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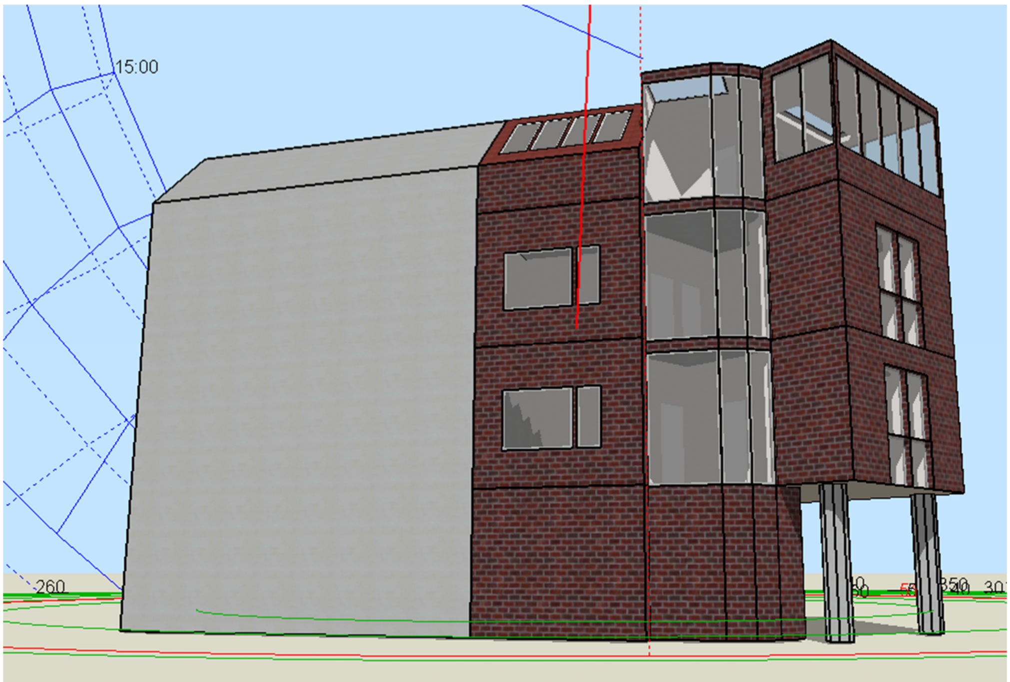
Dynamic Thermal Modelling

Proposed residential development at:

6J King Henrys Road, London, NW3 3RP



Author: H Dunn
Checked: J Southworth

29th January 2025

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Contents

1. Executive Summary

This report details the methodology and findings of a study into the overheating risk for the proposed refurbishment of a single dwelling at 6J King Henrys Road, London, NW3 3RP using dynamic thermal modelling. The purpose of this report is to assess the level of overheating risk after the level of mitigation provided by the proposed refurbishment works and application of acoustic restrictions on site. following the requirements of the cooling hierarchy.

<u>Description of development</u>

6J King Henrys Road is a four-storied end-terrace two-bedroom dwellinghouse. The existing building has uninsulated walls, roof and floor and single glazed windows.

The following works are proposed:

- Upgrading external glazing to double glazing where possible
- Addition of ceiling fans where possible
- Painting roof white to reflect solar gain
- Addition of solar panels on the roof
- High volumes of openable windows

<u>Dynamic Thermal Modelling and CIBSE TM59</u>

The building thermal model estimates the buildings environmental conditions and the calculation results are based on the modelling inputs and parameters as detailed herein this report in Section 5. Section 5 includes fabric U-values, internal heat gains, occupancy patterns, air permeability rate, ventilation strategy and window openings used for the thermal model.

Whilst what constitutes "too hot" is subjective, and will depend on both human and environmental factors, the health and wellbeing impacts of overheating can be severe. For

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example, very high temperatures (>35°C) can lead to stress, anxiety and even early deaths for vulnerable occupants, whilst high bedroom temperatures (>26°C) can lead to sleep deprivation.

This report provides an assessment of compliance against the requirements of Approved Document O, using the CIBSE TM59 thermal comfort metric[1].

In providing a prescriptive approach with clearly defined pass/fail criteria, CIBSE TM59:

- allows different designs to be compared with a common approach, based on reasonable assumptions;
- supports design decisions that improve comfort without cooling; and
- provides consistency across the industry, with all consultants using the same standardised methodology for the assessment of overheating risk in homes.

It should be noted the TM59 methodology will not guarantee that people will always be comfortable in compliant spaces, however they act, nor does it take into account unusual use.

This analysis has been performed using DesignBuilder software which provides full dynamic thermal analysis and is a CIBSE certified Level 5 approved Dynamic Simulation Modelling Software. This analysis has been carried out in accordance with user instructions set out in DesignBuilder manuals and CIBSE AM11 Building Energy and Environmental Modelling. The most current CIBSE Design Summer Year (DSY) Weather File for London Weather Centre was chosen for the simulation (London Weather Centre CIBSE DSY1 2020's high emissions 50th percentile range weather file), in accordance with CIBSE guide TM59:2017 "Design methodology for the assessment of overheating risk in homes" guidelines.

[1] As modified following the guidance of paragraph 2.6 of Approved Document O (detailed in Section 4 of this report).

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1.1. Results and conclusions:

Existing dwelling

All occupied zones within the existing dwelling have been found to be at high risk of overheating.

Proposed refurbishment and the cooling hierarchy

As part the proposed refurbishment works the following practicable passive means of limiting unwanted solar gains and removing excess heat have also been incorporated into the building by following the cooling hierarchy:

1. **Minimise internal heat generation through energy efficient design: All appliances will be A rated for energy efficiency and all lighting will be LED.**

2. **Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls: Glazing to be upgraded. Internal Blinds to be used and pipes to be insulated. Roof to be painted white and receive solar panels atop.**

3. **Manage the heat within the building through exposed internal thermal mass and high ceilings: The design retains high ceilings and exposed thermal mass.**

4. **Passive ventilation: The design has retained openable windows and cross ventilation throughout during the day. Due to acoustic constraints, windows are to remain closed in the bedrooms overnight. Openable rooflights in circulation to allow for stack ventilation.**

5. **Mechanical ventilation: Mechanical ventilation not to be included due to the dwelling overheating despite it's proposed installation (see Simulation 2). Ceiling fans to be integrated in all habitable spaces to promote ventilation.**

As the simulation results show, the passive design measures detailed above are sufficient for some zones to achieve thermal comfort without relying on comfort cooling. For the majority of zones that are still at high risk of overheating, comfort cooling should form part of the as-built specification in order to maintain thermal comfort during the hottest parts of the year.

Full details of the thermal comfort analysis follow.

2. CIBSE TM52 "The Limits of Thermal Comfort: Avoiding Overheating in European Buildings 2013"

CIBSE Technical Memorandum 52 provides a robust, yet balanced, assessment of the risk of overheating within buildings in the UK and Europe.

TM52 concludes that the temperatures at which a person feels comfortable are related to the outdoor temperature. This comfortable temperature is related to the thermal history the person experiences, with more recent experiences being more influential. For example during a hot period, people are more likely to wear lighter clothes and hence a higher indoor temperature is more likely to be comfortable. Therefore a running mean is used to describe the external conditions. This running mean puts greater weight on the temperature for the days closer to the present.

To help define whether or not a building overheats, CIBSE recommends that a maximum acceptable temperature, which is related to the external running mean temperature, is set.

Three criteria have been set, which are all defined in terms of the difference between the actual operative temperature in the room at any time and the maximum acceptable temperature.

1. **Criterion 1 (Hours of Exceedance)** sets a limit of 3% on the number of occupied hours that the operative temperature can exceed the threshold comfort temperature, Tmax, by 1K or more during the occupied hours of a typical non-heating season – 1 May to 30 September. Tmax is a function of the outdoor running-mean temperature.

2. **Criterion 2 (Daily Weighted Exceedance)** deals with the severity of overheating within any one day, which can be as important as its frequency. This is a function of both temperature above Tmax and its duration. This criterion sets a daily limit for acceptability. If each hour (or part-hour) in which the temperature exceeds Tmax by at least 1K is multiplied by the number of degrees by which it is exceeded, then this 'excess' should not be more than six degree-hours.

3. **Criterion 3 (Upper Limit Temperature)** sets an absolute maximum temperature of (Tmax + 4) °C for a room (Tupp), beyond which the level of overheating is unacceptable. The overheating risk is assessed between the 1st of May and the 31st of September.

3. CIBSE TM59 "Design methodology for the assessment of overheating risk in homes"

3.1. Criteria for homes predominantly naturally ventilated

Based on the principals of CIBSE TM52, CIBSE Technical Memorandum 59 sets two simplified criteria for compliance:

1. **Criterion A** - For living rooms, kitchens and bedrooms: the number of hours during which DT is greater than or equal to one degree (K) during the period May to September inclusive shall not be more than 3 per cent of occupied hours. (CIBSE TM52 Criterion 1: Hours of exceedance).
2. **Criterion B** - For bedrooms only: to guarantee comfort during the sleeping hours the operative temperature in the bedroom from 10 pm to 7 am 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).

3.2. Criteria for homes predominantly mechanically ventilated

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 (CIBSE Guide A (2015a)).

4. Approved Document O

To demonstrate compliance with Approved Document O using the dynamic thermal modelling method, all of the following guidance should be followed.

a. CIBSE's TM59 methodology for predicting overheating risk.

b. The limits on the use of CIBSE's TM59 methodology (detailed in Section 4.1).

c. The acceptable strategies for reducing overheating risk (detailed in Section 4.2)

4.1. Limits on CIBSE's TM59 modelling

CIBSE's TM59 method requires the modeller to make choices. Approved Document O applies limits to these choices. These limits should be applied when following the guidance in CIBSE's TM59.

All of the following limits on CIBSE's TM59, apply.

a. When a room is occupied during the day (8am to 11pm), openings should be modelled to do all of the following.

   i. Start to open when the internal temperature exceeds 22°C.

   ii. Be fully open when the internal temperature exceeds 26°C.

   iii. Start to close when the internal temperature falls below 26°C.

   iv. Be fully closed when the internal temperature falls below 22°C.

b. At night (11pm to 8am), openings should be modelled as fully open if both of the following apply.
    i. The opening is on the first floor or above and not easily accessible.
    ii. The internal temperature exceeds 23°C at 11pm.
c. When a ground floor or easily accessible room is unoccupied, both of the following apply.
    i. In the day, windows, patio doors and balcony doors should be modelled as open, if this can be done securely using fixed or lockable louvred shutters, window grilles or railings.
    ii. At night, windows, patio doors and balcony doors should be modelled as closed.
d. An entrance door should be included, which should be shut all the time.

4.2. Acceptable strategies for reducing overheating risk

4.2.1. Limiting solar gains

Solar gains in summer should be limited by any of the following means.

a. Fixed shading devices, comprising any of the following.
    i. Shutters.
    ii. External blinds.
    iii. Overhangs.
    iv. Awnings.
b. Glazing design, involving any of the following solutions.
    i. Size.
    ii. Orientation.
    iii. g-value.
    iv. Depth of the window reveal.
c. Building design – for example, the placement of balconies.
d. Shading provided by adjacent permanent buildings, structures or landscaping.

Although internal blinds and curtains provide some reduction in solar gains, they should not be taken into account when considering whether the requirements of Approved Document O have been met. Likewise shading from foliage, such as tree cover, should not be included.

4.2.2. Removing excess heat

Excess heat should be removed from the residential building by any of the following means.

a. Opening windows (the effectiveness of this method is improved by cross-ventilation).

b. Ventilation louvres in external walls.

c. A mechanical ventilation system.

d. A mechanical cooling system

The building should be constructed to meet the requirements of Approved Document O using passive means as far as reasonably practicable. It should be demonstrated to the building control body that all practicable passive means of limiting unwanted solar gains and removing excess heat have been used first before adopting mechanical cooling. Any mechanical cooling (air-conditioning) is expected to be used only where requirement O1 cannot be met using openings.

5. The Buildings

CIBSE TM59 stipulates that the sample of dwellings assessed should include those at greatest risk of overheating. These will typically be dwellings with the following characteristics:

a) having large areas of glazing;

b) on the topmost floor;

c) with less shading;

d) having large, sun-facing windows;

e) having a single aspect; or

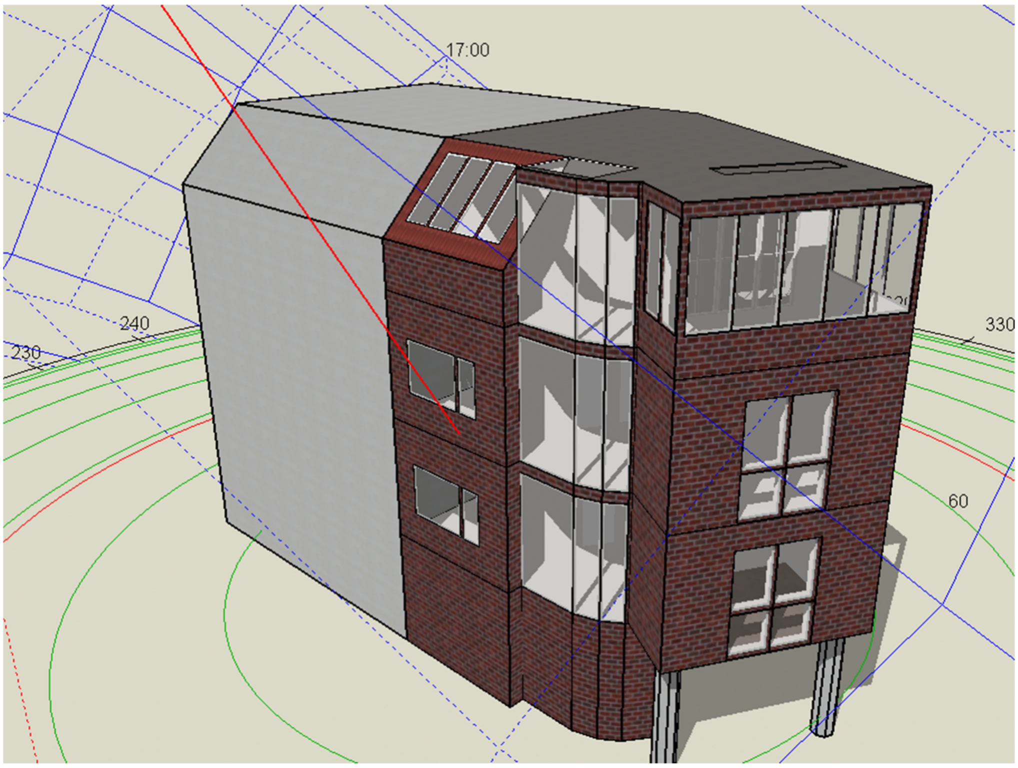
f) having limited openable windows.

This analysis has been undertaken on the sole dwelling within the proposed development. This dwelling contains the following zones:

- Bedrooms
- Bathrooms
- Living Rooms

- Study
- Winter Garden
- Store

Figure 1 - Graphical Image of Simulation Model:



6. The Model

The following factors affect the calculation of predicted indoor temperature by dynamic simulation model:

i. Mean outdoor temperatures.

ii. Geometry.

iii. External shading.

iv. Internal shading.

v. Fabric.

vi. Glazing.

vii. Infiltration.

viii. Internal gains.

ix. Natural ventilation.

x. Mechanical ventilation.

xi. Active cooling.

xii. Heat losses from pipework and heat interface units (HIUs)

Details for each of these are provided below.

6.1. Mean outdoor temperatures

In accordance with the guidance and recommendations of CIBSE TM59, representative dwellings have been modelled against the DSY1 weather file most appropriate to the site location (in this case the London Weather Centre weather file location), for the 2020s, high emissions, 50% percentile scenario.

6.2. Geometry

A 3-D model of the dwelling has been created based on information contained within the set of architects drawings provided to Achieve Green.

The dwelling has been split into internal zones based on the following activities:

- Kitchen Dining
- Living
- Bedrooms
- Bathrooms
- Circulation Areas

Figure 2 – proposed floor plans:

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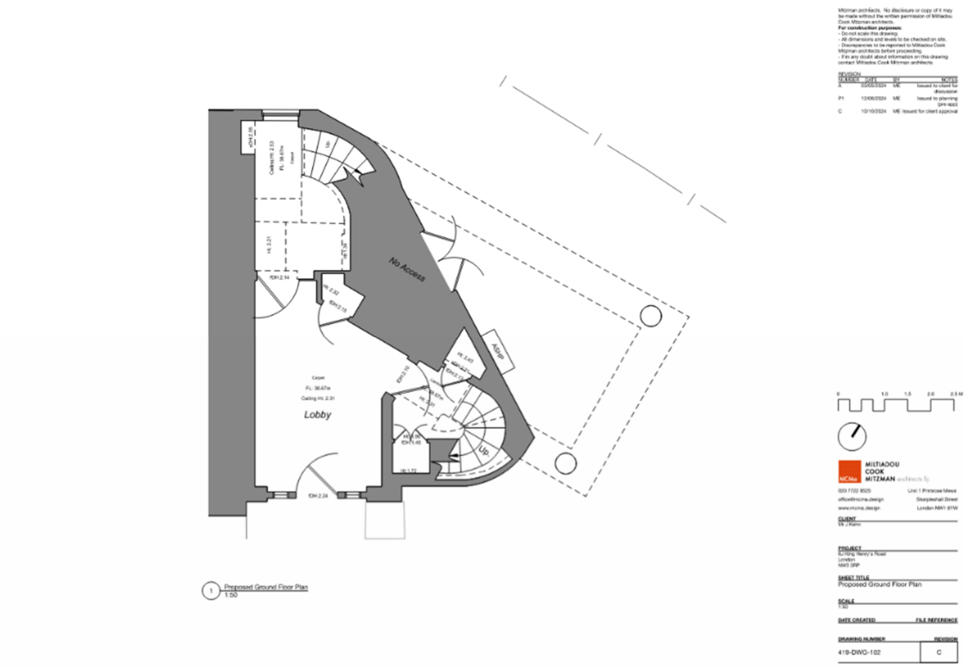

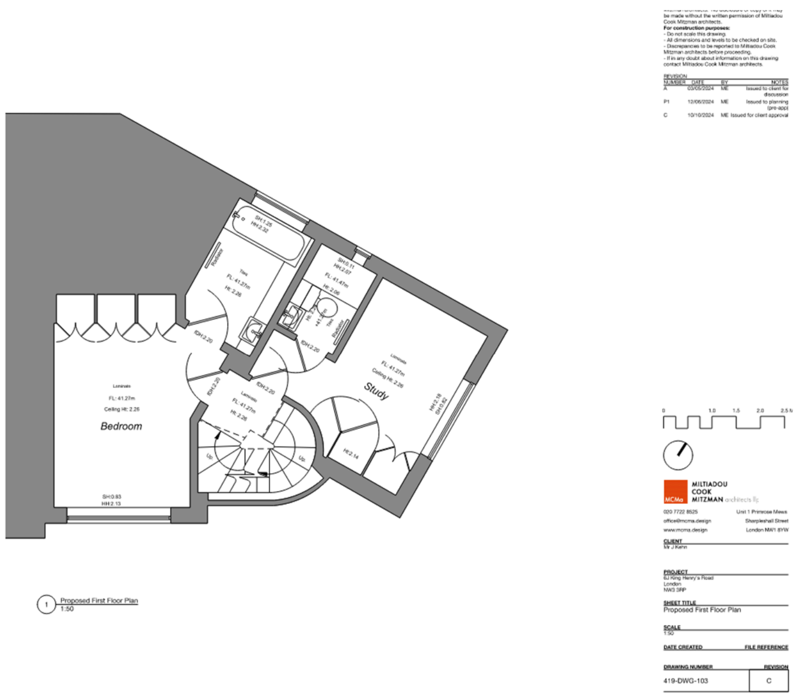

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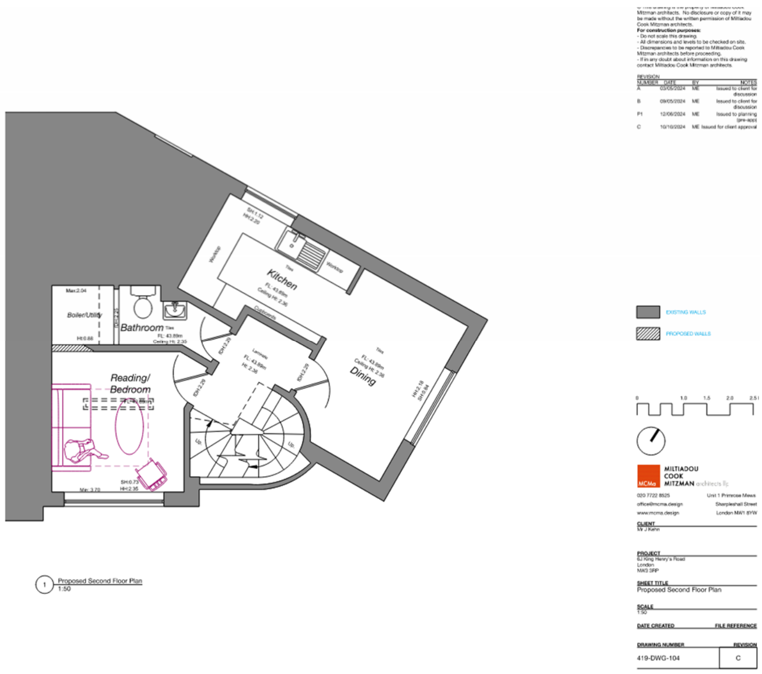


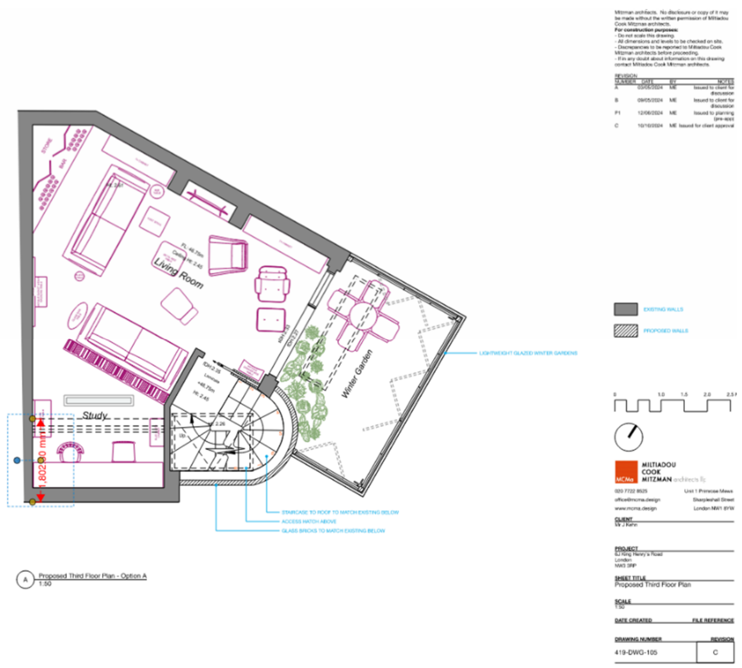
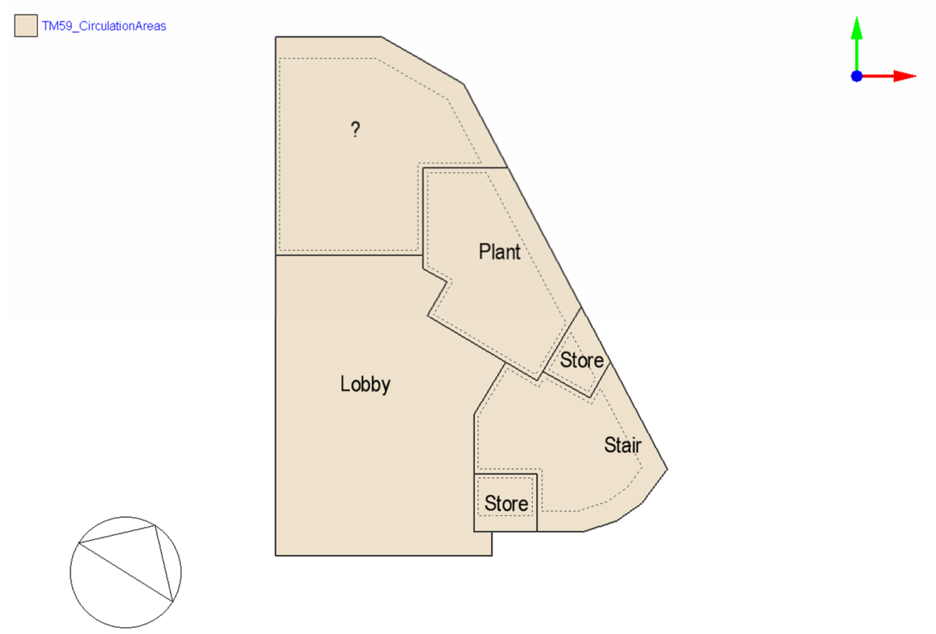
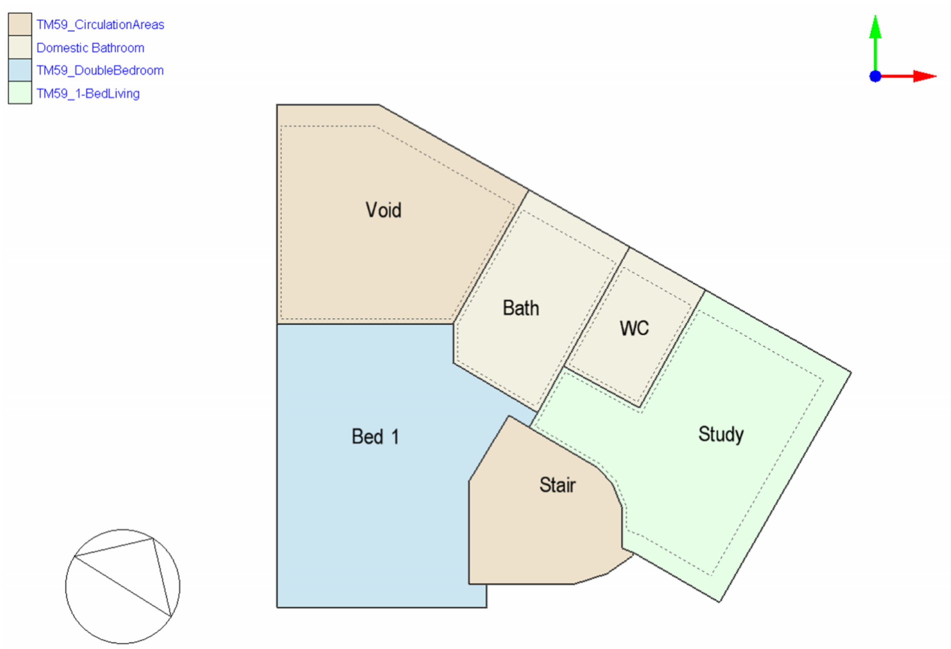


Figure 3 – proposed internal zone layout:





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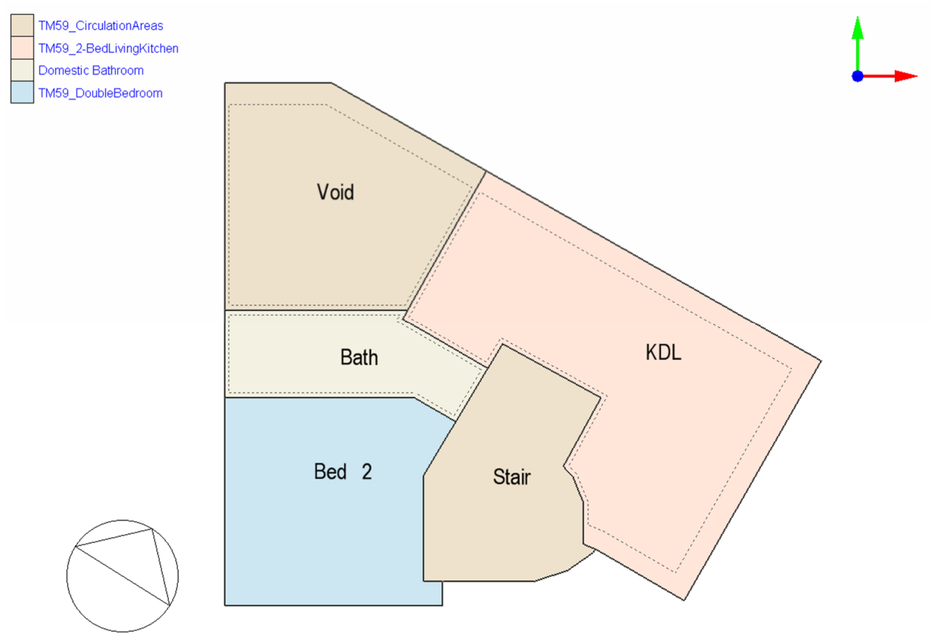

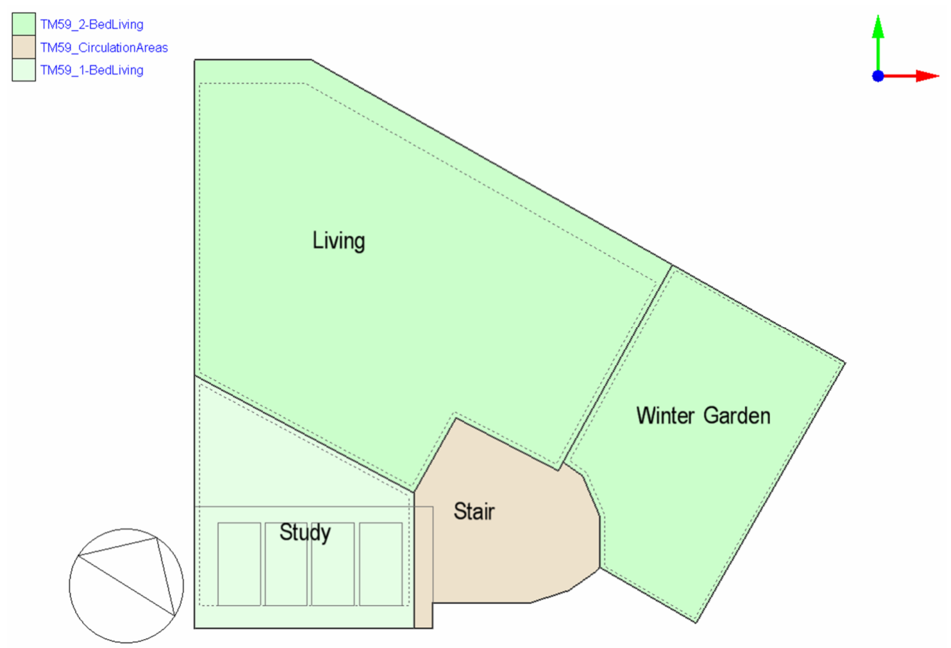

6.3. External shading

External shading is not provided on this project.

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6.4. Internal shading

Results are presented with shading from internal blinds excluded from the calculation.

6.5. Fabric

The following construction fabric data has been input into the simulation model. Information is based upon data confirmed by the project architect.

Existing property fabric values

Element	U-Value (W/m².K)
External wall	2.1
Ground floor	1
Flat roof	1

Proposed property fabric values

Element	U-Value (W/m².K)
External wall	2.1
Ground Floor	0.15
Flat roof	0.15

6.6. Glazing

Windows and fully glazed doors have been entered into the model based on the following parameters: -

Existing window glazing

- Solar transmittance value (g-value) – 0.750
- Light transmittance value – 0.80
- U-value – 4.80 W/m^2K

Proposed window glazing

- Solar transmittance value (g-value) – 0.60
- Light transmittance value – 0.71
- U-value – 1.40 W/m^{2}K

Frame widths have been entered at 50mm.

6.7. Infiltration

Air infiltration through the building fabric has been assigned based upon the design air permeability rate of 10m³/m².hr@50Pa. Note that air permeability can have both a positive and negative effect upon internal conditions, dependent upon the internal/external temperatures and internal set-point temperature.

6.8. Internal gains: lighting

Heat gains arising as a result of artificial lighting have been input into the simulation model based upon the following profile data:

- 2W/m^2 of floor area, from 6pm to 11pm daily.

6.9. Internal gains: occupancy and equipment

Heat gains arising as a result of building occupancy and equipment have been input into the simulation model based upon the following profile data:

Unit/ room type	Occupancy	Equipment load
Studio	2 people at all times	• 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 10 pm to 12 pm • Base load of 85 W for the rest of the day
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

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Unit/ room type	Occupancy	Equipment load
1-bedroom apartment: living room	1 person 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
1-bedroom apartment: kitchen	1 person 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
2-bedroom apartment: living room/kitchen	2 people 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
3-bedroom apartment: living room/kitchen	3 people 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 • 200W 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
3-bedroom apartment: living room	3 people at 5% 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

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Unit/ room type	Occupancy	Equipment load
3-bedroom apartment: kitchen	3 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
Single bedroom (too small to accommodate double bed)	• 1 person at 70% gains from 11 pm to 8 am • 1 person at full gains from 8 am to 11 pm	• Peak load of 80 W from 8 am to 11 pm • Base load of 10 W during sleeping hours
Communal corridors	Assumed to be zero	Pipework heat loss only; see section 3.1 above
* All times in GMT		

6.10. Natural ventilation

Natural ventilation is provided via openable windows and doors. Due to acoustic restriction's the windows within the bedrooms must remain closed overnight (23:00-08:00).

Opening areas have been entered into the simulation model in accordance with the details provided by the project architect. Apertures have been entered into the model with a frame thickness of 50mm. Openable windows are assumed to be able to be opened to a degree of 100% of the total aperture size.

Windows are set to be open based on the following limitations detailed within Approved Document O:

a. When a room is occupied during the day (8am to 11pm), openings should be modelled to do all of the following.

   i. Start to open when the internal temperature exceeds 22°C.

   ii. Be fully open when the internal temperature exceeds 26°C.

iii. Start to close when the internal temperature falls below 26°C.

iv. Be fully closed when the internal temperature falls below 22°C.

b. At night (11pm to 8am), openings should be modelled as fully open if both of the following apply.

v. The opening is on the first floor or above and not easily accessible. Except bedrooms due to railway acoustic constraints.

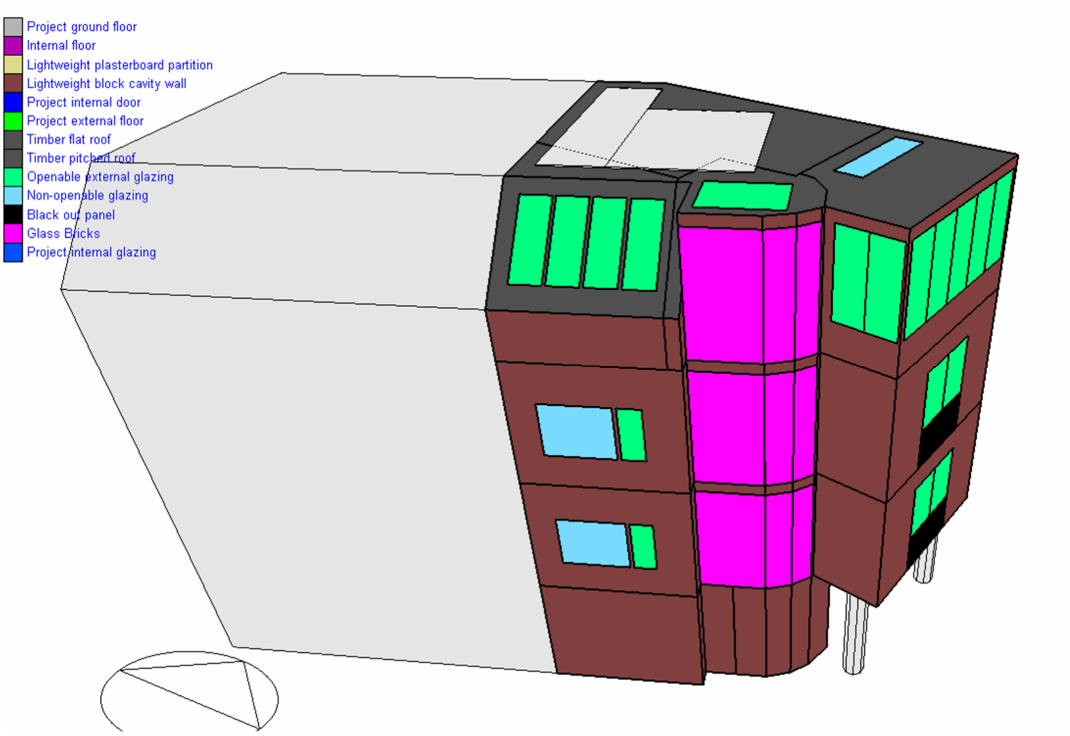
vi. The internal temperature exceeds 23°C at 11pm.

c. When a ground floor or easily accessible room is unoccupied, both of the following apply.

vii. In the day, windows, patio doors and balcony doors should be modelled as open, if this can be done securely using fixed or lockable louvred shutters, window grilles or railings.

viii. At night, windows, patio doors and balcony doors should be modelled as closed.

Windows, glazed doors and rooflights that are assigned as openable are highlighted in green within the following images:



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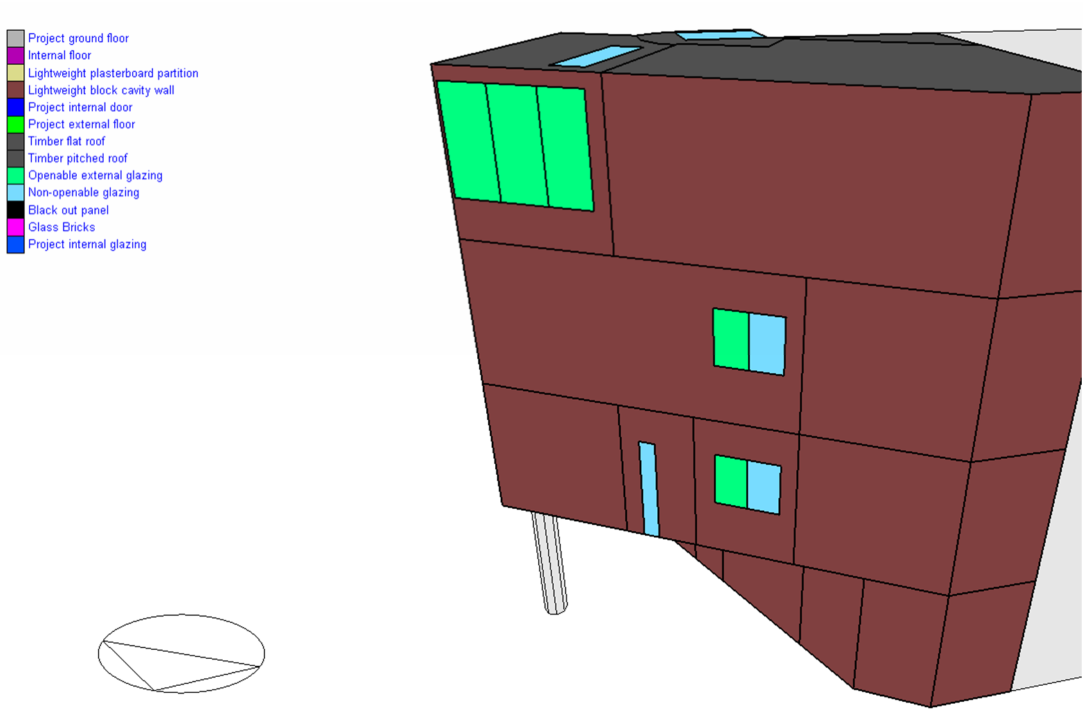

6.11. Mechanical ventilation

Mechanical ventilation cannot be installed due to design constraints.

6.12. Active cooling

Although the proposed specification for this dwelling includes comfort cooling, it should be demonstrated to the building control body that all practicable passive means of limiting unwanted solar gains and removing excess heat have also been incorporated into the building. The purpose of this report is to assess the impact of these practical passive measures, without reliance on comfort cooling, and for that reason **comfort cooling has not been included in the simulation model**.

6.13. Heat loss from hot water cylinder

It is assumed that there will be a continuous 96W heat loss from a hot water cylinder.

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7. Results

The results for the zone known as 'Winter Garden' have been excluded from the simulation results. This is due to the space being external from the heated dwelling and as during the assessment period (May - September), the area will remain open to act as a sheltered balcony space, therefore becoming considered as an external space and not assessable.

7.1. Simulation 1 – Existing Dwelling

Block	Zone Name	Criteria A - (%Hrs Top-Tmax>=1K to be no greater than 3%).	Criteria B - (Number of night hours exceeding 26°C for bedrooms to be no greater than 32).	Overall Compliance
1	BED1	3.07	174.17	Fail
1	STUDY	4.15	N/A	Fail
2	BED2	8.17	292.83	Fail
2	KDL	3.9	N/A	Fail
3	LIVING	68.33	N/A	Fail
3	STUDY	83.88	N/A	Fail

7.2. Simulation 2 – Proposed dwelling after refurbishment with MVHR (active cooling excluded from simulation)

Block	Zone Name	Criteria A - (%Hrs Top-Tmax>=1K to be no greater than 3%).	Criteria B - (Number of night hours exceeding 26°C for bedrooms to be no greater than 32).	Overall Compliance
1	BED1	3.15	366.83	Fail
1	STUDY	4.54	N/A	Fail

2	BED2	4.33	436	Fail
2	KDL	2.57	N/A	Pass
3	LIVING	1.91	N/A	Pass
3	STUDY	14.31	N/A	Fail

7.3. Simulation 3 – Proposed dwelling after refurbishment with cooling

Block	Zone Name	Criteria A - (%Hrs Top-Tmax>=1K to be no greater than 3%).	Criteria B - (Number of night hours exceeding 26°C for bedrooms to be no greater than 32).	Overall Compliance
1	BED1	0	0.17	Pass
1	BED1	0	0.5	Pass
1	STUDY	0.35	N/A	Pass
2	BED2	0	0.83	Pass
2	KDL	0.36	N/A	Pass
3	LIVING	0.9	N/A	Pass
3	STUDY	2.5	N/A	Pass

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8. Conclusion

Existing dwelling

All occupied zones within the existing dwelling have been found to be at high risk of overheating.

Proposed refurbishment and the cooling hierarchy

The results for the zone known as 'Winter Garden' have been excluded from the simulation results. This is due to the space being external from the heated dwelling and as during the assessment period (May - September), the area will remain open to act as a sheltered balcony space, therefore becoming considered as an external space and not assessable.

As part the proposed refurbishment works the following practicable passive means of limiting unwanted solar gains and removing excess heat have also been incorporated into the building by following the cooling hierarchy:

6. **Minimise internal heat generation through energy efficient design: All appliances will be A rated for energy efficiency and all lighting will be LED.**

7. **Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls: Glazing to be upgraded. Internal Blinds to be used and pipes to be insulated. Roof to be painted white and receive solar panels atop.**

8. **Manage the heat within the building through exposed internal thermal mass and high ceilings: The design retains high ceilings and exposed thermal mass.**

9. **Passive ventilation: The design has retained openable windows and cross ventilation throughout during the day. Due to acoustic constraints, windows are to remain closed in the bedrooms overnight. Openable rooflights in circulation to allow for stack ventilation.**

10. **Mechanical ventilation: Mechanical ventilation not to be included due to the dwelling overheating despite it's proposed installation (see Simulation 2). Ceiling fans to be integrated in all habitable spaces to promote ventilation.**

As the simulation results show, the passive design measures detailed above are sufficient for some zones to achieve thermal comfort without relying on comfort cooling. For the majority of zones that are still at high risk of overheating, comfort cooling should form part of the as-built specification in order to maintain thermal comfort during the hottest parts of the year.