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COLDHARBOUR FARM ROAD DEVELOPMENT, EMSWORTH
OVERHEATING REPORT

Prepared by: CBG Consultants Ltd
South House, 3 Farmoor Court, Cumnor Road, Oxford, OX2 9LU
Tel: 01865 864500
www.cbgc.com

Prepared for: Genesis Town Planning
26 Chapel Street
Chichester
West Sussex
PO19 1DL



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1. EXECUTIVE SUMMARY

This report has been prepared for Genesis Town Planning to assess the risk of overheating in 15 dwellings within the proposed development to west of Coldharbour Farm Road, Emsworth. The modelled dwellings are plots 39-44 in Block Type D, and Plots 18-26 which are Type A1.

Modelling results from WYG's Noise Assessment (June 2019) showed that when windows are open, internal noise levels are likely to exceed both daytime and night-time criteria. This means that open windows cannot be used as a means of providing background ventilation, nor as a method of managing overheating in summer months. It is therefore assumed that mechanical ventilation with heat recovery (MVHR) will provide fresh air to each dwelling.

The work presented in this report uses CIBSE TM59 *Design Methodology for the Assessment of Overheating Risk in Homes* (2017) to determine the risk of overheating. This is a standardised approach to predicting overheating risk for residential building designs using dynamic thermal analysis. CIBSE TM59 states:

For homes with restricted window openings, the CIBSE fixed temperature test must be followed, i.e. all occupied rooms should not exceed an operative temperature of 26°C for more than 3% of the annual occupied annual hours.

We have run three simulations (all with windows closed) to demonstrate the likely internal temperatures results:

1. Background ventilation only. These ventilation rates are typical to meet the Part F minimum fresh air rates: 8 l/s for bedrooms, 13 l/s for living rooms. It is assumed the system will be balanced by extracting from kitchens and bathrooms.
2. Increased mechanical ventilation rates. A maximum ventilation rate of 100 l/s per dwelling is typical for domestic MVHR units. Any higher and the MVHR unit and ductwork becomes too large, or the system becomes too noisy.
3. A system to cool the temperature of supply air. This reduces the peak temperature but does not condition the whole space to a set temperature. The ventilation rate remains the same as Simulation 2 with 100 l/s per dwelling.

Results show that even when ventilation rates are increased to 100 l/s per dwelling, temperatures in all occupied spaces still exceed 26°C for more than 3% of annual occupied hours and are therefore deemed to be at risk of overheating. A third simulation has demonstrated that by cooling the supply air, the CIBSE TM59 criterion can be achieved. A product for this solution could be the Zehnder ComfoCool Q600, or similar.

2. INTRODUCTION

This report has been prepared for Genesis Town Planning to assess the risk of overheating in 15 dwellings within the proposed development to west of Coldharbour Farm Road, Emsworth. This report has been commissions following the results of the Noise Assessment issued by WYG (A113742 *Coldharbour Emsworth Noise 28Jun19 incl Sketches.pdf*).

The dwellings included in this assessment are those closest to noise receptor locations R02, R03, R04 and R05, as shown in Figure 1. Block Type D to the south-west of the development contains six one-bedroom flats (Plots 39-44) – three on the ground floor, and three on the first floor. Three blocks of Type A1 are located across the southern boundary of the development (Plots 18-26). Each block contains three dwellings giving a total of nine two-storey, two-bedroom houses.



Figure 1: Dwellings included in this overheating risk assessment

Modelling results from WYG’s Noise Assessment showed that when windows are open, internal noise levels are likely to exceed both daytime and night-time criteria. The report therefore concluded that “all areas of the development will feature standard double glazing $R_w + C_{tr}$ 30 dB and an alternative means of ventilation in order to meet both ventilation and internal ambient noise criteria.”

This means that open windows cannot be used as a means of providing background ventilation, nor as a method of managing overheating in summer months. It is therefore likely that the proposed design will include mechanical ventilation with heat recovery (MVHR) as a means of providing fresh air to each dwelling.

The work presented in this report uses CIBSE TM59 *Design Methodology for the Assessment of Overheating Risk in Homes* (2017) to determine the risk of overheating. This is a standardised approach to predicting overheating risk for residential building designs using dynamic thermal analysis.

All results are based on the output from dynamic computer modelling software and should be taken as an indication of the likely final situation. These conditions, however, cannot be guaranteed and can be influenced by a variety of factors, including occupant lifestyle, where behaviour will not always conform to modelled assumptions.

3. CIBSE TM59 OVERHEATING CRITERIA

CIBSE TM59 outlines a specific methodology for how residential buildings should be modelled. The methodology is prescriptive so that it is consistently applied, and it allows different designs to be compared with a common approach. This includes:

- Standardised heat gains
- Standardised variation profiles
- Constraints for opening windows and doors
- Specific compliance criteria, which differs depending on whether a dwelling is predominantly naturally or mechanically ventilated.

CIBSE TM59 states that the methodology will not guarantee that people will always be comfortable. This standard is designed to preclude the worst levels of overheating and enables designers to find cost effective options to limit overheating risk.

3.1 CIBSE TM59 Criterion for Predominately Mechanically Ventilated Homes

CIBSE TM59 states:

For homes with restricted window openings, the CIBSE fixed temperature test must be followed, i.e. all occupied rooms should not exceed an operative temperature of 26°C for more than 3% of the annual occupied annual hours.

Occupied rooms are bedroom, kitchens and living areas. Results for transient spaces such as bathrooms and circulation areas should be reported, but do not need to meet the TM59 overheating criterion.

4. THERMAL MODEL

For this overheating assessment, a dynamic simulation model is been created in IES Virtual Environment software (version 2019.2.0.0). The creation of a dynamic model of this kind requires the definition of many variables including building fabric, internal heat gains, ventilation strategy, and occupant behaviour. These inputs are listed in this section.

4.1 Model Geometry

The orientation and geometry of the has been created from the following drawings:

- P0768-RHP-00-ZZ-PL-A-1001-Proposed Block Plan-P1.pdf
- P0768-RHP-ZZ-XX-DR-A-2001-House Type Block A1 Proposed Floorplans and Elevations-P1.pdf
- P0768-RHP-ZZ-XX-DR-A-2007-Appartment Type D Block Proposed Floorplans and Elevations-P1.pdf - 02-08-19.pdf

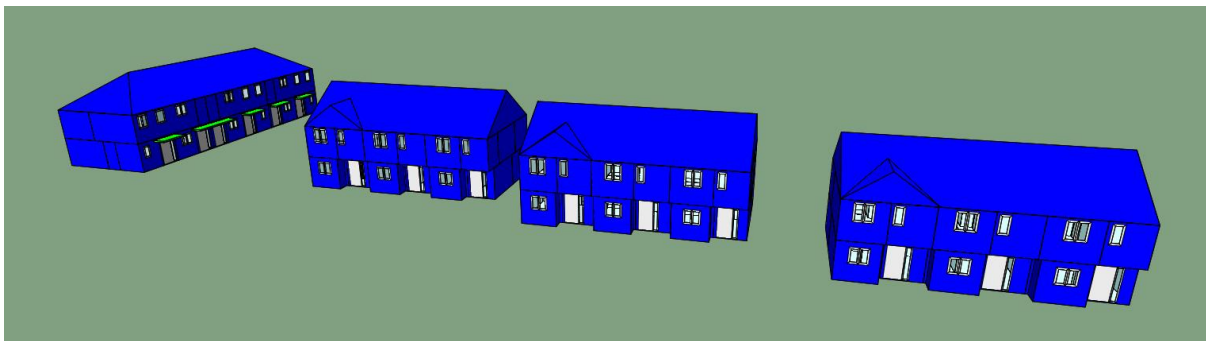


Figure 2: IES model

4.2 Weather Data

CIBSE TM59 states the weather file to be used is the DSY1 file most appropriate to the site location, for the 2020s, high emissions, 50% percentile scenario. As Southampton is the nearest location, the model uses the *Southampton_DSY1_2020High50_.epw* weather file.

4.3 Constructions

Table 1 shows the thermal properties applied to the model. These are indicative values provided by project architect Spencer Hatton. The indicative glazing U-value provided was 1.2 W/m²K which is typical for a centre-pane U-value in double glazing. In the thermal model the U-value must also account for the frame, i.e. the whole unit. We have therefore used an adjusted U-value of 1.4 W/m²K to represent the whole unit. (For comparison, a whole-unit U-value of 1.2 W/m²K would be triple glazing.)

Element Type	U Value (W/m ² K)	G Value	Construction
Walls	0.20	-	Insulated cavity wall, plasterboard finish
Floor	0.12	-	Slab on ground, screed over insulation
Roof	0.11	-	Insulated at ceiling level
Solid Doors	1.20	-	-
Glazing	1.40	0.6	Double glazing

Table 1: Constructions applied to the model

An air leakage rate of 0.25 air changes per hour has been assumed.

4.4 Internal Gains

The internal gains from people, lighting and equipment have been based on the guidance provided in CIBSE TM59. Table 1 lists the daily profiles used for each type of occupied room within the model: double bedrooms, kitchen/living areas in Block Type D, and separate kitchens and living rooms in Block Type A1.

Unit/ room type	Occupancy	Equipment load
1-bedroom apartment: living room/kitchen	1 person from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 450 W from 6 pm to 8 pm 200 W from 8 pm to 10 pm 110 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 85 W for the rest of the day
2-bedroom apartment: living room	2 people at 75% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 150 W from 6 pm to 10 pm 60 W from 9 am to 6 pm and from 10 pm to 12 pm Base load of 35 W for the rest of the day
2-bedroom apartment: kitchen	2 people at 25% gains from 9 am to 10 pm; room is unoccupied for the rest of the day	Peak load of 300 W from 6 pm to 8 pm Base load of 50 W for the rest of the day
Double bedroom	2 people at 70% gains from 11 pm to 8 am 2 people at full gains from 8 am to 9 am and from 10 pm to 11 pm 1 person at full gain in the bedroom from 9 am to 10 pm	Peak load of 80 W from 8 am to 11 pm Base load of 10 W during the sleeping hours

Table 2: Internal heat gain profiles from CIBSE TM59

Following the CIBSE TM59 methodology, lighting energy is assumed to be proportional to floor area, i.e. measured in W/m². From 6 pm to 11 pm, 2 W/m² is assumed for an efficient new-build home. This assumes that good daylight levels are available.



4.5 Ventilation

New dwellings are built to be very air-tight in order to reduce heat loss. This means mechanical ventilation with heat recovery (MVHR) is now a common solution to maintain fresh air levels (as required by Part F), especially when external noise prohibits the opening of windows.

In the first simulation, MVHR with an in-built summer bypass function has been modelled to provide good levels of fresh air, without the use of heat recovery in summer months. The bypass opens when the extract air temperature exceeds the outside temperature. By providing this facility, the heat exchanger is isolated and the risk of unnecessarily warming the incoming air is removed. However, the ventilation rates from domestic MVHR units are sized to provide enough fresh air for occupants; they are not designed to provide the large quantities required to manage overheating in summer. We have therefore completed three simulations (all with windows closed) to demonstrate the results:

1. Background ventilation only.
2. Increased mechanical ventilation rates.
3. A system to cool the temperature of supply air.

Internal doors have been included in the model. They have been modelled as open during the day but closed when the occupants are sleeping.

Note: it is still best practice to provide openable windows so that the occupants can choose how to manage their environment. However, the purpose of this assessment is to determine a ventilation/overheating mitigation strategy that does not rely on opening windows. The occupant should not have to choose between it being too hot with windows closed, or it being too noisy from open windows.

4.5.1 Simulation 1: Background Ventilation Only

In this simulation we have modelled a typical domestic MVHR unit running in summer bypass mode i.e. no heat recovery, the supply air is external air temperature. The ventilation rates are typical to meet the Part F minimum fresh air rates:

- Bedrooms: 8 l/s
- Living areas: 13 l/s

It is assumed the system will be balanced by extracting air from kitchens and bathrooms.

4.5.2 Simulation 2: Boosted Mechanical Ventilation Rates

In the second simulation we have modelled higher mechanical ventilation rates to help dissipate internal heat gains. The ventilation rates that are achievable are limited by the size of the MVHR unit and ductwork. Increasing the ventilation rate through same sized ductwork increases the pressure which increases the noise. Depending on the MVHR product used, the maximum supply for the whole dwelling would be around 100 l/s. We have therefore divided that flow rate as follows:

- Dwelling Type A1
 - Living room: 50 l/s
 - Bedroom 1: 25 l/s
 - Bedroom 2: 25 l/s
- Dwelling Type D
 - Living area: 65 l/s
 - Bedroom: 35 l/s

4.5.3 Simulation 3: Tempered Supply Air

In the third simulation we have modelled a scenario where the supply air is cooled. This reduces the peak temperature but does not condition the whole space to a set temperature. An example product is the Zehnder ComfoCool Q¹. It sits on top of their MVHR unit to provide a 1.5 kW cooling capacity. Unlike split cooling systems, it does not require an external heat pump, it just uses the ventilation unit ductwork (Figure 3). It does require a larger MVHR unit and therefore a suitable location needs to be designed into the dwelling layout – see Figure 4 for dimensions. Ventilation rates in each space remain the same as Simulation 2.

¹ <https://www.zehnder.co.uk/products-and-systems/comfortable-indoor-ventilation/system-extensionsystem-extensionsystem>



Figure 3: The Zehnder ComfoCool system

Height	1780 mm
Width	733 mm
Depth	564 mm

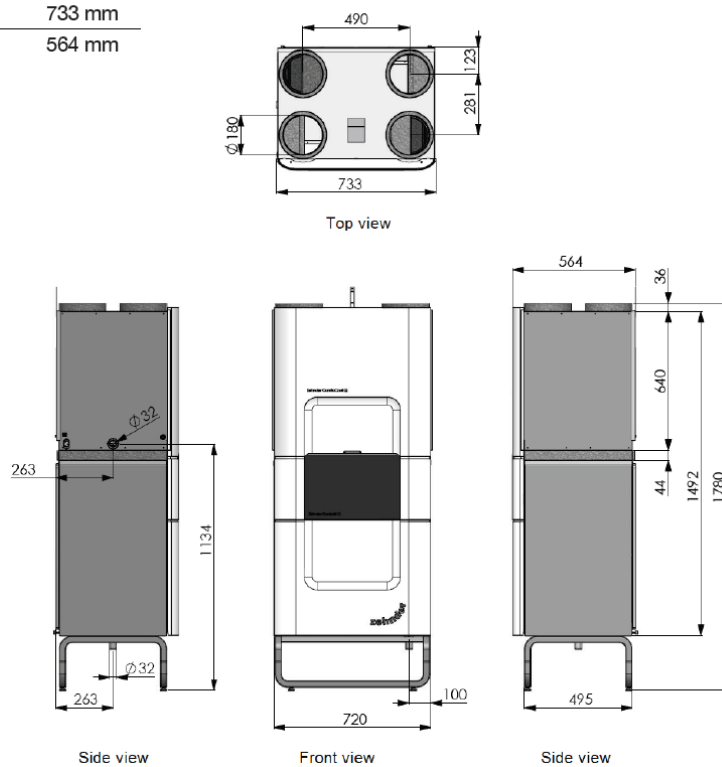


Figure 4: Dimensions of the Zehnder ComfoCool system: the cooling unit sits on top of their ComfoAir Q600 unit to create a complete, packaged system

5. OVERHEATING RESULTS

During these dynamic simulations the room temperatures are calculated on an hourly basis and are measured against the CIBSE TM59 target: all occupied rooms should not exceed an operative temperature of 26°C for more than 3% of the annual occupied annual hours.

5.1 Simulation 1: Background Ventilation Only

Results show significant overheating in all occupied spaces and all therefore all fail to comply with the 3% target. A full table of results is in Appendix A. Table 3 shows a summary; out of all the occupied spaces modelled a peak temperature of 38.8°C was recorded the kitchen/living area of Plot 40. This is a top-floor flat in Block D where the west-facing orientation means the peak solar gains coincide with the peak internal gains of the early evening. Results from spaces within the two-bedroom houses are slightly better—not exceeding 34.6°C—but the percentage of hours over 26°C still significantly exceeds the 3% limit.

	Minimum	Maximum	Mean
Peak temperature when occupied	33.2°C Living room in Plot 21	38.9°C Kitchen/Living in Plot 40	34.6°C Average peak of all occupied spaces
% hours above 26°C	23%	30%	26%

Table 3: Results from Simulation 1

5.2 Simulation 2: Boosted Mechanical Ventilation Rates

In simulation 2, where ventilation rates were boosted to 100 l/s per dwelling, results have improved but all spaces still fail to meet the 3% target. A full table of results is in Appendix B. Table 4 shows a summary; peak temperatures are still very high, but there is a noticeable reduction in the percentage of hours over 26°C. Now, on average, spaces exceed 26°C for 7% of annual occupied hours, compared to 26% in simulation 1. However, this is still deemed to be too high and all spaces are at risk of overheating.

	Minimum	Maximum	Mean
Peak temperature when occupied	30.2°C Living room in Plot 21	33.5°C Kitchen/Living in Plot 40	31.1°C Average peak of all occupied spaces
% hours above 26°C	5%	13%	7%

Table 4: Results from Simulation 2

5.3 Simulation 3: Tempered Supply Air

Results from Simulation 3 show that when the supply air of 100 l/s per dwelling is cooled, all spaces comply with the CIBSE TM59 overheating criterion. A full table of results is in Appendix C. Table 4 shows a summary; although peak temperatures still are still high, they happen very infrequently. This is demonstrated by results showing all spaces remain below 26°C for the vast majority of the year.

	Minimum	Maximum	Mean
Peak temperature when occupied	25.9°C Kitchen/Living in Plot 42	29.1°C Kitchen/Living in Plot 40	27.2°C Average peak of all occupied spaces
% hours above 26°C	0%	2%	1%

Table 5: Results from Simulation 3

6. CONCLUSION

This report has demonstrated that if windows are kept closed to limit noise from outside, the risk of overheating is significant, especially if mechanical ventilation rates are designed for background fresh air only. Even when ventilation rates are increased to 100 l/s per dwelling, temperatures in occupied spaces still exceed 26°C for more than 3% of annual occupied hours. Under the industry-standard guidance of CIBSE TM59, this means there is a risk of overheating. Increasing the mechanical ventilation rate enough to manage the overheating is not possible with domestic-scale MVHR units. A third simulation has demonstrated that by cooling the supply air, the CIBSE TM59 criterion can be achieved. An example product for this solution is the Zehnder ComfoCool Q600.

APPENDIX A: SIMULATION 1 RESULTS - BACKGROUND VENTILATION ONLY

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
A1_18 Bathroom	32.3	-	-	-	-
A1_18 Bedroom 1	33.4	33.4	8760	23	Fail
A1_18 Bedroom 2	33.3	33.3	8760	25	Fail
A1_18 Hall	33.2	-	-	-	-
A1_18 Kitchen	34.1	34.1	4745	-	-
A1_18 Landing	33.1	-	-	-	-
A1_18 Living	33.3	33.3	4745	24	Fail
A1_18 WC	32.2	-	-	-	-
A1_19 Bathroom	33.2	-	-	-	-
A1_19 Bedroom 1	33.9	33.9	8760	25	Fail
A1_19 Bedroom 2	34.1	34.1	8760	27	Fail
A1_19 Hall	33.6	-	-	-	-
A1_19 Kitchen	34.5	34.5	4745	-	-
A1_19 Landing	33.7	-	-	-	-
A1_19 Living	33.8	33.8	4745	26	Fail
A1_19 WC	32.6	-	-	-	-
A1_20 Bathroom	32.2	-	-	-	-
A1_20 Bedroom 1	33.5	33.5	8760	23	Fail
A1_20 Bedroom 2	33.8	33.8	8760	25	Fail
A1_20 Hall	33.1	-	-	-	-
A1_20 Kitchen	34.2	34.2	4745	-	-
A1_20 Landing	33.2	-	-	-	-
A1_20 Living	33.4	33.4	4745	24	Fail
A1_20 WC	32.2	-	-	-	-
A1_21 Bathroom	33.2	-	-	-	-
A1_21 Bedroom 1	33.5	33.5	8760	24	Fail
A1_21 Bedroom 2	33.7	33.7	8760	26	Fail
A1_21 Hall	33.3	-	-	-	-
A1_21 Kitchen	34.2	34.2	4745	-	-
A1_21 Landing	33.3	-	-	-	-
A1_21 Living	33.2	33.2	4745	25	Fail
A1_21 WC	32.3	-	-	-	-
A1_22 Bathroom	33.3	-	-	-	-
A1_22 Bedroom 1	34.0	34.0	8760	25	Fail
A1_22 Bedroom 2	34.2	34.2	8760	27	Fail
A1_22 Hall	33.6	-	-	-	-
A1_22 Kitchen	34.6	34.6	4745	-	-
A1_22 Landing	33.8	-	-	-	-
A1_22 Living	33.8	33.8	4745	26	Fail
A1_22 WC	32.6	-	-	-	-
A1_23 Bathroom	32.3	-	-	-	-
A1_23 Bedroom 1	33.5	33.5	8760	23	Fail
A1_23 Bedroom 2	33.8	33.8	8760	26	Fail
A1_23 Hall	33.1	-	-	-	-
A1_23 Kitchen	34.2	34.2	4745	-	-
A1_23 Landing	33.2	-	-	-	-
A1_23 Living	33.4	33.4	4745	24	Fail
A1_23 WC	32.2	-	-	-	-

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
A1_24 Bathroom	33.2	-	-	-	-
A1_24 Bedroom 1	33.6	33.6	8760	24	Fail
A1_24 Bedroom 2	33.7	33.7	8760	26	Fail
A1_24 Hall	33.3	-	-	-	-
A1_24 Kitchen	34.2	34.2	4745	-	-
A1_24 Landing	33.4	-	-	-	-
A1_24 Living	33.2	33.2	4745	25	Fail
A1_24 WC	32.3	-	-	-	-
A1_25 Bathroom	33.3	-	-	-	-
A1_25 Bedroom 1	34.0	34.0	8760	25	Fail
A1_25 Bedroom 2	34.2	34.2	8760	27	Fail
A1_25 Hall	33.7	-	-	-	-
A1_25 Kitchen	34.6	34.6	4745	-	-
A1_25 Landing	33.8	-	-	-	-
A1_25 Living	33.8	33.8	4745	26	Fail
A1_25 WC	32.6	-	-	-	-
A1_26 Bathroom	32.3	-	-	-	-
A1_26 Bedroom 1	33.5	33.5	8760	24	Fail
A1_26 Bedroom 2	33.9	33.9	8760	26	Fail
A1_26 Hall	33.2	-	-	-	-
A1_26 Kitchen	34.3	34.3	4745	-	-
A1_26 Landing	33.2	-	-	-	-
A1_26 Living	33.4	33.4	4745	24	Fail
A1_26 WC	32.3	-	-	-	-
D_39 Bathroom	32.6	-	-	-	-
D_39 Bedroom	37.3	37.3	8760	28	Fail
D_39 Hall	37.0	-	-	-	-
D_39 Kitchen/Living	38.7	38.7	4745	30	Fail
D_39 Store	32.6	-	-	-	-
D_40 Bathroom	33.6	-	-	-	-
D_40 Bedroom	38.0	38.0	8760	29	Fail
D_40 Hall	37.3	-	-	-	-
D_40 Kitchen/Living	38.9	38.9	4745	30	Fail
D_40 Store	33.9	-	-	-	-
D_41 Bathroom	32.7	-	-	-	-
D_41 Bedroom	37.3	37.3	8760	28	Fail
D_41 Hall	37.0	-	-	-	-
D_41 Kitchen/Living	38.6	38.6	4745	30	Fail
D_41 Store	32.8	-	-	-	-
D_42 Bathroom	35.0	-	-	-	-
D_42 Bedroom	36.4	36.4	8760	27	Fail
D_42 Hall	35.2	-	-	-	-
D_42 Kitchen/Living	35.4	35.4	4745	27	Fail
D_42 Stairs	34.0	-	-	-	-
D_42 Store	34.0	-	-	-	-
D_43 Bathroom	34.8	-	-	-	-
D_43 Bedroom	36.8	36.8	8760	28	Fail
D_43 Hall	35.5	-	-	-	-
D_43 Kitchen/Living	35.9	35.9	4745	28	Fail
D_43 Stairs	34.1	-	-	-	-

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
D_43 Store	34.3	-	-	-	-
D_44 Bathroom	34.7	-	-	-	-
D_44 Bedroom	36.4	36.4	8760	27	Fail
D_44 Hall	35.1	-	-	-	-
D_44 Kitchen/Living	35.4	35.4	4745	27	Fail
D_44 Stairs	33.9	-	-	-	-
D_44 Store	33.9	-	-	-	-

APPENDIX B: SIMULATION 2: RESULTS - BOOSTED MECHANICAL VENTILATION RATES

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
A1_18 Bathroom	29.7	-	-	-	-
A1_18 Bedroom 1	30.4	30.4	8760	5	Fail
A1_18 Bedroom 2	30.4	30.4	8760	5	Fail
A1_18 Hall	30.4	-	-	-	-
A1_18 Kitchen	31.4	31.4	4745	-	-
A1_18 Landing	30.2	-	-	-	-
A1_18 Living	30.2	30.2	4745	7	Fail
A1_18 WC	29.4	-	-	-	-
A1_19 Bathroom	30.6	-	-	-	-
A1_19 Bedroom 1	30.8	30.8	8760	5	Fail
A1_19 Bedroom 2	31.1	31.1	8760	6	Fail
A1_19 Hall	30.7	-	-	-	-
A1_19 Kitchen	31.7	31.7	4745	-	-
A1_19 Landing	30.7	-	-	-	-
A1_19 Living	30.6	30.6	4745	8	Fail
A1_19 WC	29.6	-	-	-	-
A1_20 Bathroom	30.0	-	-	-	-
A1_20 Bedroom 1	30.5	30.5	8760	5	Fail
A1_20 Bedroom 2	30.9	30.9	8760	6	Fail
A1_20 Hall	30.4	-	-	-	-
A1_20 Kitchen	31.5	31.5	4745	-	-
A1_20 Landing	30.2	-	-	-	-
A1_20 Living	30.3	30.3	4745	7	Fail
A1_20 WC	29.4	-	-	-	-
A1_21 Bathroom	30.5	-	-	-	-
A1_21 Bedroom 1	30.5	30.5	8760	5	Fail
A1_21 Bedroom 2	30.6	30.6	8760	6	Fail
A1_21 Hall	30.5	-	-	-	-
A1_21 Kitchen	31.5	31.5	4745	-	-
A1_21 Landing	30.4	-	-	-	-
A1_21 Living	30.2	30.2	4745	7	Fail
A1_21 WC	29.5	-	-	-	-
A1_22 Bathroom	30.6	-	-	-	-
A1_22 Bedroom 1	30.9	30.9	8760	5	Fail
A1_22 Bedroom 2	31.1	31.1	8760	7	Fail
A1_22 Hall	30.7	-	-	-	-
A1_22 Kitchen	31.7	31.7	4745	-	-
A1_22 Landing	30.7	-	-	-	-
A1_22 Living	30.5	30.5	4745	8	Fail
A1_22 WC	29.7	-	-	-	-
A1_23 Bathroom	30.0	-	-	-	-
A1_23 Bedroom 1	30.5	30.5	8760	5	Fail
A1_23 Bedroom 2	30.9	30.9	8760	6	Fail
A1_23 Hall	30.4	-	-	-	-
A1_23 Kitchen	31.5	31.5	4745	-	-
A1_23 Landing	30.3	-	-	-	-
A1_23 Living	30.3	30.3	4745	7	Fail

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
A1_23 WC	29.5	-	-	-	-
A1_24 Bathroom	30.5	-	-	-	-
A1_24 Bedroom 1	30.5	30.5	8760	5	Fail
A1_24 Bedroom 2	30.6	30.6	8760	6	Fail
A1_24 Hall	30.5	-	-	-	-
A1_24 Kitchen	31.5	31.5	4745	-	-
A1_24 Landing	30.4	-	-	-	-
A1_24 Living	30.3	30.3	4745	7	Fail
A1_24 WC	29.5	-	-	-	-
A1_25 Bathroom	30.6	-	-	-	-
A1_25 Bedroom 1	30.9	30.9	8760	5	Fail
A1_25 Bedroom 2	31.1	31.1	8760	7	Fail
A1_25 Hall	30.7	-	-	-	-
A1_25 Kitchen	31.7	31.7	4745	-	-
A1_25 Landing	30.7	-	-	-	-
A1_25 Living	30.6	30.6	4745	8	Fail
A1_25 WC	29.7	-	-	-	-
A1_26 Bathroom	30.1	-	-	-	-
A1_26 Bedroom 1	30.6	30.6	8760	5	Fail
A1_26 Bedroom 2	30.9	30.9	8760	6	Fail
A1_26 Hall	30.4	-	-	-	-
A1_26 Kitchen	31.5	31.5	4745	-	-
A1_26 Landing	30.3	-	-	-	-
A1_26 Living	30.3	30.3	4745	7	Fail
A1_26 WC	29.5	-	-	-	-
D_39 Bathroom	29.0	-	-	-	-
D_39 Bedroom	31.9	31.9	8760	5	Fail
D_39 Hall	31.9	-	-	-	-
D_39 Kitchen/Living	33.4	33.4	4745	10	Fail
D_39 Store	28.2	-	-	-	-
D_40 Bathroom	29.5	-	-	-	-
D_40 Bedroom	32.5	32.5	8760	6	Fail
D_40 Hall	32.1	-	-	-	-
D_40 Kitchen/Living	33.5	33.5	4745	10	Fail
D_40 Store	29.2	-	-	-	-
D_41 Bathroom	29.1	-	-	-	-
D_41 Bedroom	31.9	31.9	8760	5	Fail
D_41 Hall	31.9	-	-	-	-
D_41 Kitchen/Living	33.4	33.4	4745	10	Fail
D_41 Store	28.4	-	-	-	-
D_42 Bathroom	30.6	-	-	-	-
D_42 Bedroom	31.6	31.6	8760	5	Fail
D_42 Hall	30.5	-	-	-	-
D_42 Kitchen/Living	30.7	30.7	4745	6	Fail
D_42 Stairs	29.9	-	-	-	-
D_42 Store	29.3	-	-	-	-
D_43 Bathroom	30.5	-	-	-	-
D_43 Bedroom	32.0	32.0	8760	5	Fail
D_43 Hall	30.8	-	-	-	-
D_43 Kitchen/Living	31.0	31.0	4745	7	Fail

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
D_43 Stairs	30.1	-	-	-	-
D_43 Store	29.5	-	-	-	-
D_44 Bathroom	30.5	-	-	-	-
D_44 Bedroom	31.6	31.6	8760	5	Fail
D_44 Hall	30.5	-	-	-	-
D_44 Kitchen/Living	30.7	30.7	4745	6	Fail
D_44 Stairs	29.9	-	-	-	-
D_44 Store	29.3	-	-	-	-

APPENDIX C: SIMULATION 3 RESULTS - TEMPERED SUPPLY AIR

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
A1_18 Bathroom	27.2	-	-	-	-
A1_18 Bedroom 1	26.4	26.4	8760	0	Pass
A1_18 Bedroom 2	26.3	26.3	8760	0	Pass
A1_18 Hall	27.1	-	-	-	-
A1_18 Kitchen	28.3	28.3	4745	-	-
A1_18 Landing	26.5	-	-	-	-
A1_18 Living	26.3	26.3	4745	0	Pass
A1_18 WC	26.4	-	-	-	-
A1_19 Bathroom	28.0	-	-	-	-
A1_19 Bedroom 1	26.7	26.7	8760	0	Pass
A1_19 Bedroom 2	27.0	27.0	8760	0	Pass
A1_19 Hall	27.3	-	-	-	-
A1_19 Kitchen	28.4	28.4	4745	-	-
A1_19 Landing	26.9	-	-	-	-
A1_19 Living	26.6	26.6	4745	0	Pass
A1_19 WC	26.6	-	-	-	-
A1_20 Bathroom	27.9	-	-	-	-
A1_20 Bedroom 1	26.5	26.5	8760	0	Pass
A1_20 Bedroom 2	27.0	27.0	8760	0	Pass
A1_20 Hall	27.1	-	-	-	-
A1_20 Kitchen	28.3	28.3	4745	-	-
A1_20 Landing	26.6	-	-	-	-
A1_20 Living	26.4	26.4	4745	0	Pass
A1_20 WC	26.5	-	-	-	-
A1_21 Bathroom	28.0	-	-	-	-
A1_21 Bedroom 1	26.5	26.5	8760	0	Pass
A1_21 Bedroom 2	26.7	26.7	8760	0	Pass
A1_21 Hall	27.1	-	-	-	-
A1_21 Kitchen	28.3	28.3	4745	-	-
A1_21 Landing	26.7	-	-	-	-
A1_21 Living	26.3	26.3	4745	0	Pass
A1_21 WC	26.5	-	-	-	-
A1_22 Bathroom	28.0	-	-	-	-
A1_22 Bedroom 1	26.7	26.7	8760	0	Pass
A1_22 Bedroom 2	27.0	27.0	8760	0	Pass
A1_22 Hall	27.3	-	-	-	-
A1_22 Kitchen	28.5	28.5	4745	-	-
A1_22 Landing	26.9	-	-	-	-
A1_22 Living	26.6	26.6	4745	0	Pass
A1_22 WC	26.6	-	-	-	-
A1_23 Bathroom	27.9	-	-	-	-
A1_23 Bedroom 1	26.5	26.5	8760	0	Pass
A1_23 Bedroom 2	27.0	27.0	8760	0	Pass
A1_23 Hall	27.1	-	-	-	-
A1_23 Kitchen	28.4	28.4	4745	-	-
A1_23 Landing	26.7	-	-	-	-
A1_23 Living	26.5	26.5	4745	0	Pass
A1_23 WC	26.5	-	-	-	-

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
A1_24 Bathroom	28.0	-	-	-	-
A1_24 Bedroom 1	26.5	26.5	8760	0	Pass
A1_24 Bedroom 2	26.7	26.7	8760	0	Pass
A1_24 Hall	27.1	-	-	-	-
A1_24 Kitchen	28.3	28.3	4745	-	-
A1_24 Landing	26.7	-	-	-	-
A1_24 Living	26.3	26.3	4745	0	Pass
A1_24 WC	26.5	-	-	-	-
A1_25 Bathroom	28.0	-	-	-	-
A1_25 Bedroom 1	26.7	26.7	8760	0	Pass
A1_25 Bedroom 2	27.1	27.1	8760	0	Pass
A1_25 Hall	27.3	-	-	-	-
A1_25 Kitchen	28.5	28.5	4745	-	-
A1_25 Landing	26.9	-	-	-	-
A1_25 Living	26.6	26.6	4745	0	Pass
A1_25 WC	26.6	-	-	-	-
A1_26 Bathroom	28.0	-	-	-	-
A1_26 Bedroom 1	26.6	26.6	8760	0	Pass
A1_26 Bedroom 2	27.0	27.0	8760	0	Pass
A1_26 Hall	27.2	-	-	-	-
A1_26 Kitchen	28.4	28.4	4745	-	-
A1_26 Landing	26.7	-	-	-	-
A1_26 Living	26.5	26.5	4745	0	Pass
A1_26 WC	26.5	-	-	-	-
D_39 Bathroom	26.5	-	-	-	-
D_39 Bedroom	27.6	27.6	8760	0	Pass
D_39 Hall	27.7	-	-	-	-
D_39 Kitchen/Living	29.0	29.0	4745	1	Pass
D_39 Store	25.3	-	-	-	-
D_40 Bathroom	26.6	-	-	-	-
D_40 Bedroom	27.9	27.9	8760	0	Pass
D_40 Hall	27.9	-	-	-	-
D_40 Kitchen/Living	29.1	29.1	4745	1	Pass
D_40 Store	25.7	-	-	-	-
D_41 Bathroom	26.6	-	-	-	-
D_41 Bedroom	27.6	27.6	8760	0	Pass
D_41 Hall	27.7	-	-	-	-
D_41 Kitchen/Living	29.0	29.0	4745	1	Pass
D_41 Store	25.4	-	-	-	-
D_42 Bathroom	27.5	-	-	-	-
D_42 Bedroom	27.1	27.1	8760	0	Pass
D_42 Hall	26.2	-	-	-	-
D_42 Kitchen/Living	25.9	25.9	4745	0	Pass
D_42 Stairs	26.4	-	-	-	-
D_42 Store	25.4	-	-	-	-
D_43 Bathroom	27.7	-	-	-	-
D_43 Bedroom	27.4	27.4	8760	0	Pass
D_43 Hall	26.4	-	-	-	-
D_43 Kitchen/Living	26.2	26.2	4745	0	Pass
D_43 Stairs	26.6	-	-	-	-

Room Name	Peak Temp (°C)	Peak Occupied Temp (°C)	Annual Occupied Time (Hours)	All Occupied Rooms. Operative Temp (% Occupied Hours > 26°C)	Outcome
D_43 Store	25.5	-	-	-	-
D_44 Bathroom	27.6	-	-	-	-
D_44 Bedroom	27.1	27.1	8760	0	Pass
D_44 Hall	26.2	-	-	-	-
D_44 Kitchen/Living	26.0	26.0	4745	0	Pass
D_44 Stairs	26.4	-	-	-	-
D_44 Store	25.4	-	-	-	-



OXFORD: South House, Farmoor Court, Cumnor Road, Oxford, OX2 9LU

Tel: 01865 864500

Email: oxf@cbgc.com

LONDON: 38 Warren Street, London, W1T 6AE

Tel: 02073 874 175

Email: lon@cbgc.com

www.cbgc.com