DESIGN NOTE

Project: **Holly Walk**

Doc Ref: **4593 DSN03 r1**

Date: **16th June 2020**

Subject: **Overheating Analysis and The Requirement for Additional Cooling**

Queen Square House
18-21 Queen Square
Bristol
BS1 4NH

0117 238 0909

1 Introduction

1.1 Document Overview

This document summarises the predicted overheating risk of the proposed works at 11 Holly Walk, in line with Camden Council Local Plan document 'Energy Efficiency and Adaptation CPG', clause 10.5.

The building is a large 2 bedroom dwelling. It is split over 4 levels, with the kitchen and dining room in a basement space at the bottom and an attic studio space at the top. The dining room, study, living room and studio spaces all have large panels of glazing which can be opened fully to provide natural ventilation.

As the building is domestic, the results will be compared with CIBSE TM59 overheating criteria, in line with the requirements of the aforementioned CPG.

TM59 sets out guidance as to what the internal conditions in the building will be, including peak internal gains and their variation profiles. It also sets out criteria to which the results can be compared in order to predict if the spaces will be comfortable for occupants. The criteria for spaces occupied during the day generally track external temperatures over the year, accounting for what the occupant is used to- whether that is warmer or cooler weather. The criteria for bedrooms is more rigid to account for occupants' vulnerability and sensitivity while sleeping.

1.2 Software

The design analysis has been carried out using a 3D building model in IES virtual environment software. This software is approved for use as a compliance tool for Part L2A calculations.

1.3 Weather Data

The weather files used in this analysis are the CIBSE DSY (Design Summer Years) files for overheating analysis. CIBSE weather files are available for the following emissions scenarios.

2020: High emissions, 10th/50th/90th Percentile
2050: Medium/High emissions, 10th/50th/90th Percentile
2080: Low/Medium/High emissions, 10th/50th/90th Percentile

Each location has 3 DSY scenarios available, representing different types of hot spells.

DSY 1: Moderately warm summer
DSY 2: Short, intense spell
DSY 3: Long, less intense warm spell

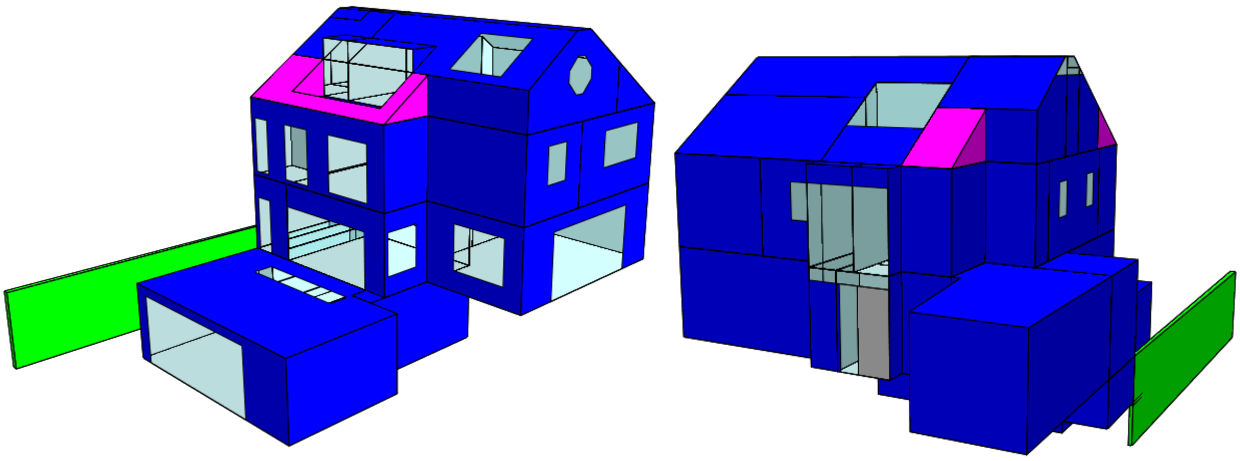
CIBSE TM59 recommends that the DSY1 2020 (50th Percentile) weather file is used for overheating analysis. The weather file location selected for this analysis was London.

2 Model Geometry and Assumptions

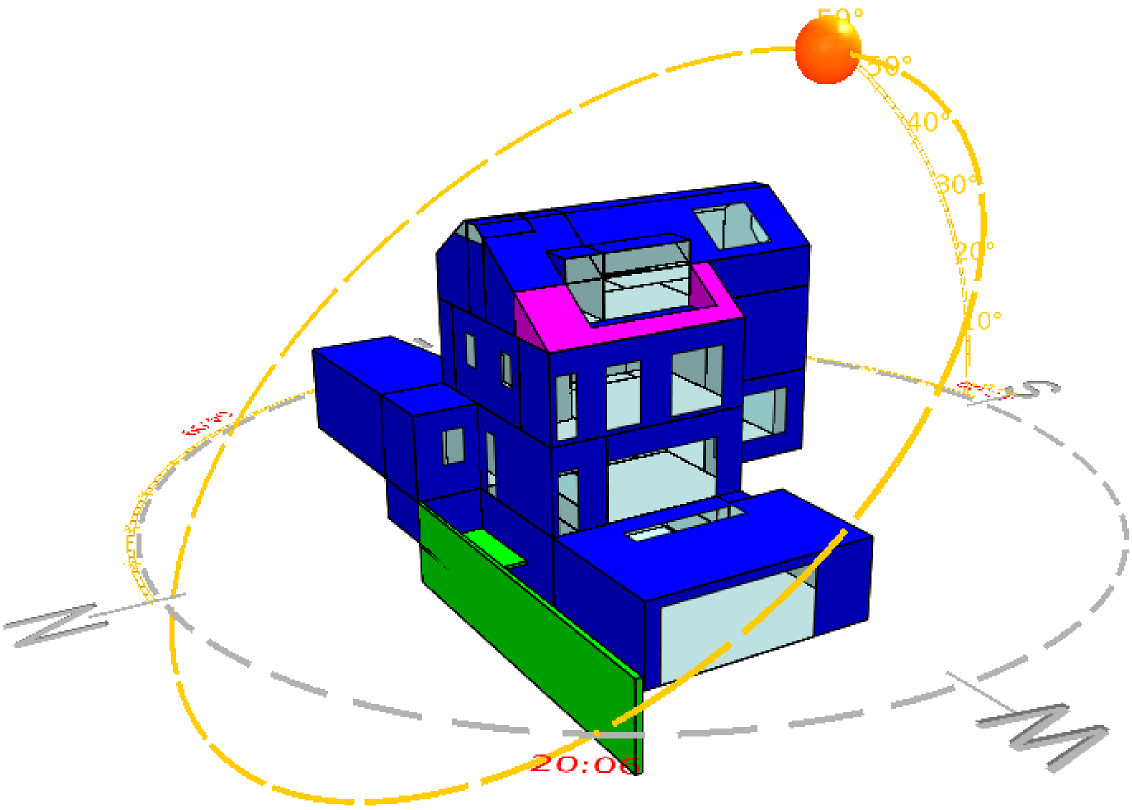
2.1 Geometry

The image below illustrates the model used in the analysis. The model was built using the following architects' drawings issued on 27th May 2020:

- HLW-100: Lower Ground Floor Plan
- HLW-101: Ground Floor Plan
- HLW-102: First Floor Plan
- HLW-103: Second Floor Plan
- HLW-300: East Elevation
- HLW-301: South Elevation
- HLW-302: West Elevation
- HLW-303: North Elevation



3D building model in IES



Sunpath tracking at 5pm in June

2.2 Constructions

The following assumptions are applied to the model. All constructions and U values are assumed based on standard dwelling construction types and should be reviewed and confirmed by the architect.

Fabric Element	Element Build Up	U Value / G Value
Walls		
EW01	Domestic brick wall	0.26W/m^{2}K
Internal Partition		
IW01	Plasterboard cavity wall	
Floors		
GF01	Concrete floor slab, with wood flooring	0.18W/m^{2}K
Internal Floor/Ceiling		
IF01	Joist cavity with plasterboard ceiling below and wood flooring above	
Roofs		
R01	Existing pitched roof, wood joists with roof tiles	0.34W/m^{2}K
R02	Concrete roof slab, with plasterboard ceiling below	0.17W/m^{2}K
External Glazing		
G01	Existing timber frame, double glazed windows	U value = 2.6W/m^{2}K G value = 0.7
G02	New aluminium, double glazed doors	U value = 1.4W/m^{2}K G value = 0.6
G03	New timber, double glazed windows	U value = 1.6W/m^{2}K G value = 0.6
RL01	Rooflights	U value = 1.3W/m^{2}K G value = 0.6
Air Permeability m3/hm2	5m^3/m^2/hr	0.2ach

2.3 Internal Heat Gains

The table below shows the internal gains applied to the building. The gain profiles specified in CIBSE TM59 have been used in the kitchen, living room, dining room and bedrooms. Where the room profiles are not defined by TM59, National Calculation Methodology (NCM) data has been used.

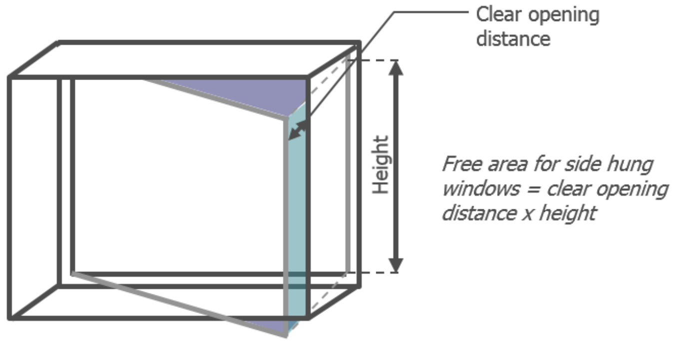
The table below summarises the internal gains and ventilation rates used in the key rooms of the base model.

Space Name	Occupied Hours (time)	Occupancy (People)	Lighting Sensible Load (W/m^2)	Equipment Sensible Load (W)	Reference
Living room	9am-10pm	2	5	150 peak 35 base	TM59
Dining room	9am-10pm	2	5	150 peak 35 base	TM59: living room
Kitchen	9am-10pm	2	5	300 peak 50 base	TM59
Bedrooms	2 people: 10pm-9am 1 person: 9am-10pm	2	5	80 peak 10 base	TM59
Studio	9am-4pm	2	7.5	150 base	NCM: small workshop
Study	8am-6pm	1	7.5	225 base	NCM: office

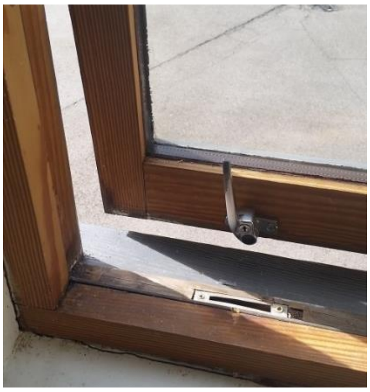
Internal gains and ventilation rates specified within the model

2.4 Ventilation Strategy

Openable percentage is the free area expressed as a percentage of the opening drawn in E3 IES model (which is the structural opening).



Free area calculation method

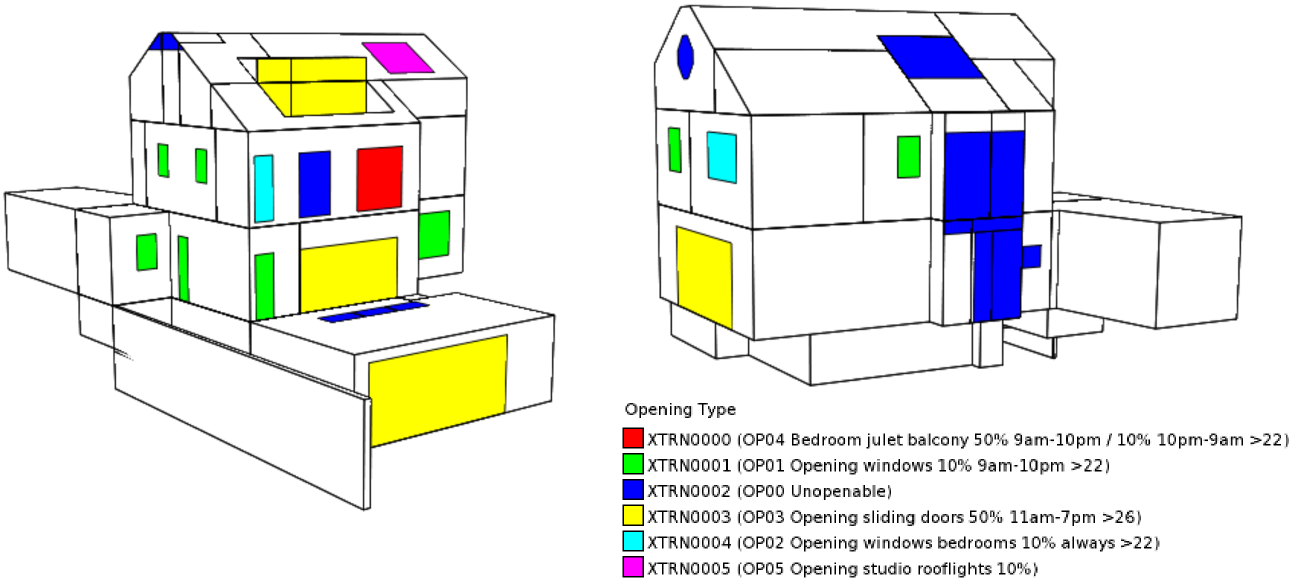


Example of a window opening impeded by reveal

The clear opening distance is the unobstructed distance for ventilation (refer to image above, left). It should take into account the frame thickness, window sills, reveals, and any other restrictions, see image above, right for an example of a window where the clear opening distance would be reduced as a result of the window reveal. It should be noted that it is often significantly less than the length of a window restrictor, or an actuator's stroke length. Any free area assumptions made by E3 for the thermal analysis must be reviewed and confirmed by the architect. We would strongly recommend that architect's window schedules and drawings produced for procurement clearly state the free area (in m^2) that is to be achieved for each window.

The images below show the window free areas applied to the final model. Free areas have been assumed by E3 and should be confirmed by the architect. TM59 advises that windows should be modelled as opened when internal air temperatures exceed 22°C and the room is occupied. See explanations below for the parameters of each opening type.

- OP00: Unopenable windows
- OP01: Windows openable to 10% from 9am-10pm when the air temperature exceeds 22°C.
- OP02: Bedroom windows openable to 10% at all times when the air temperature exceeds 22°C.
- OP03: Sliding doors openable to 50% from 11am-7pm when the air temperature exceeds 26°C. Doors modelled in groups so 50% allows for unopenable panels.
- OP04: Bedroom 2 juliet balcony openable to 50% between 9am-10pm when air temperature exceeds 22°C. Overnight, openable to 10% when air temperature exceeds 22°C.
- OP05: Rooflights in studio openable to 10% when air temperature exceeds 22°C.



This analysis considers ventilation for occupant comfort only, and does not consider the purge ventilation requirements outlined in Appendix B of Building Regulations Approved Document Part F. This contains requirements regarding minimum sizes for opening windows and doors which the architect should agree directly with the building control approved inspector.

2.5 Additional Assumptions

- The shading effect from any window reveals has not been considered.
- Glazing has been modelled in simplified blocks, with openings reduced to account for unopenable panels.
- All free areas have been assumed based on standard domestic windows.

3 Overheating Results

3.1.1 Criteria

CIBSE TM59 'Design methodology for assessment of overheating risk in homes' uses dynamic thermal analysis to provide a standard approach for predicting overheating in residential buildings. The testing methodology focusses on flats, but is also applicable to houses. TM59 provides different compliance criteria for buildings that are predominantly naturally vented, and buildings that are predominantly mechanically vented.

As this house is predominantly naturally ventilated, the criteria that it will be compared against are:

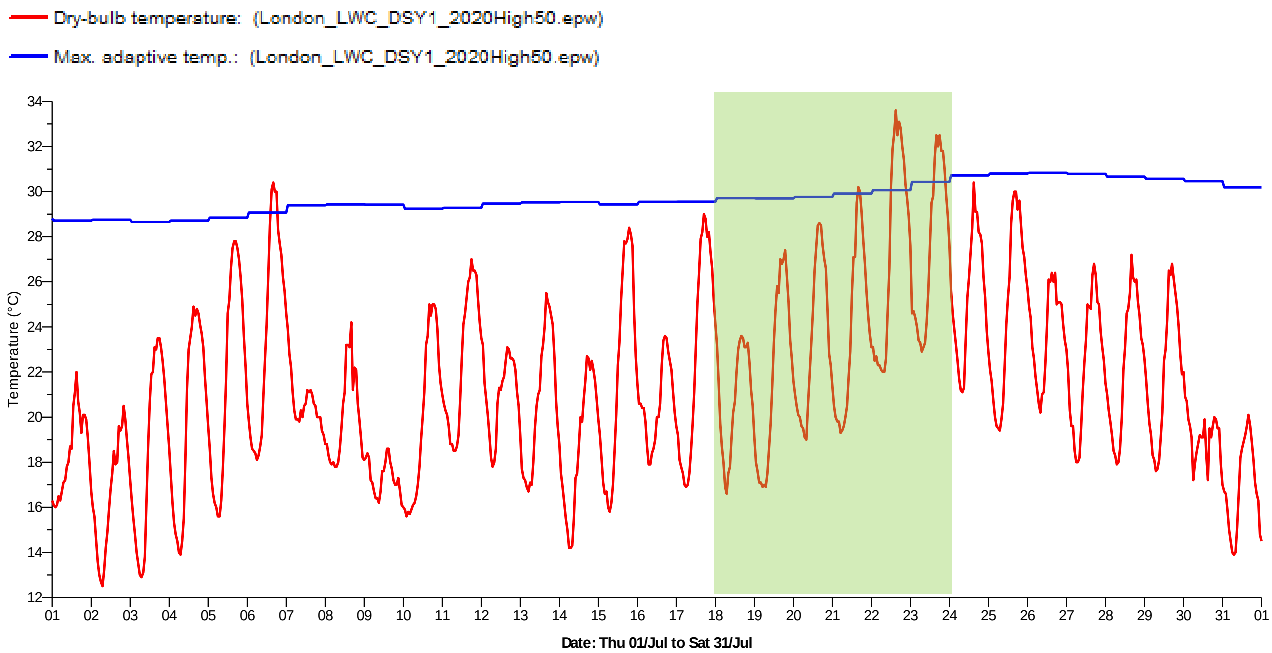
- Living rooms, kitchens and bedrooms: The operative temperature (T_{op}) of the space should not exceed T_{max} (defined below) by 1°C for more than 3% of occupied hours.

- Bedrooms: For overnight comfort, between 10pm and 7am the operative temperature should not exceed 26ºC for more than 1% of annual occupied hours, this equates to 32 hours.

Occupied rooms should also be capable of achieving the purge ventilation criteria set out in Part F of the Building Regulations for England. This requires the spaces to be capable of achieving a purge ventilation rate of 4ach.

T_{max} is a temperature given by a function of the 'daily running mean' of the external temperature, and a factor given for the vulnerability of the building's occupants. In this analysis we have selected the factor for category 3 which is applicable to moderate expectation in existing buildings.

It is designed to adapt with the weather to account for the occupant's adjusting expectations. The relationship between the predicted outdoor dry-bulb temperature and the maximum adaptive temperature for Central London (London Weather Centre DSY1 2020) in July is shown in the figure below.



Max adaptive temperature and dry bulb temperature for London Weather Centre DSY1 2020 in July

3.1.2 Results

The table below shows the TM59 results for each space.

Annual cumulative overheating		
Room Name	%Occupied Hrs T_{op}-T_{max}≥1K	**Pass/Fail**
Max. acceptable value	*3*	
RB.01 Kitchen	3.6	**Fail**
RB.02 Dining	5.6	**Fail**
RG.03 Living Room	3	**Fail**
RG.04 Study	3.5	**Fail**
RF.03 Bedroom 2	5.8	**Fail**
RF.05 Bedroom 1	4.7	**Fail**
RS.02 Studio	8.2	**Fail**

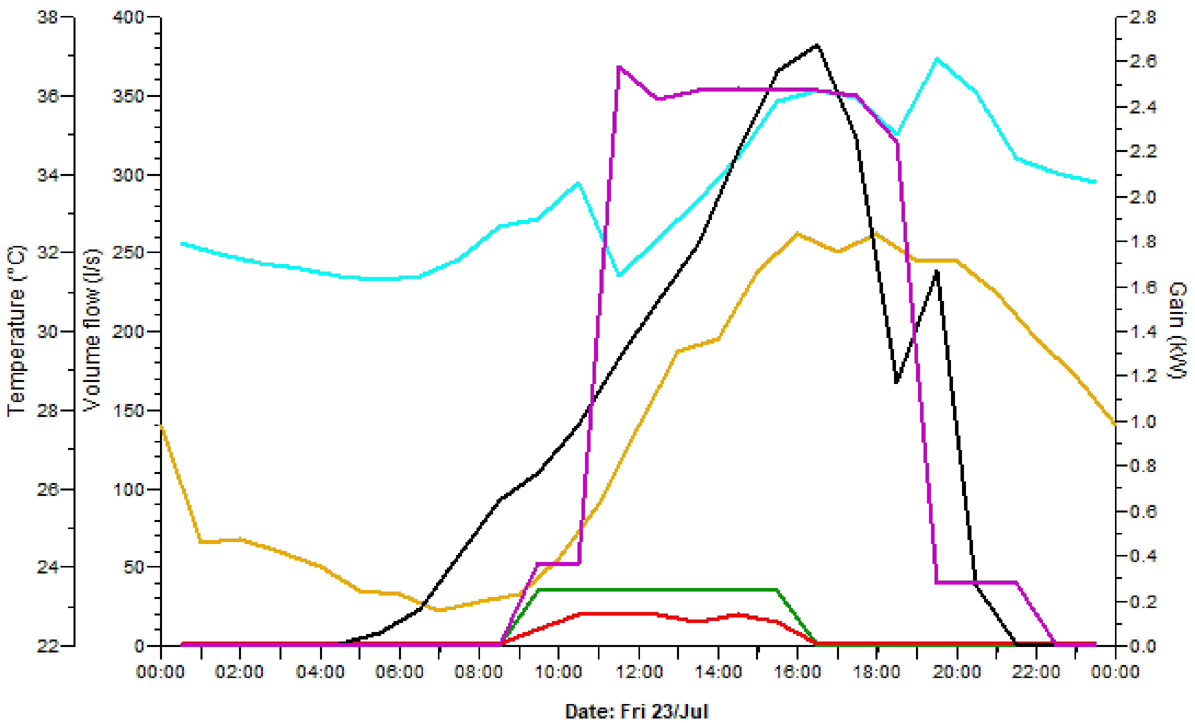
TM59 results for all occupied spaces (living rooms, kitchens, bedrooms)

The table below shows the TM59 results for bedrooms between 10pm and 7am.

Overnight temperature (10pm-7am)		
Room Name	Max. Occupied Hrs T_{op}≥26°C	**Pass/Fail**
Max. acceptable value	*1% = 32hrs*	
RF.03 Bedroom 2	116 (3.6%)	**Fail**
RF.05 Bedroom 1	101 (3.2%)	**Fail**

TM59 results for bedrooms at night

The graph below shows the internal operative temperature against the internal and solar gains experienced in the roofspace studio on the hottest day of the year, 23rd July.



Operative temperature and internal gains in the RS.02 Studio on 23 July

Discussion

The main spaces benefit from large openable areas in the form of sliding glazed doors. Solar gains are relatively high due to the large glazed areas, although this is offset by large openings providing high levels of natural cooling.

However, the spaces are not predicted to pass the criteria without additional measures.

The Cooling Hierarchy

The Camden Plan advises that all spaces should be considered under the 'cooling hierarchy' in order to prioritise passive measures over mechanical cooling. The following discussion addresses the energy hierarchy with respect to this building. Some elements are not discussed as this is an existing building and elements such as the floor to ceiling heights and building orientation cannot be altered.

Minimise internal heat generation through energy efficient design:

Spaces with the highest internal gains are located where solar gain is lowest. The laundry and plant spaces are located on the North side of the house. These rooms are also separate rooms, minimising the effect that their internal gains will have on the rest of the house.

The kitchen is located in the basement with no windows. The only other space located on this floor is the dining room which is likely to be used in conjunction with the kitchen. The dining room also benefits from large openable glazing which can be used to purge internal heat gains from both spaces.

Low energy lighting is proposed throughout. The modelled internal gains reflect this.

The spaces which are occupied at night benefit from night cooling. However, those on the ground and lower ground floor cannot as leaving windows open overnight would pose a security risk.

Reduce the amount of heat entering a building in summer:

The majority of the glazing is concentrated on the West facing façade, providing evening sunlight when the outside air temperature is cooler. This also allows the occupants to use less electric lighting in the evenings, saving on electricity and internal gains also.

The South façade includes one large panel of openable glazing into the living room. However with such high opening areas, the solar gain is offset by the high levels of natural ventilation cooling.

The balcony surrounding the glazed doors in the studio space will provide some solar shading.

Passive ventilation:

The building benefits from large openable areas in the form of openable windows and large glazed doors.

The open plan layout of the ground floor means that the spaces benefit from cross ventilation between the glazing in the study and living room.

The open plan layout of the basement floor allows the kitchen to benefit from natural ventilation via the dining room opening doors without additional direct solar gain.

Mechanical ventilation:

Mechanical ventilation has been modelled in the spaces where extract is required (e.g. kitchen). This encourages through flow of ventilation and air movement.

However, no centralised MVHR system is proposed. CIBSE and BRUK guidance on mechanically ventilated homes generally advises MVHR systems where building airtightness is $>3m^2/m^2/h$ @ 50Pa. As this is an existing dwelling, it is highly unlikely that this number is achieved, therefore the implementation of a full mechanical ventilation system would not be beneficial to the spaces and would waste energy.

Active cooling:

Active cooling is a last resort solution to ensure a comfortable internal temperature. However due to the 'urban heat island' effect, London has a particularly warm climate which can rise dramatically within a few days. For example, from July 18-23 (highlighted in green in section 3.1.1) the external air temperature rises by 9K over

5 days. This sort of steep rise is difficult for occupants to adjust to, and the criteria reflects that as it the external air temperature rises above the max allowable temperature.

As a result, natural ventilation alone can never provide sufficient natural cooling effect to pass the criteria as the outside air is too warm to cool the spaces to below T_{max}. We therefore recommend that comfort cooling is included in the design to provide cooling at peak times.

The cooling is to be provided by a high efficiency DX multi-split system.

To demonstrate the results and test the extent of cooling required, we modelled a further case where comfort cooling was introduced to the main occupied spaces while the spaces are occupied.

Further Analysis

As required by Camden Council's Energy Efficiency and Adaptation CPG, the table below outlines the level of cooling applied to each space to meet the criteria.

Cooling Provided	**OH2 Cooling**			
Room Name	Cooling Setpoint	Operating Hours	Peak Cooling Load	Annual Consumption
	°C		kW	kWh
RB.01 Kitchen	*No direct cooling, cooled indirectly by dining room system*			
RB.02 Dining	29	9am-10pm	9.2	237
RG.03 Living Room	29	9am-10pm	3.5	103
RG.04 Study	29	9am-10pm	10.9	105
RF.03 Bedroom 2	29 (day) / 26 (night)	All times	1.2	141
RF.05 Bedroom 1	29 (day) / 26 (night)	All times	4.7	326
RS.02 Studio	29	9am-10pm	4.3	220

Cooling applied to each space

The table below shows the TM59 results for each space with and without cooling.

Annual cumulative overheating	**OH1 Natural Vent Only**		**OH2 Cooling**	
Room Name	%Occupied Hrs T_{op}-T_{max}≥1K	Pass/Fail	%Occupied Hrs T_{op}-T_{max}≥1K	Pass/Fail
Max. acceptable value	*3*		*3*	
RB.01 Kitchen	3.6	**Fail**	0.2	**Pass**
RB.02 Dining	5.6	**Fail**	1.1	**Pass**
RG.03 Living Room	3	**Fail**	0.2	**Pass**
RG.04 Study	3.5	**Fail**	0.9	**Pass**
RF.03 Bedroom 2	5.8	**Fail**	0.2	**Pass**
RF.05 Bedroom 1	4.7	**Fail**	0.4	**Pass**
RS.02 Studio	8.2	**Fail**	2.5	**Pass**

TM59 results for all occupied spaces (living rooms, kitchens, bedrooms)

The table below shows the TM59 results for bedrooms between 10pm and 7am with and without cooling.

Overnight temperature (10pm-7am)	**OH1 Natural Vent Only**		**OH2 Cooling**	
Room Name	Max. Occupied Hrs T_{op}≥26°C	Pass/Fail	Max. Occupied Hrs T_{op}≥26°C	Pass/Fail
Max. acceptable value	*1% = 32hrs*		*1% = 32hrs*	
RF.03 Bedroom 2	116 (3.6%)	**Fail**	0	**Pass**
RF.05 Bedroom 1	101 (3.2%)	**Fail**	0	**Pass**

TM59 results for bedrooms at night

Based on the above cooling scenario, the cooling is only predicted to be required for 5% of the year on average. The rest of the year the building can be adequately cooled by passive means such as natural ventilation.

4 Conclusions

We would recommend that the architect verifies the key assumptions.

- Construction build-ups, U values and g values
- Ventilation free areas

Based on the analysis, we recommend that cooling is included in the main occupied spaces of the dwelling to provide the comfort conditions recommended under the TM59 guidance. With the highly variable London climate, it is not possible to maintain comfortable internal temperatures through natural ventilation alone.