BURO HAPPOLD

UCL 40 Bernard Street

RIBA Stage 4

051430

Overheating Study

7 June 2022

Revision P02

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Revision	Description	Issued by	Date	Checked
P01	Draft for Comments	AH MAH	25.05.2022	DC
P02	Draft for comments	MAH	07.06.2022	DC

Report Disclaimer

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Contents

Glossary

Term	Definition
ACH	Air Change Hour
AHU	Air Handling Unit
UHI	Urban Heat Island
BCO	British Council for Offices
CY	Façade orientation to internal courtyard
2020 or 2050 DSY future weather files	2020 or 2050 Design Summer Year weather files, as outlined in the CIBSE TM49 document, projected to account for future climate change for a time frame centred around the decade notation (i.e. 2020 files account for 2010-2040, and 2050 from 2040-2070). These weather files account for more extreme peak temperatures as well as high frequency of occurrence (reduced return periods).
GLA	Greater London Authority
HVRF	Hybrid Variable Refrigerant Flow
CIBSE TM52	Chartered Institution of Building Services Engineers Technical Memorandum 52 - The Limits of Thermal Comfort: Avoiding Overheating in European Buildings outlines thermal comfort judgement criteria for assessment in both residential and non-residential buildings.
CIBSE AM10	CIBSE Application Manual 10 Natural Ventilation in Non-Domestic Buildings
CIBSE TM49	Chartered Institution of Building Services Engineers Technical Memorandum 49 - Design Summer Years for London, May 2014 outlines the background to the baseline DSY 1,2 and 3 weather files as well as the future climate predictions.
DSY 1	Design Summer Year 1 is a near-extreme weather files of April–September average temperature (middle of the upper quartile) with a return period of 9 years. Weather data from London Heathrow Airport (LHR) from the year 1989 representing a moderately warm summer. CIBSE TM59 asks for compliance with this weather file.
DSY 2	Design Summer Year 2 based on the 2003 year, represents a more extreme year with two-week extreme heat wave with a return period of 19 years. CIBSE TM59 suggests that design should consider risk of this weather file, however it is not strictly required to show compliance.
DSY 3	Design Summer Year 2 based on the 1979, represents a more extreme year with a more persistently warm summer return period of 27 years. CIBSE TM59 suggests that design should consider risk of this weather file, however it is not strictly required to show compliance.
Glazing ratio (Window/Wall)(GR)	A ratio of the glazing area as a % of external net façade area, excludes servicing voids and slab edges. If "glazing ratio" is quoted in the report, Window/Wall is being referenced. If Window/floor is being referenced specific notation will be provided.
Thermal comfort	That condition of mind which expresses satisfaction with the thermal environment, as defined by BS EN ISO 7730.

1 Executive Summary

Dynamic thermal analysis has been carried out to assess the overheating risk for the UCL 40 Bernard Street Fit-out and make recommendations on proposed solutions if overheating occurs.

The study evaluates the impact of overheating for Level 2 and Level 4 measured against adaptive comfort standard specified in CIBSE technical memorandum 52. The analysis has been carried out using IES VE 2021.0.2.0 software. TM52 criteria considers human ability to gradually acclimatise to periods of increased temperature. A room is classed as overheating if it fails any two of the three TM52 criteria.

The current design of 40 Bernard Street uses natural ventilation through side panes of all windows frames. These open when the room temperature exceeds the outside temperature and is above 20 degrees. The London Plan Cooling Hierarchy was considered, and each requirement was addressed in this study. Results shown in Table 1—1 indicate that given high heat gains, poor thermally performing glazing and single-sided ventilation openable windows, a combination of active cooling and mechanical ventilation is needed to ensure optimum thermal comfort in most of occupied spaces.

Table 1—1 DSY 1_2020High50 - current climate overheating results

Zone name	Modelling Inputs			CIBSE TM52 Criteria			
	Floor	Glazing orientation	Nat vent	Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Results*
30+1 Person teaching room R1	2	W	3%	5.8	41	4.9	Fail
30+1 Person teaching room R2	2	W	3%	6.3	42	5.2	Fail
21+1 Person teaching room	2	SW	5%	6.8	47	5.6	Fail
24+1 Person teaching room	2	S	3.6%	6.9	48	4.9	Fail
40+1 Person teaching room	2	CY (Internal courtyard)	3.4%	2.0	30	3.8	Close Fail
22 Person Mac suite R1	4	S	4.7%	9.1	58	6.2	Fail
22 Person Mac suite R2	4	S	4.7%	8.0	49	5.5	Fail
14+1 Person teaching room	4	N	1.9%	1.8	26	3.7	Close Fail
20 person Mac suite R3	4	N	2.1%	4.5	39	4.8	Fail
30 Person VR lab R1	4	CY (Internal courtyard)	2.1%	2.7	34	4.1	Close Fail
30 person VR lab R2	4	CY (Internal courtyard)	1.5%	3.8	40	4.8	Fail
42+1 Person teaching room	4	CY (Internal courtyard)	1.8%	4.5	36	4.5	Fail
Seminar room	4	CY	1.4%	5.7	46	5.0	Fail
Social learning space 1	4	W	2.6%	5.0	40	4.6	Fail
Social learning space 2	4	E	2.6%	3.0	36	4.3	Close Fail
Social learning space 3	4	S	3.6%	3.4	38	4.1	Close Fail
Shared office/Touchdown	4	N	2.1%	1.5	25	3.5	Close Fail

*Active cooling is recommended for TM52 comfort compliance

Figure 1—1 and Figure 1—2 show the key GA layouts used for the study issued by Twelve Architects and approved by UCL stakeholders.

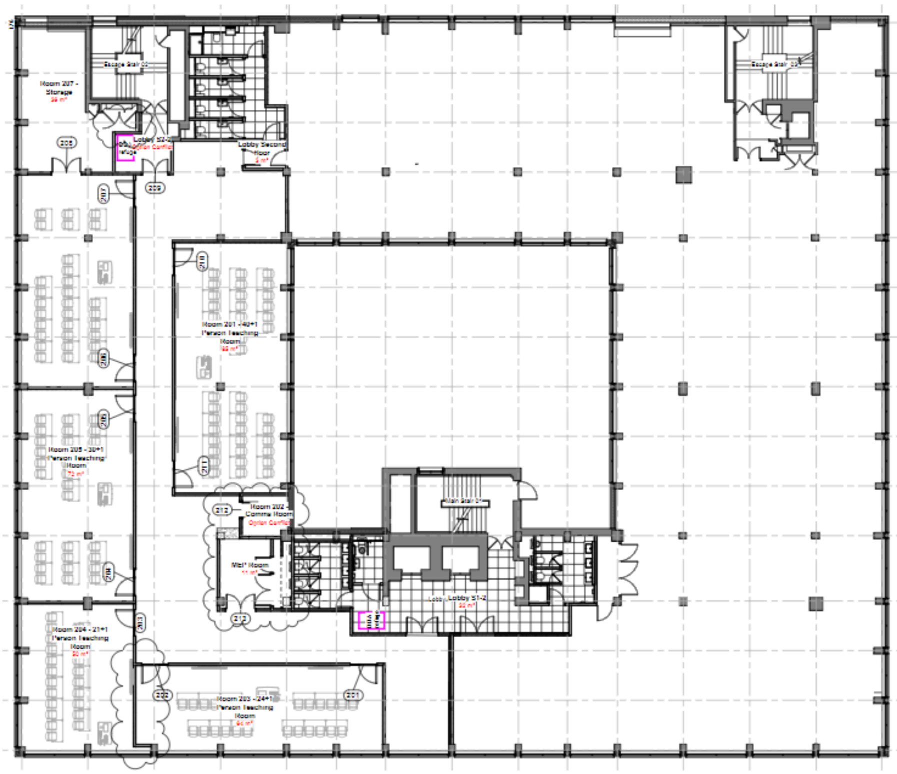


Figure 1—1 Second floor - general teaching GA layout

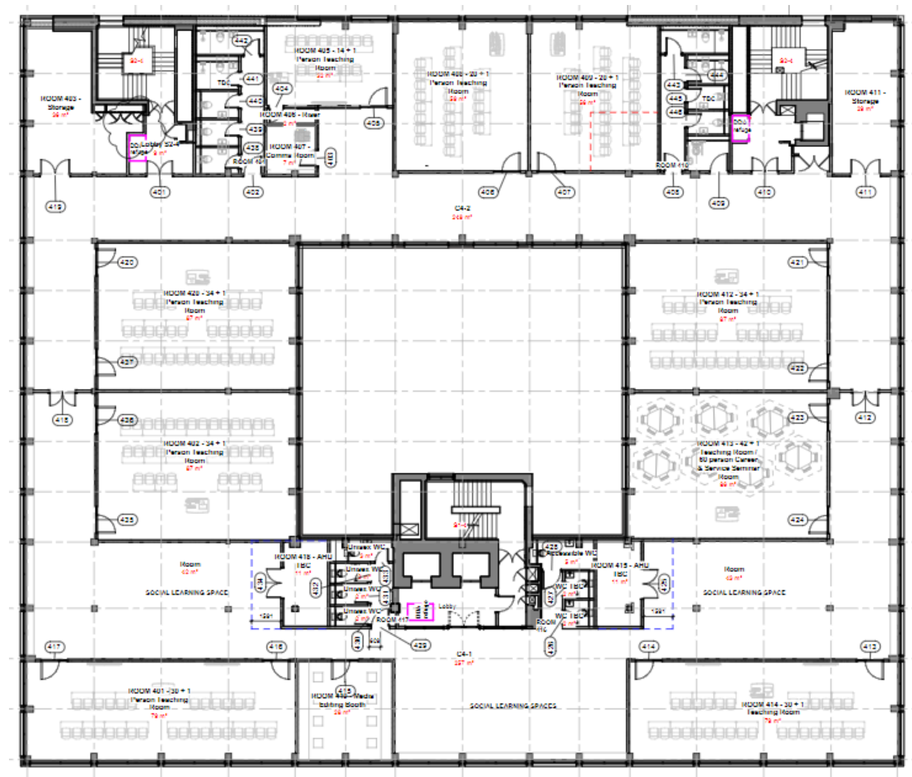


Figure 1—2 Fourth floor - general teaching GA layout

2 Introduction

This overheating assessment has been prepared by Buro Happold to support planning application (Ref: 2022/1513/P) which seeks permission for the "installation for the condenser units, louvres, and associated ductwork on the 2nd and 5th floor roof levels".

The site is located at 40 Bernard Street, London, within a 10-minute walk from the Bloomsbury Campus. The space is split over 5 floors (mezzanine, first floor, second floor, third floor & fourth floor). It has a 'doughnut' floor plan that is flexible with good access. The space is being fitted out to be part of UCL's 'student bulge'. The project is currently in RIBA Stage 5 and the proposed interior space includes teaching rooms, seminar rooms, social learning spaces, shared offices, VR labs and break out rooms. There will be no changes to the façade, including the single glazed windows.

The current design of 40 Bernard Street uses natural ventilation through side panes of all windows frames. This open when the room temperature exceeds the outside temperature and is above 20 degrees.

Active cooling system in place in the existing building, however Buro Happold has been instructed to conduct an overheating assessment to ensure active cooling is necessary for the assessed rooms on 2nd and 4th floor. The key spaces included in the overheating study are shown in Figure 2—3 and Figure 2—3.

Overheating can be defined as a sensation of discomfort resulting from excessive temperature. The sensation of overheating is subjective; the conditions at which it occurs vary between people. Consequently, there are multiple metrics for assessing overheating.

The last relevant planning permission at the Site (ref: 2012/1264/P) was approved on 4 May 2012 for the following: *"Variation of condition 5 (construction in accordance with approved plans) of planning permission dated 09/09/11 (2011/3351/P) for alterations to fifth floor level including installation of two air conditioning units in existing plant enclosure, replacement of single glazed windows/doors with double glazed windows/doors, replacement of metal railings with glazed panels on south elevation with frameless glass balustrade and stainless steel handrail, installation of new stairs to terrace, handrails and retractable awnings to east and west elevations, replacement of part of roof covering with new insulated felt, removal of existing rooflights, and installation of infill rendered panels to office building (Class B1), namely alterations to the Herbrand Street elevation to insert louvred doors at ground floor level."*

This report sets out the scope of the overheating risk assessment, relevant London environmental strategy and Camden Council requirements, UCL sustainable standards, inputs, overheating methodology and results carried out in the building.

This overheating risk assessment covers the plant installation that forms part of the planning applications (ref: 2012/1264/P) and the associated floors (Level 2 and 4) this will impact.

2.1 Scope of assessment

Figure 2—1 shows the selected floorplates in the 3d model to assess overheating risk including the surroundings.

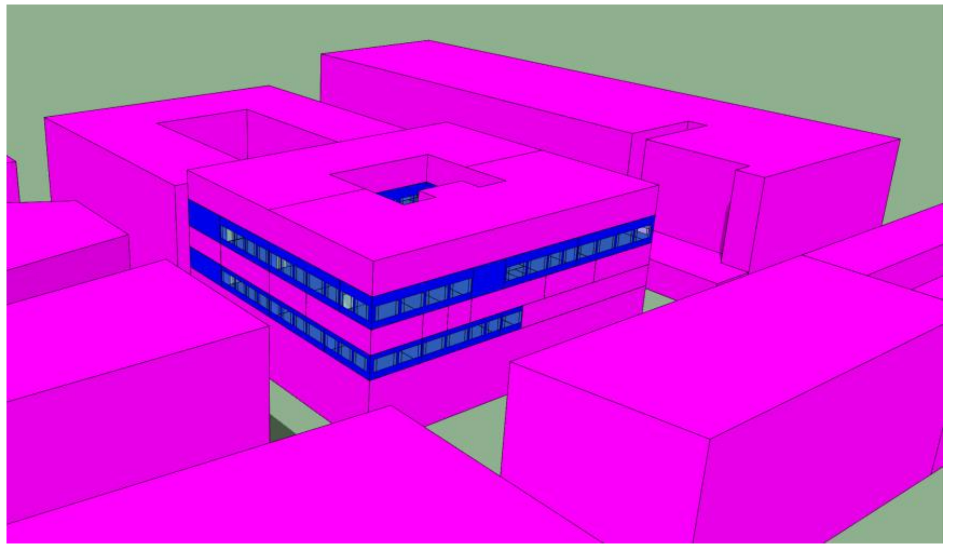


Figure 2—1 IES Thermal model for overheating study

Figure 2—2 and Figure 2—3 illustrates the floor plan areas included in the overheating assessment.

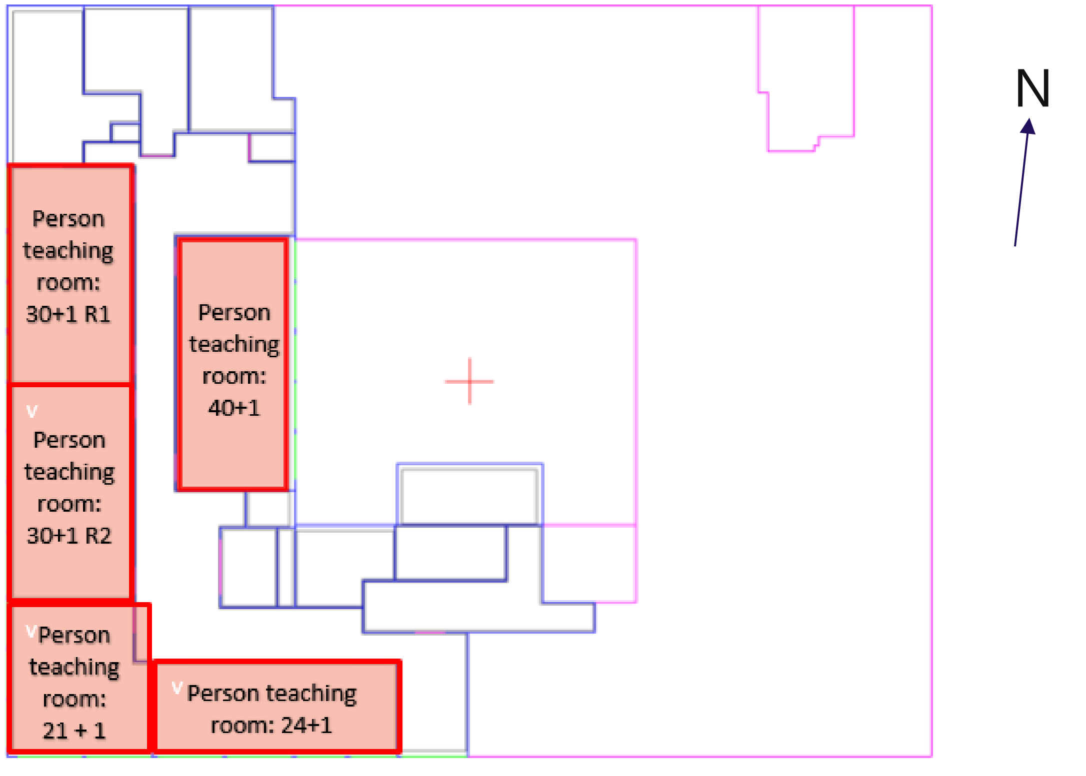


Figure 2—2 Areas included in the overheating assessment- Second floor

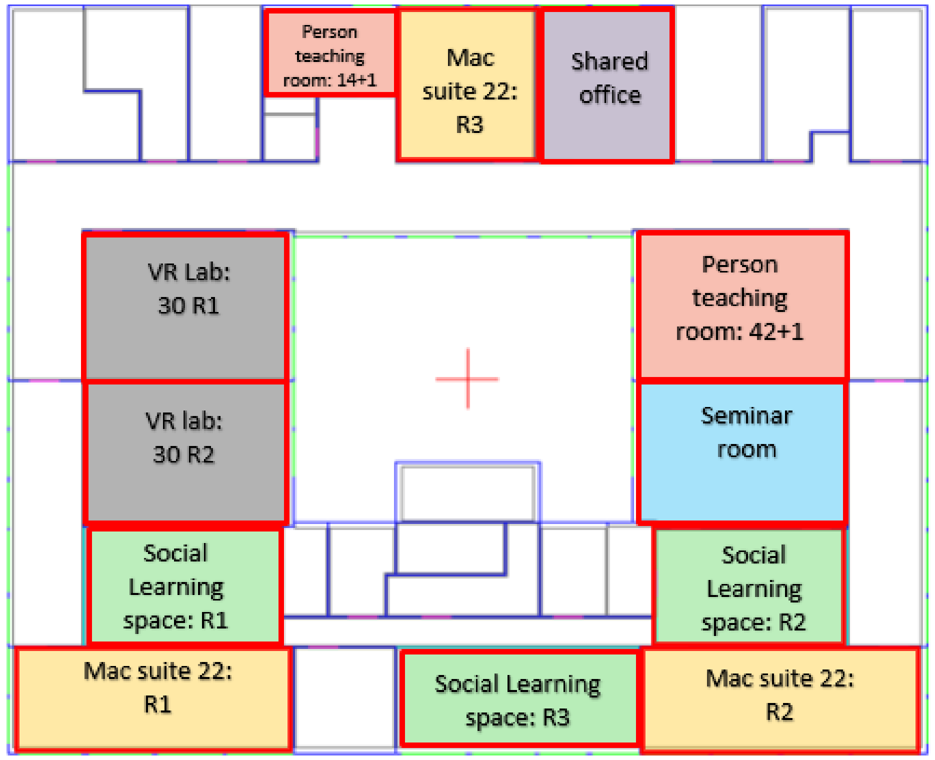


Figure 2—3 Areas included in the overhearing assessment- Fourth floor

3 Requirements

3.1 London Environment Strategy

Based on the Policy 8.4.3 (Minimise the risk of new development overheating), proposal 8.4.3a, of the London Environment Strategy 2018, published by GLA, "the Mayor will consider policies through the new London Plan that encourage developers to carry out overheating modelling against extreme weather scenarios which will provide the necessary detail for developers to design developments with the appropriate mitigation measures installed. Developers will be required to follow the cooling hierarchy to reduce the risk of developments overheating and reduce the impact on the UHI effect through avoiding mechanical cooling where possible and promoting passive cooling measures. Where mechanical cooling is proposed, developers will need to consider the use of low global warming potential refrigerants to reduce harmful emissions."

3.2 The London Plan

According to the Policy SI 4 (Managing heat risk) of the London Plan 2021, published by GLA, major development proposal should demonstrate through an energy strategy how they will reduce the potential for internal overheating and reliance on air conditioning systems in accordance with the cooling hierarchy listed in Table 3—1 which is aligned with the London Plan GLA cooling hierarchy in Figure 3—1.

BH sustainability commentary is also included in Table 3—1 to explain how each of the cooling hierarchy requirements has been addressed and why the below requirements are not applicable here.

Table 3—1 Cooling Hierarchy requirements

Requirement	BH Sustainability Commentary
1-Reduce the amount of heat entering a building through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure	The overheating risk assessment in this report is reflective of the existing building and the proposed systems. The overheating assessment includes all feasible façade items such as existing openable windows to enhance natural ventilation. The upgrade or replacement of existing fenestration of level 2 and 4 are unfeasible as confirmed by the architects at this stage. This is an existing building that UCL are leasing for a short period of time.
2-Minimise internal heat generation through energy efficiency design	Energy efficient lighting, power, HVAC & ICT are proposed. All rooms need to be fit for purpose.
3-Manage the heat within the building through exposed internal thermal mass and high ceiling	The second-floor height slab to slab is 2.65m with the ceiling at 2.4m. There are no high ceilings, the existing slabs are not in a suitable condition to expose, and the existing building is not designed to have a thermal mass and night time cooling strategy.
4-Provide passive ventilation	The overheating assessment includes all openable window areas to maximise available natural ventilation.
5-Provide mechanical ventilation	The physical constraints of the existing building negate the use of mechanical ventilation for cooling purposes. On floor ventilation systems with room level demand control, sized to provide minimum fresh air at 10 l/s/p is feasible, as designed.
6-Provide active cooling systems	That leads the design to active cooling, which was present in the original BCO office building and is required for the UCL teaching facility.

The London Plan section 5.9 requires that major development proposals demonstrate how the design, materials, construction and operation of the Proposed Development minimise overheating and also meet its cooling needs. It states that new developments in London should be designed to avoid the need for energy-intensive air conditioning systems as much as possible.

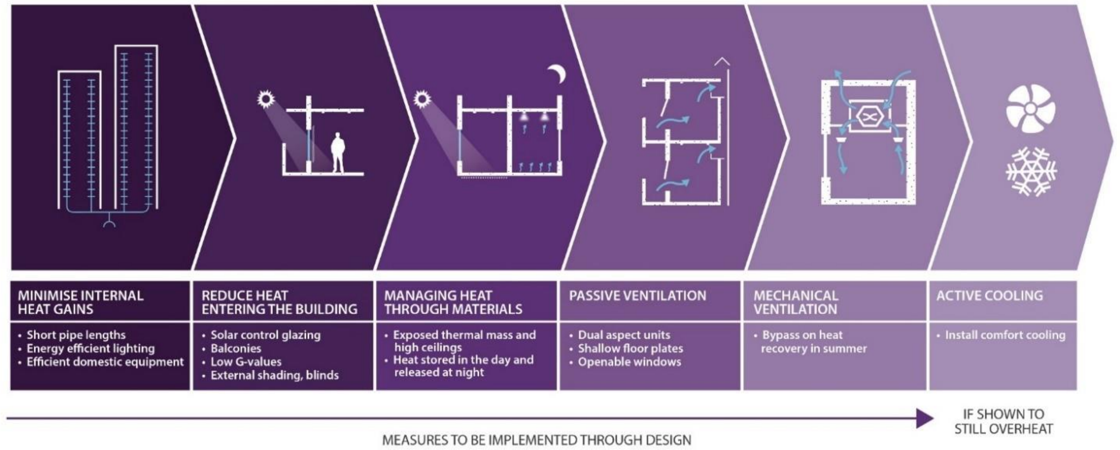


Figure 3—1 The GLA cooling hierarchy and measures to be implemented through design

3.3 Camden Local Plan - Overheating

Policy CC2 (Adapting to climate change) of the Camden Local Plan (2017) requires all development to adopt appropriate climate change adaptation measures such as "… measure to reduce the impact of urban and dwelling overheating, including application of the cooling hierarchy."

The Camden Local Plan Section 8.41 requires: *"All new developments will be expected to submit a statement demonstrating how the London Plan's colling hierarchy has informed the building design. Any development that is likely to be at risk of overheating (for example due to large expanses of south or southwest facing glazing) will be required to complete dynamic thermal modelling to demonstrate that any risk of overheating has been mitigated."*

The Camden Local Plan Section 8.42 specifies: *"Active cooling (air conditioning) will only be permitted where dynamic thermal modelling demonstrates there is a clear need for it after all of the preferred measures are incorporated in line with the cooling hierarchy."*

Camden Planning Guidance (CPG) – energy efficiency and adaptation (2021) also explain that "Active cooling (air conditioning) will only be permitted where its need is demonstrated and the steps in the cooling hierarchy are followed (Local Plan policy CC2). Development is expected to reduce overheating risk through following the steps in the cooling hierarchy. All new development should submit a statement demonstrating how the cooling hierarchy has been followed (Local Plan policy CC2)."

Table 3—2 outlines the Camden Council planning requirements in relation to sustainability for existing buildings and applied to UCL 40 Bernard Street building.

Table 3—2 Camden Council planning requirements on sustainability- Relevant to 40 Bernard Street

Requirement	BH Sustainability Commentary	Page/Section reference
Overheating - dynamic thermal modelling completed using TM52 and TM49?	Yes - dynamic thermal modelling (IES) following TM52, has been carried out	Page 10 - Modelling inputs
Cooling hierarchy followed and passive design measures incorporated?	Yes - the cooling hierarchy has been followed.	Page 9- Thermal modelling methodology
Is active cooling proposed?	Yes - it is proposed in the "Mechanical Specification Section B Project Specific Particular Requirements" that Levels 2 & 4 shall be provided with heating and cooling through the use of HVRF units. The IES dynamic thermal modelling confirmed the proposed solution to include active cooling.	Page 13 - Proposed active cooling

3.4 UCL Sustainable Building Standard 2020

UCL Sustainable Building Standard states: "All buildings should balance energy, daylight and overheating (i.e. energy performance should not create an adverse overheating risk)."

Issue 2.16 (Ventilation efficiency) says: "The type of ventilation used will ultimately be based on the results of thermal modelling and any specialist/ lab uses and aim to achieve the best balance between comfort and low energy consumption. CIBSE TM52 will be applied for new build and major refurbishments projects to ensure appropriate ventilation of the space/ minimise risk of overheating."

Issue 2.6 (Passive design analysis) of the UCL Sustainable Building Standard says: "Overheating and daylight studies should also be carried out in tandem to ensure an optimum balance between: size of glazing; natural daylight; natural ventilation; and active cooling needs."

4 Overheating assessment

4.1 Thermal Modelling Methodology

4.1.1 Methods of assessing overheating in summer for naturally ventilated spaces

Dynamic thermal modelling can be used for an accurate prediction of overheating risk. Different weather files can be used to represent different scenarios such as a standard hot summer year, extreme weather or future climate change prediction.

CIBSE TM52 adaptive comfort criteria is the recommended guidance for non-domestic spaces. TM52 criteria takes into account human ability to gradually acclimatise to periods of increased temperature. A room is considered to overheat. According to CIBSE TM52 methodology, a room or building that fails any two of the three criteria is classed as overheating:

1. The first criterion sets a limit for the number of hours that the operative temperature can exceed the threshold comfort temperature (upper limit of the range of comfort temperature) by 1°K or more during the occupied hours of a typical non-heating season (1st May to 30th September).
2. The second criterion deals with the severity of overheating within any one day, which can be as important as its frequency, the level of which is a function of both temperatures rise and its duration. This criterion sets a daily limit for acceptability.
3. The third criterion sets an absolute maximum daily temperature for a room, beyond which the level of overheating is unacceptable.

4.1.2 Method of assessing thermal comfort in air-conditioned spaces

For air-conditioned and mechanically ventilated spaces the winter and summer operative temperatures should be assessed to ensure they fall within the upper and lower limits set by CIBSE Guide A (*CIBSE Guide A 2018 – Table 1.5: Recommended comfort criteria for specific applications*).

CIBSE Guide A reads: "*The predicted indoor temperature or values of PNV should not exceed the tabulated values for more than 3% of occupied hours"*. CIBSE Guide A recommends that within educational spaces the operative temperature should not exceed 26°C for more than 3% the annual occupied hours.

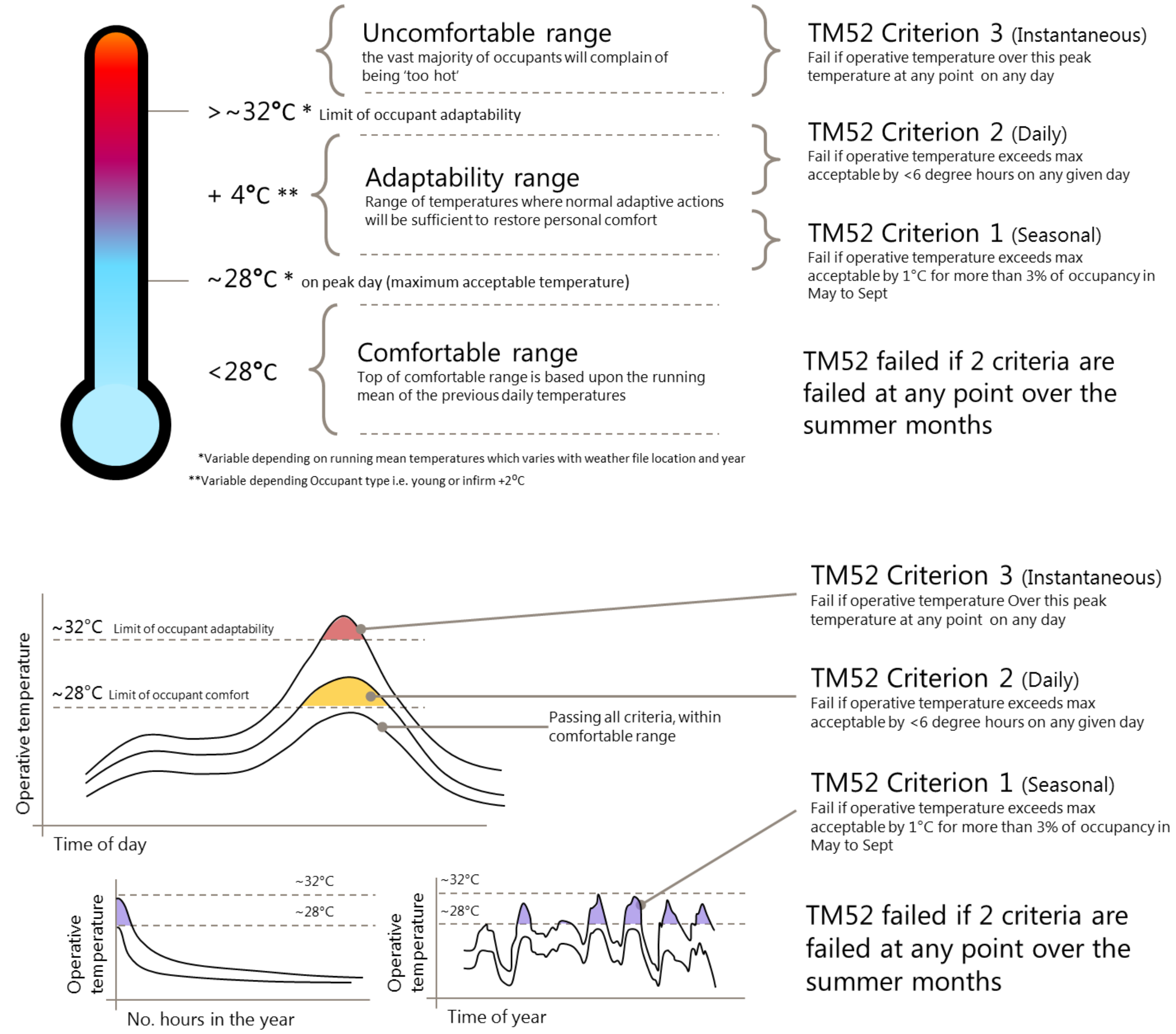


Figure 4—1 **Visual representation of the TM52 pass/fail criteria**

4.2 Modelling inputs

The overheating assessment has been carried out using IES Virtual Environment software 2021. Values for internal gains and occupancy profiles are aligned with best practice industry guidance and specifications (e.g. CIBSE Guide A).

Table 4—1 Modelling input assumption

<table>
<tr><th>Item</th><th>Modelling input</th></tr>
<tr><td>Calculation</td><td>Software - IES Virtual Environment v. 2021 3.0.0
Calculation tool – ApacheSIM</td></tr>
<tr><td>Weather files</td><td>Thermal analysis for the site will be based on the CIBSE 2016 Design Summer Year (DSY) weather files for London Weather Centre. In line with CIBSE TM59 guidance the weather file used was the DSY1: Moderately warm summer, for the 2020s, high emissions, 50% percentile scenario: London_LWC_DSY1_2020High50.epw.
The undertaken overheating assessment was based primarily on DSY1 file, representing a moderately warm summer. The weather data set for London Central Weather are listed below:
• DSY1 – Moderately warm summer
• DSY2 – Intense single warm spell
• DSY3 – Long period of persistent warmth
For context, TM49 demonstrates the probability of a summer being as warm as or warmer than DSY1 is 1 in 9, for DSY2 this decreases to 1 in 19 and 1 in 27 for DSY 2 and 3 respectively (based on weighted cooling degree hours metric).</td></tr>
<tr><td>Fabric performance</td><td>External Wall U-value = 0.3 W/m²K
Glazing U-value = 5.7 W/m²K
g-value = 0.47</td></tr>
<tr><td>Glazing opening strategy</td><td>The windows are largely unopenable bar separated panes of 0.4m in width on the edges. These were modelled as ramping open when the internal temperature was higher than the external and over 20 degrees.

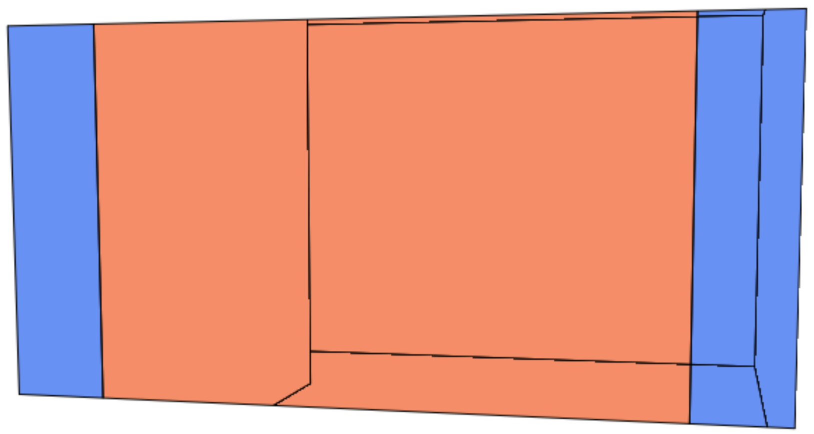



Figure 4—2 Opening panes highlighted in blue</td></tr>
<tr><td>Internal door opening strategy</td><td>All Internal doors were modelled as being open during summer period</td></tr>
<tr><td>Occupancy</td><td><table><tr><th>Room type</th><th>No. occupancy</th><th>m^2/p</th></tr><tr><td>Person Teaching space</td><td></td><td>3</td></tr><tr><td>Person teaching/Seminar room</td><td>45</td><td>2</td></tr><tr><td>VR lab</td><td>30</td><td>2.3</td></tr><tr><td>Mac suite</td><td>22</td><td>4</td></tr><tr><td>Shared office/touchdown</td><td>13</td><td>4.5</td></tr><tr><td>Learning area (breakout)</td><td>10</td><td>4.5</td></tr><tr><td>Transition areas (circulation)</td><td>N/A</td><td>N/A</td></tr></table></td></tr>
</table>

<table>
<tr><th>Item</th><th>Modelling input</th></tr>
<tr><td></td><td>Weekday occupancy profile   Weekend occupancy profile

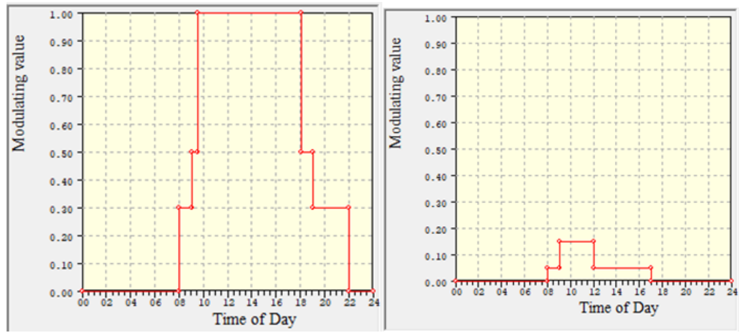



Figure 4—3 Occupancy use profiles by space</td></tr>
<tr><td>Lighting</td><td>Lighting weekday profile   Lighting weekend profile

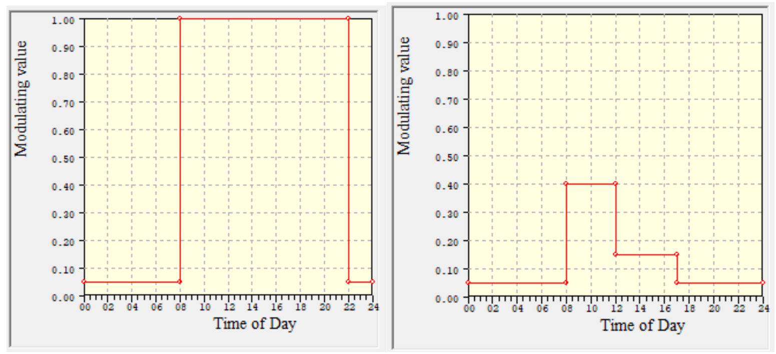



Figure 4—4 Lighting user profile
Lighting dimming profile

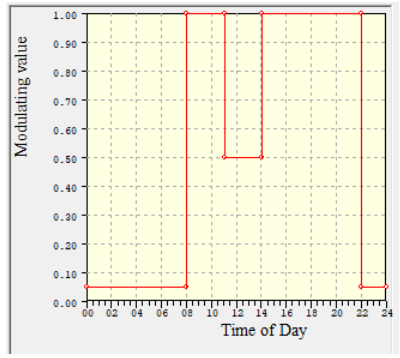



Figure 4—5 Lighting dimming user profile</td></tr>
<tr><td>Equipment</td><td>Internal gains: All spaces excluding circulation and breakout space: 15 W/m2 and diversity = 0.8
Breakout space: 5 W/m2 and diversity 0.8</td></tr>
</table>

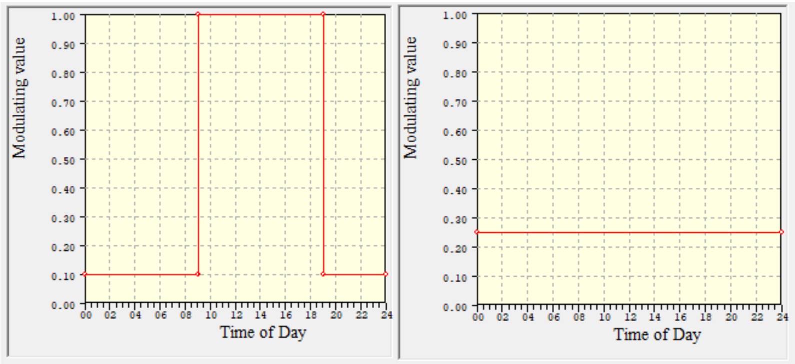
Item	Modelling input
	Equipment weekday profile **Equipment weekend profile**  **Figure 4—6 Equipment use profile**
Infiltration	Infiltration has been applied at 0.1 ach for winter months (Sept-May) and 0.05 ach for summer months (May-Sept)

Figure 4—7 Modelling assumptions

Figure 4—8 show the thermal model used for the overheating assessment.

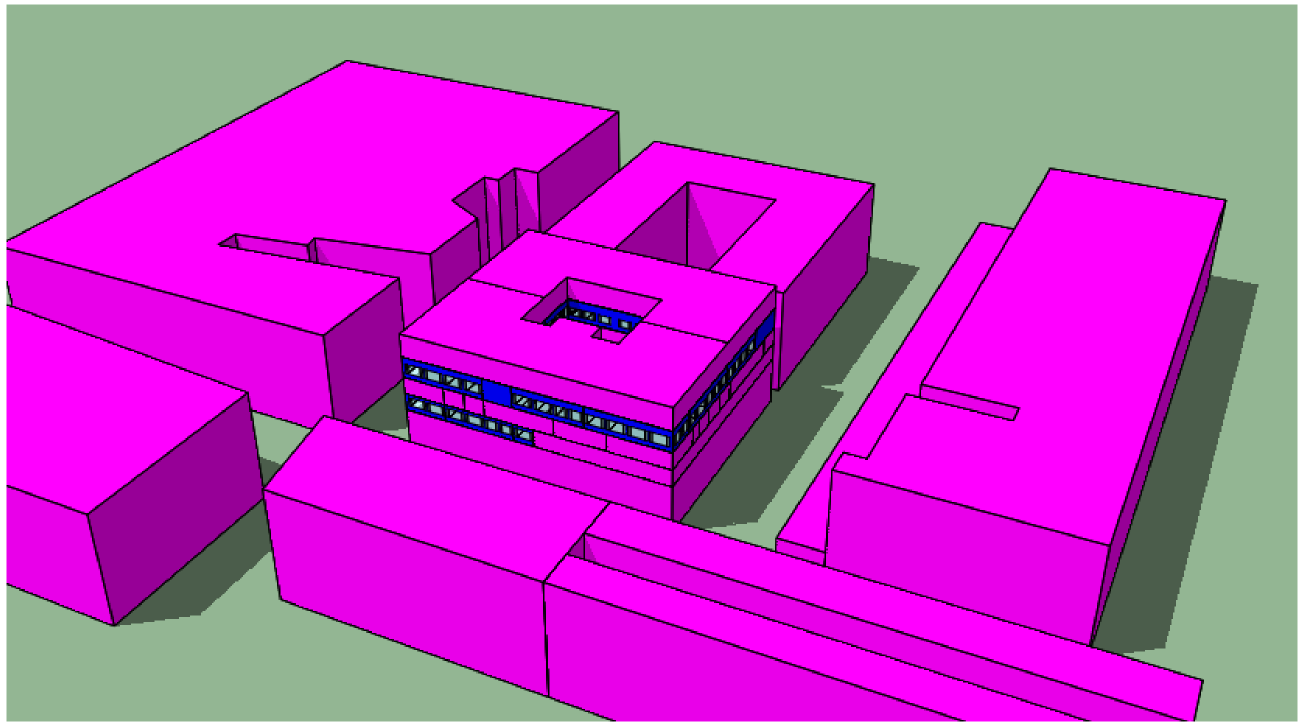


Figure 4—8 Computer model used for overheating analysis in IES-VE 2021

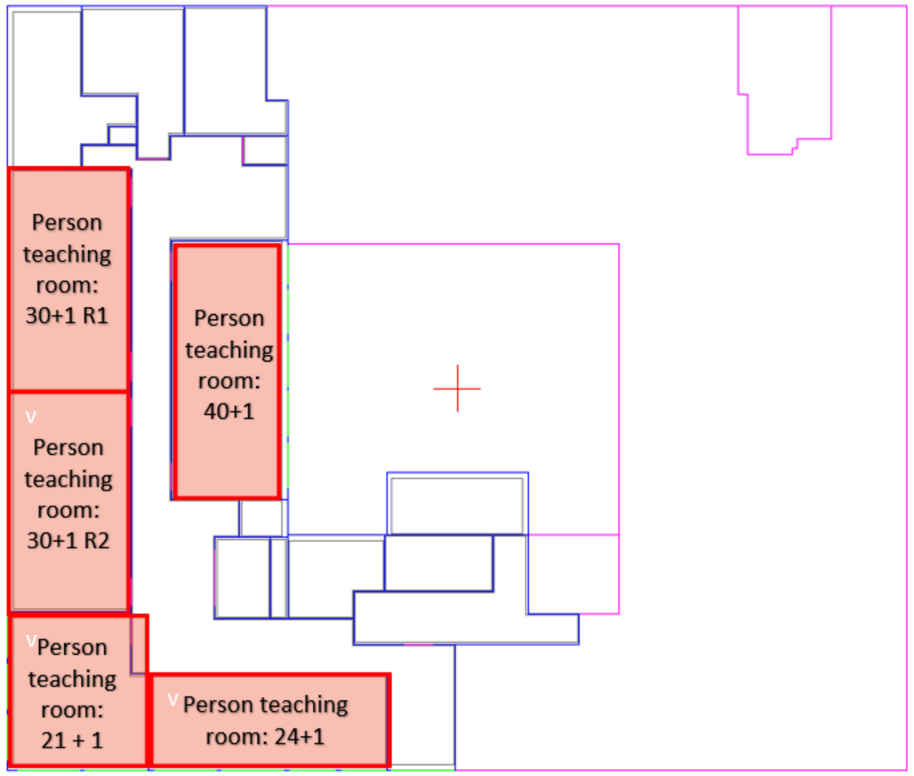


Figure 4—9 Rooms included in overheating assessment floor 2

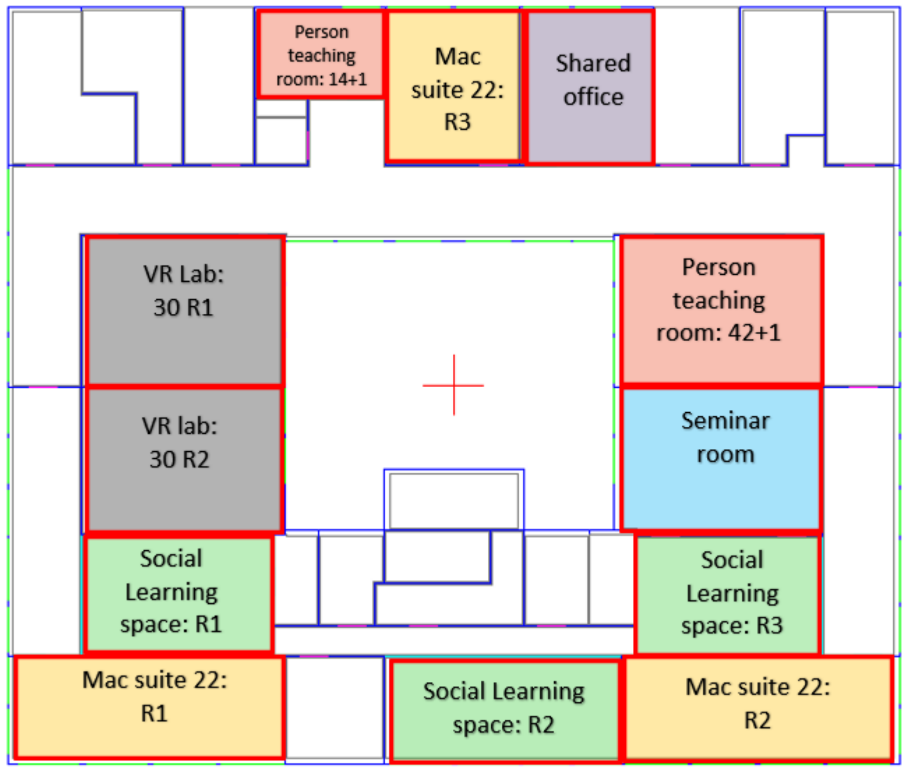


Figure 4—10 Rooms included in overheating assessment floor 4

4.3 Overheating assessment results

Given the input parameters described in Table 4—1, the assessment demonstrates the following:

- Natural ventilation strategies assessed under CIBSE TM52 demonstrate all rooms are under high overheating risk for DSY 1, DSY2 and DSY3 weather scenarios, as shown in Table 4—2
- Six spaces are close to fail CIBSE TM52 criteria 1 and 3 for the DSY1 weather scenario, however due to high occupancy density active cooling is still recommended to pass more extreme climate over summer months.
- Overheating occurs primarily during period of intense heat and not for sustained periods.

Table 4—2 describe the thermal comfort summary results against Design Summer Year 2020 scenario, assessing only natural ventilation. "Close fail" in the following tables means "fail but by a close margin".

Table 4—2 Thermal Comfort summary results – Natural Ventilation Only

Zones name	Results tested under London_LWC_DSY1_2020High50.epw	Results tested under London_LWC_DSY2_2020High50.epw	Results tested under London_LWC_DSY3_2020High50.epw
30+1 Person teaching room R1	Fail	Fail	Fail
30+1 Person teaching room R2	Fail	Fail	Fail
21+1 Person teaching room	Fail	Fail	Fail
24+1 Person teaching room	Fail	Fail	Fail
40+1 Person teaching room	Close Fail	Fail	Fail
22 Person Mac suite R1	Fail	Fail	Fail
22 Person Mac suite R2	Fail	Fail	Fail
14+1 Person teaching room	Close Fail	Fail	Fail
20 person Mac suite R3	Fail	Fail	Fail
30 Person VR lab R1	Close Fail	Fail	Fail
30 person VR lab R2	Fail	Fail	Fail
42+1 Person teaching room	Fail	Fail	Fail
Seminar room	Fail	Fail	Fail
Social learning space 1	Fail	Fail	Fail
Social learning space 2	Close Fail	Fail	Fail
Social Learning space 3	Close Fail	Fail	Fail
Shared office/Touchdown	Close Fail	Fail	Fail

Figure 4—11 Illustrates the short period of overheating. Most of the year the space is comfortable but during intense heat events overheating occurs.

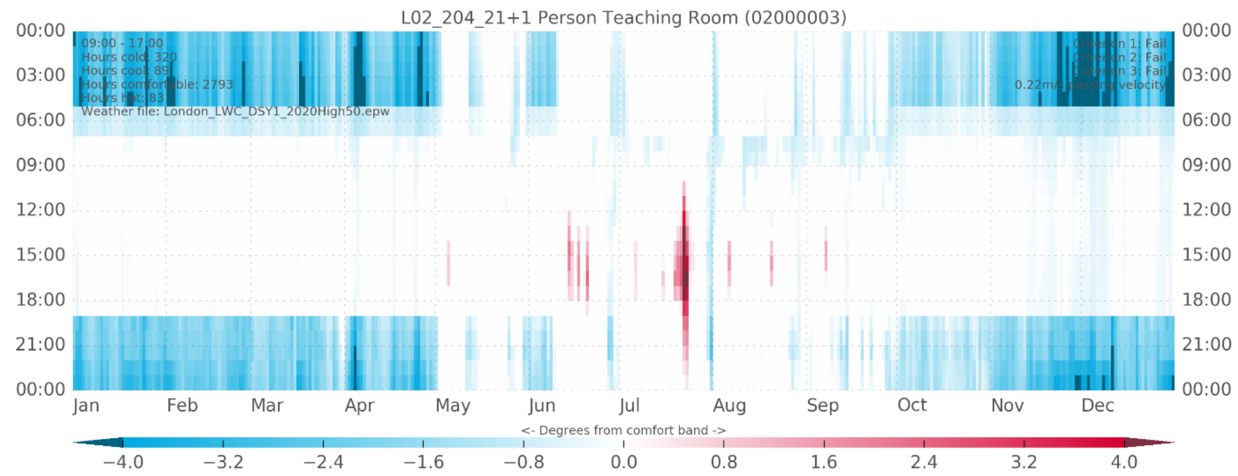


Figure 4—11 Comfort heat map showing overheating with natural ventilation only

It should be noted 40 Bernard street is a university building and therefore occupancy will be reduced in summer, reducing the internal gains within the space improving results

4.4 Social Learning space

Table 4—3 shows a detailed breakdown of CIBSE TM52 overheating scores for the three social learning spaces.

Table 4—3 Social Learning space 1,2 and 3 CIBSE TM52 DSY1 results

Zone name	Modelling inputs			CIBSE TM52			
	Floor	Glazing orientation	Nat vent	Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	Results
Social learning space 1	4	W	2.6%	5.0	40	4.6	Fail
Social learning space 2	4	E	2.6%	3.0	36	4.3	Close Fail
Social learning space 3	4	S	3.6%	3.4	38	4.1	Close Fail

Figure 4—12 shows the difference in solar gain in one hottest day. Space 3 in green which is close failing has highest solar gain in the occupied hours, whereas space 2 in blue has greater solar gain between 5am-10am. We have defined a close failure as within 0.5% of a pass/fail, this gives a margin of error for the result. The solar gain is highest when internal gains also peak. This means cooling loads are higher and hence the space is more likely to overheat.

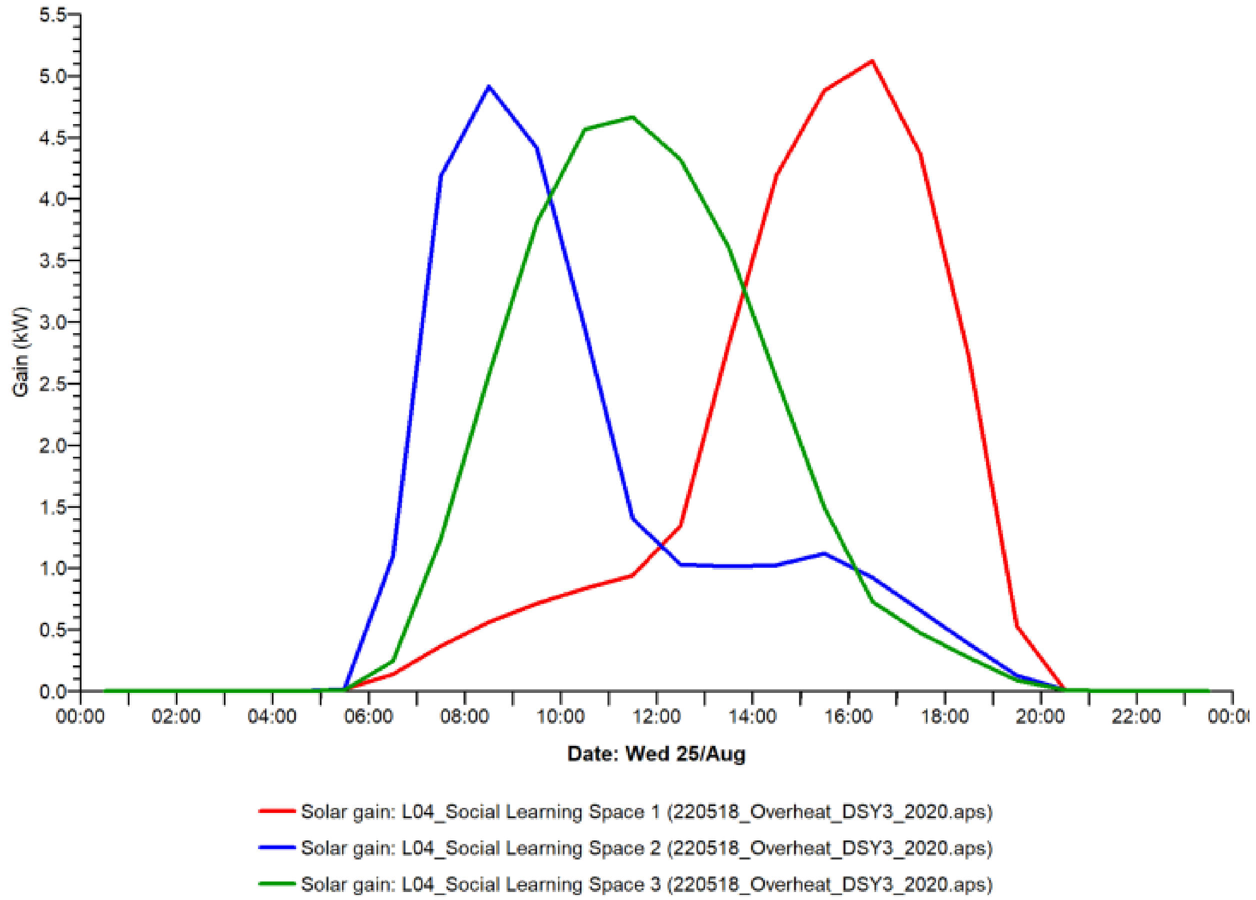


Figure 4—12 Internal gain for social learning space 1 and 2 and 3

4.5 VR Labs

The results in the VR labs demonstrate that VR Lab space fail the overheating analysis.

Table 4—4 VR Labs CIBSE TM62 DSY 1 2020 results

Zone name	Modelling inputs			CIBSE TM52			
	Floor	**Glazing Orientation**	**Nat vent**	**Criteria 1 (%hours exceeded)**	**Criteria 2 (Max. Daily Deg.Hrs)**	**Criteria 3 (max.DeltaT)**	**CIBSE Guide TM52 Compliance**
20 Person VR lab R1	4	CY	2.1%	2.7	34	4.1	Close fail
30 person VR lab R2	4	CY	1.4%	3.8	40	4.8	Fail

Figure 4—13 Thermal comfort graph VR R2s a thermal comfort graph for an overheated VR lab.

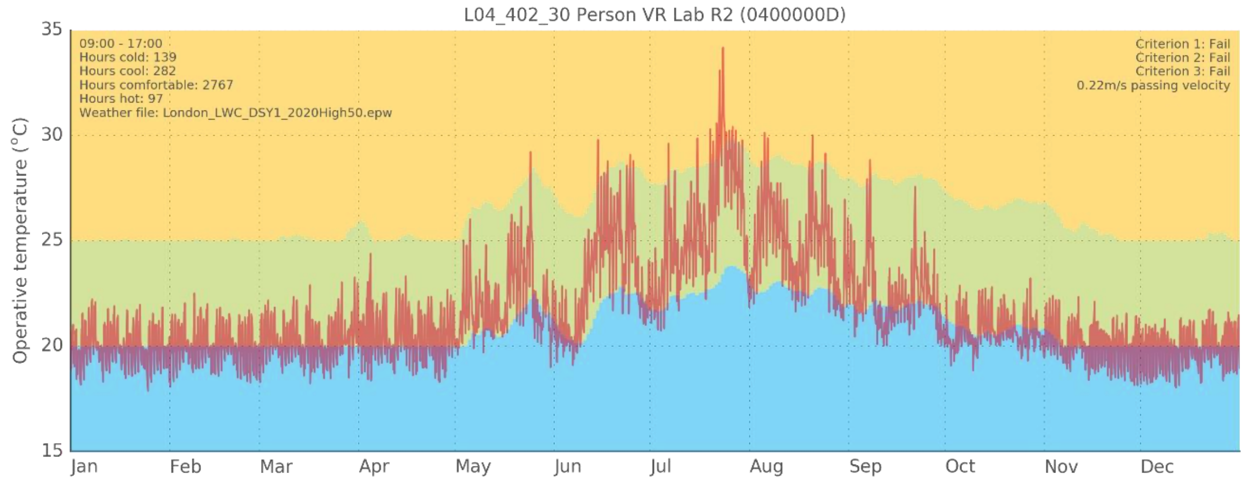


Figure 4—13 Thermal comfort graph VR R2

4.6 Proposed Active Cooling

The overheating assessment has shown that the spaces will need active cooling during summer season, the current single-sided natural ventilation is not sufficient to provide the needed comfort and indoor air quality to occupants. Active cooling for the UCL building is currently installed and it will be supplied by a HVRF system with a heat recovery outdoor unit.

5 Conclusions

This report assessed the overheating risk for the Fit-out of 40 Bernard Street. As explained in Table 3—1, the London Plan Hierarchy was followed as below:

1. **Reduce the amount of heat entering a building through orientation, shading, high albedo materials, fenestration, insulation and the provision of green infrastructure:** This is unfeasible for this project - This an existing building that UCL are leasing for a short period of time. The overheating risk assessment in this report is reflective of the existing building and the proposed systems. The assessment includes all feasible items such as existing openable windows.
2. **Minimise internal heat generation through energy efficiency design:** Energy efficient lighting, power, HVAC & ICT are proposed. All rooms need to be fit for purpose.
3. **Manage the heat within the building through exposed internal thermal mass and high ceiling:** The second-floor height slab to slab is 2.65m with the ceiling at 2.4m. There are no high ceilings, the existing slabs are not in a suitable condition to expose, and the existing building is not designed to have a thermal mass and night time cooling strategy.
4. **Provide passive ventilation:** The overheating assessment includes all openable window areas to maximise available natural ventilation.
5. **Provide mechanical ventilation:** The physical constraints of the existing building negate the use of mechanical ventilation for cooling purposes. On floor ventilation systems with room level demand control, sized to provide minimum fresh air at 10 l/s/p is feasible, as designed.
6. **Provide active cooling systems:** That leads the design to active cooling, which was present in the original BCO office building and is required for the UCL teaching facility.

The CIBSE TM52 compliance was not achieved in all of spaces under only a moderately warm summer (DSY 1 2020 weather file).

The results demonstrated the requirement for cooling strategies in all spaces, where natural ventilation fails to provide sufficient cooling. The overheating risk is minimised if the following features are adopted:

- Openable windows are manually controlled, and users shall be indicated to operate them when internal temperature is over 20 degrees and above external temperature.
- Cooling supplied by a HVRF system with a heat recovery outdoor unit.
- General improvements to fabric performance namely the glazing U value will produce a similar result, as well as blinds.

These additional measures will prevent overheating in the days the space is currently exceeding the acceptable temperature range during the summer.

Appendix A Overheating results

A.1 DSY 1 weather file

DSY weather files are designed to represent a year with a hot, but not extreme summer. DSY1 is a moderately warm summer. Summers typically have a 1-in-7 chance of being equal to or hotter than this DSY.

Table 5—1 DSY 1_2020High50 - current climate overheating results

Zone name	Floor	Glazing orientation	Nat vent	CIBSE TM52			
				Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	CIBSE Guide TM52 Compliance
				<3%		<4.5	
30+1 Person teaching room R1	2	W	3%	5.8	41	4.9	Fail
30+1 Person teaching room R2	2	W	3%	6.3	42	5.2	Fail
21+1 Person teaching room	2	SW	5%	6.8	47	5.6	Fail
24+1 Person teaching room	2	S	3.6%	6.9	48	4.9	Fail
40+1 Person teaching room	2	CY	3.4%	2.0	30	3.8	Close Fail
22 Person Mac suite R1	4	S	4.7%	9.1	58	6.2	Fail
22 Person Mac suite R2	4	S	4.7%	8.0	49	5.5	Fail
14+1 Person teaching room	4	N	1.9%	1.8	26	3.7	Close Fail
20 person Mac suite R3	4	N	2.1%	4.5	39	4.8	Fail
30 Person VR lab R1	4	CY	2.1%	2.7	34	4.1	Close Fail
30 person VR lab R2	4	CY	1.5%	3.8	40	4.8	Fail
42+1 Person teaching room	4	CY	1.8%	4.5	36	4.5	Fail
Seminar room	4	CY	1.4%	5.7	46	5.0	Fail
Social learning space 1	4	W	2.6%	5.0	40	4.6	Fail
Social learning space 2	4	E	2.6%	3.0	36	4.3	Close Fail
Social learning space 3	4	S	3.6%	3.4	38	4.1	Close Fail
Shared office/Touchdown	4	N	2.1%	1.5	25	3.5	Close Fail

Table 5—2 DSY 1_2050High50 - future climate overheating results

Zone name	Floor	Glazing orientation	Nat vent	CIBSE TM52			
				Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	CIBSE Guide TM52 Compliance
				<3%		<4.5	
30+1 Person teaching room R1	2	W	3%	10.5	55	6.2	Fail
30+1 Person teaching room R2	2	W	3%	11.7	60	6.4	Fail
21+1 Person teaching room	2	SW	5%	12.1	65	6.9	Fail
24+1 Person teaching room	2	S	3.6%	13.7	63	6.2	Fail
40+1 Person teaching room	2	CY	3.4%	5.8	47	5.0	Fail
22 Person Mac suite R1	4	S	4.7%	14.8	73	7.5	Fail
22 Person Mac suite R2	4	S	4.7%	14.4	67	6.7	Fail
14+1 Person teaching room	4	N	1.9%	5.2	44	4.9	Fail
20 person Mac suite R3	4	N	2.1%	9.8	56	6.0	Fail
30 Person VR lab R1	4	CY	2.1%	7.5	51	5.3	Fail
30 person VR lab R2	4	CY	1.5%	10.1	57	6.0	Fail
42+1 Person teaching room	4	CY	1.8%	9.1	54	5.8	Fail
Seminar room	4	CY	1.4%	11.2	62	6.3	Fail
Social learning space 1	4	W	2.6%	9.5	56	5.9	Fail
Social learning space 2	4	E	2.6%	7.4	54	5.5	Fail
Social learning space 3	4	S	3.6%	8.9	54	5.4	Fail
Shared office/Touchdown	4	N	2.1%	4.9	44	4.7	Fail

A.2 DSY 2 weather file

DSY 2 is a summer with a short intense warm spell. An intense summer with a heat event the same length of that of DSY1 but with higher intensity

Table 5—3 DSY2_2020High50 current climate overheating results

Zone name	Floor	Glazing orientation	Nat vent	CIBSE TM52			
				Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	CIBSE Guide TM52 Compliance
30+1 Person teaching room R1	2	W	3%	8.8	72	8.3	Fail
30+1 Person teaching room R2	2	W	3%	8.9	78	8.9	Fail
21+1 Person teaching room	2	SW	5%	9.4	90	9.8	Fail
24+1 Person teaching room	2	S	3.6%	10.4	90	8.8	Fail
40+1 Person teaching room	2	CY	3.4%	5.6	52	6.5	Fail
22 Person Mac suite R1	4	S	4.7%	11.5	99	9.7	Fail
22 Person Mac suite R2	4	S	4.7%	11.3	93	9.2	Fail
14+1 Person teaching room	4	N	1.9%	4.8	55	6.2	Fail
20 person Mac suite R3	4	N	2.1%	7.4	70	7.7	Fail
30 Person VR lab R1	4	CY	2.1%	6.8	63	6.9	Fail
30 person VR lab R2	4	CY	1.5%	8.9	72	8.4	Fail
42+1 Person teaching room	4	CY	1.8%	8.5	75	8.5	Fail
Seminar room	4	CY	1.4%	8.8	82	8.5	Fail
Social learning space 1	4	W	2.6%	8.5	82	9.1	Fail
Social learning space 2	4	E	2.6%	7.1	72	7.9	Fail
Social learning space 3	4	S	3.6%	7.7	80	8.0	Fail
Shared office/Touchdown	4	N	2.1%	4.5	53	5.8	Fail

Table 5—4 DSY 2_2050High50 future climate overheating results

Zone name	Floor	Glazing orientation	Nat vent	CIBSE TM52			
				Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	CIBSE Guide TM52 Compliance
30+1 Person teaching room R1	2	W	3%	13.0	86	9.4	Fail
30+1 Person teaching room R2	2	W	3%	14.3	92	10.0	Fail
21+1 Person teaching room	2	SW	5%	14.4	104	10.8	Fail
24+1 Person teaching room	2	S	3.6%	16.8	104	9.9	Fail
40+1 Person teaching room	2	CY	3.4%	9.3	68	7.6	Fail
22 Person Mac suite R1	4	S	4.7%	16.7	113	10.8	Fail
22 Person Mac suite R2	4	S	4.7%	17.8	106	10.3	Fail
14+1 Person teaching room	4	N	1.9%	8.2	69	7.2	Fail
20 person Mac suite R3	4	N	2.1%	12.5	85	8.6	Fail
30 Person VR lab R1	4	CY	2.1%	10.8	77	7.9	Fail
30 person VR lab R2	4	CY	1.5%	13.9	87	9.4	Fail
42+1 Person teaching room	4	CY	1.8%	12.5	91	9.5	Fail
Seminar room	4	CY	1.4%	14.5	98	9.6	Fail
Social learning space 1	4	W	2.6%	12.5	97	10.2	Fail
Social learning space 2	4	E	2.6%	11.8	87	8.9	Fail
Social learning space 3	4	S	3.6%	12.3	94	9.1	Fail
Shared office/Touchdown	4	N	2.1%	8.0	67	6.8	Fail

A.3 DSY 3 Weather file

DSY 3 is a summer with a long less intense warm spell. The heat event is less intense than DSY 2 but has a higher intensity than DSY1.

Table 5—5 DSY 3_2020High50 current climate overheating results

Zone name	Floor	Glazing orientation	Nat vent	CIBSE TM52			
				Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	CIBSE Guide TM52 Compliance
30+1 Person teaching room R1	2	W	3%	9.7	47	6.0	Fail
30+1 Person teaching room R2	2	W	3%	10.4	52	6.6	Fail
21+1 Person teaching room	2	SW	5%	10.4	57	6.9	Fail
24+1 Person teaching room	2	S	3.6%	10.2	53	6.0	Fail
40+1 Person teaching room	2	CY	3.4%	5.2	35	4.7	Fail
22 Person Mac suite R1	4	S	4.7%	12.6	66	7.5	Fail
22 Person Mac suite R2	4	S	4.7%	9.1	52	6.4	Fail
14+1 Person teaching room	4	N	1.9%	5.4	36	4.4	Fail
20 person Mac suite R3	4	N	2.1%	7.9	46	5.8	Fail
30 Person VR lab R1	4	CY	2.1%	6.0	39	5.2	Fail
30 person VR lab R2	4	CY	1.5%	6.9	42	5.8	Fail
42+1 Person teaching room	4	CY	1.8%	8.3	46	5.7	Fail
Seminar room	4	CY	1.4%	9.2	52	6.3	Fail
Social learning space 1	4	W	2.6%	8.2	49	6.2	Fail
Social learning space 2	4	E	2.6%	6.3	40	5.4	Fail
Social learning space 3	4	S	3.6%	7.4	45	5.	Fail
Shared office/Touchdown	4	N	2.1%	5.4	33	4.2	Fail

Table 5—6 DSY 3_2050High50 future climate overheating results

Zone name	Floor	Glazing orientation	Nat vent	CIBSE TM52			
				Criteria 1 (% hours exceeded)	Criteria 2 (Max. Daily Deg.Hrs)	Criteria 3 (Max. DeltaT)	CIBSE Guide TM52 Compliance
30+1 Person teaching room R1	2	W	3%	13.0	86	9.4	Fail
30+1 Person teaching room R2	2	W	3%	14.3	92	10.0	Fail
21+1 Person teaching room	2	SW	5%	14.4	104	10.8	Fail
24+1 Person teaching room	2	S	3.6%	16.8	104	9.9	Fail
40+1 Person teaching room	2	CY	3.4%	9.3	68	7.6	Fail
22 Person Mac suite R1	4	S	4.7%	16.7	113	10.8	Fail
22 Person Mac suite R2	4	S	4.7%	17.8	106	10.3	Fail
14+1 Person teaching room	4	N	1.9%	8.2	69	7.2	Fail
20 person Mac suite R3	4	N	2.1%	12.5	85	8.6	Fail
30 Person VR lab R1	4	CY	2.1%	10.8	77	7.9	Fail
30 person VR lab R2	4	CY	1.5%	13.9	87	9.4	Fail
42+1 Person teaching room	4	CY	1.8%	12.5	91	9.5	Fail
Seminar room	4	CY	1.4%	14.5	98	9.6	Fail
Social learning space 1	4	W	2.6%	12.5	97	10.2	Fail
Social learning space 2	4	E	2.6%	11.8	87	8.9	Fail
Social learning space 3	4	S	3.6%	12.3	94	9.1	Fail
Shared office/Touchdown	4	N	2.1%	8.0	67	6.8	Fail

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