebedroom	73
06_A06.02-doublebedroom	138
06_D06.01-doublebedroom	68
06_D06.02-doublebedroom1	195
06_D06.02-doublebedroom2	200
06_D06.02-singlebedroom	149
07_B06.01-doublebedroom	57
07_B06.01-singlebedroom	55

WEATHER FILE: DSY 1 – MVHR +G-0.4

Room	Night-time hours >26˚C per annum
01_A01.01-doublebedroom1	64
01_A01.01-doublebedroom2	68
01_A01.01-singlebedroom	62
01_A01.02-doublebedroom1	63
01_A01.02-doublebedroom2	64
03_A03.01-doublebedroom1	26
03_A03.01-doublebedroom2	20
03_A03.01-singlebedroom	26
03_A03.02-doublebedroom1	38
03_A03.02-doublebedroom2	36
03_A03.03-doublebedroom1	58
03_A03.03-doublebedroom2	50
03_A03.03-singlebedroom	54
03_A03.04-doublebedroom1	40
03_A03.04-doublebedroom2	44
03_A03.05-doublebedroom	25
03_B02.07-doublebedroom1	32
03_B02.07-doublebedroom2	32
03_B02.08-doublebedroom1	47
03_B02.08-doublebedroom2	60
03_B02.08-singlebedroom	28
03_D03.01-doublebedroom	24
03_D03.01-singlebedroom	16
03_D03.02-doublebedroom	33
03_D03.03-doublebedroom	44
03_D03.04-doublebedroom	42
03_D03.04-singlebedroom	50
03_D03.05-doublebedroom	20
06_A06.01-doublebedroom	63
06_A06.01-singlebedroom	67
06_A06.02-doublebedroom	116
06_D06.01-doublebedroom	64
06_D06.02-doublebedroom1	159
06_D06.02-doublebedroom2	169
06_D06.02-singlebedroom	124
07_B06.01-doublebedroom	55
07_B06.01-singlebedroom	48

WEATHER FILE: DSY 1 – MVHR +G-0.4+ MVHR with Cooling

Room	Night-time hours >26°C per annum
01_A01.01-doublebedroom1	0
01_A01.01-doublebedroom2	0
01_A01.01-singlebedroom	0
01_A01.02-doublebedroom1	0
01_A01.02-doublebedroom2	0
03_A03.01-doublebedroom1	5
03_A03.01-doublebedroom2	1
03_A03.01-singlebedroom	5
03_A03.02-doublebedroom1	0
03_A03.02-doublebedroom2	0
03_A03.03-doublebedroom1	0
03_A03.03-doublebedroom2	0
03_A03.03-singlebedroom	0
03_A03.04-doublebedroom1	0
03_A03.04-doublebedroom2	0
03_A03.05-doublebedroom	3
03_B02.07-doublebedroom1	1
03_B02.07-doublebedroom2	1
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	0
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	5
03_D03.01-singlebedroom	1
03_D03.02-doublebedroom	0
03_D03.03-doublebedroom	0
03_D03.04-doublebedroom	0
03_D03.04-singlebedroom	0
03_D03.05-doublebedroom	2
06_A06.01-doublebedroom	0
06_A06.01-singlebedroom	0
06_A06.02-doublebedroom	0
06_D06.01-doublebedroom	0
06_D06.02-doublebedroom1	0
06_D06.02-doublebedroom2	0
06_D06.02-singlebedroom	0
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

WEATHER FILE: DSY 2 – MVHR +G-0.4+ MVHR with Cooling

Room	Night-time hours >26°C per annum
01_A01.01-doublebedroom1	0
01_A01.01-doublebedroom2	0
01_A01.01-singlebedroom	0
01_A01.02-doublebedroom1	0
01_A01.02-doublebedroom2	0
03_A03.01-doublebedroom1	16
03_A03.01-doublebedroom2	11
03_A03.01-singlebedroom	14
03_A03.02-doublebedroom1	0
03_A03.02-doublebedroom2	0
03_A03.03-doublebedroom1	0
03_A03.03-doublebedroom2	0
03_A03.03-singlebedroom	0
03_A03.04-doublebedroom1	0
03_A03.04-doublebedroom2	0
03_A03.05-doublebedroom	12
03_B02.07-doublebedroom1	12
03_B02.07-doublebedroom2	16
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	0
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	18
03_D03.01-singlebedroom	11
03_D03.02-doublebedroom	0
03_D03.03-doublebedroom	0
03_D03.04-doublebedroom	0
03_D03.04-singlebedroom	0
03_D03.05-doublebedroom	12
06_A06.01-doublebedroom	0
06_A06.01-singlebedroom	0
06_A06.02-doublebedroom	0
06_D06.01-doublebedroom	0
06_D06.02-doublebedroom1	0
06_D06.02-doublebedroom2	0
06_D06.02-singlebedroom	0
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

WEATHER FILE: DSY 3 – MVHR +G-0.4+MVHR with Cooling

Room	Night-time hours >26˚C per annum
01_A01.01-doublebedroom1	0
01_A01.01-doublebedroom2	0
01_A01.01-singlebedroom	0
01_A01.02-doublebedroom1	0
01_A01.02-doublebedroom2	0
03_A03.01-doublebedroom1	35
03_A03.01-doublebedroom2	27
03_A03.01-singlebedroom	31
03_A03.02-doublebedroom1	0
03_A03.02-doublebedroom2	0
03_A03.03-doublebedroom1	0
03_A03.03-doublebedroom2	0
03_A03.03-singlebedroom	0
03_A03.04-doublebedroom1	0
03_A03.04-doublebedroom2	0
03_A03.05-doublebedroom	25
03_B02.07-doublebedroom1	24
03_B02.07-doublebedroom2	24
03_B02.08-doublebedroom1	0
03_B02.08-doublebedroom2	0
03_B02.08-singlebedroom	0
03_D03.01-doublebedroom	38
03_D03.01-singlebedroom	22
03_D03.02-doublebedroom	0
03_D03.03-doublebedroom	0
03_D03.04-doublebedroom	0
03_D03.04-singlebedroom	0
03_D03.05-doublebedroom	25
06_A06.01-doublebedroom	0
06_A06.01-singlebedroom	0
06_A06.02-doublebedroom	0
06_D06.01-doublebedroom	0
06_D06.02-doublebedroom1	0
06_D06.02-doublebedroom2	0
06_D06.02-singlebedroom	0
07_B06.01-doublebedroom	0
07_B06.01-singlebedroom	0

Appendix E – Prorated Results

Block A	Block B	Block C	Block D
A-01.01	B-01.01	C-01.03	D-01.01
A-01.02	B-01.02	C-01.04	D-01.02
A-01.03	B-02.01	C-02.09	D-01.03
A-01.04	B-02.02	C-02.10	D-01.04
A-01.05	B-02.03	C-02.11	D-01.05
A-01.06	B-02.04	C-02.12	D-02.01
A-02.01	B-02.05	C-02.13	D-02.02
A-02.02	B-02.06	C-02.14	D-02.03
A-02.03	B-02.07	C-02.15	D-02.04
A-02.04	B-02.08	C-02.16	D-02.05
A-02.05	B-04.01	C-04.09	D-03.01
A-02.06	B-04.02	C-04.10	D-03.02
A-03.01	B-04.03	C-04.11	D-03.03
A-03.02	B-04.04	C-04.12	D-03.04
A-03.03	B-04.05	C-04.13	D-03.05
A-03.04	B-04.06	C-04.14	D-04.01
A-03.05	B-04.07	C-04.15	D-04.02
A-04.01	B-04.08	C-04.16	D-04.03
A-04.02	B-06.01	C-06.09	D-04.04
A-04.03	B-06.02	C-06.10	D-04.05
A-04.04	B-06.03	C-06.11	D-05.01
A-04.05	B-06.04	C-06.12	D-05.02
A-05.01	B-06.05	C-06.13	D-06.01
A-05.02	B-06.06	C-06.14	D-06.02
A-05.03	B-06.07	C-06.15	
A-05.04	B-06.08	C-06.16	
A-06.01			
A-06.02			

	Block A	Block B	Block C	Block D	TOTAL
Strategy 1	10	0	0	7	17
Strategy 2	0	14	14	0	28
Strategy 3	18	12	12	17	59
TOTAL	28	26	26	24	104

Strategy 1			**Supply Temperature**
MVHR	2	ach	Summer bypass
Strategy 2			
G-value 0.4	2	ach	Summer bypass
Strategy 3			
MVHR with Cooling	2	ach	$T_{supply} = T_{external} - 15^{o}C$