BUROHAPPOLD ENGINEERING

UCL Institute of Education

Interim Sustainability and Energy Statement - Phase 2C level 3 and 4 entrances

035833

15 January 2021

Revision 01

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00	Interim Sustainability and Energy Statement - Phase 2C level 3 and 4 entrances	DC	08/01/2021	MD
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date	**15 January 2021**
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signature	
date	**15 January 2021**

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Appendix D – Thermal Comfort results, baseline climate

Appendix E – Overheating risk assessment level 3 and 4 entrances

1 Executive Summary

This report sets out the interim sustainability and energy statement for Phase 2C level 3 and 4 entrances to support planning application of the UCL Institute of Education refurbishment. It combines the below spaces:

- Level 3 and 4 entrances, social and working spaces interconnected to the atrium in zone B;
- Level 5 to 9 Zone A;
- Level 6 to 9 wing and core A-B-C zones;

This report follows the approved planning application for Phase 2B (ref. 2020/1567/L and 2020/1520/P) submitted on 26th of March 2020.

The studies covered in this report contain a summary of the Camden Council planning requirements, the energy strategy, overheating risk analysis, thermal comfort assessment and BREEAM strategy. The UCL Institute of Education is a Grade II* listed building, however despite this limiting factor significant efforts are being made by the design team to enhance the sustainability of the building. Key measures include:

- Improving the thermal performance of the building fabric in line with heritage constraints, through the addition of secondary glazing, where consented, and internal insulation to cladding panels.
- Upgrading all major MEP systems and lighting. To comply with Building Regulations, all performance values are better or equal to Part L2B 2013 (including 2016 amendments) and Non-Domestic Building Services Compliance Guide 2013.
- Retaining connection to the Bloomsbury Heat and Power network, which includes boiler and combined heat and power plant, enabling up to 80% of the building's electricity to come from low carbon sources.
- BREEAM 'Excellent' strategy – this includes a wide variety of sustainability measures including the integration of low flow water fittings, responsible sourcing of construction materials, measures to enhance site ecology, security studies, acoustic measures and stringent sustainability criteria for the Contractor.

In terms of total CO_2 reduction for the Phase 2 areas Figure 1—1, preliminary modelling following the GLA energy statement guidance shows up to a 39% reduction in regulated CO_2 emissions compared to the existing building, from passive measures, HVAC improvements and connection to the Bloomsbury Heat and Power network.

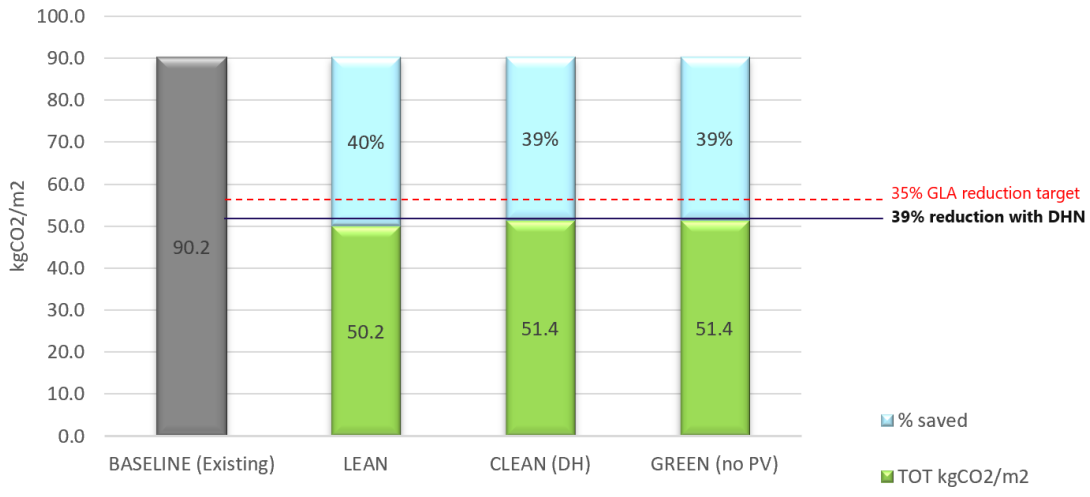


Figure 1—1 CO_2 emissions for the Baseline (existing) and lean, clean and green scenarios

In line with the energy hierarchy reporting requirements for Camden, Table 1—1 shows the calculated 'Lean, Clean, Green' CO_2 savings for the proposed upgrade works.

Table 1—1 - Total CO2 reduction for Phase 2 areas

	UCL IoE Phase 2 refurbishment		
	Total CO_2 (tCO_2)	**Stage reduction (tCO_2)**	**Stage reduction (% CO_2)**
Baseline	478	-	-
Be Lean	266	212	44%
Be Clean	272	206	43%
Be Green	272	206	43%
Total	272	206	43%
Target (Be Green)	310	168	35%
Shortfall	0	0	0

In terms of renewable energy, there is a Camden Planning requirement to target at least a 20% reduction in CO_2 emissions through the installation of on-site renewable energy technologies. Solar photovoltaic (PV) panels will not be included in the application for Phase 2C, as it falls outside of the scope of works. The implementation of solar PV was investigated as part of a masterplan wide study and it will be taken in consideration in future phases of the masterplan if deemed acceptable to heritage.

The thermal comfort results (Appendix E) and the overheating risk assessment for level 3 and 4 entrances (Appendix F) were carried out using IES-Virtual Environment in accordance with the methodology described in CIBSE TM52. Results indicate that the natural ventilation strategy and mechanical ventilation approach integrated with the fabric improvements ensure optimum comfort passing the CIBSE TM52 criteria. Overall, the proposed building cooling demand is lower than the notional as shown below.

Table 1—2 - Summary of notional vs. actual cooling demand

		Notional	Actual
MJ/m^2	Cooling demand	349.4	161.7

In relation to BREEAM, there is good potential to undertake an extensive and sustainable refurbishment for the UCL Institute of Education, which achieves a BREEAM Excellent rating. Phases 1, 2 of the UCL IOE refurbishment will be submitted together under one BREEAM 2014 (RFO) refurbishment and fit out assessment 2014. The summary information presented in this submission shows progress to date on the Phase 1-2 works.

2 Planning Checklist

2.1 Camden Planning Guidance – Sustainability CGP3

Table 2—1 outlines the Camden Council planning requirements in relation to sustainability for existing buildings. Commentary in relation to the proposed Phase 2 works is given.

Table 2—1

Requirement	Commentary
Energy efficiency: existing buildings • All buildings, whether being updated or refurbished, are expected to reduce their carbon emissions by making improvements to the existing building. Work involving a change of use or an extension to an existing property is included. As a guide, at least 10% of the project cost should be spent on the improvements. • Where retro-fitting measures are not identified at application stage we will most likely secure the implementation of environmental improvements by way of condition. • Development involving a change of use or a conversion of more than 500sq m of any floorspace, will be expected to achieve 60% of the un-weighted credits in the Energy category in their BREEAM assessment. • Special consideration will be given to buildings that are protected e.g. listed buildings	*Substantial works are planned to improve the energy efficiency of this Grade II* listed building. Works in phase 1-2 include new secondary glazing, internal wall and roof insulation works where practical and new MEP systems throughout. Overall a 39% reduction in regulated CO2 is calculated following the 'lean, clean, green' hierarchy. For Phase 1, based on the interim cost check report, it was estimated that 19.8% of project costs are being spent on energy efficiency. Phase 2 will be similar, given the same level of energy efficiency is being applied.*
Decentralised energy • Where feasible and viable your development will be required to connect to a decentralised energy network or include CHP.	*Phase 1-2 areas will be connected to the Bloomsbury Heat and Power (BHP) district heating network*
Cooling hierarchy • Proposals should align to the GLA cooling hierarchy: a. Minimising internal heat generation through energy efficient design b. Reducing the amount of heat entering the building in summer c. Use of thermal mass and high ceilings to manage the heat within the building d. Passive ventilation e. Mechanical ventilation	*The GLA cooling hierarchy has been followed. The strategy maximises passive design where feasible using exposed thermal mass, blinds on all windows to reduce solar gain, and low energy lighting/small power to reduce internal heat gains.* *In this report for all spaces including Phase 2C, BREEAM thermal comfort modelling has been carried out.*
Monitoring and management • Proposals should include appropriate Building Management Systems, metering, monitoring and management	*The refurbishment works for Phase 2 areas include the provision of new energy meters that will be connected to the UCL BMS.*
Renewable energy • All developments are to target at least a 20% reduction in carbon dioxide emissions through the installation of on-site renewable energy technologies. Special consideration will be given to heritage buildings and features to ensure that their historic and architectural features are preserved.	*Solar photovoltaic (PV) panels will not be included in the application for Phase 2.*

<table>
<tr>
<td>Sustainability assessment tools (BREEAM)
Submission of a pre-assessment report at the planning application stage. The report should summarise the design strategy for achieving your chosen level of BREEAM and/or Code for Sustainable Homes and include details of the credits proposed to be achieved.
Pre-assessment report is to be carried out by a licensed assessor. The name of the assessor and their licence number should be clearly stated on the report.
You are strongly encouraged to meet the following standards in accordance with Development Policy DP22 - Promoting sustainable design and construction:
<table>
<tr><th>Time period</th><th>Minimum rating</th><th>Minimum standard for categories (% of un-weighted credits)</th></tr>
<tr><td>2010-2012</td><td>‘very good’</td><td rowspan="2">Energy 60%
Water 60%
Materials 40%</td></tr>
<tr><td>2013+</td><td>‘excellent’</td></tr>
</table></td>
<td>The project is targeting a BREEAM Excellent rating with a single assessment across Phases 1 up to 3. BREEAM Excellent rating of 75.8% is currently deemed achievable for the development. The project is currently targeting 10 credits for the development under Energy category Ene01. 77% of credits are targeted in the water category. 61% of credits are targeted in the material category and 63% in the waste category. Buro Happold are appointed as BREEAM Assessor and BREEAM AP for the scheme. The Contractor also has a BREEAM AP as their sustainability champion.</td>
</tr>
<tr>
<td>Water efficiency
The Council expects all developments to be designed to be water efficient by minimising water use and maximising the re-use of water. This includes new and existing buildings.
The Council will require developments over 1000sq m to include a grey water harvesting system, unless the applicant demonstrates to the Council’s satisfaction that this is not feasible.</td>
<td>Low flow fittings will be targeted as part of refurbishment works in line with BREEAM Wat 01. Grey water recycling feasibility to be confirmed by MEP engineer in Phases 3.</td>
</tr>
<tr>
<td>Sustainable use of materials & waste
All developments should aim for at least 10% of the total value of materials used to be derived from recycled and reused sources. This should relate to the WRAP Quick Wins assessments or equivalent. Special consideration will be given to heritage buildings and features to ensure that their historic and architectural features are preserved.
Major developments are anticipated to be able to achieve 15-20% of the total value of materials used to be derived from recycled and reused sources.
Construction waste and waste to landfill should be minimised</td>
<td>For Phase 2 a pre-refurbishment audit will be carried out by the Contractor to identify opportunities for material re-use and recycling with monitoring the construction waste activities throughout construction works.</td>
</tr>
<tr>
<td>Adapting to climate change
All development is expected to consider the impact of climate change and be designed to cope with the anticipated conditions.</td>
<td>A climate change risk assessment was conducted for BREEAM credit Wst05 covering the masterplan.</td>
</tr>
<tr>
<td>Brown roofs, green roofs and green walls
The Council will expect all developments to incorporate brown roofs, green roofs and green walls unless it is demonstrated this is not possible or appropriate. This includes new and existing buildings. Special consideration will be given to historic buildings to ensure historic and architectural features are preserved.</td>
<td>As the building is listed, the ecologist has recommended that external terrace areas include planters with native species.</td>
</tr>
<tr>
<td>Flooding
Developments must not increase the risk of flooding and are required to put in place mitigation measures where there is known to be a risk of flooding. Within the areas shown on Core Strategy Map 5 (Development Policies Map 2) we will expect water infrastructure to be designed to cope with a 1 in 100-year storm event in order to limit the flooding of, and damage to, property.</td>
<td>The site is in flood risk zone 1 (low risk of flooding). The proposed Phase 2 refurbishment works will not increase surface water run-off.</td>
</tr>
</table>

External lighting • Lighting can have particular negative impacts on biodiversity. Unnecessary lighting should be avoided. Where lighting may harm biodiversity timers or specific coloured lighting will be required to minimise any disturbance.	*BREEAM requirements for external lighting have been embedded into the project.*
Local food growing • We encourage food to be grown wherever possible and suitable. Rooftops and shared spaces such as gardens and parks provide opportunities.	*Local food growing is not incorporated into the scheme.*
Biodiversity • Proposals should demonstrate how biodiversity considerations have been incorporated into the development; if any mitigation measures will be included; and what positive measures for enhancing biodiversity are planned.	*An ecology study has been completed, recommending planting of native species on external terrace areas. However, the ecology report is not relevant to this Phase 2C submission.*

3 BREEAM Assessment Strategy

3.1 Overview

BREEAM (which stands for the "Building Research Establishment Environmental Assessment Methodology") sets the standard for best practice in sustainable building design, construction and operation and has become one of the most comprehensive and widely recognised measures of a building's environmental performance.

Phases 1, 2 and 3 of the UCL IOE refurbishment will be submitted together under one BREEAM Refurbishment and Fit-out 2014 (RFO). The "UCL Sustainable Building Standard" states that all refurbishment projects with building services or building fabric upgrades must achieve a **BREEAM Excellent** rating.

In order to facilitate this approach in a complex phased project will require careful project management with the Contractor providing design stage and post construction BREEAM evidence for each element of the project as if it were a single assessment in its own right.

Supporting this process, the Contractor has nominated a Sustainability Champion throughout the design and construction process to formally report progress on BREEAM items to the client and BREEAM Assessor. Providing overall leadership to the BREEAM assessment are Buro Happold, who are appointed in a client side role as BREEAM Assessor and BREEAM AP for the project.

3.2 Pre-assessment score

The BREEAM pre-assessment score (consisting of Phase 1 and 2 combined works) for the UCL IOE masterplan is shown in Figure 3—1. As shown, the project is on track to achieve a score is 75.8% surpassing the 'Excellent' threshold.

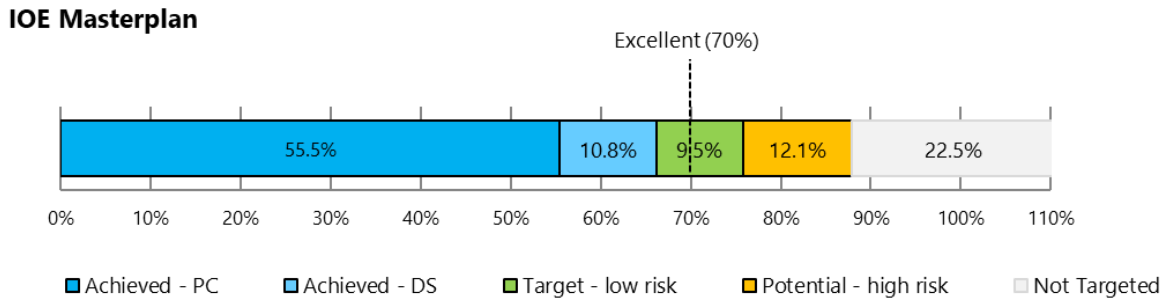
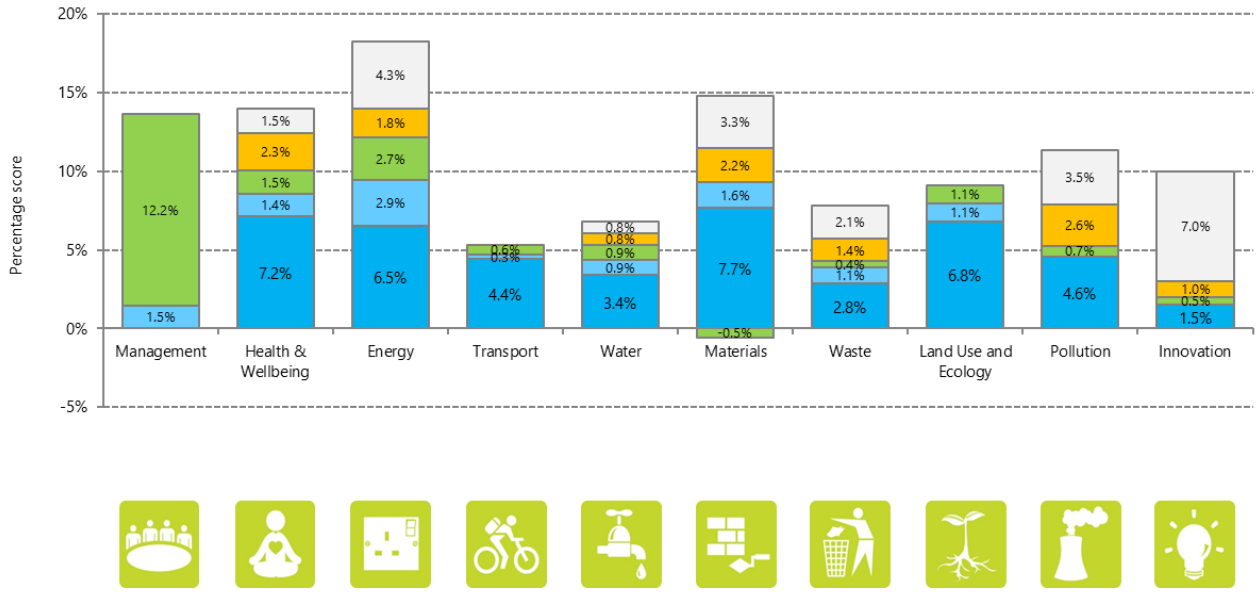


Figure 3—1 – BREEAM pre-assessment score (Phase 1 and 2 masterplan progress)

The Masterplan assessment tracking schedule has been updated for Phase 2 works based on information and advice received from the design team in order to identify the targeted and potential scores for the development. As shown, 55.5% of 'post construction' evidence has already been secured based on 'masterplan' studies from Phase 1 that can be carried forward into Phase 2.



Error! Reference source not found. **shows the build-up of the BREEAM score by category.**

3.3 Supporting commentary

In support of the Camden planning checklist, further commentary on key areas of interest are provided below:

Materials sourcing and waste

As part of the BREEAM assessment a number of credits are targeted relating to materials sourcing. Overall, in the materials category 62% of credits are targeted at low risk. Credits include sourcing A/A+ rated materials using the BRE green guide, responsible sourcing, designing for durability and robustness and tracking of material efficiency decisions. Regarding waste, 54.5% of credits in the waste category are targeted at low risk. Specifically, for Phase 2 a pre-refurbishment audit was carried out to identify opportunities for material re-use and recycling. Construction waste activities shall also be monitored throughout construction works.

Green infrastructure and biodiversity

In line with the ecologist's recommendations, planters with native species shall be provided to terrace areas. Overall, in the ecology category 4/4 credits are targeted.

Water efficiency and SuDS (including rainwater and greywater harvesting)

Low flow water fittings have been specified achieving a reduction in potable water usage of over 40%. Overall in the water category 77.7% of credits are targeted. The site is located in flood risk zone 1 (low risk of flooding). The proposed Phase 2 refurbishment works will not increase surface water run-off.

Building Management Systems, metering, monitoring and management

The sub-metering for Phase 2 covers LTHW, cooling, AHUs, MCCP control panels, systems above 50kW, lighting and small power. Metering and Sub-metering for data will be made available to the UCL campus wide metering EMON System and Schneider Stuxtureware platform.

4 Energy strategy

4.1 Overview

This section of the report describes the energy strategy for the overall Phase 2 works including level 3 and 4 entrances of the UCL IOE refurbishment.

In order to comply with Camden Planning requirements for refurbishments, energy modelling following the GLA energy statement is required. This must be achieved by reporting performance through a 'Lean, Clean, Green' approach as illustrated in Figure 4—1.

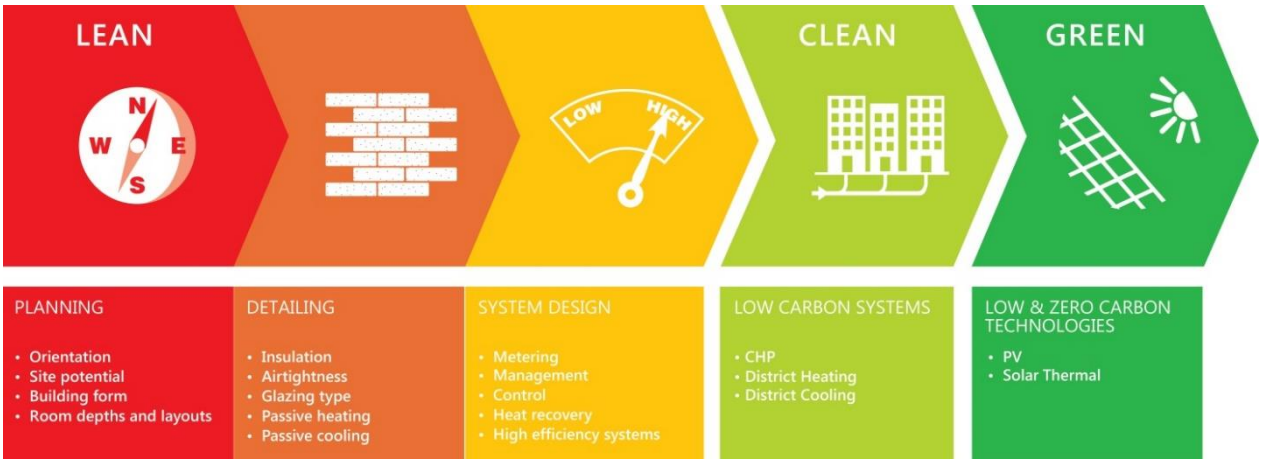


Figure 4—1 - Summary of GLA 'lean, clean, green' energy hierarchy (indicative)

4.2 Modelling summary

Energy modelling has been conducted in IES Virtual Environment 2019. The whole building energy model, and Phase 2 areas (as shown in Figure 4—2 and Figure 4—3 respectively) is based on layouts received by Perkinswill architects, Feb 2020.

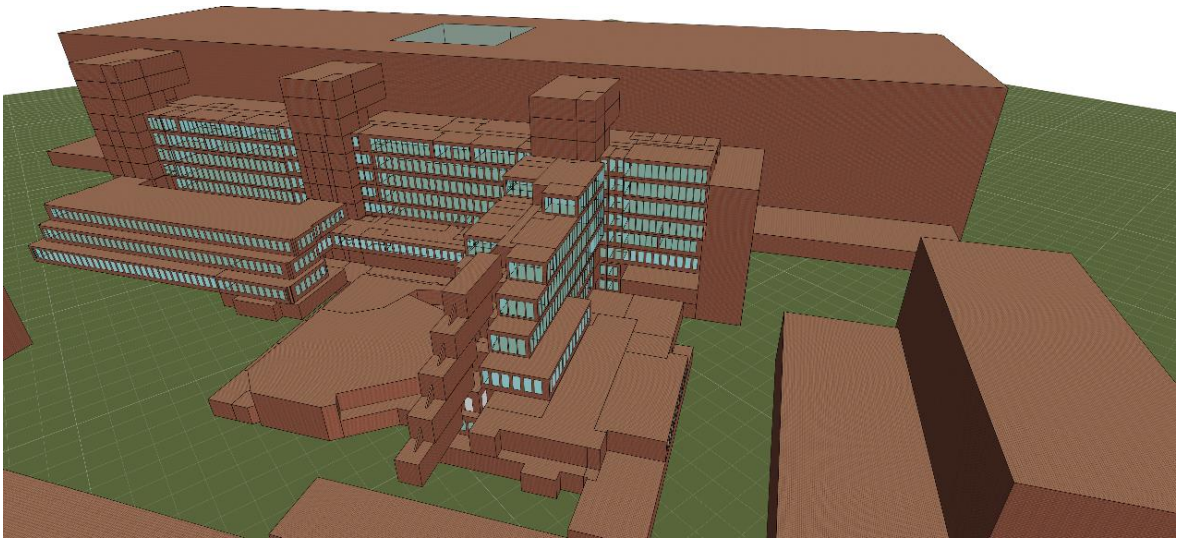
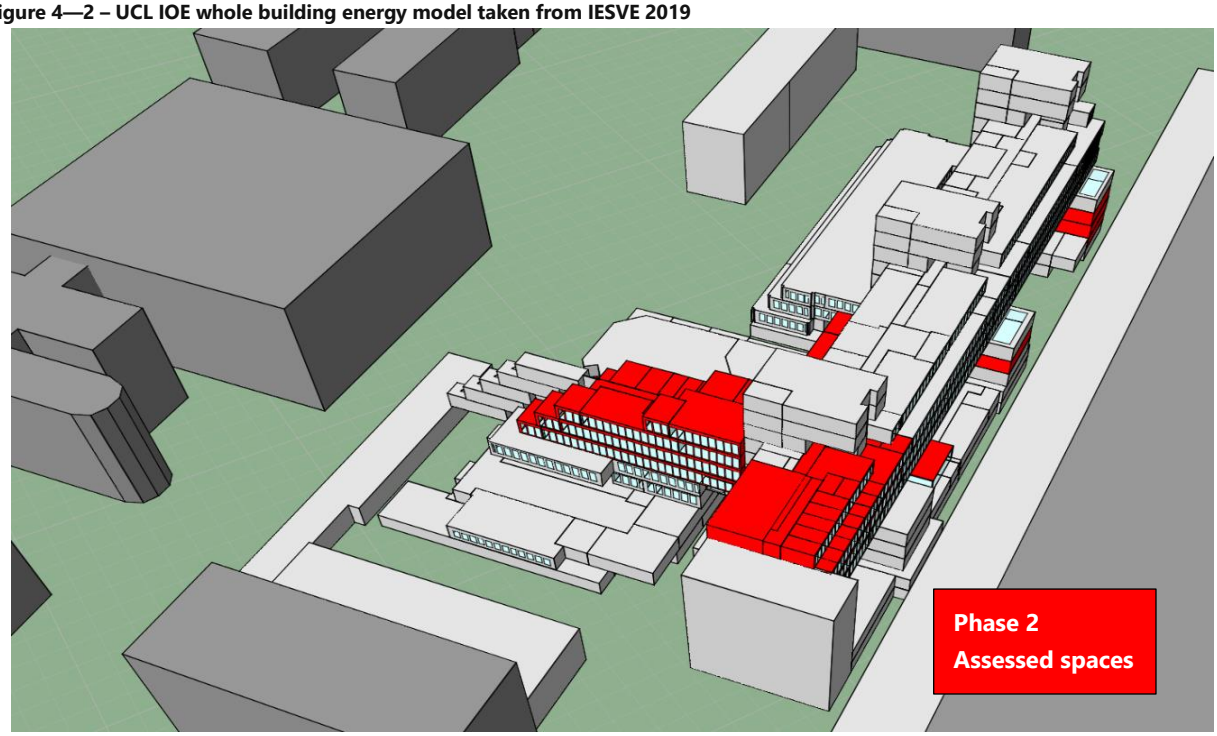


Figure 4—2 – UCL IOE whole building energy model taken from IESVE 2019



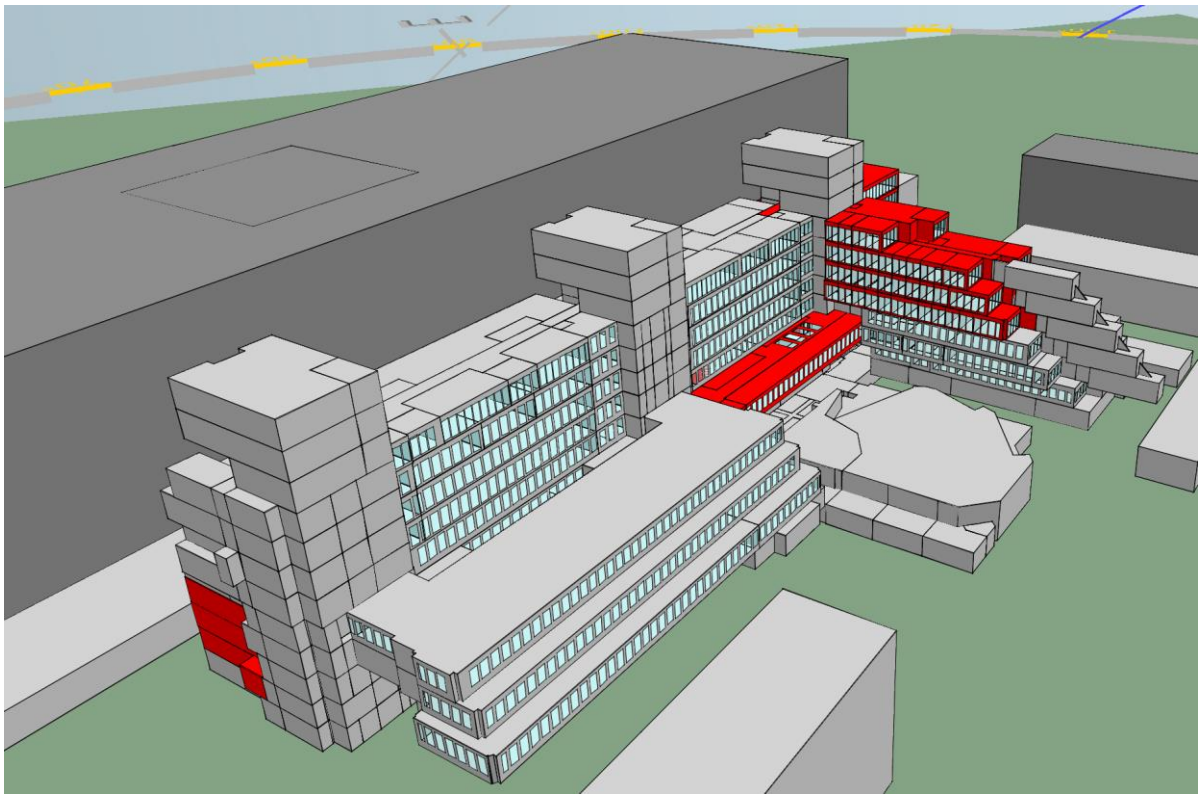


Figure 4—3 - UCL IOE energy model (Phase 2 areas highlighted) taken from IESVE 2019

In line with GLA reporting requirements for refurbished buildings, the following design scenarios have been modelled:

- **GLA Baseline**
  - Existing building with existing building fabric parameters, but with gas boiler & standard air conditioning
- **BE LEAN**
  - Actual building with improved building elements
  - Daylight dimming and improved lighting energy efficiency
  - Improved HVAC efficiency & improved boiler efficiency
- **BE CLEAN**
  - Actual building with Bloomsbury campus district heating system
- **BE GREEN**
  - Model is the same as the clean model, no PV or other renewables will be implemented as part of this refurbishment.

District heating

In terms of the 'clean' improvements, the building is currently connected to the existing Bloomsbury Heat and Power (BHP) district heating network, which provides low-carbon heat as well as renewable electricity generated simultaneously via a CHP (combined heat and power) engine. The Bloomsbury campus district heating supplies medium temperature heating water (MTHW) to multiple spaces within the IOE complex by using local heat exchangers to distribute low variable and constant temperature heating water circuits throughout the complex. Therefore, the "Clean" energy strategy for the project must include a district heating network providing heating and DHW whereas newly formed and existing chillers with primary cooling system is serving cooling to the whole development.

4.3 Building Fabric inputs

Building fabric input parameters for the existing and proposed building models are summarised in Table 4—1. Note that in some cases Part L2B U-values are not technically feasible on the listed building, but this has been deemed as acceptable by Building Control.

Table 4—1 - Modelling inputs tested (building fabric parameters) and Part L2B

		Existing Model	Improved Model	Part L2B 2013 (for reference)		
		(assumed based on review of available information)	**(Includes curtain wall upgrade, secondary glazing, roof insulation and skylights replacement)**	**Threshold of retained Element**	**Value of replacement element**	**New thermal elements and controlled fittings**
Fabric U-values (W/m2K)	Curtain wall panel	Average curtain wall value assumed to be 3.24 W/m^2*K: 13mm aluminium, 23mm asbestos insulation, 8mm aluminium	Opaque panelling below the glazing shall be upgraded to a centre pane U-value of 0.3 W/m^2. K (equivalent to an overall U-value of 1.7 W/m^2*K when all thermal bridging is considered)			

	Glazing	Glazing at 5.7 W/m^2 * K: single glazing metal frame	Secondary glazing, U-value 2.1 W/m^2. K g-value: 0.4	3.3 W/m^{2}K	1.8 W/m^{2}K heritage constraint does not allow to achieve a centre pane U value of 1.8 W/m^{2}K	
	Solid wall	2.6 W/m^2. K (300mm cast dense concrete, membrane)	Where not feasible 0.7 W/m2 K as a minimum value. Walls (forming the external envelope) shall be internally insulated to achieve a U-value of 0.3 W/m^{2}K	0.7 W/m^{2}K	0.3 W/m^{2}K	0.28 W/m^{2}K
	Roof	2.3 W/m^2. K (400mm concrete deck & membrane, concrete tile 100mm)	0.18 W/m^2. K for improved elements (400mm concrete deck, insulation 100mm & membrane, concrete tile 100mm) *	0.35 W/m^{2}K	0.18 flat roof W/m^{2}K	
	Internal wall	1.58 W/m^2. K (200mm cast concrete medium)	0.95 W/m^2. K (lightweight plaster)			
	Internal floor/ceiling	2.5 W/m^{2}K (300 reinf concrete, 20mm screed)	2.5 W/m^{2}K (300 reinforced concrete, 20mm screed)			
	Ground floor	0.60 W/m^2. K (400mm reinf. Concrete & 30mm screed + adjustment)	0.32 W/m^2. K			0.22 W/m^{2}K
	Exposed floor	0.6 W/m^2. K	0.6 W/m^2.K			0.22 W/m^{2}K

Glazing thermal properties		**Existing Model**	**Improved Model**	**Part L2B 2013 Threshold of retained Element**	**Part L2B 2013 New thermal elements and controlled fittings**
**External Glazing Level 3 new pavilion (entrance)	U-value	5.7 W/m^2. K	1.8 W/m^2. K or better	3.3 W/m^{2}K	1.8 W/m^{2}K
	G-value	0.73	0.26-0.31		
	LT (Light transmittance %)	69%	41%		
**External Glazing Level 4 west façade (Core B)	U-value	5.7 W/m^2. K	NO thermal upgrade	3.3 W/m^{2}K	1.8 W/m^{2}K
	G-value	0.47			
	LT (Light transmittance %)	41%			
Roof lights Level 5 Core B-C	U-value	Glazing at 5.7 W/m^{2}K: single glazing metal frame	NO thermal upgrade	3.3 W/m^{2}K	1.8 W/m^{2}K
	G-value	0.73			

**New Rooflights Level 4 Core B	U-value	Glazing at 5.7 W/m^{2}K: single glazing metal frame	1.8 W/m^2. K or better		
	G-value	0.73	0.25		
	LT (Light transmittance %)	69%	41%		
Air tightness	50 Pa (m3/h.m2 @ 50 Pa)	19 (to be tested by contractor)	9.5 (as per Phase 1A measured performance), although note that the Employers Requirements require 6.5, thus a conservative position has been taken for the model.		

* Conservative values taken – Contractor to confirm Part L compliant strategy

** L3-L4 fabric thermal values incorporated in Phase 2 energy model for the energy and CO_2 reduction results

4.4 Building Services Inputs

Building services input parameters for the existing and proposed building models are summarised in Table 4—2.

Table 4—2 - Building services inputs for heating, cooling, ventilation, DHW and lighting

	Existing	**Improved**	**Part L2B limiting efficiencies for new systems**
Heating	**Central heating using water, radiators**	**Central heating using water, radiators**	**-**
Description	Existing radiators	Zone A and Wing A levels with new radiator	
Heat source	District heating	District heating	
Pump type	Constant speed	Constant Speed	
SCOP	0.92	0.92	
Cooling			
Chillers	2no DX cooled existing chillers cater for Level 5-6 Core B and Core C	New chilled water circuit in Core A plant room 2 served by 2no. new chillers cater for the Wing and Core A	
Power kW	475	499 / 659	
SEER / EER	3	4.43 / 4.62	
Terminal units		DX cooling (split-multi split system in comms rooms)	
Terminal units	existing fan coil systems Level 5-6 Core B	Water cooled fan coil systems	
Ventilation	**Centralised balanced mech vent**	**Centralised balanced mech vent**	
Duct air leakage standard	Not tested	Not tested	

AHU air leakage standard	Class worse than L3 or not tested	L1	
Pump type	Constant speed	VSDs will be specified to comply with necessary regulations.	*Either of B&ES DW/144, BS EN1507:2066, BS EN 12237:2003, BS EN 13403:2003*
Heat recovery %	0%	80%	*Thermal wheel > 65%*
core A toilets Extract fan SFP (W/(l/s)	0.8 @ 10ACH	0.4-0.5 @ 10ACH. Extract Fan is remote from Zone (located in Plant Room) and serves WCs on all floors.	*< 0.4*
core B toilets Extract fan SFP (W/(l/s)	0.8 @ 10ACH	0.4-0.5 @ 10ACH. Extract Fan is remote from Zone (located in Plant Room) and serves WCs on all floors.	*< 0.4*
core C toilets Extract fan SFP (W/(l/s)	0.8 @ 10ACH	Not currently in scope	*< 0.4*
Central ventilation AHU Specific fan power SFP (W/(l/s)	Centralised balance mech vent (AHU Plant selected to have SFP less than 3 W/(l/s))	AHU Plant selected with SFP less than 2.2 W/(l/s))	Centralised balance mech vent (AHU Plant selected to have SFP less than 2.2 W/(l/s))
terminal ventilation SFP (W/(l/s) - FCUs	0.5	0.15 Average (0.23 maximum SFP currently)	*< 0.5*
terminal ventilation SFP (W/(l/s) - indoor packaged VAV unit		AHU Plant selected with SFP less than 2.2 W/(l/s) No additional fan associated with VAV units, systems served by central air handling unit plant.	Centralised balance mech vent (AHU Plant selected to have SFP less than 2.2 W/(l/s))
Metering			
System metering	no	yes	
Metering warn "out of range" values	no	yes	
DHW			
Storage volume	existing 800 L Vessels	Retaining existing 800 L Vessels	
Storage losses (kWh/(l.day))	0.0063	As Existing following validation of existing systems.	
Circulation losses (W/m)	30	As Existing following validation of existing systems.	
Pump power	0.2	As Existing following validation of existing systems.	
Heating system controls			*To comply with as a minimum with the Non-Domestic Building Services Compliance Guide*
Central time control	no	yes	
Optimum start and stop	no	yes	
Local temperature control	no	yes	
Local time control	no	yes	
Weather compensation	no	no	
Lighting Phase 2			
Efficacy Llm/W (Back of the house)	40	*>80 Llm/W*	*>60 Llm/W*
Efficacy Llm/W (Office)	40	*>95 Llm/W*	*>60 Llm/W*
Efficacy Llm/W (meeting room)	40	*>95 Llm/W*	*>60 Llm/W*

Efficacy Llm/W (social/break out)	40	*>80 Llm/W*	*>60 Llm/W*
Efficacy Llm/W (teaching room)	40	*>80 Llm/W*	*>60 Llm/W*
Efficacy Llm/W (circulation)	40	*>80 Llm/W*	*>60 Llm/W*
Efficacy Llm/W café	40	*>80 Llm/W*	*>60 Llm/W*
Efficacy Llm/W breakout	40	*>80 Llm/W*	*>60 Llm/W*
Efficacy Llm/W circulation	40	*>80 Llm/W*	*>60 Llm/W*
Controls	Switch	Dimming/PIR/Time	
Parasitic power W/m2	0.1 W/m2	0.3 W/m2	

4.5 Energy and carbon emission results

Energy modelling and CO_2 reduction modelling results are given below in Table 4—3. The table gives a summary of the GLA modelling results, whereby the % saving represents the reduction against the Part L 2013 Notional Building and 35% improvement is typically required to meet London Plan performance.

Table 4—3 - Energy modelling results for Phase 2

		LEAN			**CLEAN**	**GREEN**
Annual carbon emissions ($kgCO_2/m^2$)	**GLA Baseline**	**Improved fabric**	**Lighting controls & efficiency**	**Improved HVAC efficiency**	**DH system**	**No renewable**
Heating	30	9			10	10
Hot water	44	20			21	21
Cooling	0	2			2	2
Fans	12	14			14	14
Lighting	5	4			4	4
Building emission rate Total CO_2	90.2	50.2			51.4	51.4
% saving		-40.1%			-39%	-39%

Figure 4—4 illustrates the CO2 saving results. As shown, the preliminary modelling results achieve a **40%** improvement over the GLA Baseline. The district heating system efficiently reduces the carbon emissions by **39%** over GLA Baseline model without significant negative impacts. As no renewable energy systems (e.g. PV panels) are proposed specifically for Phase 2 there is no renewable reduction.

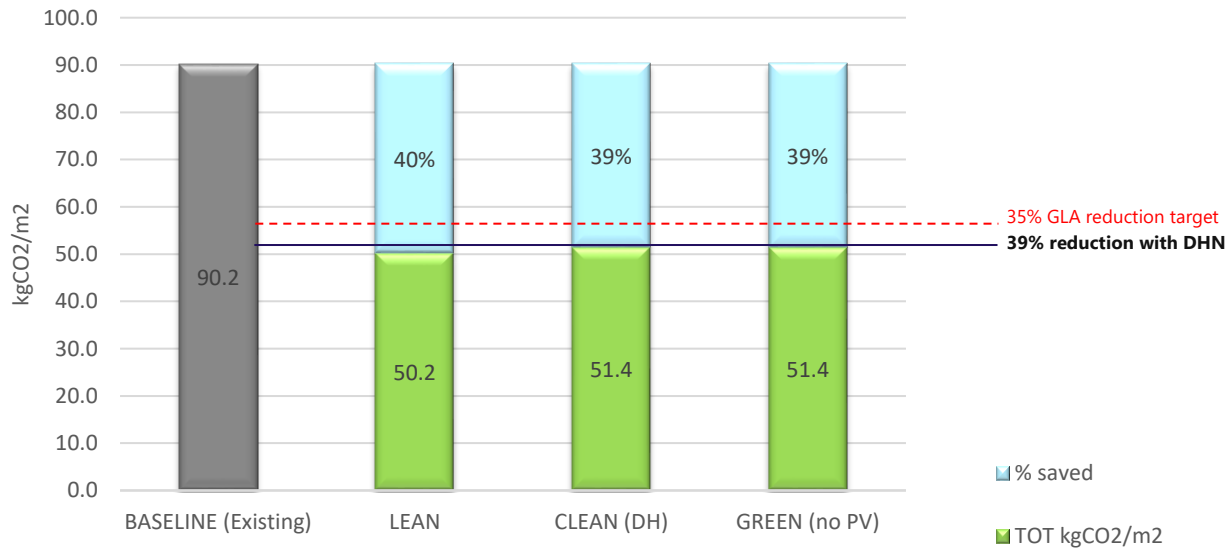
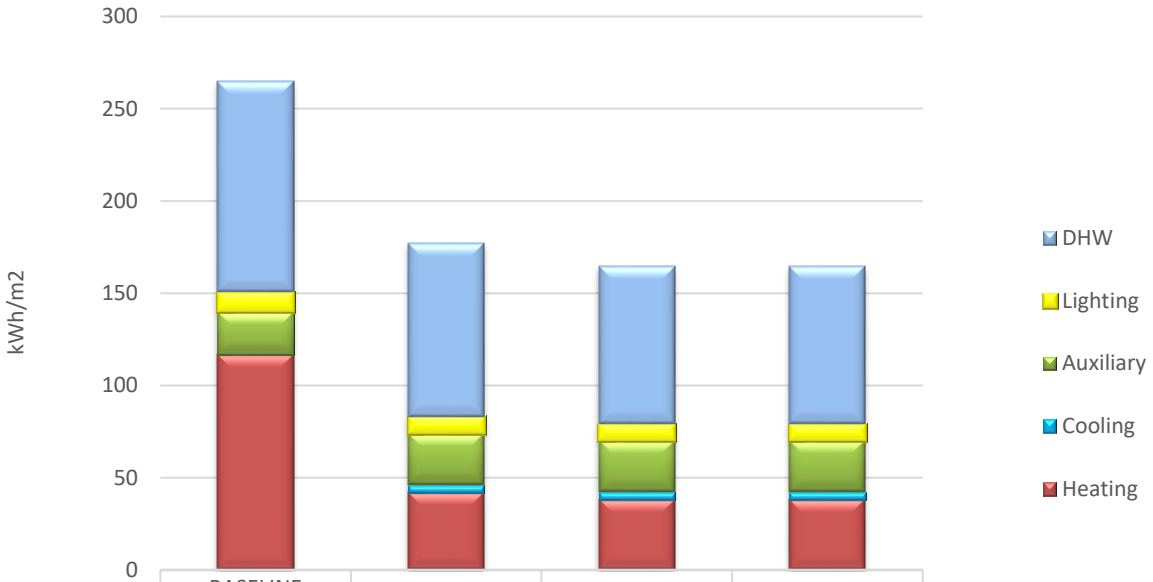


Figure 4—4 – Regulated CO2 reduction results expressed using the GLA lean, clean, green hierarchy

Figure 4—5 and Table 4—4 gives a summary of the modelling results in terms of energy end-use consumption. As shown, the highest energy consumption is from DHW, due to the existing storage heat losses and secondary circulation losses. The next highest load in the 'actual' building is heating energy use, followed by auxiliary energy for fans and pumping.



	BASELINE (Existing)	LEAN	CLEAN (DH)	GREEN (no PV)
DHW	115	94	85	85
Lighting	10	9	9	9
Auxiliary	24	28	28	28
Cooling	0	4	4	4
Heating	117	42	38	38

Figure 4—5 – Modelled regulated energy reduction for UCL IOE Phase 2 areas

Table 4—4 - Energy end use results and CO_2 reduction modelling results for Phase 2

		Baseline (Existing)	LEAN	CLEAN	GREEN
Building emission rate ($kgCO_2/m^2$)		90.2	50.2	51.4	51.4
Carbon savings (%)		-	40.1%	39%	39%
$kgCO_2/m^2$	Heating	30	9	10	10
	Cooling	0	2	2	2
	Auxiliary	12	14	14	14
	Lighting	5	4	4	4
	Domestic hot water	44	20	21	21
Energy kWh/m^2	Heating	117	42	38	38
	Cooling	0	4	4	4
	Auxiliary	24	28	28	28
	Lighting	10	9	9	9
	Domestic hot water	115	94	85	85

For further details of the energy models, see the BRUKL reports in Appendix A-C.

5 Thermal comfort analysis

5.1 Overview

This section contains a thermal comfort assessment for Phase 2 occupied rooms within the building. The assessment covers the baseline and future climate assessment against the adaptive comfort standard specified in CIBSE Technical Memorandum 52 according with BREEAM 2014 UK Refurbishment Non-domestic buildings. For this planning submission the thermal comfort calculations have been aligned with the ventilation layouts stage 4 final issue provided by Long&Partners on 30th of June 2020 and based on the latest mechanical system inputs.

The thermal comfort strategy for UCL IOE has been developed following the GLA cooling hierarchy shown below, whereby active cooling systems are only utilised when all passive design measures have been exhausted.

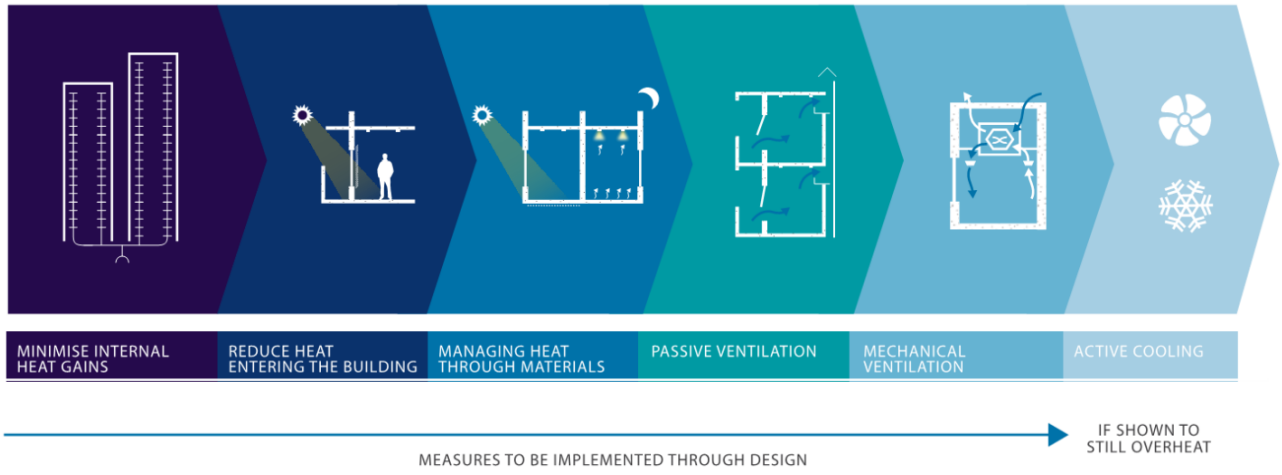


Figure 5—1 - Summary of GLA cooling hierarchy followed (indicative)

5.2 Phase 2C overheating risk assessment

The following chapter describes the overheating principles for Phase 2 overall. For the overheating assessment results for the phase 2C level 3 and 4 entrances separately reported, see Appendix E. In summary, the naturally ventilated occupied spaces (Level 3 and 4 entrances, reception, working spaces) under the current and future climate are classed PASS the CIBSE TM52 overheating criteria.

5.3 Modelling summary

The thermal comfort assessment was carried out IES Virtual Environment 2019, in accordance with CIBSE AM11 and BREEAM credit Hea04. Results are assessed against the CIBSE TM52 criteria. 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.

An image of the IES model, incorporating the rooms assessed for comfort is shown in Figure 5—2. The model and the internal layouts reflect the Stage 4 final issue design (refer to Long&Partners drawings LP-CA-04—DR-M-1000)

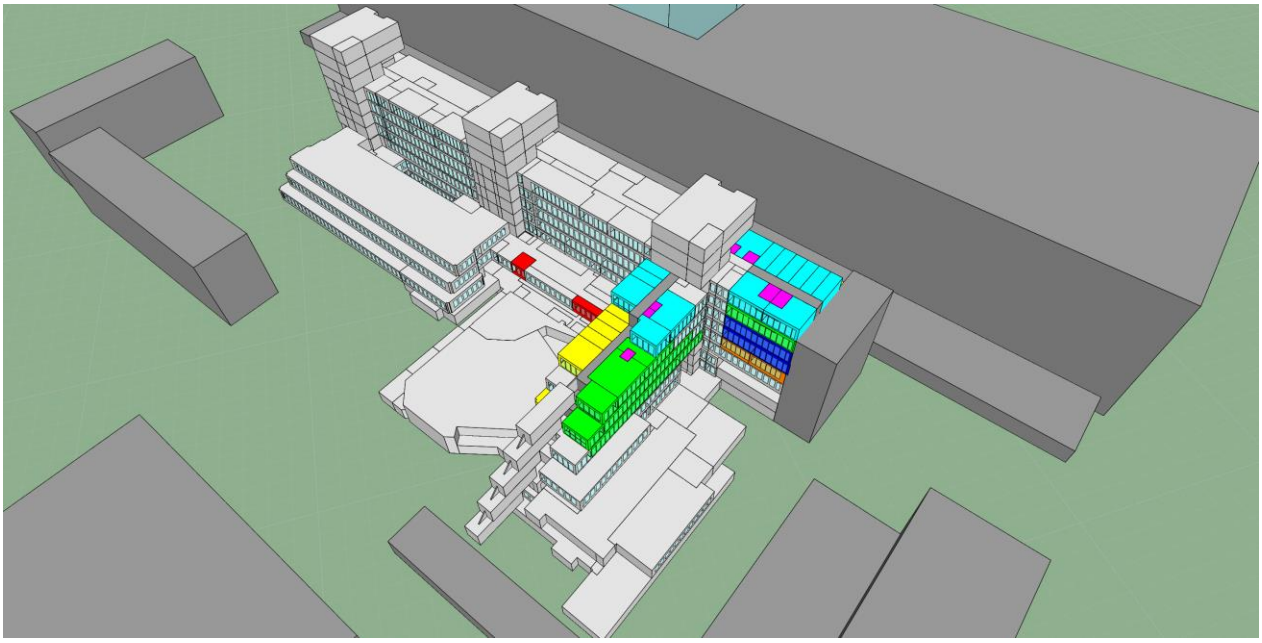


Figure 5—2 - Phase 2 Core A and B level 4 to 9 and Wing Level 6 to 9 model geometry created in IES

Weather files

As per BREEAM Hea04 and UCL Sustainable Building Standard guidelines, two sets of weather files were tested:

Table 5—1 - Summary of weather files used

Weather file set	Description	Notes
LWC1989_baseline.epw	CIBSE weather file (DSY1 moderately warm summer)	In accordance with the BREEAM the naturally ventilated spaces as workspaces, shared hub and office units are tested in the current scenario
LWC1989_2050Med50pct.epw	Future weather predictions for 2050's under medium-risk climate change scenario	In accordance with BREEAM the naturally ventilated spaces as workspaces, shared hub and office units are tested in a 2050 scenario

PMV/PPD criteria

For air-conditioned spaces, the predicted mean value (PMV) and predicted percentage dissatisfied (PPD) values indicate the level of thermal comfort in a space. Table 5—2 provides the acceptable ranges for PMV and PPD for any space, as defined in CIBSE Guide A. Both values must fall within their respective ranges for each space in winter and summer in order to demonstrate compliance.

Table 5—2 - PMV and PPD ranges

	Minimum allowable value	Maximum allowable value	Notes
PMV	-0.5	+0.5	It is desirable to achieve a PMV of 0; negative scores suggest temperatures are below the optimal thermal comfort (i.e. too cold), and positive scores are above optimal thermal comfort (i.e. too hot).
PPD	5%	10%	The PPD is a percentage that represents the number of people that would be thermally uncomfortable with the same conditions, level of activity and clothing in each thermal environment

Heat gains

Inputs for internal equipment and lighting heat gains are given in Table 5—3. It is assumed that most of the equipment gains in the teaching spaces will be from personal laptop use by students, whereas in the offices there is likely to be a mix of laptops, screens, computers and additional facilities such as photocopiers.

Table 5—3 - Internal gains for occupancy, equipment and lighting

Space type	Occupancy diversity	Occupancy (people)	Load/Person	Lighting (W/m^2)	Equipment (W/m^2)
Cellular office	80%	3	Sens. Load (75 W/p) Lat. Load (55 W/p)	6	25
Shared hub	80%	6	Sens. Load (75 W/p) Lat. Load (55 W/p)	4	15
Shared hub	80%	7	Sens. Load (75 W/p) Lat. Load (55 W/p)	4	15
Teaching IOE studies	100%	3	Sens. Load (75 W/p) Lat. Load (55 W/p)	4	15
Quiet space	100%	1	Sens. Load (75 W/p) Lat. Load (55 W/p)	5	15
Meeting room	100%	2	Sens. Load (75 W/p) Lat. Load (55 W/p)	5	25
Meeting room	100%	4	Sens. Load (75 W/p) Lat. Load (55 W/p)	5	25
Meeting room	100%	8	Sens. Load (75 W/p) Lat. Load (55 W/p)	5	25
Break out	80%	16	Sens. Load (75 W/p) Lat. Load (55 W/p)	5	10
Profile		30% 8AM to 9AM 50% 9AM to 9.30AM 100% 9.30AM to 6PM 50% 6PM to 7PM 30% 7PM to 10PM		100% 8AM to 10PM, 10% at night	100% 9AM to 7PM, 10% at night

Assumed occupancy densities for the Phase 2 occupied spaces on level 4 up to 9 are illustrated in Table 5—3. Circulation spaces are typically not considered occupied if not occupied for longer than 30 minutes, however, the circulation space on the shared hub may be considered a transition space with working area, it is likely that such an area might be used by staff or students and is taken into account during the overheating and thermal comfort analysis.

5.4 HVAC strategy

The ventilation strategy is illustrated below:

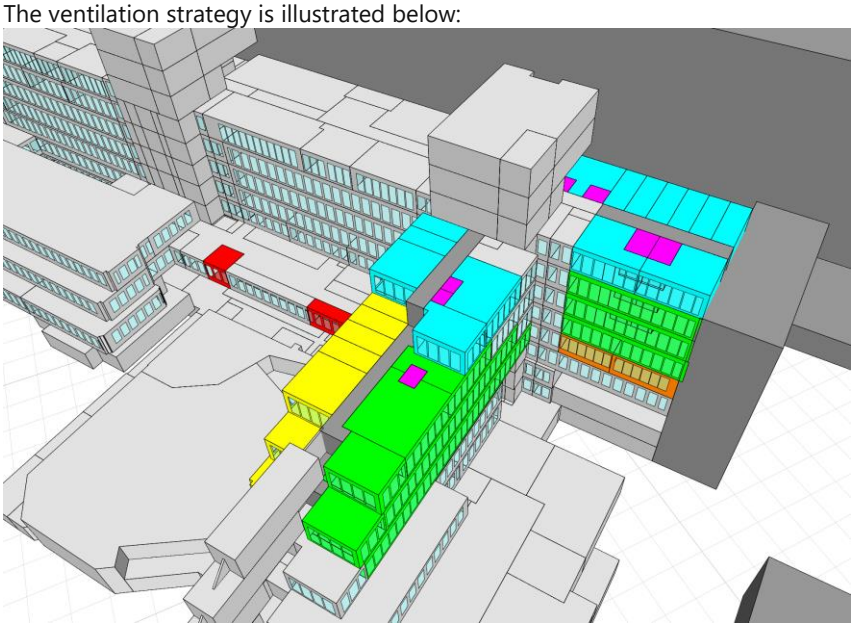


Figure 5—3 - Phase 2 HVAC strategy

L4 breakout/group study (Zone B – west façade) – only heating served by FCUs

L5 Teaching spaces (Zone B and A) – heating and cooling served by FCUs

L6-L7-L8 offices (Zone A and Wing) – naturally ventilated with additional fresh air supplied at 18-20°C. The cellular and open plan offices are controlled by localised VAV boxes with combined CO2 and temperature sensors.

L6-L7-L8 Shared hub (Zone A and Wing) - naturally ventilated with additional fresh air supplied at 18-20°C. The spaces are controlled by localised VAV boxes with combined CO2 and temperature sensors.

L6-L7-L8-L9 Inner small meeting rooms (Zone A and Wing) – locally controlled for thermal comfort by combined CO2 and temperature sensor connect to VAV box

L9 Wing and zone A areas will be thermally controlled via localised FCUs

Windows in the wing and core A spaces on level 5 to 9 are sash windows, proposed to be improved with a secondary glazing panel. Sash windows are typically openable up to 50%. However, due to adjacency of the terrace to certain windows, these are locked and limited to an opening of circa 10% due to security reasons.

In order to achieve adequate thermal comfort TM52 thermal standards the wing and core A rooms from level 5 to 9 have the following HVAC features:

- Variable and constant air volume (VAV/CAV) and CO_2 sensors shall be installed in an occupied space and connected to VAV systems to modulate the fresh air provision into each room.
- Provision of airflow 3 l/s m^2 supplied at 18 °C delivered when outside air temperature exceeds 28°C and auxiliary flow rate of 3 l/s m^2 at 20°C.
- Possibility for users to open the sash windows to reflect the manually bottom/top panel opening profile in occupied hours. In order to simulate the manually opening it was considered a ventilation opening profile in IES thermal model applied to the bottom/top vent panels.
- Occupied rooms at level 9 zone A (office, shared hub and meeting room) and in the wing spaces (offices and shared hub) shall be mechanically ventilated treated with FCUs.
- Combined CO2 and temperature sensors shall be provided into the inner small meeting rooms to control locally the thermal comfort.

The tables Table 5—4 and Table 5—5 outline the HVAC strategy in terms of flow rates to Wing levels 6-9 and Core A (levels 5-9) respectively. In Table 5—6, the heating and cooling set points as agreed with the building services engineers are set out.

5.4.1 HVAC Strategy – Level 6 to 9 Wing

Table 5—4 - Air flow rate controlled by temperature profile and window opening profile applied to thermal model in IESVE 2019

Phase 2 wing occupied zones (Level 6 to 9)	Occupancy Diversity factor	HVAC strategy	Opening profile IES thermal model
Cellular Office (naturally ventilated with minimum fresh air ventilation)	80%	Flow rate 3 l/s m^2 supplied at 18°C controlled by outside air temperature	The rooms with openings have an openable area 50% based on modulating profile applied to sash window. In IES software the manual opening profile is assumed as below: • The bottom/top panel gradually opens when internal temperature is over 22 °C until is fully open at 24 °C in summer months.
Shared hub (naturally ventilated with minimum fresh air ventilation)	80%	Flow rate 3 l/s m^2 supplied at 18°C controlled by outside air temperature	
Level 9 offices **Level 9 shared hub**	80%	cooling provision via FCUs	
Inner small meeting room (2/4 people) and quiet rooms	100%	Min design flow rate 31 l/s served by VAV system and locally controlled by CO2 and temperature sensors. The CO2 sensor is connected to the VAV box and the temperature controller is connected to the heat battery.	
Break out (naturally ventilated with minimum fresh air ventilation)	80%	Flow rate 3 l/s m^2 supplied at 18°C controlled by outside air temperature	

5.4.2 HVAC Strategy – Level 4 to 9 Zone A

Table 5—5 - Air flow rate controlled by temperature profile and window opening profile applied to thermal model in IESVE 2019

Phase 2 Core A (level 4 to 9)	Occupancy Diversity factor	HVAC strategy	Opening profile IES thermal model
Breakout spaces Level 4	80%	Only heating provision from FCUs	No openable windows

Inner small meeting room/quiet rooms	100%	Min design flow rate 31 l/s served by VAV system and locally controlled by CO2 and temperature sensors. The CO2 sensor is connected to the VAV box and the temperature controller is connected to the heat battery.	No openable windows
Teaching space	100%	Heating and cooling provision from FCUs	Openable area 50% based on modulating profile applied to sash window: The bottom/top panel gradually opens when internal temperature is over 22 °C until is fully open at 24 °C in summer months.
Cellular Office naturally ventilated with minimum fresh air ventilation	80%	Flow rate 3 l/s m^2 supplied at 20°C controlled by outside air temperature	
Shared hub naturally ventilated with minimum fresh air ventilation	80%	Flow rate 3 l/s m^2 supplied at 20°C controlled by outside air temperature	
Level 9 meeting rooms east facing	100%	Cooling provision from FCUs	
Break out naturally ventilated with minimum fresh air ventilation	80%	Flow rate 3 l/s m^2 supplied at 20°C controlled by outside air temperature	

Table 5—6 - Heating and cooling set points per space function

Space use	Assumed Heating set-point (°C)	Assumed Cooling set-point (°C)
Office	22 ±4	-
Shared hub	22 ±2	-
Meeting room/quiet room	22 ±2	-
Meeting room (mechanically ventilated with FCUs)	22 ±2	24 ±2
Break out	22 ±2	-

Table 5—7 UCL environmental criteria for comfort

Space use	Internal conditions (Min and Max Dry resultant Temperature)
Office	Winter Min Dry Temp 20°C and in Summer Max Temperature 26°C. RH% is uncontrolled
Shared hub (VAV system and ventilated with openable windows)	
Small meeting room (1-2 people)/quiet room (VAV system with local reheat vent based on air volume to offset the heat losses)	
Meeting room with 8-10 people (air-conditioned with FCUs)	
Break out (VAV system and ventilated with openable windows)	

5.5 Baseline Climate Results

Appendix D contains the modelling results for all spaces assessed against baseline climate for the Phase 2 wing and core zone A within the occupied spaces. Spaces naturally ventilated are deemed to "Pass" the TM52 overheating criteria if at least 2 of 3 requirements are met. As shown Table 5—8, all spaces PASS at least 2 of 3 of the TM52 criteria in the baseline weather file. Only the shared hubs in the South Wing are closed to fail due to solar gain increasing up to level 8. Therefore, it is recommended to enhance the max air volume provision from VAV system to offset the solar and internal heat gains. See Appendix D.

The comfort in winter has been achieved and compliant with the CIBSE guide A min and max temperatures in accordance with the UCL environmental criteria. See Appendix D.

Table 5—8 TM52 Overheating results for naturally ventilated rooms (Phase 2)

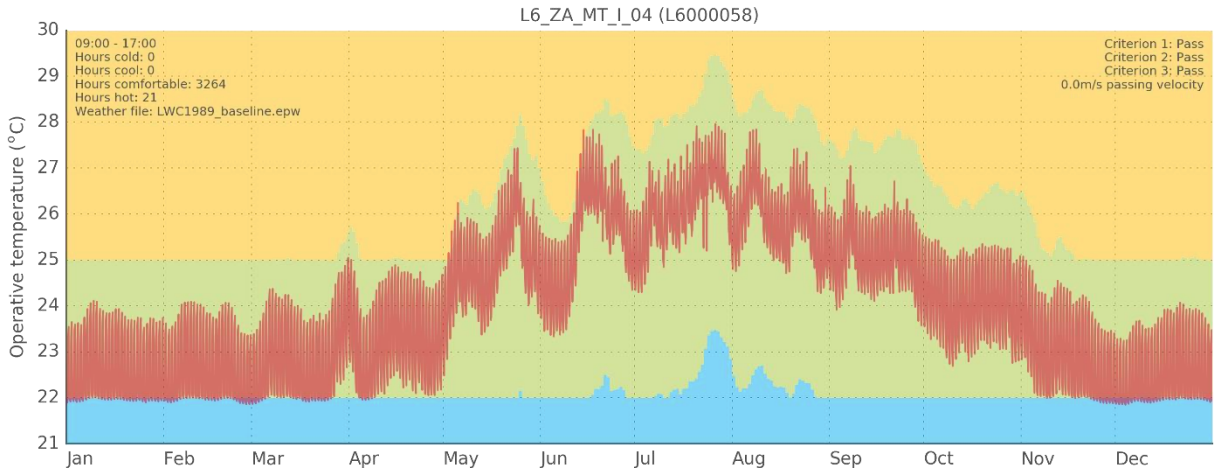
		TM52 Overheating results (summer)			Result
Level	**Space type**	**Criteria 1 (%Hrs Top-Tmax>=1K**	**Criteria 2 (Max. Daily Deg.Hrs):**	**Criteria 3 (Max, DeltaT):**	
	PHASE 2 occupied rooms	**Criterion 1**	**Criterion 2**	**Criterion 3**	
Level 6	L6_WI_WS_N_10	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_09	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_08	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_07	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_06	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_04	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_03	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_N_02	Pass	Pass	Pass	PASS
Level 6	L6_WI_WS_NW_01	Pass	Fail	Pass	PASS
Level 6	L6_WI_WS_N_11	Pass	Pass	Pass	PASS
Level 6	L6_WI_QR_S_01	Pass	Pass	Pass	PASS
Level 6	L6_WI_QR_02	Pass	Pass	Pass	PASS
Level 6	L6_WI_QR_03	Pass	Pass	Pass	PASS
Level 6	L6_WI_MT_S_01	Pass	Pass	Pass	PASS
Level 6	L6_WI_MT_S_01	Pass	Pass	Pass	PASS
Level 6	L6_WI_QR_04	Pass	Pass	Pass	PASS
Level 6	L6_WI_MR_I_01	Pass	Pass	Pass	PASS
Level 6	L6_WI_QR_05	Pass	Pass	Pass	PASS
Level 6	L6_ZA_MT_I_04	Pass	Pass	Pass	PASS
Level 6	L6_ZA_MT_I_02	Pass	Pass	Pass	PASS
Level 6	L6_ZA_Breakout_N_01	Pass	Pass	Pass	PASS
Level 6	L6_ZA_WS_NE_01	Pass	Pass	Pass	PASS

Level 6	L6_ZA_WS_NE_02	Pass	Pass	Pass	PASS
Level 6	L6_ZA_WS_NE_04	Pass	Pass	Pass	PASS
Level 6	L6_ZA_WS_NE_03	Pass	Pass	Pass	PASS
Level 6	L6_ZA_MT_I_05	Pass	Pass	Pass	PASS
Level 6	L6_ZA_QS_I_01	Pass	Fail	Pass	PASS
Level 6	L6_ZA_MT_I_01	Pass	Pass	Pass	PASS
Level 6	L6_ZA_SH_W_02	Pass	Fail	Pass	PASS
Level 6	L6_ZA_SH_W_01	Pass	Fail	Pass	PASS
Level 6	L6_WI_Teapoint_S_01	Pass	Pass	Pass	PASS
Level 6	L6_WI_SH_S_02	Pass	Pass	Pass	PASS
Level 6	L6_WI_SH_S_03	Pass	Pass	Pass	PASS
Level 6	L6_WI_SH_S_05	Pass	Pass	Pass	PASS
Level 6	L6_WI_SH_S_04	Pass	Pass	Pass	PASS
Level 7	L7_WI_SH_S_01	Pass	Fail	Pass	PASS
Level 7	L7_WI_WS_N_07	Pass	Pass	Pass	PASS
Level 7	L7_WI_WS_N_06	Pass	Pass	Pass	PASS
Level 7	L7_WI_WS_N_05	Pass	Pass	Pass	PASS
Level 7	L7_WI_WS_N_04	Pass	Pass	Pass	PASS
Level 7	L7_WI_WS_N_03	Pass	Pass	Pass	PASS
Level 7	L7_ZA_BREAKOUT_N	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_03	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_04	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_05	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_06	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_07	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_02	Pass	Pass	Pass	PASS
Level 7	L7_ZA_WS_N_01	Pass	Pass	Pass	PASS
Level 7	L7_ZA_QR_I	Pass	Pass	Pass	PASS
Level 7	L7_ZA_MT_I	Pass	Pass	Pass	PASS
Level 7	L7_ZA_MR_I_05	Pass	Fail	Pass	PASS
Level 7	L7_ZA_MT_I_06	Pass	Pass	Pass	PASS
Level 7	L7_ZA_MT_I_07	Pass	Pass	Pass	PASS
Level 7	L7_ZA_MT_I_08	Pass	Pass	Pass	PASS
Level 7	L7_WI_WS_N_08	Pass	Pass	Pass	PASS
Level 7	L7_WI_WS_N_01	Pass	Fail	Pass	PASS
Level 7	L7_WI_WS_N_02	Pass	Pass	Pass	PASS
Level 7	L7_WI_MT_I_01	Pass	Pass	Pass	PASS
Level 7	L7_WI_MR_I_02	Pass	Pass	Pass	PASS
Level 7	L7_WI_QS_I_02	Pass	Pass	Pass	PASS
Level 7	L7_WI_QS_I_03	Pass	Pass	Pass	PASS
Level 7	L7_WI_MT_I_03	Pass	Pass	Pass	PASS
Level 7	L7_WI_ENTRANCE_S_01	Pass	Pass	Pass	PASS

Level 7	L7_ZA_MR_I_02	Pass	Pass	Pass	PASS
Level 7	L7_ZA_MR_I_01	Pass	Pass	Pass	PASS
Level 7	L7_ZA_SH_W_02	Pass	Fail	Pass	PASS
Level 7	L7_ZA_SH_W_01	Pass	Fail	Pass	PASS
Level 7	L7_WI_SH_S_02	Pass	Fail	Pass	PASS
Level 7	L7_WI_SH_S_03	Pass	Fail	Pass	PASS
Level 7	L7_WI_SH_S_05	Pass	Fail	Pass	PASS
Level 7	L7_WI_SH_S_04	Pass	Fail	Pass	PASS
Level 8	L8_WI_SH_SE_01	Fail	Fail	Fail	Close to failing
Level 8	L8_WI_WS_N_06	Pass	Pass	Pass	PASS
Level 8	L8_WI_WS_N_05	Pass	Pass	Pass	PASS
Level 8	L8_WI_WS_N_04	Pass	Pass	Pass	PASS
Level 8	L8_WI_WS_N_03	Pass	Pass	Pass	PASS
Level 8	L8_ZA_MR_N_01	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_01	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_02	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_03	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_04	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_05	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_06	Pass	Pass	Pass	PASS
Level 8	L8_ZA_WS_N_07	Pass	Fail	Pass	PASS
Level 8	L8_ZA_BREAKOUT_N_01	Pass	Pass	Pass	PASS
Level 8	L8_ZA_MR_I_05	Pass	Pass	Pass	PASS
Level 8	L8_ZA_MR_I_04	Pass	Pass	Pass	PASS
Level 8	L8_ZA_MT_I_05	Pass	Pass	Pass	PASS
Level 8	L8_ZA_QS_I_01	Pass	Pass	Pass	PASS
Level 8	L8_ZA_MT_I_07	Pass	Pass	Pass	PASS
Level 8	L8_ZA_QS_I_02	Pass	Pass	Pass	PASS
Level 8	L8_ZA_MT_I_08	Pass	Pass	Pass	PASS
Level 8	L8_WI_WS_N_07	Pass	Pass	Pass	PASS
Level 8	L8_WI_WS_N_02	Pass	Fail	Pass	PASS
Level 8	L8_WI_WS_NW_01	Pass	Fail	Pass	PASS
Level 8	L8_WI_FOCUS_02	Pass	Pass	Pass	PASS
Level 8	L8_WI_FOCUS_01	Pass	Pass	Pass	PASS
Level 8	L8_WI_FOCUS_I_03	Pass	Fail	Pass	PASS
Level 8	L8_ZA_SH_W_02	Pass	Fail	Pass	PASS
Level 8	L8_ZA_SH_W_01	Pass	Fail	Pass	PASS
Level 8	L8_WI_BREAKOUT/WELCOME_S_01	Pass	Pass	Pass	PASS
Level 8	L8_WI_SH_S_03	Pass	Fail	Pass	PASS
Level 8	L8_WI_SH_S_02	Pass	Fail	Pass	PASS
Level 9	L9_ZA_MT_I_01	Pass	Pass	Pass	PASS

Level 9	L9_ZA_MT_I_02	Pass	Pass	Pass	PASS
Level 9	L9_ZA_MR_I_03	Pass	Pass	Pass	PASS
Level 9	L9_ZA_QS_I	Pass	Pass	Pass	PASS
Level 9	L9_WI_entrance	Pass	Pass	Pass	PASS
Level 9	L9_WI_MT_I	Pass	Pass	Pass	PASS
Level 9	L9_WI_QS_I	Pass	Pass	Pass	PASS

The comfort band graph below has shown in the inner small meeting rooms operative temperatures with peaks >28°C in summer only for 21 hours, that it is acceptable to meet the overheating criteria.



In conclusion the overheating and thermal comfort assessment have shown that all occupied rooms will meet comfort targets. See the results in Appendix D.

In terms of the PMV/PPD results, Table 5—9 and Table 5—10 summarise the figures, with all spaces meet the CIBSE criteria.

Table 5—9 - Summary of PMV/PPD results, baseline climate

	PMV scale		PPD (%)		RESULT
Space ID	**Mean winter**	**Mean summer**	**Mean winter**	**Mean summer**	
Air-Conditioned occupied spaces	-0.5	-0.1	8.0	10.9	**Acceptable**

Table 5—10 - Summary of PMV/PPD results, future climate

	PMV scale		PPD (%)		RESULT
Space ID	**Mean winter**	**Mean summer**	**Mean winter**	**Mean summer**	
Conditioned occupied spaces	0.30	0.50	8.1	11.7	**Acceptable**

5.6 Cooling demand vs. notional building – Phase 2 summary

The area weighted average building cooling demand (MJ/m2) from the BRUKL for all Phase 2 areas, both Actual and Notional are below. As shown, the Actual cooling demand is below the Notional, demonstrating the GLA cooling hierarchy was applied successfully.

Table 5—11 - Heating and cooling demand for the Notional building compared to actual

	Fan coil system energy demand	Constant Volume system energy demand	Single duct VAV energy demand	Total Cooling energy demand	% saved
	MJ/m²	MJ/m²	MJ/m²	MJ/m²	%
Actual	57.3	33.6	70.8	**161.7**	
Notional	125.1	80.2	144.1	**349.4**	**54%**

5.7 UCL IoE Phase 2C results

This chapter described the overheating principles for Phase 2 overall. For the overheating assessment results for the phase 2C level 3 and 4 entrances separately reported, see Appendix E. In summary, the naturally ventilated occupied spaces (Level 3 and 4 entrances, reception, working spaces) under the current and future climate are classed pass the CIBSE TM52 overheating criteria.

6 Conclusion

In order to support the Phase 2C planning application, this report has covered the energy strategy, thermal comfort and overheating assessment and BREEAM pre-assessment strategy in accordance with the planning requirements.

Headline outcomes include:

- The project is on track to achieve a BREEAM Excellent rating, with a score of 75.8%
- The Phase 2 energy strategy achieves a 39% reduction in regulated CO_2 emissions
- The naturally ventilated occupied spaces (Level 3 and 4 entrances, reception, working spaces) under the current and future climate are classed pass the CIBSE TM52 overheating criteria.
- Similarly, the air-conditioned rooms which include cooling demonstrated adequate thermal comfort has been achieved with a cooling demand far lower than the notional building.

In summary, there is good potential to undertake an extensive and sustainable refurbishment for the UCL Institute of Education, which achieves BREEAM Excellent and provides comfortable internal environments. Works undertaken to date for Phase 2 have shown that this will require investment in passive design and fabric improvements, for which an appropriate strategy has been developed in line with the heritage consultant advice.

Appendix A - 'Lean' BRUKL report

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

UCL_IOE_Phase 2 PartL2B_LEAN.rev00 As built

Date: Tue Mar 24 14:51:27 2020

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.12

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.12

BRUKL compliance check version: v5.6.a.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

The building does not comply with England Building Regulations Part L 2013

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	21.9
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	21.9
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	51.2
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.32	0.47	L300001A:Surf[3]
Floor	0.25	0.27	0.77	L4000023:Surf[16]
Roof	0.25	0.82	2.26	L4000038:Surf[1]
Windows***, roof windows, and rooflights	2.2	2.04	5.7	L2000010:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- radiators with extract_WC

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	-	0	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

2- Circulation supply+extract

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	4.62	0	2.1	0.8
Standard value	0.91*	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

3- AHU (FCUs)+rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	4.6	0	2.1	0.8
Standard value	0.91*	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

4- Nat_radiators

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	-	0	0	-
Standard value	0.91*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

5- DX cooling_comms room

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	3.2	-	0	-
Standard value	0.91*	3.2	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

6- VAV+rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.91	4.62	0	2.1	0.8
Standard value	0.91*	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.

^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	**Zone**	**Standard**
L2_WC	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XC_TS_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching space	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_WC	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XA_WC_I_02	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XA_WC_I_02	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XB_TS_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L4_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XC_TS_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_E_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_W_03	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L5_ZA_TS_W_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_08	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_09	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_11	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_ZA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_ZA_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_08	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_09	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_XA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_XA_MR_I_03	-	-	-	-	-	-	-	0.8	-	-	N/A
L7_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XA_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XA_MR_I_03	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L8_XB_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XB_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_S_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_BREAKOUT_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
L2_store	90	-	-	8
L2_WC	-	80	-	66
L2_XA_WC_I_01	-	80	-	77
L2_XB_CIRC_I_02	-	80	-	89
L2_XB_WC_I_01	-	80	-	161
L2_XB_WC_I_01	-	80	-	82
L2_XC_TS_I_01	90	-	-	660
L3_atrium	-	90	-	64
L3_cafe_store	90	-	-	15
L3_ISD rooms	80	-	-	268
L3_store	90	-	-	6
L3_teaching area	90	-	-	145
L3_teaching area	90	-	-	146
L3_teaching area	90	-	-	149
L3_teaching space	90	-	-	654
L3_WC	-	80	-	73
L3_XA_COMMS_E_01	90	-	-	48
L3_XA_STORE_E_01	90	-	-	6
L3_XA_WC_I_01	-	80	-	90
L3_XA_WC_I_02	-	80	-	80
L3_XB_CC_I_01	-	80	-	131

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L3_XB_WC_I_01	80	-	-	259
L3_ZB_CIRC_I_01	-	80	-	87
L3_ZB_CIRC_I_02	-	80	-	215
L4_XA_WC_I_01	-	80	-	128
L4_XA_WC_I_02	-	80	-	77
L4_XB_CIRC_I_01	-	80	-	134
L4_XB_STORE_I_01	90	-	-	4
L4_XB_STORE_I_02	90	-	-	8
L4_XB_TS_I_01	90	-	-	624
L4_XB_WC_I_01	-	80	-	78
L4_XB_WC_I_01	-	80	-	138
L4_XC_TS_E_01	90	-	-	621
L4_ZB_BREAKOUT_I_08	-	80	-	217
L5_XA_CIRC_I_02	-	80	-	81
L5_ZA_TS_E_01	90	-	-	293
L5_ZA_TS_E_02	90	-	-	304
L5_ZA_TS_W_03	90	-	-	190
L5_ZA_TS_W_04	90	-	-	225
L6_WI_CIRC_I_01	-	80	-	115
L6_WI_MR_I_01	90	-	-	81
L6_WI_MR_I_02	90	-	-	169
L6_WI_MR_W_01	90	-	-	129
L6_WI_WS_N_01	90	-	-	125
L6_WI_WS_N_02	90	-	-	120
L6_WI_WS_N_03	90	-	-	117
L6_WI_WS_N_04	90	-	-	116
L6_WI_WS_N_05	90	-	-	116
L6_WI_WS_N_06	90	-	-	117
L6_WI_WS_N_07	90	-	-	117
L6_WI_WS_N_08	90	-	-	116
L6_WI_WS_N_09	90	-	-	116
L6_WI_WS_N_10	90	-	-	116
L6_WI_WS_N_11	90	-	-	116
L6_WI_WS_N_12	90	-	-	140
L6_WI_WS_S_01	90	-	-	850
L6_XA_CIRC_I_01	-	80	-	151
L6_ZA_BREAKOUT_E_01	-	80	-	158
L6_ZA_MR_I_01	90	-	-	70
L6_ZA_MR_I_02	90	-	-	73
L6_ZA_WS_W_01	90	-	-	835
L6_ZB_LAWTON_DINING_E_01	-	90	-	433
L7_WI_CIRC_I_01	-	80	-	106
L7_WI_MR_I_01	90	-	-	161

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L7_WI_MR_W_01	90	-	-	129
L7_WI_WS_N_01	90	-	-	113
L7_WI_WS_N_02	90	-	-	113
L7_WI_WS_N_03	90	-	-	113
L7_WI_WS_N_04	90	-	-	113
L7_WI_WS_N_05	90	-	-	113
L7_WI_WS_N_07	90	-	-	113
L7_WI_WS_N_07	90	-	-	113
L7_WI_WS_N_08	90	-	-	113
L7_WI_WS_N_09	90	-	-	113
L7_WI_WS_N_10	90	-	-	168
L7_WI_WS_S_01	90	-	-	777
L7_XA_CIRC_I_01	-	80	-	148
L7_XA_MR_I_01	80	-	-	118
L7_XA_MR_I_03	80	-	-	172
L7_ZA_BREAKOUT_E_01	80	-	-	496
L7_ZA_MR_E_01	80	-	-	151
L7_ZA_WS_E_01	90	-	-	106
L7_ZA_WS_E_02	90	-	-	100
L7_ZA_WS_E_03	90	-	-	105
L7_ZA_WS_E_04	90	-	-	103
L7_ZA_WS_E_05	90	-	-	103
L7_ZA_WS_E_07	90	-	-	93
L7_ZA_WS_W_01	90	-	-	774
L8_WI_CIRC_I_01	-	80	-	105
L8_WI_MR_I_01	90	-	-	79
L8_WI_MR_W_01	90	-	-	128
L8_WI_WS_N_01	90	-	-	113
L8_WI_WS_N_02	90	-	-	113
L8_WI_WS_N_03	90	-	-	113
L8_WI_WS_N_04	90	-	-	113
L8_WI_WS_N_05	90	-	-	108
L8_WI_WS_N_06	90	-	-	107
L8_WI_WS_N_07	90	-	-	107
L8_WI_WS_N_08	90	-	-	108
L8_WI_WS_N_10	90	-	-	110
L8_WI_WS_S_01	90	-	-	432
L8_XA_CIRC_I_01	-	80	-	148
L8_XA_MR_I_02	90	-	-	160
L8_XA_MR_I_03	90	-	-	151
L8_XB_MR_E_01	90	-	-	97
L8_XB_MR_I_01	90	-	-	172
L8_ZA_BREAKOUT_E_01	-	80	-	159

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L8_ZA_MR_E_01	90	-	-	83
L8_ZA_WS_E_01	90	-	-	78
L8_ZA_WS_E_02	80	-	-	109
L8_ZA_WS_E_03	90	-	-	103
L8_ZA_WS_E_04	90	-	-	100
L8_ZA_WS_E_05	90	-	-	100
L8_ZA_WS_E_06	90	-	-	100
L8_ZA_WS_E_07	90	-	-	89
L8_ZA_WS_W_01	80	-	-	1241
L9_WI_MR_W_01	90	-	-	140
L9_WI_WS_N_01	90	-	-	107
L9_WI_WS_N_02	90	-	-	107
L9_WI_WS_N_10	90	-	-	137
L9_WI_WS_S_01	90	-	-	416
L9_XA_CIRC_I_01	-	80	-	147
L9_ZA_BREAKOUT_E_01	-	80	-	106
L9_ZA_MR_E_01	90	-	-	74
L9_ZA_MR_I_01	90	-	-	91
L9_ZA_WS_E_03	90	-	-	93
L9_ZA_WS_E_04	90	-	-	90
L9_ZA_WS_E_05	90	-	-	90
L9_ZA_WS_E_06	90	-	-	90
L9_ZA_WS_E_07	90	-	-	79
L9_ZA_WS_W_01	90	-	-	166
L9_ZA_WS_W_01	90	-	-	521
L3_cafe	-	80	-	200
L3_ZB_ENTRANCE_E_01	-	90	80	183
L4_ZB_BREAKOUT_I_05	-	80	-	260
L4_ZB_STAIR_I_01	-	80	-	171
L4_ZB_CIRC_I_01	-	80	-	743
L4_ZB_ENTRANCE_I_01	-	90	80	79

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L2_XB_CIRC_I_02	N/A	N/A
L2_XC_TS_I_01	N/A	N/A
L3_ISD rooms	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching space	N/A	N/A
L3_XA_COMMS_E_01	NO (-91.7%)	YES
L3_XB_CC_I_01	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L3_XB_WC_I_01	NO (-49.5%)	YES
L4_XB_CIRC_I_01	N/A	N/A
L4_XB_TS_I_01	N/A	N/A
L4_XC_TS_E_01	N/A	N/A
L5_XA_CIRC_I_02	N/A	N/A
L5_ZA_TS_E_01	NO (-72.4%)	YES
L5_ZA_TS_E_02	NO (-50.1%)	YES
L5_ZA_TS_W_03	NO (-34.8%)	YES
L5_ZA_TS_W_04	NO (-45%)	YES
L6_WI_CIRC_I_01	N/A	N/A
L6_WI_MR_I_01	N/A	N/A
L6_WI_MR_I_02	N/A	N/A
L6_WI_MR_W_01	NO (-48.2%)	YES
L6_WI_WS_N_01	NO (-65.7%)	YES
L6_WI_WS_N_02	NO (-53.7%)	YES
L6_WI_WS_N_03	NO (-51.2%)	YES
L6_WI_WS_N_04	NO (-50.7%)	YES
L6_WI_WS_N_05	NO (-50.7%)	YES
L6_WI_WS_N_06	NO (-51.2%)	YES
L6_WI_WS_N_07	NO (-50.7%)	YES
L6_WI_WS_N_08	NO (-50.8%)	YES
L6_WI_WS_N_09	NO (-52.2%)	YES
L6_WI_WS_N_10	NO (-52.3%)	YES
L6_WI_WS_N_11	NO (-51.4%)	YES
L6_WI_WS_N_12	NO (-42.4%)	YES
L6_WI_WS_S_01	NO (-35.3%)	YES
L6_XA_CIRC_I_01	N/A	N/A
L6_ZA_BREAKOUT_E_01	NO (-43.5%)	YES
L6_ZA_MR_I_01	N/A	N/A
L6_ZA_MR_I_02	N/A	N/A
L6_ZA_WS_W_01	NO (-64%)	YES
L6_ZB_LAWTON_DINING_E_01	NO (-18.4%)	YES
L7_WI_CIRC_I_01	N/A	N/A
L7_WI_MR_I_01	N/A	N/A
L7_WI_MR_W_01	NO (-48.9%)	YES
L7_WI_WS_N_01	NO (-62.5%)	YES
L7_WI_WS_N_02	NO (-52.4%)	YES
L7_WI_WS_N_03	NO (-52.4%)	YES
L7_WI_WS_N_04	NO (-52.4%)	YES
L7_WI_WS_N_05	NO (-52.4%)	YES
L7_WI_WS_N_07	NO (-52.4%)	YES
L7_WI_WS_N_07	NO (-52.4%)	YES
L7_WI_WS_N_08	NO (-52.4%)	YES
L7_WI_WS_N_09	NO (-52.4%)	YES
L7_WI_WS_N_10	NO (-45.6%)	YES
L7_WI_WS_S_01	NO (-34%)	YES
L7_XA_CIRC_I_01	N/A	N/A
L7_XA_MR_I_01	N/A	N/A
L7_XA_MR_I_03	N/A	N/A

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L7_ZA_BREAKOUT_E_01	NO (-51.8%)	YES
L7_ZA_MR_E_01	NO (-55.3%)	YES
L7_ZA_WS_E_01	NO (-47.3%)	YES
L7_ZA_WS_E_02	NO (-41.1%)	YES
L7_ZA_WS_E_03	NO (-43.5%)	YES
L7_ZA_WS_E_04	NO (-42.9%)	YES
L7_ZA_WS_E_05	NO (-42.9%)	YES
L7_ZA_WS_E_07	NO (-91.5%)	YES
L7_ZA_WS_W_01	NO (-62.2%)	YES
L8_WI_CIRC_I_01	N/A	N/A
L8_WI_MR_I_01	N/A	N/A
L8_WI_MR_W_01	NO (-49.1%)	YES
L8_WI_WS_N_01	NO (-62.5%)	YES
L8_WI_WS_N_02	NO (-52.4%)	YES
L8_WI_WS_N_03	NO (-52.4%)	YES
L8_WI_WS_N_04	NO (-52.4%)	YES
L8_WI_WS_N_05	NO (-52.4%)	YES
L8_WI_WS_N_06	NO (-52.6%)	YES
L8_WI_WS_N_07	NO (-52.6%)	YES
L8_WI_WS_N_08	NO (-52.2%)	YES
L8_WI_WS_N_10	NO (-43.7%)	YES
L8_WI_WS_S_01	NO (-31.1%)	YES
L8_XA_CIRC_I_01	N/A	N/A
L8_XA_MR_I_02	N/A	N/A
L8_XA_MR_I_03	N/A	N/A
L8_XB_MR_E_01	NO (-43.9%)	YES
L8_XB_MR_I_01	N/A	N/A
L8_ZA_BREAKOUT_E_01	NO (-50.5%)	YES
L8_ZA_MR_E_01	NO (-48.4%)	YES
L8_ZA_WS_E_01	NO (-47.3%)	YES
L8_ZA_WS_E_02	NO (-41.1%)	YES
L8_ZA_WS_E_03	NO (-43.5%)	YES
L8_ZA_WS_E_04	NO (-42.9%)	YES
L8_ZA_WS_E_05	NO (-42.9%)	YES
L8_ZA_WS_E_06	NO (-42.9%)	YES
L8_ZA_WS_E_07	NO (-91.5%)	YES
L8_ZA_WS_W_01	NO (-62.2%)	YES
L9_WI_MR_W_01	NO (-49.4%)	YES
L9_WI_WS_N_01	NO (-62.6%)	YES
L9_WI_WS_N_02	NO (-52.6%)	YES
L9_WI_WS_N_10	NO (-44.1%)	YES
L9_WI_WS_S_01	NO (-53.9%)	YES
L9_XA_CIRC_I_01	N/A	N/A
L9_ZA_BREAKOUT_E_01	NO (-77.7%)	YES
L9_ZA_MR_E_01	NO (-47.6%)	YES
L9_ZA_MR_I_01	N/A	N/A
L9_ZA_WS_E_03	NO (-43.5%)	YES
L9_ZA_WS_E_04	NO (-43%)	YES
L9_ZA_WS_E_05	NO (-42.9%)	YES

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L9_ZA_WS_E_06	NO (-42.9%)	YES
L9_ZA_WS_E_07	NO (-81.9%)	YES
L9_ZA_WS_W_01	N/A	N/A
L9_ZA_WS_W_01	NO (-54.4%)	YES
L3_ZB_ENTRANCE_E_01	NO (-36.4%)	YES
L4_ZB_ENTRANCE_I_01	NO (-42%)	YES

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	5190.2	5190.2
External area [m^2]	4998.7	5770
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	5128.85	2799.3
Average U-value [W/m^2K]	1.03	0.49
Alpha value* [%]	9.18	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
100	**C2 Residential Institutions: Universities and colleges**
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	42.74	13.46
Cooling	3.99	6.63
Auxiliary	28.8	13.93
Lighting	9.02	14.36
Hot water	96.32	6.3
Equipment*	30.79	30.79
TOTAL**	**180.86**	**54.69**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	170.55	132.26
Primary energy* [kWh/m^2]	294.77	128.66
Total emissions [kg/m^2]	51.2	21.9

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	339.8	0	110.4	0	1.8	0.85	0	0.91	0
	Notional	112.2	0	36.1	0	1.8	0.86	0	----	----
[ST] Central heating using water: radiators, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	55.1	0	17.9	0	14.1	0.85	0	0.91	0
	Notional	31.3	0	10.1	0	14.1	0.86	0	----	----
[ST] Fan coil systems, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	85.6	57.3	28	4.8	12.3	0.85	3.35	0.91	4.4
	Notional	32	125.1	10.3	9.2	16.1	0.86	3.79	----	----
[ST] Constant volume system (fixed fresh air rate), [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	56.5	33.6	16.9	4.4	32.4	0.93	2.11	0.91	4.43
	Notional	11	80.2	3.5	5.9	21.9	0.86	3.79	----	----
[ST] Single-duct VAV, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	69	70.8	26.8	6.9	65.1	0.71	2.85	0.91	4.43
	Notional	17.3	144.1	5.6	10.6	18.2	0.86	3.79	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0	0	0	0	0	0.85	2.13	0.91	3
	Notional	0	0	0	0	0	0.86	3.79	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	$U_{i\text{-}Typ}$	$U_{i\text{-}Min}$	Surface where the minimum value occurs*
Wall	0.23	-	L3000009:Surf[9]
Floor	0.2	0.11	L4000020:Surf[0]
Roof	0.15	0.18	L2000016:Surf[0]
Windows, roof windows, and rooflights	1.5	0.71	L300002B:Surf[0]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)] $U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
$m^3/(h.m^2)$ at 50 Pa	5	10

Appendix B – 'Clean' BRUKL report

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

UCL_IOE_Phase 2 PartL2B_CLEAN.rev00 As built

Date: Tue Mar 24 14:21:59 2020

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.12

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.12

BRUKL compliance check version: v5.6.a.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

The building does not comply with England Building Regulations Part L 2013

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	22.1
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	22.1
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	52.5
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.32	0.47	L300001A:Surf[3]
Floor	0.25	0.27	0.77	L4000023:Surf[16]
Roof	0.25	0.82	2.26	L4000038:Surf[1]
Windows***, roof windows, and rooflights	2.2	2.04	5.7	L2000010:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- radiators with extract_WC

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

2- Circulation supply+extract

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	4.62	0	2.1	0.8
Standard value	N/A	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

3- AHU (FCUs)+rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	4.6	0	2.1	0.8
Standard value	N/A	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

4- Nat_radiators

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

5- DX cooling_comms room

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	3.2	-	0	-
Standard value	0.91*	3.2	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

6- VAV+rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	4.62	0	2.1	0.8
Standard value	N/A	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L2_WC	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XC_TS_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching space	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_WC	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XA_WC_I_02	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XA_WC_I_02	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XB_TS_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L4_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XC_TS_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_E_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_W_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_W_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L6_WI_WS_N_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_08	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_09	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_11	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_ZA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_ZA_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_08	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_09	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_XA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_XA_MR_I_03	-	-	-	-	-	-	-	0.8	-	-	N/A
L7_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XA_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XA_MR_I_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XB_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XB_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_S_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_BREAKOUT_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L9_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
L2_store	90	-	-	8
L2_WC	-	80	-	66
L2_XA_WC_I_01	-	80	-	77
L2_XB_CIRC_I_02	-	80	-	89
L2_XB_WC_I_01	-	80	-	161
L2_XB_WC_I_01	-	80	-	82
L2_XC_TS_I_01	90	-	-	660
L3_atrium	-	90	-	64
L3_cafe_store	90	-	-	15
L3_ISD rooms	80	-	-	268
L3_store	90	-	-	6
L3_teaching area	90	-	-	145
L3_teaching area	90	-	-	146
L3_teaching area	90	-	-	149
L3_teaching space	90	-	-	654
L3_WC	-	80	-	73
L3_XA_COMMS_E_01	90	-	-	48
L3_XA_STORE_E_01	90	-	-	6
L3_XA_WC_I_01	-	80	-	90
L3_XA_WC_I_02	-	80	-	80
L3_XB_CC_I_01	-	80	-	131
L3_XB_WC_I_01	80	-	-	259
L3_ZB_CIRC_I_01	-	80	-	87
L3_ZB_CIRC_I_02	-	80	-	215
L4_XA_WC_I_01	-	80	-	128
L4_XA_WC_I_02	-	80	-	77
L4_XB_CIRC_I_01	-	80	-	134
L4_XB_STORE_I_01	90	-	-	4
L4_XB_STORE_I_02	90	-	-	8
L4_XB_TS_I_01	90	-	-	624

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L4_XB_WC_I_01	-	80	-	78
L4_XB_WC_I_01	-	80	-	138
L4_XC_TS_E_01	90	-	-	621
L4_ZB_BREAKOUT_I_08	-	80	-	217
L5_XA_CIRC_I_02	-	80	-	81
L5_ZA_TS_E_01	90	-	-	293
L5_ZA_TS_E_02	90	-	-	304
L5_ZA_TS_W_03	90	-	-	190
L5_ZA_TS_W_04	90	-	-	225
L6_WI_CIRC_I_01	-	80	-	115
L6_WI_MR_I_01	90	-	-	81
L6_WI_MR_I_02	90	-	-	169
L6_WI_MR_W_01	90	-	-	129
L6_WI_WS_N_01	90	-	-	125
L6_WI_WS_N_02	90	-	-	120
L6_WI_WS_N_03	90	-	-	117
L6_WI_WS_N_04	90	-	-	116
L6_WI_WS_N_05	90	-	-	116
L6_WI_WS_N_06	90	-	-	117
L6_WI_WS_N_07	90	-	-	117
L6_WI_WS_N_08	90	-	-	116
L6_WI_WS_N_09	90	-	-	116
L6_WI_WS_N_10	90	-	-	116
L6_WI_WS_N_11	90	-	-	116
L6_WI_WS_N_12	90	-	-	140
L6_WI_WS_S_01	90	-	-	850
L6_XA_CIRC_I_01	-	80	-	151
L6_ZA_BREAKOUT_E_01	-	80	-	158
L6_ZA_MR_I_01	90	-	-	70
L6_ZA_MR_I_02	90	-	-	73
L6_ZA_WS_W_01	90	-	-	835
L6_ZB_LAWTON_DINING_E_01	-	90	-	433
L7_WI_CIRC_I_01	-	80	-	106
L7_WI_MR_I_01	90	-	-	161
L7_WI_MR_W_01	90	-	-	129
L7_WI_WS_N_01	90	-	-	113
L7_WI_WS_N_02	90	-	-	113
L7_WI_WS_N_03	90	-	-	113
L7_WI_WS_N_04	90	-	-	113
L7_WI_WS_N_05	90	-	-	113
L7_WI_WS_N_07	90	-	-	113
L7_WI_WS_N_07	90	-	-	113
L7_WI_WS_N_08	90	-	-	113

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L7_WI_WS_N_09	90	-	-	113
L7_WI_WS_N_10	90	-	-	168
L7_WI_WS_S_01	90	-	-	777
L7_XA_CIRC_I_01	-	80	-	148
L7_XA_MR_I_01	80	-	-	118
L7_XA_MR_I_03	80	-	-	172
L7_ZA_BREAKOUT_E_01	80	-	-	496
L7_ZA_MR_E_01	80	-	-	151
L7_ZA_WS_E_01	90	-	-	106
L7_ZA_WS_E_02	90	-	-	100
L7_ZA_WS_E_03	90	-	-	105
L7_ZA_WS_E_04	90	-	-	103
L7_ZA_WS_E_05	90	-	-	103
L7_ZA_WS_E_07	90	-	-	93
L7_ZA_WS_W_01	90	-	-	774
L8_WI_CIRC_I_01	-	80	-	105
L8_WI_MR_I_01	90	-	-	79
L8_WI_MR_W_01	90	-	-	128
L8_WI_WS_N_01	90	-	-	113
L8_WI_WS_N_02	90	-	-	113
L8_WI_WS_N_03	90	-	-	113
L8_WI_WS_N_04	90	-	-	113
L8_WI_WS_N_05	90	-	-	108
L8_WI_WS_N_06	90	-	-	107
L8_WI_WS_N_07	90	-	-	107
L8_WI_WS_N_08	90	-	-	108
L8_WI_WS_N_10	90	-	-	110
L8_WI_WS_S_01	90	-	-	432
L8_XA_CIRC_I_01	-	80	-	148
L8_XA_MR_I_02	90	-	-	160
L8_XA_MR_I_03	90	-	-	151
L8_XB_MR_E_01	90	-	-	97
L8_XB_MR_I_01	90	-	-	172
L8_ZA_BREAKOUT_E_01	-	80	-	159
L8_ZA_MR_E_01	90	-	-	83
L8_ZA_WS_E_01	90	-	-	78
L8_ZA_WS_E_02	80	-	-	109
L8_ZA_WS_E_03	90	-	-	103
L8_ZA_WS_E_04	90	-	-	100
L8_ZA_WS_E_05	90	-	-	100
L8_ZA_WS_E_06	90	-	-	100
L8_ZA_WS_E_07	90	-	-	89
L8_ZA_WS_W_01	80	-	-	1241

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L9_WI_MR_W_01	90	-	-	140
L9_WI_WS_N_01	90	-	-	107
L9_WI_WS_N_02	90	-	-	107
L9_WI_WS_N_10	90	-	-	137
L9_WI_WS_S_01	90	-	-	416
L9_XA_CIRC_I_01	-	80	-	147
L9_ZA_BREAKOUT_E_01	-	80	-	106
L9_ZA_MR_E_01	90	-	-	74
L9_ZA_MR_I_01	90	-	-	91
L9_ZA_WS_E_03	90	-	-	93
L9_ZA_WS_E_04	90	-	-	90
L9_ZA_WS_E_05	90	-	-	90
L9_ZA_WS_E_06	90	-	-	90
L9_ZA_WS_E_07	90	-	-	79
L9_ZA_WS_W_01	90	-	-	166
L9_ZA_WS_W_01	90	-	-	521
L3_cafe	-	80	-	200
L3_ZB_ENTRANCE_E_01	-	90	80	183
L4_ZB_BREAKOUT_I_05	-	80	-	260
L4_ZB_STAIR_I_01	-	80	-	171
L4_ZB_CIRC_I_01	-	80	-	743
L4_ZB_ENTRANCE_I_01	-	90	80	79

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L2_XB_CIRC_I_02	N/A	N/A
L2_XC_TS_I_01	N/A	N/A
L3_ISD rooms	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching space	N/A	N/A
L3_XA_COMMS_E_01	NO (-91.7%)	YES
L3_XB_CC_I_01	N/A	N/A
L3_XB_WC_I_01	NO (-49.5%)	YES
L4_XB_CIRC_I_01	N/A	N/A
L4_XB_TS_I_01	N/A	N/A
L4_XC_TS_E_01	N/A	N/A
L5_XA_CIRC_I_02	N/A	N/A
L5_ZA_TS_E_01	NO (-72.4%)	YES
L5_ZA_TS_E_02	NO (-50.1%)	YES
L5_ZA_TS_W_03	NO (-34.8%)	YES
L5_ZA_TS_W_04	NO (-45%)	YES

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L6_WI_CIRC_I_01	N/A	N/A
L6_WI_MR_I_01	N/A	N/A
L6_WI_MR_I_02	N/A	N/A
L6_WI_MR_W_01	NO (-48.2%)	YES
L6_WI_WS_N_01	NO (-65.7%)	YES
L6_WI_WS_N_02	NO (-53.7%)	YES
L6_WI_WS_N_03	NO (-51.2%)	YES
L6_WI_WS_N_04	NO (-50.7%)	YES
L6_WI_WS_N_05	NO (-50.7%)	YES
L6_WI_WS_N_06	NO (-51.2%)	YES
L6_WI_WS_N_07	NO (-50.7%)	YES
L6_WI_WS_N_08	NO (-50.8%)	YES
L6_WI_WS_N_09	NO (-52.2%)	YES
L6_WI_WS_N_10	NO (-52.3%)	YES
L6_WI_WS_N_11	NO (-51.4%)	YES
L6_WI_WS_N_12	NO (-42.4%)	YES
L6_WI_WS_S_01	NO (-35.3%)	YES
L6_XA_CIRC_I_01	N/A	N/A
L6_ZA_BREAKOUT_E_01	NO (-43.5%)	YES
L6_ZA_MR_I_01	N/A	N/A
L6_ZA_MR_I_02	N/A	N/A
L6_ZA_WS_W_01	NO (-64%)	YES
L6_ZB_LAWTON_DINING_E_01	NO (-18.4%)	YES
L7_WI_CIRC_I_01	N/A	N/A
L7_WI_MR_I_01	N/A	N/A
L7_WI_MR_W_01	NO (-48.9%)	YES
L7_WI_WS_N_01	NO (-62.5%)	YES
L7_WI_WS_N_02	NO (-52.4%)	YES
L7_WI_WS_N_03	NO (-52.4%)	YES
L7_WI_WS_N_04	NO (-52.4%)	YES
L7_WI_WS_N_05	NO (-52.4%)	YES
L7_WI_WS_N_07	NO (-52.4%)	YES
L7_WI_WS_N_07	NO (-52.4%)	YES
L7_WI_WS_N_08	NO (-52.4%)	YES
L7_WI_WS_N_09	NO (-52.4%)	YES
L7_WI_WS_N_10	NO (-45.6%)	YES
L7_WI_WS_S_01	NO (-34%)	YES
L7_XA_CIRC_I_01	N/A	N/A
L7_XA_MR_I_01	N/A	N/A
L7_XA_MR_I_03	N/A	N/A
L7_ZA_BREAKOUT_E_01	NO (-51.8%)	YES
L7_ZA_MR_E_01	NO (-55.3%)	YES
L7_ZA_WS_E_01	NO (-47.3%)	YES
L7_ZA_WS_E_02	NO (-41.1%)	YES
L7_ZA_WS_E_03	NO (-43.5%)	YES
L7_ZA_WS_E_04	NO (-42.9%)	YES
L7_ZA_WS_E_05	NO (-42.9%)	YES
L7_ZA_WS_E_07	NO (-91.5%)	YES
L7_ZA_WS_W_01	NO (-62.2%)	YES

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L8_WI_CIRC_I_01	N/A	N/A
L8_WI_MR_I_01	N/A	N/A
L8_WI_MR_W_01	NO (-49.1%)	YES
L8_WI_WS_N_01	NO (-62.5%)	YES
L8_WI_WS_N_02	NO (-52.4%)	YES
L8_WI_WS_N_03	NO (-52.4%)	YES
L8_WI_WS_N_04	NO (-52.4%)	YES
L8_WI_WS_N_05	NO (-52.4%)	YES
L8_WI_WS_N_06	NO (-52.6%)	YES
L8_WI_WS_N_07	NO (-52.6%)	YES
L8_WI_WS_N_08	NO (-52.2%)	YES
L8_WI_WS_N_10	NO (-43.7%)	YES
L8_WI_WS_S_01	NO (-31.1%)	YES
L8_XA_CIRC_I_01	N/A	N/A
L8_XA_MR_I_02	N/A	N/A
L8_XA_MR_I_03	N/A	N/A
L8_XB_MR_E_01	NO (-43.9%)	YES
L8_XB_MR_I_01	N/A	N/A
L8_ZA_BREAKOUT_E_01	NO (-50.5%)	YES
L8_ZA_MR_E_01	NO (-48.4%)	YES
L8_ZA_WS_E_01	NO (-47.3%)	YES
L8_ZA_WS_E_02	NO (-41.1%)	YES
L8_ZA_WS_E_03	NO (-43.5%)	YES
L8_ZA_WS_E_04	NO (-42.9%)	YES
L8_ZA_WS_E_05	NO (-42.9%)	YES
L8_ZA_WS_E_06	NO (-42.9%)	YES
L8_ZA_WS_E_07	NO (-91.5%)	YES
L8_ZA_WS_W_01	NO (-62.2%)	YES
L9_WI_MR_W_01	NO (-49.4%)	YES
L9_WI_WS_N_01	NO (-62.6%)	YES
L9_WI_WS_N_02	NO (-52.6%)	YES
L9_WI_WS_N_10	NO (-44.1%)	YES
L9_WI_WS_S_01	NO (-53.9%)	YES
L9_XA_CIRC_I_01	N/A	N/A
L9_ZA_BREAKOUT_E_01	NO (-77.7%)	YES
L9_ZA_MR_E_01	NO (-47.6%)	YES
L9_ZA_MR_I_01	N/A	N/A
L9_ZA_WS_E_03	NO (-43.5%)	YES
L9_ZA_WS_E_04	NO (-43%)	YES
L9_ZA_WS_E_05	NO (-42.9%)	YES
L9_ZA_WS_E_06	NO (-42.9%)	YES
L9_ZA_WS_E_07	NO (-81.9%)	YES
L9_ZA_WS_W_01	N/A	N/A
L9_ZA_WS_W_01	NO (-54.4%)	YES
L3_ZB_ENTRANCE_E_01	NO (-36.4%)	YES
L4_ZB_ENTRANCE_I_01	NO (-42%)	YES

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	5190.2	5190.2
External area [m^2]	4998.7	5770
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	5128.85	2799.3
Average U-value [W/m^{2}K]	1.03	0.49
Alpha value* [%]	9.18	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
100	**C2 Residential Institutions: Universities and colleges**
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	38.89	11.6
Cooling	3.99	6.63
Auxiliary	28.8	13.93
Lighting	9.02	14.36
Hot water	87.08	6.04
Equipment*	30.79	30.79
TOTAL**	**167.77**	**52.56**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	170.55	132.26
Primary energy* [kWh/m^2]	276.39	125.72
Total emissions [kg/m^2]	52.5	22.1

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	339.8	0	100.5	0	1.8	0.94	0	1	0
	Notional	112.2	0	31.2	0	1.8	1	0	----	----
[ST] Central heating using water: radiators, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	55.1	0	16.3	0	14.1	0.94	0	1	0
	Notional	31.3	0	8.7	0	14.1	1	0	----	----
[ST] Fan coil systems, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	85.6	57.3	25.5	4.8	12.3	0.93	3.35	1	4.4
	Notional	32	125.1	8.9	9.2	16.1	1	3.79	----	----
[ST] Constant volume system (fixed fresh air rate), [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	56.5	33.6	15.4	4.4	32.4	1.02	2.11	1	4.43
	Notional	11	80.2	3	5.9	21.9	1	3.79	----	----
[ST] Single-duct VAV, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	69	70.8	24.4	6.9	65.1	0.78	2.85	1	4.43
	Notional	17.3	144.1	4.8	10.6	18.2	1	3.79	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0	0	0	0	0	0.93	2.13	1	3
	Notional	0	0	0	0	0	0.86	3.79	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	$U_{i\text{-}Typ}$	$U_{i\text{-}Min}$	Surface where the minimum value occurs*
Wall	0.23	-	L3000009:Surf[9]
Floor	0.2	0.11	L4000020:Surf[0]
Roof	0.15	0.18	L2000016:Surf[0]
Windows, roof windows, and rooflights	1.5	0.71	L300002B:Surf[0]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)] $U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
$m^3/(h.m^2)$ at 50 Pa	5	10

Appendix C – 'GREEN' BRUKL report

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2013

Project name

UCL_IOE_Phase 2 PartL2B_GREEN.rev00 As built

Date: Tue Mar 24 14:34:43 2020

Administrative information

Building Details

Address: Address 1, City, Postcode

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.12

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.12

BRUKL compliance check version: v5.6.a.1

Owner Details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Criterion 1: The calculated CO_2 emission rate for the building must not exceed the target

The building does not comply with England Building Regulations Part L 2013

CO_2 emission rate from the notional building, $kgCO_2/m^2.annum$	22.1
Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	22.1
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	52.5
Are emissions from the building less than or equal to the target?	BER > TER
Are as built details the same as used in the BER calculations?	Separate submission

Criterion 2: The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Values which do not achieve the standards in the Non-Domestic Building Services Compliance Guide and Part L are displayed in red.

Building fabric

Element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	Surface where the maximum value occurs*
Wall**	0.35	0.32	0.47	L300001A:Surf[3]
Floor	0.25	0.27	0.77	L4000023:Surf[16]
Roof	0.25	0.82	2.26	L4000038:Surf[1]
Windows***, roof windows, and rooflights	2.2	2.04	5.7	L2000010:Surf[0]
Personnel doors	2.2	-	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	-	No Vehicle access doors in building
High usage entrance doors	3.5	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [$W/(m^2K)$]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [$W/(m^2K)$]
$U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [$W/(m^2K)$]

* There might be more than one surface where the maximum U-value occurs.
** Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
*** Display windows and similar glazing are excluded from the U-value check.
N.B.: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air Permeability	Worst acceptable standard	This building
$m^3/(h.m^2)$ at 50 Pa	10	10

Building services

The standard values listed below are minimum values for efficiencies and maximum values for SFPs. Refer to the Non-Domestic Building Services Compliance Guide for details.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	>0.95

1- radiators with extract_WC

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

2- Circulation supply+extract

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	4.62	0	2.1	0.8
Standard value	N/A	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

3- AHU (FCUs)+rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	4.6	0	2.1	0.8
Standard value	N/A	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

4- Nat_radiators

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	0	0	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

5- DX cooling_comms room

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	3.2	-	0	-
Standard value	0.91*	3.2	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO
* Standard shown is for gas single boiler systems <=2 MW output. For single boiler systems >2 MW or multi-boiler systems, (overall) limiting efficiency is 0.86. For any individual boiler in a multi-boiler system, limiting efficiency is 0.82.					

6- VAV+rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	4.62	0	2.1	0.8
Standard value	N/A	2.55	N/A	1.6^	0.65
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
^ Limiting SFP may be extended by the amounts specified in the Non-Domestic Building Services Compliance Guide if the system includes additional components as listed in the Guide.					

"No HWS in project, or hot water is provided by HVAC system"

Local mechanical ventilation, exhaust, and terminal units

ID	System type in Non-domestic Building Services Compliance Guide
A	Local supply or extract ventilation units serving a single area
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal supply and extract ventilation units serving a single room or zone with heating and heat recovery
E	Local supply and extract ventilation system serving a single area with heating and heat recovery
F	Other local ventilation units
G	Fan-assisted terminal VAV unit
H	Fan coil units
I	Zonal extract system where the fan is remote from the zone with grease filter

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L2_WC	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L2_XC_TS_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching area	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_teaching space	-	-	-	-	-	-	-	0.2	-	-	N/A
L3_WC	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XA_WC_I_02	0.4	-	-	-	-	-	-	-	-	-	N/A
L3_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XA_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XA_WC_I_02	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XB_TS_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L4_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XB_WC_I_01	0.4	-	-	-	-	-	-	-	-	-	N/A
L4_XC_TS_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_E_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_W_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L5_ZA_TS_W_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L6_WI_WS_N_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_08	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_09	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_WI_WS_N_11	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_ZA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L6_ZA_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_08	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_WI_WS_N_09	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_XA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L7_XA_MR_I_03	-	-	-	-	-	-	-	0.8	-	-	N/A
L7_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XA_MR_I_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XA_MR_I_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XB_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_XB_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L8_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_MR_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_02	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_N_10	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_WI_WS_S_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_BREAKOUT_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	1.9	1.6	0.5	1.1	0.5	1	Zone	Standard
L9_ZA_MR_E_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_MR_I_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_03	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_04	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_05	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_06	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_E_07	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A
L9_ZA_WS_W_01	-	-	-	-	-	-	-	0.2	-	-	N/A

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	Luminaire	Lamp	Display lamp	General lighting [W]
Standard value	60	60	22	
L2_store	90	-	-	8
L2_WC	-	80	-	66
L2_XA_WC_I_01	-	80	-	77
L2_XB_CIRC_I_02	-	80	-	89
L2_XB_WC_I_01	-	80	-	161
L2_XB_WC_I_01	-	80	-	82
L2_XC_TS_I_01	90	-	-	660
L3_atrium	-	90	-	64
L3_cafe_store	90	-	-	15
L3_ISD rooms	80	-	-	268
L3_store	90	-	-	6
L3_teaching area	90	-	-	145
L3_teaching area	90	-	-	146
L3_teaching area	90	-	-	149
L3_teaching space	90	-	-	654
L3_WC	-	80	-	73
L3_XA_COMMS_E_01	90	-	-	48
L3_XA_STORE_E_01	90	-	-	6
L3_XA_WC_I_01	-	80	-	90
L3_XA_WC_I_02	-	80	-	80
L3_XB_CC_I_01	-	80	-	131
L3_XB_WC_I_01	80	-	-	259
L3_ZB_CIRC_I_01	-	80	-	87
L3_ZB_CIRC_I_02	-	80	-	215
L4_XA_WC_I_01	-	80	-	128
L4_XA_WC_I_02	-	80	-	77
L4_XB_CIRC_I_01	-	80	-	134
L4_XB_STORE_I_01	90	-	-	4
L4_XB_STORE_I_02	90	-	-	8
L4_XB_TS_I_01	90	-	-	624

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L4_XB_WC_I_01	-	80	-	78
L4_XB_WC_I_01	-	80	-	138
L4_XC_TS_E_01	90	-	-	621
L4_ZB_BREAKOUT_I_08	-	80	-	217
L5_XA_CIRC_I_02	-	80	-	81
L5_ZA_TS_E_01	90	-	-	293
L5_ZA_TS_E_02	90	-	-	304
L5_ZA_TS_W_03	90	-	-	190
L5_ZA_TS_W_04	90	-	-	225
L6_WI_CIRC_I_01	-	80	-	115
L6_WI_MR_I_01	90	-	-	81
L6_WI_MR_I_02	90	-	-	169
L6_WI_MR_W_01	90	-	-	129
L6_WI_WS_N_01	90	-	-	125
L6_WI_WS_N_02	90	-	-	120
L6_WI_WS_N_03	90	-	-	117
L6_WI_WS_N_04	90	-	-	116
L6_WI_WS_N_05	90	-	-	116
L6_WI_WS_N_06	90	-	-	117
L6_WI_WS_N_07	90	-	-	117
L6_WI_WS_N_08	90	-	-	116
L6_WI_WS_N_09	90	-	-	116
L6_WI_WS_N_10	90	-	-	116
L6_WI_WS_N_11	90	-	-	116
L6_WI_WS_N_12	90	-	-	140
L6_WI_WS_S_01	90	-	-	850
L6_XA_CIRC_I_01	-	80	-	151
L6_ZA_BREAKOUT_E_01	-	80	-	158
L6_ZA_MR_I_01	90	-	-	70
L6_ZA_MR_I_02	90	-	-	73
L6_ZA_WS_W_01	90	-	-	835
L6_ZB_LAWTON_DINING_E_01	-	90	-	433
L7_WI_CIRC_I_01	-	80	-	106
L7_WI_MR_I_01	90	-	-	161
L7_WI_MR_W_01	90	-	-	129
L7_WI_WS_N_01	90	-	-	113
L7_WI_WS_N_02	90	-	-	113
L7_WI_WS_N_03	90	-	-	113
L7_WI_WS_N_04	90	-	-	113
L7_WI_WS_N_05	90	-	-	113
L7_WI_WS_N_07	90	-	-	113
L7_WI_WS_N_07	90	-	-	113
L7_WI_WS_N_08	90	-	-	113

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L7_WI_WS_N_09	90	-	-	113
L7_WI_WS_N_10	90	-	-	168
L7_WI_WS_S_01	90	-	-	777
L7_XA_CIRC_I_01	-	80	-	148
L7_XA_MR_I_01	80	-	-	118
L7_XA_MR_I_03	80	-	-	172
L7_ZA_BREAKOUT_E_01	80	-	-	496
L7_ZA_MR_E_01	80	-	-	151
L7_ZA_WS_E_01	90	-	-	106
L7_ZA_WS_E_02	90	-	-	100
L7_ZA_WS_E_03	90	-	-	105
L7_ZA_WS_E_04	90	-	-	103
L7_ZA_WS_E_05	90	-	-	103
L7_ZA_WS_E_07	90	-	-	93
L7_ZA_WS_W_01	90	-	-	774
L8_WI_CIRC_I_01	-	80	-	105
L8_WI_MR_I_01	90	-	-	79
L8_WI_MR_W_01	90	-	-	128
L8_WI_WS_N_01	90	-	-	113
L8_WI_WS_N_02	90	-	-	113
L8_WI_WS_N_03	90	-	-	113
L8_WI_WS_N_04	90	-	-	113
L8_WI_WS_N_05	90	-	-	108
L8_WI_WS_N_06	90	-	-	107
L8_WI_WS_N_07	90	-	-	107
L8_WI_WS_N_08	90	-	-	108
L8_WI_WS_N_10	90	-	-	110
L8_WI_WS_S_01	90	-	-	432
L8_XA_CIRC_I_01	-	80	-	148
L8_XA_MR_I_02	90	-	-	160
L8_XA_MR_I_03	90	-	-	151
L8_XB_MR_E_01	90	-	-	97
L8_XB_MR_I_01	90	-	-	172
L8_ZA_BREAKOUT_E_01	-	80	-	159
L8_ZA_MR_E_01	90	-	-	83
L8_ZA_WS_E_01	90	-	-	78
L8_ZA_WS_E_02	80	-	-	109
L8_ZA_WS_E_03	90	-	-	103
L8_ZA_WS_E_04	90	-	-	100
L8_ZA_WS_E_05	90	-	-	100
L8_ZA_WS_E_06	90	-	-	100
L8_ZA_WS_E_07	90	-	-	89
L8_ZA_WS_W_01	80	-	-	1241

General lighting and display lighting	Luminous efficacy [lm/W]			
Zone name	**Luminaire**	**Lamp**	**Display lamp**	**General lighting [W]**
Standard value	60	60	22	
L9_WI_MR_W_01	90	-	-	140
L9_WI_WS_N_01	90	-	-	107
L9_WI_WS_N_02	90	-	-	107
L9_WI_WS_N_10	90	-	-	137
L9_WI_WS_S_01	90	-	-	416
L9_XA_CIRC_I_01	-	80	-	147
L9_ZA_BREAKOUT_E_01	-	80	-	106
L9_ZA_MR_E_01	90	-	-	74
L9_ZA_MR_I_01	90	-	-	91
L9_ZA_WS_E_03	90	-	-	93
L9_ZA_WS_E_04	90	-	-	90
L9_ZA_WS_E_05	90	-	-	90
L9_ZA_WS_E_06	90	-	-	90
L9_ZA_WS_E_07	90	-	-	79
L9_ZA_WS_W_01	90	-	-	166
L9_ZA_WS_W_01	90	-	-	521
L3_cafe	-	80	-	200
L3_ZB_ENTRANCE_E_01	-	90	80	183
L4_ZB_BREAKOUT_I_05	-	80	-	260
L4_ZB_STAIR_I_01	-	80	-	171
L4_ZB_CIRC_I_01	-	80	-	743
L4_ZB_ENTRANCE_I_01	-	90	80	79

Criterion 3: The spaces in the building should have appropriate passive control measures to limit solar gains

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L2_XB_CIRC_I_02	N/A	N/A
L2_XC_TS_I_01	N/A	N/A
L3_ISD rooms	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching area	N/A	N/A
L3_teaching space	N/A	N/A
L3_XA_COMMS_E_01	NO (-91.7%)	YES
L3_XB_CC_I_01	N/A	N/A
L3_XB_WC_I_01	NO (-49.5%)	YES
L4_XB_CIRC_I_01	N/A	N/A
L4_XB_TS_I_01	N/A	N/A
L4_XC_TS_E_01	N/A	N/A
L5_XA_CIRC_I_02	N/A	N/A
L5_ZA_TS_E_01	NO (-72.4%)	YES
L5_ZA_TS_E_02	NO (-50.1%)	YES
L5_ZA_TS_W_03	NO (-34.8%)	YES
L5_ZA_TS_W_04	NO (-45%)	YES

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L6_WI_CIRC_I_01	N/A	N/A
L6_WI_MR_I_01	N/A	N/A
L6_WI_MR_I_02	N/A	N/A
L6_WI_MR_W_01	NO (-48.2%)	YES
L6_WI_WS_N_01	NO (-65.7%)	YES
L6_WI_WS_N_02	NO (-53.7%)	YES
L6_WI_WS_N_03	NO (-51.2%)	YES
L6_WI_WS_N_04	NO (-50.7%)	YES
L6_WI_WS_N_05	NO (-50.7%)	YES
L6_WI_WS_N_06	NO (-51.2%)	YES
L6_WI_WS_N_07	NO (-50.7%)	YES
L6_WI_WS_N_08	NO (-50.8%)	YES
L6_WI_WS_N_09	NO (-52.2%)	YES
L6_WI_WS_N_10	NO (-52.3%)	YES
L6_WI_WS_N_11	NO (-51.4%)	YES
L6_WI_WS_N_12	NO (-42.4%)	YES
L6_WI_WS_S_01	NO (-35.3%)	YES
L6_XA_CIRC_I_01	N/A	N/A
L6_ZA_BREAKOUT_E_01	NO (-43.5%)	YES
L6_ZA_MR_I_01	N/A	N/A
L6_ZA_MR_I_02	N/A	N/A
L6_ZA_WS_W_01	NO (-64%)	YES
L6_ZB_LAWTON_DINING_E_01	NO (-18.4%)	YES
L7_WI_CIRC_I_01	N/A	N/A
L7_WI_MR_I_01	N/A	N/A
L7_WI_MR_W_01	NO (-48.9%)	YES
L7_WI_WS_N_01	NO (-62.5%)	YES
L7_WI_WS_N_02	NO (-52.4%)	YES
L7_WI_WS_N_03	NO (-52.4%)	YES
L7_WI_WS_N_04	NO (-52.4%)	YES
L7_WI_WS_N_05	NO (-52.4%)	YES
L7_WI_WS_N_07	NO (-52.4%)	YES
L7_WI_WS_N_07	NO (-52.4%)	YES
L7_WI_WS_N_08	NO (-52.4%)	YES
L7_WI_WS_N_09	NO (-52.4%)	YES
L7_WI_WS_N_10	NO (-45.6%)	YES
L7_WI_WS_S_01	NO (-34%)	YES
L7_XA_CIRC_I_01	N/A	N/A
L7_XA_MR_I_01	N/A	N/A
L7_XA_MR_I_03	N/A	N/A
L7_ZA_BREAKOUT_E_01	NO (-51.8%)	YES
L7_ZA_MR_E_01	NO (-55.3%)	YES
L7_ZA_WS_E_01	NO (-47.3%)	YES
L7_ZA_WS_E_02	NO (-41.1%)	YES
L7_ZA_WS_E_03	NO (-43.5%)	YES
L7_ZA_WS_E_04	NO (-42.9%)	YES
L7_ZA_WS_E_05	NO (-42.9%)	YES
L7_ZA_WS_E_07	NO (-91.5%)	YES
L7_ZA_WS_W_01	NO (-62.2%)	YES

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
L8_WI_CIRC_I_01	N/A	N/A
L8_WI_MR_I_01	N/A	N/A
L8_WI_MR_W_01	NO (-49.1%)	YES
L8_WI_WS_N_01	NO (-62.5%)	YES
L8_WI_WS_N_02	NO (-52.4%)	YES
L8_WI_WS_N_03	NO (-52.4%)	YES
L8_WI_WS_N_04	NO (-52.4%)	YES
L8_WI_WS_N_05	NO (-52.4%)	YES
L8_WI_WS_N_06	NO (-52.6%)	YES
L8_WI_WS_N_07	NO (-52.6%)	YES
L8_WI_WS_N_08	NO (-52.2%)	YES
L8_WI_WS_N_10	NO (-43.7%)	YES
L8_WI_WS_S_01	NO (-31.1%)	YES
L8_XA_CIRC_I_01	N/A	N/A
L8_XA_MR_I_02	N/A	N/A
L8_XA_MR_I_03	N/A	N/A
L8_XB_MR_E_01	NO (-43.9%)	YES
L8_XB_MR_I_01	N/A	N/A
L8_ZA_BREAKOUT_E_01	NO (-50.5%)	YES
L8_ZA_MR_E_01	NO (-48.4%)	YES
L8_ZA_WS_E_01	NO (-47.3%)	YES
L8_ZA_WS_E_02	NO (-41.1%)	YES
L8_ZA_WS_E_03	NO (-43.5%)	YES
L8_ZA_WS_E_04	NO (-42.9%)	YES
L8_ZA_WS_E_05	NO (-42.9%)	YES
L8_ZA_WS_E_06	NO (-42.9%)	YES
L8_ZA_WS_E_07	NO (-91.5%)	YES
L8_ZA_WS_W_01	NO (-62.2%)	YES
L9_WI_MR_W_01	NO (-49.4%)	YES
L9_WI_WS_N_01	NO (-62.6%)	YES
L9_WI_WS_N_02	NO (-52.6%)	YES
L9_WI_WS_N_10	NO (-44.1%)	YES
L9_WI_WS_S_01	NO (-53.9%)	YES
L9_XA_CIRC_I_01	N/A	N/A
L9_ZA_BREAKOUT_E_01	NO (-77.7%)	YES
L9_ZA_MR_E_01	NO (-47.6%)	YES
L9_ZA_MR_I_01	N/A	N/A
L9_ZA_WS_E_03	NO (-43.5%)	YES
L9_ZA_WS_E_04	NO (-43%)	YES
L9_ZA_WS_E_05	NO (-42.9%)	YES
L9_ZA_WS_E_06	NO (-42.9%)	YES
L9_ZA_WS_E_07	NO (-81.9%)	YES
L9_ZA_WS_W_01	N/A	N/A
L9_ZA_WS_W_01	NO (-54.4%)	YES
L3_ZB_ENTRANCE_E_01	NO (-36.4%)	YES
L4_ZB_ENTRANCE_I_01	NO (-42%)	YES

Criterion 4: The performance of the building, as built, should be consistent with the calculated BER

Separate submission

Criterion 5: The necessary provisions for enabling energy-efficient operation of the building should be in place

Separate submission

EPBD (Recast): Consideration of alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Area [m^2]	5190.2	5190.2
External area [m^2]	4998.7	5770
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	10	3
Average conductance [W/K]	5128.85	2799.3
Average U-value [W/m^{2}K]	1.03	0.49
Alpha value* [%]	9.18	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	A1/A2 Retail/Financial and Professional services
	A3/A4/A5 Restaurants and Cafes/Drinking Est./Takeaways
	B1 Offices and Workshop businesses
	B2 to B7 General Industrial and Special Industrial Groups
	B8 Storage or Distribution
	C1 Hotels
	C2 Residential Institutions: Hospitals and Care Homes
	C2 Residential Institutions: Residential schools
100	**C2 Residential Institutions: Universities and colleges**
	C2A Secure Residential Institutions
	Residential spaces
	D1 Non-residential Institutions: Community/Day Centre
	D1 Non-residential Institutions: Libraries, Museums, and Galleries
	D1 Non-residential Institutions: Education
	D1 Non-residential Institutions: Primary Health Care Building
	D1 Non-residential Institutions: Crown and County Courts
	D2 General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger terminals
	Others: Emergency services
	Others: Miscellaneous 24hr activities
	Others: Car Parks 24 hrs
	Others: Stand alone utility block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	38.89	11.6
Cooling	3.99	6.63
Auxiliary	28.8	13.93
Lighting	9.02	14.36
Hot water	87.08	6.04
Equipment*	30.79	30.79
TOTAL**	**167.77**	**52.56**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	170.55	132.26
Primary energy* [kWh/m^2]	276.39	125.72
Total emissions [kg/m^2]	52.5	22.1

* Primary energy is net of any electrical energy displaced by CHP generators, if applicable.

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	339.8	0	100.5	0	1.8	0.94	0	1	0
	Notional	112.2	0	31.2	0	1.8	1	0	----	----
[ST] Central heating using water: radiators, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	55.1	0	16.3	0	14.1	0.94	0	1	0
	Notional	31.3	0	8.7	0	14.1	1	0	----	----
[ST] Fan coil systems, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	85.6	57.3	25.5	4.8	12.3	0.93	3.35	1	4.4
	Notional	32	125.1	8.9	9.2	16.1	1	3.79	----	----
[ST] Constant volume system (fixed fresh air rate), [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	56.5	33.6	15.4	4.4	32.4	1.02	2.11	1	4.43
	Notional	11	80.2	3	5.9	21.9	1	3.79	----	----
[ST] Single-duct VAV, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	69	70.8	24.4	6.9	65.1	0.78	2.85	1	4.43
	Notional	17.3	144.1	4.8	10.6	18.2	1	3.79	----	----
[ST] Split or multi-split system, [HS] LTHW boiler, [HFT] Natural Gas, [CFT] Electricity										
	Actual	0	0	0	0	0	0.93	2.13	1	3
	Notional	0	0	0	0	0	0.86	3.79	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2] = Heating energy demand
Cool dem [MJ/m2] = Cooling energy demand
Heat con [kWh/m2] = Heating energy consumption
Cool con [kWh/m2] = Cooling energy consumption
Aux con [kWh/m2] = Auxiliary energy consumption
Heat SSEFF = Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER = Cooling system seasonal energy efficiency ratio
Heat gen SSEFF = Heating generator seasonal efficiency
Cool gen SSEER = Cooling generator seasonal energy efficiency ratio
ST = System type
HS = Heat source
HFT = Heating fuel type
CFT = Cooling fuel type

Key Features

The Building Control Body is advised to give particular attention to items whose specifications are better than typically expected.

Building fabric

Element	$U_{i\text{-}Typ}$	$U_{i\text{-}Min}$	Surface where the minimum value occurs*
Wall	0.23	-	L3000009:Surf[9]
Floor	0.2	0.11	L4000020:Surf[0]
Roof	0.15	0.18	L2000016:Surf[0]
Windows, roof windows, and rooflights	1.5	0.71	L300002B:Surf[0]
Personnel doors	1.5	-	No Personnel doors in building
Vehicle access & similar large doors	1.5	-	No Vehicle access doors in building
High usage entrance doors	1.5	-	No High usage entrance doors in building

$U_{i\text{-}Typ}$ = Typical individual element U-values [W/(m²K)] $U_{i\text{-}Min}$ = Minimum individual element U-values [W/(m²K)]

* There might be more than one surface where the minimum U-value occurs.

Air Permeability	Typical value	This building
$m^3/(h.m^2)$ at 50 Pa	5	10

Appendix D – Thermal Comfort results, baseline climate

Phase 2 occupied rooms - TM52 Overheating assessment results

		TM52 Overheating results (summer)									Result
Level	Space type	Criteria 1 (%Hrs Top-Tmax>=1K) 3% hours exceeding temperature range as recommended in BS EN 15251				Criteria 2 (Max. Daily Deg.Hrs):		Criteria 3 (Max, DeltaT):			
	PHASE 2 occupied rooms	Criterion 1	Hours occupied	Hours exceeded	Hours exceeded (%)	Criterion 2	Weighted exceedance	Criterion 3	Upper limit DT	Upper limit DT*	
Level 6	L6_WI_WS_N_10	Pass	2142	8	0.4	Pass	4.0	Pass	1.0	1.2	PASS
Level 6	L6_WI_WS_N_09	Pass	2142	8	0.4	Pass	4.0	Pass	1.0	1.3	PASS
Level 6	L6_WI_WS_N_08	Pass	2142	8	0.4	Pass	4.0	Pass	1.0	1.3	PASS
Level 6	L6_WI_WS_N_07	Pass	2142	8	0.4	Pass	4.0	Pass	1.0	1.3	PASS
Level 6	L6_WI_WS_N_06	Pass	2142	8	0.4	Pass	4.0	Pass	1.0	1.3	PASS
Level 6	L6_WI_WS_N_04	Pass	2142	3	0.1	Pass	3.0	Pass	1.0	0.9	PASS
Level 6	L6_WI_WS_N_03	Pass	2142	3	0.1	Pass	3.0	Pass	1.0	0.9	PASS
Level 6	L6_WI_WS_N_02	Pass	2142	7	0.3	Pass	3.0	Pass	1.0	0.9	PASS
Level 6	L6_WI_WS_NW_01	Pass	2142	57	2.7	Fail	17.0	Pass	4.0	4.3	PASS
Level 6	L6_WI_WS_N_11	Pass	2142	3	0.1	Pass	3.0	Pass	1.0	0.8	PASS
Level 6	L6_WI_QR_S_01	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-1.0	PASS
Level 6	L6_WI_QR_02	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-0.9	PASS
Level 6	L6_WI_QR_03	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	-0.2	PASS
Level 6	L6_WI_MT_S_01	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	-0.3	PASS
Level 6	L6_WI_MT_S_01	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	0.0	PASS
Level 6	L6_WI_QR_04	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	-0.2	PASS
Level 6	L6_WI_MR_I_01	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	-0.3	PASS
Level 6	L6_WI_QR_05	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-0.5	PASS
Level 6	L6_ZA_MT_I_04	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	0.4	PASS

Level 6	L6_ZA_MT_I_02	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	0.2	PASS
Level 6	L6_ZA_Breakout_N_01	Pass	2142	1	0.0	Pass	1.0	Pass	1.0	0.6	PASS
Level 6	L6_ZA_WS_NE_01	Pass	2142	3	0.1	Pass	3.0	Pass	1.0	0.9	PASS
Level 6	L6_ZA_WS_NE_02	Pass	2142	3	0.1	Pass	3.0	Pass	1.0	1.0	PASS
Level 6	L6_ZA_WS_NE_04	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-1.0	PASS
Level 6	L6_ZA_WS_NE_03	Pass	2142	3	0.1	Pass	3.0	Pass	1.0	1.0	PASS
Level 6	L6_ZA_MT_I_05	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-0.8	PASS
Level 6	L6_ZA_QS_I_01	Pass	2142	28	1.3	Fail	7.0	Pass	2.0	1.9	PASS
Level 6	L6_ZA_MT_I_01	Pass	2142	13	0.6	Pass	4.0	Pass	1.0	1.4	PASS
Level 6	L6_ZA_SH_W_02	Close to fail	2142	83	3.9	Fail	12.0	Pass	4.0	3.7	(recommended max air volume > 105 L/s)
Level 6	L6_ZA_SH_W_01	Close to fail	2142	79	3.7	Fail	13.0	Pass	4.0	4.0	(recommended max air volume > 105 L/s)
Level 6	L6_WI_Teapoint_S_01	Pass	2142	8	0.4	Pass	6.0	Pass	2.0	1.7	PASS
Level 6	L6_WI_SH_S_02	Pass	2142	10	0.5	Pass	5.0	Pass	1.0	1.5	PASS
Level 6	L6_WI_SH_S_03	Pass	2142	10	0.5	Pass	5.0	Pass	1.0	1.4	PASS
Level 6	L6_WI_SH_S_05	Pass	2142	9	0.4	Pass	5.0	Pass	1.0	1.1	PASS
Level 6	L6_WI_SH_S_04	Pass	2142	9	0.4	Pass	4.0	Pass	1.0	1.4	PASS
Level 7	L7_WI_SH_S_01	Pass	2142	70	3.0	Fail	21	Pass	4	4.3	PASS
Level 7	L7_WI_WS_N_07	Pass	2142	7	0.3	Pass	4	Pass	1	1.0	PASS
Level 7	L7_WI_WS_N_06	Pass	2142	8	0.4	Pass	4	Pass	1	1.2	PASS
Level 7	L7_WI_WS_N_05	Pass	2142	8	0.4	Pass	4	Pass	1	1.2	PASS
Level 7	L7_WI_WS_N_04	Pass	2142	8	0.4	Pass	4	Pass	1	1.2	PASS
Level 7	L7_WI_WS_N_03	Pass	2142	3	0.1	Pass	3	Pass	1	0.6	PASS
Level 7	L7_ZA_BREAKOUT_N	Pass	2142	0	0.0	Pass	0	Pass	0	0.1	PASS
Level 7	L7_ZA_WS_N_03	Pass	2142	0	0.0	Pass	0	Pass	0	-0.1	PASS
Level 7	L7_ZA_WS_N_04	Pass	2142	0	0.0	Pass	0	Pass	0	0.0	PASS
Level 7	L7_ZA_WS_N_05	Pass	2142	0	0.0	Pass	0	Pass	0	0.0	PASS

Level 7	L7_ZA_WS_N_06	Pass	2142	0	0.0	Pass	0	Pass	0	0.1	PASS
Level 7	L7_ZA_WS_N_07	Pass	2142	9	0.4	Pass	4	Pass	1	1.4	PASS
Level 7	L7_ZA_WS_N_02	Pass	2142	0	0.0	Pass	0	Pass	-1	-0.8	PASS
Level 7	L7_ZA_WS_N_01	Pass	2142	0	0.0	Pass	0	Pass	-1	-0.6	PASS
Level 7	L7_ZA_QR_I	Pass	2142	0	0.0	Pass	0	Pass	-1	-0.5	PASS
Level 7	L7_ZA_MT_I	Pass	2142	0	0.0	Pass	0	Pass	-1	-0.6	PASS
Level 7	L7_ZA_MR_I_05	Pass	2142	43	2.0	Fail	9	Pass	1	1.2	PASS
Level 7	L7_ZA_MT_I_06	Pass	2142	21	1.0	Pass	4	Pass	1	1.3	PASS
Level 7	L7_ZA_MT_I_07	Pass	2142	9	0.4	Pass	3	Pass	1	0.9	PASS
Level 7	L7_ZA_MT_I_08	Pass	2142	6	0.3	Pass	3	Pass	1	1.0	PASS
Level 7	L7_WI_WS_N_08	Pass	2142	1	0.0	Pass	1	Pass	1	0.6	PASS
Level 7	L7_WI_WS_N_01	Pass	2142	61	2.8	Fail	11	Pass	3	3.4	PASS
Level 7	L7_WI_WS_N_02	Pass	2142	1	0.0	Pass	1	Pass	1	0.6	PASS
Level 7	L7_WI_MT_I_01	Pass	2142	0	0.0	Pass	0	Pass	0	-0.2	PASS
Level 7	L7_WI_MR_I_02	Pass	2142	0	0.0	Pass	0	Pass	0	0.2	PASS
Level 7	L7_WI_QS_I_02	Pass	2142	0	0.0	Pass	0	Pass	0	0.0	PASS
Level 7	L7_WI_QS_I_03	Pass	2142	0	0.0	Pass	0	Pass	0	-0.4	PASS
Level 7	L7_WI_MT_I_03	Pass	2142	0	0.0	Pass	0	Pass	0	-0.3	PASS
Level 7	L7_WI_ENTRANCE_S_01	Pass	2142	4	0.2	Pass	3	Pass	1	0.6	PASS
Level 7	L7_ZA_MR_I_02	Pass	2142	0	0	Pass	0	Pass	0	-0.2	PASS
Level 7	L7_ZA_MR_I_01	Pass	2142	0	0	Pass	0	Pass	0	-0.2	PASS
Level 7	L7_ZA_SH_W_02	Pass	2142	61	2.8	Fail	13	Pass	4	3.8	(recommended max air volume > 100 L/s)
Level 7	L7_ZA_SH_W_01	Pass	2142	61	2.8	Fail	13	Pass	4	4.2	(recommended max air volume > 100 L/s)
Level 7	L7_WI_SH_S_02	Pass	2142	21	1.0	Fail	11	Pass	2	2.0	PASS
Level 7	L7_WI_SH_S_03	Pass	2142	14	0.7	Fail	8	Pass	2	1.9	PASS
Level 7	L7_WI_SH_S_05	Pass	2142	14	0.7	Fail	7	Pass	2	1.9	PASS

Level 7	L7_WI_SH_S_04	Pass	2142	14	0.7	Fail	7	Pass	2	2.0	PASS
Level 8	L8_WI_SH_SE_01	Close to fail	2142	84	3.9	Fail	27	Fail	5	4.6	(recommended max air volume > 68 L/s)
Level 8	L8_WI_WS_N_06	Pass	2142	6	0.3	Pass	4	Pass	1	1.2	PASS
Level 8	L8_WI_WS_N_05	Pass	2142	13	0.6	Pass	6	Pass	2	1.6	PASS
Level 8	L8_WI_WS_N_04	Pass	2142	16	0.7	Pass	6	Pass	2	1.6	PASS
Level 8	L8_WI_WS_N_03	Pass	2142	18	0.8	Pass	6	Pass	2	1.7	PASS
Level 8	L8_ZA_MR_N_01	Pass	2142	9	0.4	Pass	4	Pass	1	1.4	PASS
Level 8	L8_ZA_WS_N_01	Pass	2142	2	0.1	Pass	2	Pass	1	0.9	PASS
Level 8	L8_ZA_WS_N_02	Pass	2142	3	0.1	Pass	3	Pass	1	1.2	PASS
Level 8	L8_ZA_WS_N_03	Pass	2142	3	0.1	Pass	3	Pass	1	1.2	PASS
Level 8	L8_ZA_WS_N_04	Pass	2142	3	0.1	Pass	3	Pass	1	1.1	PASS
Level 8	L8_ZA_WS_N_05	Pass	2142	3	0.1	Pass	3	Pass	1	1.1	PASS
Level 8	L8_ZA_WS_N_06	Pass	2142	3	0.1	Pass	3	Pass	1	1.2	PASS
Level 8	L8_ZA_WS_N_07	Pass	2142	33	1.5	Fail	14	Pass	3	3.1	PASS
Level 8	L8_ZA_BREAKOUT_N_01	Pass	2142	3	0.1	Pass	3	Pass	1	1.0	PASS
Level 8	L8_ZA_MR_I_05	Pass	2142	0	0.0	Pass	0	Pass	0	0.0	PASS
Level 8	L8_ZA_MR_I_04	Pass	2142	0	0.0	Pass	0	Pass	0	-0.1	PASS
Level 8	L8_ZA_MT_I_05	Pass	2142	0	0.0	Pass	0	Pass	0	-0.3	PASS
Level 8	L8_ZA_QS_I_01	Pass	2142	0	0.0	Pass	0	Pass	0	-0.4	PASS
Level 8	L8_ZA_MT_I_07	Pass	2142	0	0.0	Pass	0	Pass	0	0.3	PASS
Level 8	L8_ZA_QS_I_02	Pass	2142	0	0.0	Pass	0	Pass	0	0.4	PASS
Level 8	L8_ZA_MT_I_08	Pass	2142	2	0.1	Pass	2	Pass	1	0.6	PASS
Level 8	L8_WI_WS_N_07	Pass	2142	1	0.0	Pass	1	Pass	1	0.5	PASS
Level 8	L8_WI_WS_N_02	Pass	2142	19	0.9	Fail	7	Pass	2	2.0	PASS
Level 8	L8_WI_WS_NW_01	Pass	2142	19	0.9	Fail	17	Pass	4	4.0	recommended max air volume > 81 L/s
Level 8	L8_WI_FOCUS_02	Pass	2142	0	0.0	Pass	0	Pass	0	-0.4	PASS

Level 8	L8_WI_FOCUS_01	Pass	2142	0	0.0	Pass	0	Pass	-1	-0.6	PASS
Level 8	L8_WI_FOCUS_I_03	Pass	2142	31	1.4	Fail	8	Pass	3	3.0	PASS
Level 8	L8_ZA_SH_W_02	Pass	2142	61	2.8	Fail	12.0	Pass	3.0	3.3	recommended max air volume > 105 L/s
Level 8	L8_ZA_SH_W_01	Pass	2142	61	2.8	Fail	15.0	Pass	4.0	4.4	recommended max air volume > 105 L/s
Level 8	L8_WI_BREAKOUT/WELCOME_S_01	Pass	2142	11	0.5	Pass	5.0	Pass	2.0	1.6	PASS
Level 8	L8_WI_SH_S_03	Pass	2142	23	1.1	Fail	14.0	Pass	3.0	2.9	PASS
Level 8	L8_WI_SH_S_02	Pass	2142	27	1.3	Fail	17.0	Pass	3.0	3.2	PASS
Level 9	L9_ZA_MT_I_01	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-1.2	PASS
Level 9	L9_ZA_MT_I_02	Pass	2142	0	0.0	Pass	0.0	Pass	0.0	-0.1	PASS
Level 9	L9_ZA_MR_I_03	Pass	2142	9	0.4	Pass	4.0	Pass	1.0	1.1	PASS
Level 9	L9_ZA_QS_I	Pass	2142	1	0.0	Pass	1.0	Pass	1.0	0.6	PASS
Level 9	L9_WI_entrance	Pass	2142	7	0.3	Pass	4.0	Pass	1.0	1.0	PASS
Level 9	L9_WI_MT_I	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-0.8	PASS
Level 9	L9_WI_QS_I	Pass	2142	0	0.0	Pass	0.0	Pass	-1.0	-1.5	PASS

Comfort results in winter to comply with CIBSE Guide A and UCL environmental criteria (Phase 2)

Space type		Comfort results (winter)			
Level	PHASE 2 occupied rooms	Winter – Min temperature (°C)	Winter – Max temperature (°C)	UCL Environmental Temperature range (°C)	CIBSE Guide A compliance Threshold temperature exceeded > 1% of occupied hours per year
Level 4	L4_ZB_BREAKOUT_I_05	21.24	25.71	20-26	PASS
Level 4	L4_ZB_BREAKOUT_I_05	21.24	25.71	20-26	PASS
Level 5	L5_XB_TS_I_01	23.28	24.24	20-26	PASS
Level 5	L5_ZA_TS_E_01	21.72	24.45	20-26	PASS
Level 5	L5_ZA_TS_E_02	21.72	24.81	20-26	PASS
Level 5	L5_ZA_TS_W_03	21.72	24.45	20-26	PASS
Level 5	L5_ZA_TS_W_04	21.72	24.81	20-26	PASS
Level 6	L6_ZA_MT_I_04	21.89	25.5	20-26	PASS
Level 6	L6_ZA_MT_I_02	21.68	24.38	20-26	PASS
Level 6	L6_ZA_Breakout_N_01	21.68	22.17	20-26	PASS
Level 6	L6_ZA_WS_NE_01	21.68	22.17	20-26	PASS
Level 6	L6_ZA_MT_N_I_03	21.87	26	20-26	PASS
Level 6	L6_ZA_WS_NE_02	21.87	22.14	20-26	PASS
Level 6	L6_ZA_WS_NE_04	20.18	22.01	20-26	PASS
Level 6	L6_ZA_WS_NE_03	20.76	22.16	20-26	PASS
Level 6	L6_ZA_MT_I_05	21.72	24.78	20-26	PASS
Level 6	L6_ZA_QS_I_01	22.44	25.05	20-26	PASS
Level 6	L6_ZA_MT_I_01	22.61	24.97	20-26	PASS
Level 6	L6_ZA_SH_W_02	21.32	23.97	20-26	PASS

Level 6	L6_ZA_SH_W_01	21.51	24.16	20-26	PASS
Level 6	L6_WI_QR_S_01	22	24.04	20-26	PASS
Level 6	L6_WI_QR_02	22.03	23.84	20-26	PASS
Level 6	L6_WI_QR_03	22.02	24	20-26	PASS
Level 6	L6_WI_MT_S_01	22.17	24.59	20-26	PASS
Level 6	L6_WI_MT_S_01	22.17	24.59	20-26	PASS
Level 6	L6_WI_QR_04	22.02	24	20-26	PASS
Level 6	L6_WI_MR_I_01	23.37	24.64	20-26	PASS
Level 6	L6_WI_QR_05	22.94	23.91	20-26	PASS
Level 6	L6_WI_Teapoint_S_01	21.27	23.5	20-26	PASS
Level 6	L6_WI_SH_S_02	21.74	23.96	20-26	PASS
Level 6	L6_WI_SH_S_03	21.78	23.81	20-26	PASS
Level 6	L6_WI_SH_S_05	21.79	23.71	20-26	PASS
Level 6	L6_WI_SH_S_04	21.76	24	20-26	PASS
Level 6	L6_WI_WS_N_09	20.89	22.14	20-26	PASS
Level 6	L6_WI_WS_N_08	20.88	22.14	20-26	PASS
Level 6	L6_WI_WS_N_07	20.89	22.14	20-26	PASS
Level 6	L6_WI_WS_N_06	20.93	22.14	20-26	PASS
Level 6	L6_WI_WS_N_04	21.03	22.14	20-26	PASS
Level 6	L6_WI_WS_N_03	20.94	22.14	20-26	PASS
Level 6	L6_WI_WS_N_02	21.07	22.14	20-26	PASS
Level 6	L6_WI_WS_NW_01	20.82	22.13	20-26	PASS
Level 6	L6_WI_MT_N_01	20	22.72	20-26	PASS
Level 6	L6_WI_WS_N_11	21.78	22.34	20-26	PASS
Level 7	L7_ZA_BREAKOUT_N	21.77	22.17	20-26	PASS
Level 7	L7_ZA_MR_N	22.35	22.4	20-26	PASS
Level 7	L7_ZA_WS_N_03	21	22.17	20-26	PASS
Level 7	L7_ZA_WS_N_04	20.82	22.16	20-26	PASS
Level 7	L7_ZA_WS_N_05	20.65	22.15	20-26	PASS

Level 7	L7_ZA_WS_N_06	20.3	22.14	20-26	PASS
Level 7	L7_ZA_WS_N_07	18.86	22.07	20-26	PASS
Level 7	L7_ZA_WS_N_02	21.25	22.21	20-26	PASS
Level 7	L7_ZA_WS_N_01	21.63	22.21	20-26	PASS
Level 7	L7_ZA_MT_I	22.48	24.54	20-26	PASS
Level 7	L7_ZA_MR_I_04	23.34	27.35	20-26	PASS
Level 7	L7_ZA_MR_I_02	22.03	24.79	20-26	PASS
Level 7	L7_ZA_MT_I_06	22.59	25.65	20-26	PASS
Level 7	L7_ZA_MT_I_07	22.53	25.63	20-26	PASS
Level 7	L7_ZA_MT_I_08	22.38	25.24	20-26	PASS
Level 7	L7_ZA_SH_W_02	21.24	24.05	20-26	PASS
Level 7	L7_ZA_SH_W_01	21.44	24.23	20-26	PASS
Level 7	L7_WI_SH_S_01	20.8	24.9	20-26	PASS
Level 7	L7_WI_MT_I_01	22.33	24.5	20-26	PASS
Level 7	L7_WI_MR_I_02	22.27	24.82	20-26	PASS
Level 7	L7_WI_QS_I_02	22.12	23.84	20-26	PASS
Level 7	L7_WI_QS_I_03	22.05	23.83	20-26	PASS
Level 7	L7_WI_MT_I_03	22.35	24.66	20-26	PASS
Level 7	L7_WI_ENTRANCE_S_01	21.41	23.26	20-26	PASS
Level 7	L7_WI_SH_S_02	21.68	24.23	20-26	PASS
Level 7	L7_WI_SH_S_03	21.76	24.2	20-26	PASS
Level 7	L7_WI_SH_S_05	21.76	23.94	20-26	PASS
Level 7	L7_WI_SH_S_04	21.76	24.02	20-26	PASS
Level 7	L7_WI_WS_N_07	20.96	22.19	20-26	PASS
Level 7	L7_WI_WS_N_06	20.85	22.17	20-26	PASS
Level 7	L7_WI_WS_N_05	20.83	22.17	20-26	PASS
Level 7	L7_WI_WS_N_04	20.87	22.18	20-26	PASS
Level 7	L7_WI_WS_N_03	21.01	22.17	20-26	PASS
Level 7	L7_WI_MT_N_01	21.45	22.5	20-26	PASS

Level 7	L7_WI_WS_N_08	20.77	22.21	20-26	PASS
Level 7	L7_WI_WS_N_01	19.3	22.86	20-26	PASS
Level 7	L7_WI_WS_N_02	20.31	22.22	20-26	PASS
Level 8	L8_ZA_MR_N_01	22.31	22.43	20-26	PASS
Level 8	L8_ZA_WS_N_01	21.49	22.41	20-26	PASS
Level 8	L8_ZA_WS_N_02	21.01	22.16	20-26	PASS
Level 8	L8_ZA_WS_N_03	20.86	22.14	20-26	PASS
Level 8	L8_ZA_WS_N_04	20.81	22.16	20-26	PASS
Level 8	L8_ZA_WS_N_05	20.71	22.14	20-26	PASS
Level 8	L8_ZA_WS_N_06	20.34	22.16	20-26	PASS
Level 8	L8_ZA_WS_N_07	18.67	22.12	20-26	PASS
Level 8	L8_ZA_MR_N_03	22.27	22.5	20-26	PASS
Level 8	L8_ZA_BREAKOUT_N_01	21.34	22.16	20-26	PASS
Level 8	L8_ZA_MR_I_05	22.35	25.04	20-26	PASS
Level 8	L8_ZA_MT_I_05	22.68	24.76	20-26	PASS
Level 8	L8_ZA_MT_I_07	22.5	25.5	20-26	PASS
Level 8	L8_ZA_MT_I_06	22.71	24.21	20-26	PASS
Level 8	L8_ZA_QS_I_02	22.37	24.6	20-26	PASS
Level 8	L8_ZA_MT_I_08	22.57	24.88	20-26	PASS
Level 8	L8_ZA_SH_W_02	21.27	23.98	20-26	PASS
Level 8	L8_ZA_SH_W_01	21.47	24.18	20-26	PASS
Level 8	L8_WI_SH_SE_01	20.84	24.99	20-26	PASS
Level 8	L8_WI_FOCUS_02	22.6	24.65	20-26	PASS
Level 8	L8_WI_FOCUS_01	22.2	24.12	20-26	PASS
Level 8	L8_WI_FOCUS_I_03	21.88	23.73	20-26	PASS
Level 8	L8_WI_BREAKOUT/WELCOME_S_01	20.64	23.06	20-26	PASS
Level 8	L8_WI_SH_S_03	21.29	24.06	20-26	PASS
Level 8	L8_WI_SH_S_02	21.53	24.52	20-26	PASS
Level 8	L8_WI_WS_N_06	20.82	22.16	20-26	PASS

Level 8	L8_WI_WS_N_05	20.64	22.21	20-26	PASS
Level 8	L8_WI_WS_N_04	20.6	22.21	20-26	PASS
Level 8	L8_WI_WS_N_03	20.56	22.21	20-26	PASS
Level 8	L8_WI_MT_N_01	22.24	22.35	20-26	PASS
Level 8	L8_WI_WS_N_07	21.12	22.16	20-26	PASS
Level 8	L8_WI_WS_N_02	20.38	22.23	20-26	PASS
Level 8	L8_WI_WS_NW_01	20	23.21	20-26	PASS
Level 9	L9_ZA_MT_I_01	21.77	23.7	20-26	PASS
Level 9	L9_ZA_MT_I_02	21.97	24.45	20-26	PASS
Level 9	L9_ZA_BR_N_01	21.46	22.57	20-26	PASS
Level 9	L9_ZA_WS_W_02	21.25	23.97	20-26	PASS
Level 9	L9_ZA_QS_I	22.03	24.97	20-26	PASS
Level 9	L9_ZA_WS_E_03	21.24	22.21	20-26	PASS
Level 9	L9_ZA_WS_E_03	21.07	22.21	20-26	PASS
Level 9	L9_ZA_WS_E_04	21.02	22.23	20-26	PASS
Level 9	L9_ZA_WS_E_05	20.97	22.21	20-26	PASS
Level 9	L9_ZA_WS_E_06	20.78	22.26	20-26	PASS
Level 9	L9_ZA_WS_E_07	20.69	22.09	20-26	PASS
Level 9	L9_WI_WS_N_02	20.85	22.24	20-26	PASS
Level 9	L9_WI_WS_N_01	20.59	22.28	20-26	PASS
Level 9	L9_WI_entrance	20	23.38	20-26	PASS
Level 9	L9_WI_CIRC	21.22	23.38	20-26	PASS
Level 9	L9_WI_SH_SW_01	20.04	22.23	20-26	PASS
Level 9	L9_WI_MT_I	20.88	24.65	20-26	PASS
Level 9	L9_WI_QS_I	22.02	24.19	20-26	PASS
Level 9	L9_WI_SH_S_02	21.99	23.6	20-26	PASS

Appendix E – Overheating risk assessment level 3 and 4 entrances

E.1 Overview

This chapter reviews the level of summertime overheating calculated for the UCL IOE Phase 2C level 3 and 4 entrances, social and working spaces interconnected to the entrances and atrium.

The study has tested naturally ventilated spaces at level 3-4 to investigate the comfort met in current and future weather scenarios.

When Buro Happold initially reviewed the Level 4 area for the purposes of the thermal comfort analysis certain areas of the building failed the comfort criteria in summer months. Based on these initial findings an iterative overheating analysis was undertaken. The resultant ventilation design strategy and building fabric improvements were developed and the results can be found within section F5 and F6.

The assessed areas were:

- L4 central student study space
- L4 break out study space placed by west fully glazed façade
- L3 café and receptionist zone connected to main entrance and atrium

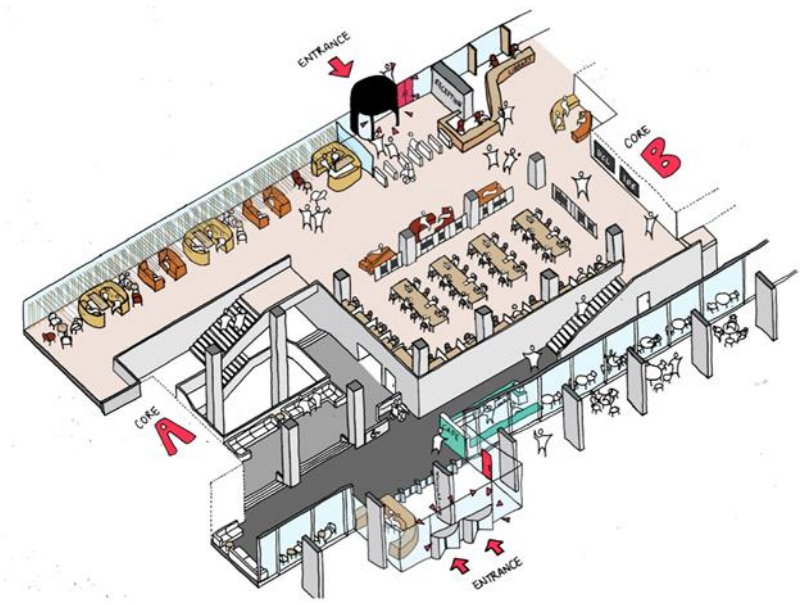


Figure 6—1 Phase 2 works – entrance halls overview

E.2 Overheating results

In terms of comfort in a typical UK warm summer and in projection of a future climate change, the study demonstrated that main entrance and café located at level 3 are the most comfortable to be naturally ventilated with the implementation of ventilation strategy has outlined below:

- New fully glazed circle sliding doors integrated with BMS to the control the opening operation,
- Ceiling strategy based on exposed concrete soffit only for the perimeter zones (café and circulation space). The concept is to exploit the concrete material to absorb heat during the day and then to be dissipated by a regime of night-time 'purging' to cool the building, in preparation for the next day.
- high level equal openings over the new pavilion for cross ventilation purposes
- New roof line over the new pavilion entrance

The central study student space and break out located at level 4 are most comfortable to be naturally ventilated with building fabric intervention and ventilation strategy which includes:

- Internal shading elements,
- External greenery screen (the screen panel has assumed in the model a specific % light transmission to reduce the solar factor of existing glazing and decrease the solar gains along west fully glass façade).
- New rooflights implemented with a set of temperature controlled motorised opening connected to BMS system
- New fully glazed sliding doors integrated with a set of temperature and humidity controlled motorised openings to provide additional air movement even though the motion detectors are off (no people movement),
- Ceiling strategy with exposed concrete soffit only for west perimeter zones (break out space, reception),
- The glazing to west façade is retained as existing, only the entrance will accommodate new fully glass circle sliding doors integrated to the existing curtain wall system,
- The central study zone at level 4 is considered as an open plan interconnected to atrium and entrance, the use of fully height glass panels to enclose this zone has been excluded to enhance cross ventilation from entrance to the rooflights.

In conclusion the natural ventilation strategy combined with the thermal fabric upgrades can maintain thermally comfortable condition for most occupied hours between 8:00am-7:00pm and avoid the risk of overheating. The overheating may occur only for a few hours mainly on afternoon with peak temperatures above 29 °C.

E.3 Scope of assessment

The overheating report looks at the Phase 2 main entrance (Level 3 Bedford Way) and secondary entrance (level 4) by assessing only the occupied related zones. The analysis covers certain open plan spaces due to risk of overheating:

- Zone 2 - Main entrance pavilion which accommodates reception area (zone 1)
- Zone 3 - Café area
- Zone 4 - Circulation area
- Zone 5 - Central study/workspace area
- Zone 6 - Perimeter Group study space (Zone B - level 4)
- Zone 7 - Second entrance and reception area (Thorn Haugh Square) and social student space

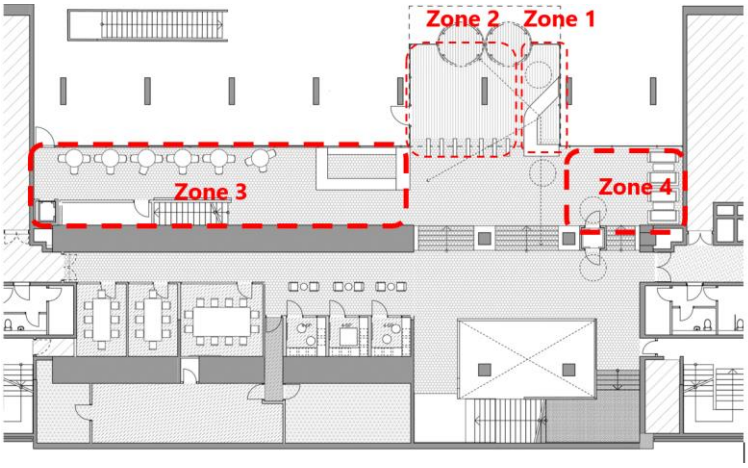


Figure 6—2 assessed zones based on new architectural layout and arrangement for level 3

UCL Estates

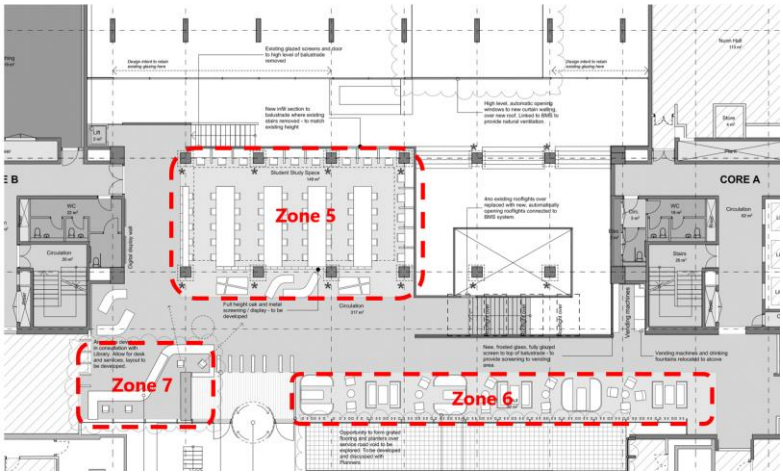


Figure 6—3 assessed zones based on new layout and arrangement for level 4

The intent of the assessment is to demonstrate that the natural ventilation strategy and fabric thermal improvements provide a good work environment and thermal comfort that encourages productivity and wellbeing. The cross and single sided flow natural ventilation strategy has been tested in the occupied spaces (L3 up to level 4 as described above) to investigate if the expected indoor temperature might be considered acceptable in a warm UK summer.

E.4 Targets

To achieve the scope of assessment above the following design criteria have been used in this study to determine what solution will be appropriate:

1. Overheating analysis in accordance with CIBSE AM11 Building Energy and Environmental Modelling. The results are assessed against the CIBSE TM52 criteria.

2. Overheating Analysis in accordance with the UCL Sustainable Building Standard guidelines by using a set of weather files for both current scenario 2020 and future weather projected in 2050:

    - **DSY1** – Baseline scenario - moderately warm summer (1989)

- **DSY1** – Future scenario - the model was also tested using future weather data file LWC1989_2050Med50pct.epw, which is the design summer year projection for 2050 for the London Weather Centre Location (accounting for urban heat island effect).

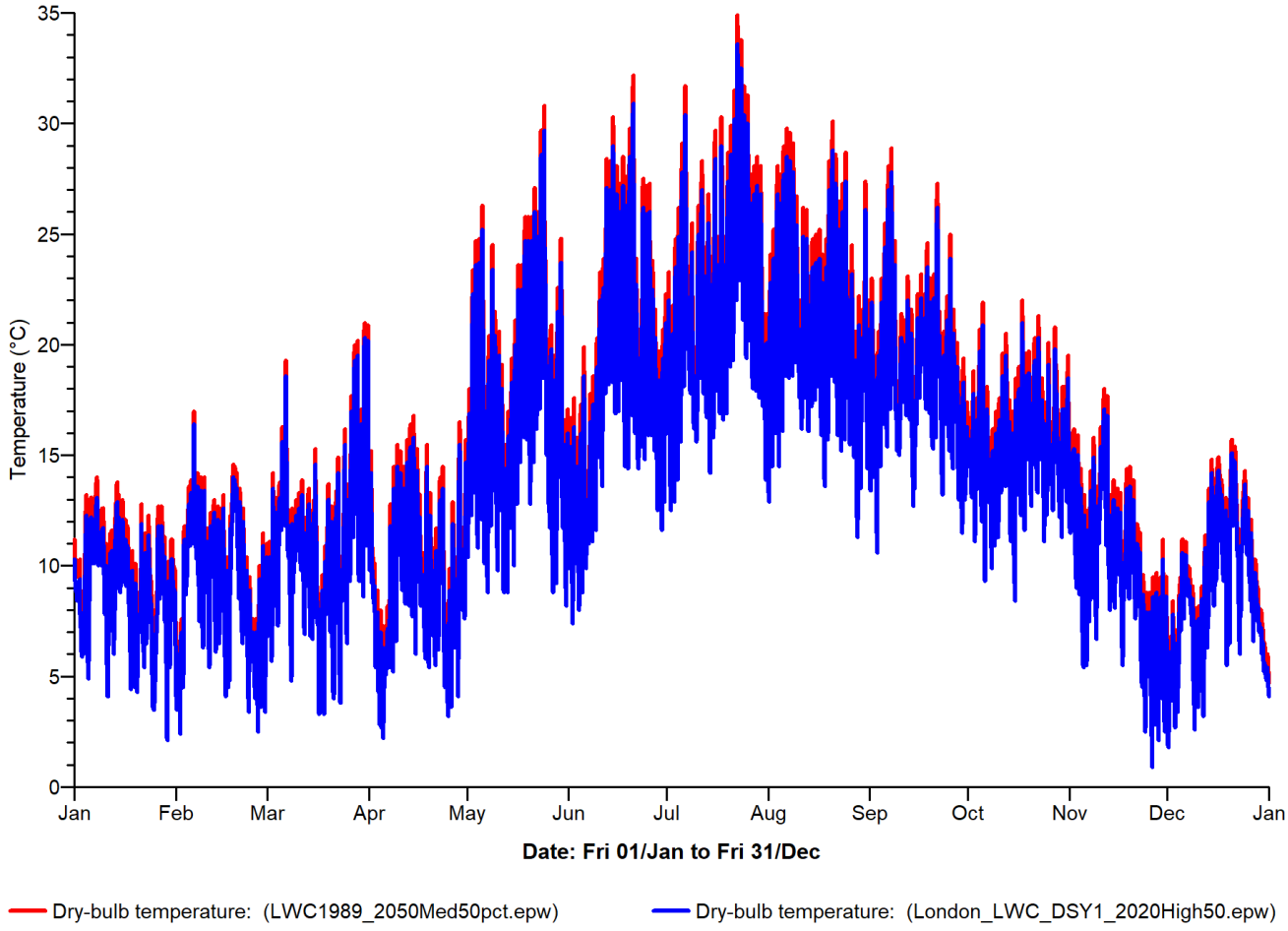


Figure 6—4 weather files for overheating analysis

E.5 Result summary

E.5.1 DSY baseline climate - Natural Ventilation

The section summarises the results of the modelling carried out to demonstrate the level of comfort achieved utilising the adaptive comfort criteria described in BS EN 15251:2007 and CIBSE TM52 and CIBSE guide A.

The target is to meet at least two of the CIBSE TM52 criteria in the occupied rooms or open plan occupied spaces considered for Phase 2C refurbishment at level 3 and 4. The summary of the current design assessment and recommendations are shown in table 1:

Table 1 – baseline results and design solutions

	Results		Design solution to alleviate overheating
Room	**2020's climate scenario/ occurrence (2011-2040)**	**Criteria failing (not more than TM52 criteria one failing)**	
	Baseline scenario		
Zone 1 reception	Thermal comfort can be achieved with occupancy of 6.6 m2/pers The max indoor temperature in the reception area achieves a peak of 34°C only for 1 hour in May, the indoor temperature remains within an acceptable range of 20-26 °C for the occupied hours.	**PASS** The indoor temperature exceeds the max acceptable temperature for only 1.8% < 3% occupied hours during the typical no-heating season**.**	- Overheating will not occur in the reception and entrance area due to the air movement across the top-hung high-level openings into the main entrance. - **Night ventilation** can be achieved with top-hung windows operating and controlled by indoor temperature, the panel fully opens when ambient temperature is over 16°C and greater than outdoor temperature. - During the daytime the top hung window opening profile is set controlled by indoor temperature, it opens above 22°C and fully opens above 24°C. - Enhance air movement with **circle-sliding doors** controlled by indoor temperature above 22°C and fully open above 24°C, the operation opening profiles of the doors are set on ambient temperature control and triggered by direction sensitive motion detectors. Night ventilation might be achieved when indoor temperature is over 16°C and outdoor T °C, and when outdoor temperature is above 15°C.
Zone 2 New pavilion L3 Entrance	Thermal comfort can be achieved with occupancy of 9 m2/pers The max indoor temperature achieves a peak of 33.5°C only for 1 hour in July, the indoor temperature remains within an acceptable range of 20-26 °C for the occupied hours.	**PASS** The indoor temperature exceeds the max acceptable temperature for only 1.2% < 3% occupied hours during the typical no-heating season.	
Zone 3 Café Student social	Thermal comfort can be achieved with occupancy of 1.6 m2/pers The max indoor temperature achieves a peak of 32.8°C only for 1 hour in July after 6:30 pm, the indoor temperature remains within an acceptable range of 20-26 °C for the occupied hours.	**PASS** The indoor temperature exceeds the max acceptable temperature for only 1.4% < 3% occupied hours during the typical no-heating season.	Overheating will not occur in the café due to the air movement across the circulation-atrium spaces, The air flow movement is led by top-hung openings (located above new pavilion) and circle sliding doors.
Zone 4 Circulation/lobby	The max indoor temperature achieves a peak of 32.6°C only for 1 hour in July, the indoor temperature remains within an acceptable range of 20-26 °C for occupied hours.	**PASS** The indoor temperature exceeds the max acceptable temperature for only 0.8% < 3% occupied hours during the typical no-heating season.	

Zone 5 **Level 4 - Break out**	Thermal comfort can be achieved with occupancy of 2.5 m2/pers The max indoor temperature achieves a peak of 32.6°C only for 1 hour in July after 5:30 pm, the indoor temperature remains within an acceptable range of 20-26 °C for occupied hours	**PASS** The indoor temperature exceeds the max acceptable temperature for only 0.90% < 3% occupied hours during the typical no-heating season.	Enhance **solar control system** to west fully glass façade due to high solar gains (peak of 3.8 kW in August after 15:30 pm) Recommend installing internal vertical fins to inner glass panel. Their dimensions are aligned with the existing glass height and shall have right/left projections between 600-800 mm. Internal fins can be oriented to suit sun angle. Recommended **removing the frosted fully glass screen** (architectural layouts issued by P&P) as it might obstruct the air movement from the Level 4 entrance across the breakout and study spaces. Enhance % openable area of new rooflight above 82% with max angle of 40-degree
Zone 6 **Level 4 - Central Study student space**	Thermal comfort can be achieved with occupancy of 2.3 m2/pers The max indoor temperature achieves a peak of 33°C only for 1 hour in July after 5:30 pm, the indoor temperature remains within an acceptable range of 20-26 °C for occupied hours	**PASS** The indoor temperature exceeds the max acceptable temperature for only 1.2% < 3% occupied hours during the typical no-heating season.	
Zone 7 **Level 4 - Reception**	Thermal comfort can be achieved with occupancy of 6.8 m2/pers The max indoor temperature achieves a peak of 32.2°C only for 1 hour in July after 5:30 pm, the indoor temperature remains within an acceptable range of 20-26 °C for 53% of occupied hours	**PASS** The indoor temperature exceeds the max acceptable temperature for only 0.80% < 3% occupied hours during the typical no-heating season	Recommended installing Internal vertical fins to inner glass panel to reduce the solar gains. Their dimensions are aligned with the existing glass height and shall have right/left projections between 600-800 mm. Internal fins can be oriented to suit sun angle in function of incident solar radiation to the wall.

The study demonstrates the natural ventilation strategy in the study group spaces and café/entrance and receptions work without any mechanical cooling for external temperature lower than 33.6°C.

The graph below (Figure 6—5) shows the operative temperature in the breakout space at level 4 under current scenario (baseline) without any mechanical ventilation/cooling. The temperature is unlikely to exceed the max acceptable comfort temperature if the ventilation strategy is applied.

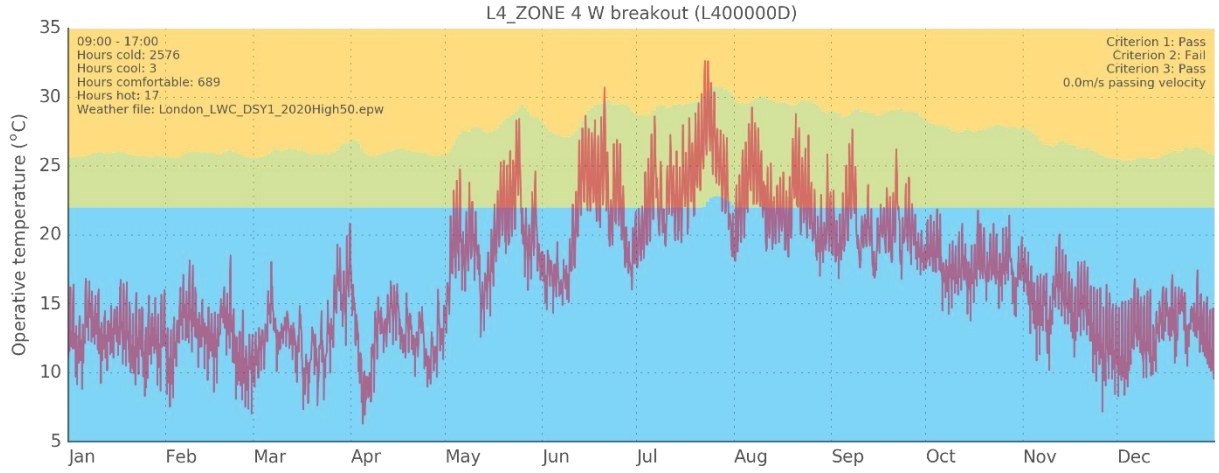


Figure 6—5 The comfort band chart showing the acceptable "feels like" operative temperatures across the baseline year

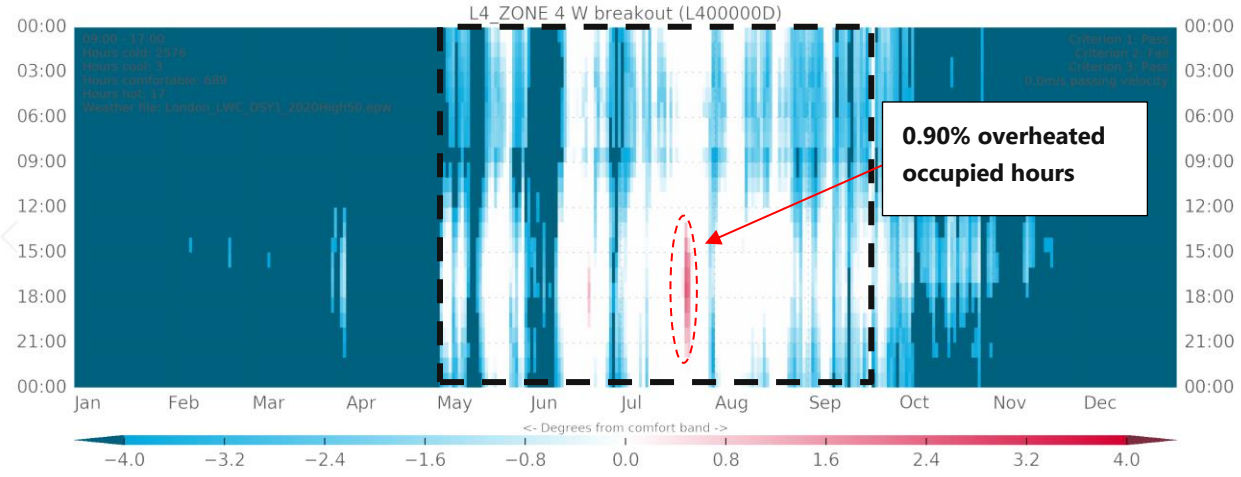


Figure 6—6 Degree of comfort over the year (based upon 1989_2050) for Break out space without any mechanical ventilation/cooling

The Figure 6—6 demonstrates that only 17 hours in July will experience a degree of discomfort, however it entails that only the 0.90% of occupied hours are overheated which is acceptable according to the TM52 criteria.

E.6 2050's climate - Natural Ventilation

The graph in Figure 6—7 shows 'feels like temperature under future weather projected in 2050' in the breakout space and central circulation space at level 4 (future weather) without any mechanical ventilation/cooling. The temperature is unlikely to exceed the max acceptable comfort temperature if the ventilation strategy is applied.

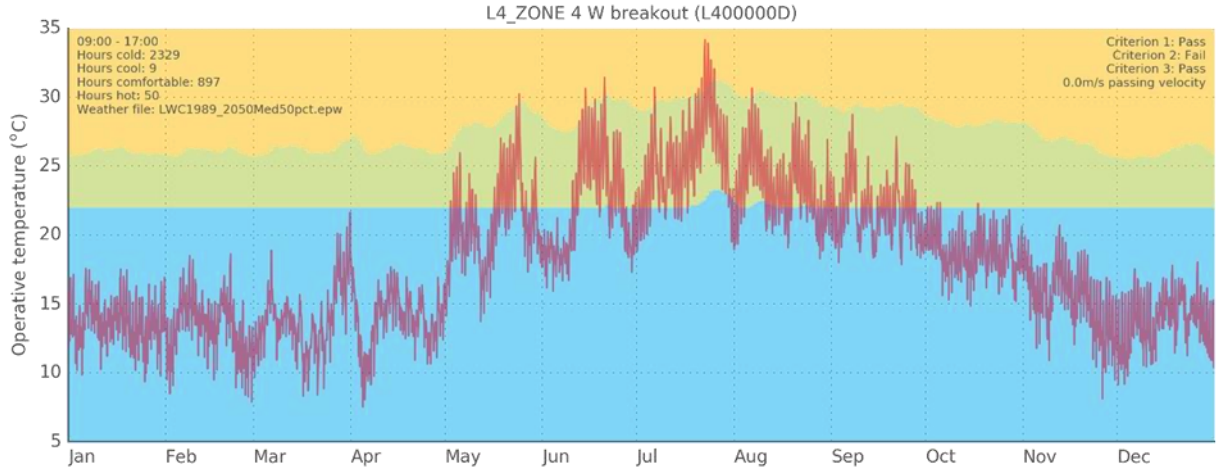


Figure 6—7 The comfort band chart showing the acceptable "feels like" operative temperatures across the future weather

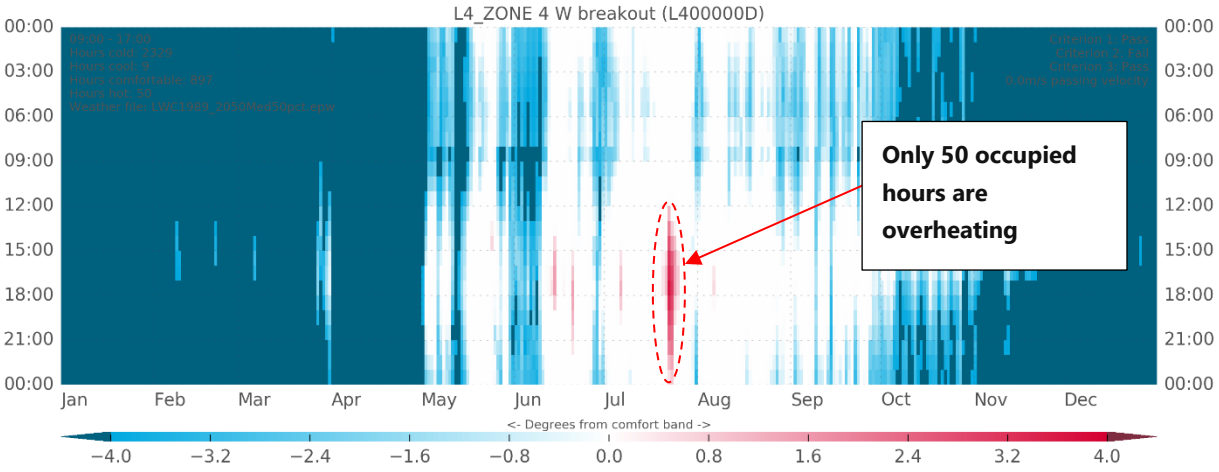


Figure 6—8 Degree of comfort over the year (future weather projected in 2050) for Breakout space without any mechanical ventilation/cooling

The Figure 6—8 demonstrates that only 50 hours in future summer will experience a degree of discomfort, however it entails that only a small % of occupied hours that are overheated which is acceptable according to the TM52 criteria.

E.6.1 Solar control strategy

In order to meet the TM52 criteria against the future weather file, an additional external shading element has been considered and coordinated with the Perkinswill architects, please refer to 726-06A-IOE-Phase2-Level3&4-Design Development. The solar control recommendations are listed below:

- External greenery screen placed in front of the west fully glass façade at level 4 (Figure 6—9). These shall be offset by 1000 mm from the wall to drop the solar gains. The green shading element has been modelled as a shutter with its own operation profile in function of the incident solar radiation and with specific light transmittansion properties,

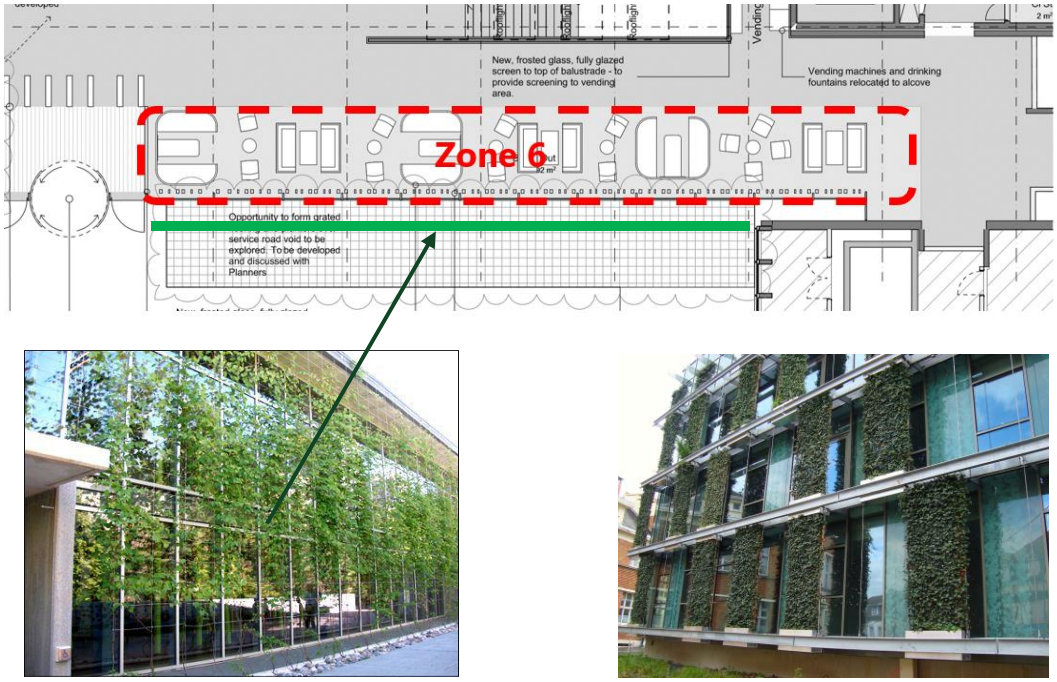


Figure 6—9

- The west façade glass light transmittance has been adjusted to 30% based on correspondance with the architect. This, combined with the external green screen achieves a lower solar transmission (e.g it may achieve 20% which indicates a low percentage of the solar heat).
- The green screen scatters some of the radiant heat and reduces the solar gains through the glass.

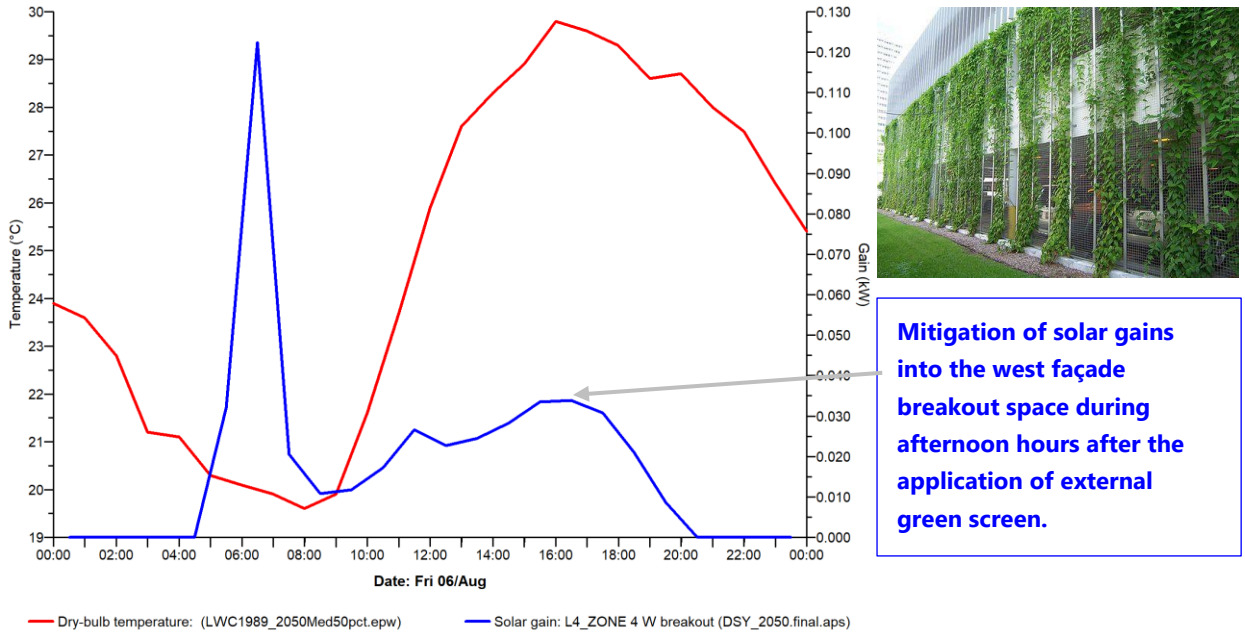


Figure 6—10 Solar gain with external green screen and outdoor temperature profile in a hottest day in summer upon future weather

E.7 Assessment Methodology

A virtual model was created based on drawings and specifications from the Architect and M&E Engineers. Geometries, orientations, façade design, weather conditions and opening systems were simulated to predict the overheating performance of the Level 3&4 development. The model has been simulated across the full year (1Jan– 31Dec) in order to assess thermal comfort and in specific the overheating in occupied spaces.

Below the IES VE 2019 model showing the simulated spaces based on the natural ventilation strategy, incorporating adjacent buildings. The model reflects the RIBA Stage 3 design and is based on Phase 2 Masterplan drawings issued by the architect on 12-08-2019.

Figure 6—11 Level 3 atrium/main entrance (purple block) - geometry created in IES

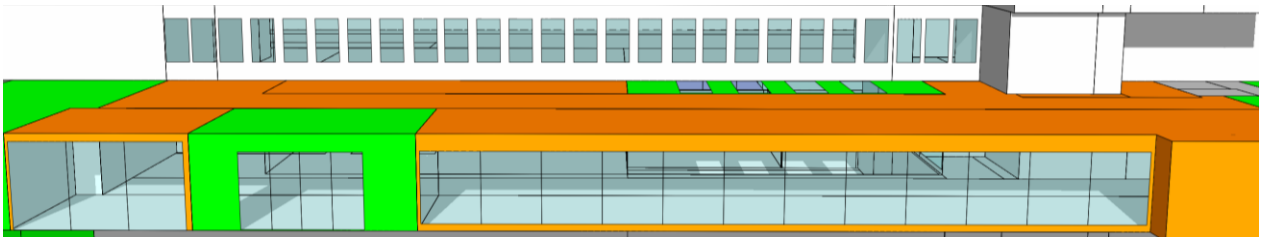


Figure 6—12 Level 4 secondary entrance (green block) and breakout space (orange block) - geometry created in IES

E.7.1 Methods of assessing overheating

Overheating can be defined as a sensation of discomfort resulting from excessive operative temperature and internal gains caused by people, lighting and equipment loads. Additional factors potentially affecting the overheating are horizontal and vertical air temperature differences and radiation exchange with adjacent cool/hot surfaces such as glazing, overhead radiant heaters or cold windows.

The sensation of overheating is subjective; the conditions at which it occurs vary between people. Consequently, there are multiple metrics for assessing overheating.

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 predictions. Accuracy of results is dependent on accuracy of base assumptions.

CIBSE Guide A historically recommended that 1% of working hours must not exceed dry resultant temperatures of 28ºC. This methodology provides a simplistic but easily understood way to quantify overheating. The TM52 adaptive comfort

criteria are now recommended by CIBSE as a more accurate representation of overheating. TM52 criteria are more complex and consider human ability to gradually acclimatise to periods of increased temperature. A room is considered to overheat if it fails two or more of the TM52 criteria, which are summarised below. Under the CIBSE guide A and TM52 assessment criteria, overheating can only occur when rooms are occupied, which is linked to the occupancy profiles assigned to each zone.

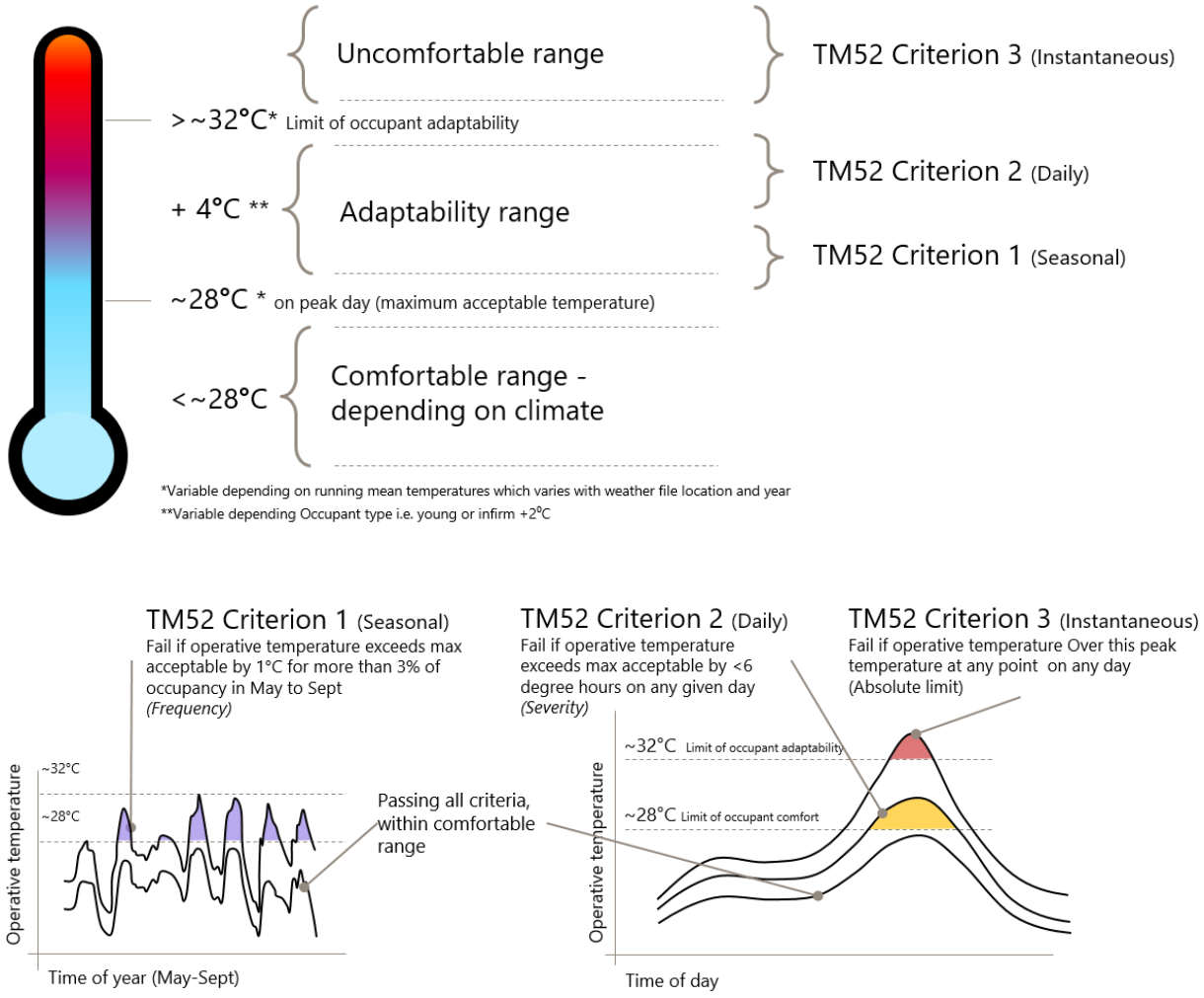


Figure 8—6—13 TM52 adaptive comfort criteria

The comfort band in 'green' in the chart (see figure 8-4) shows the acceptable 'feels like' (operative) temperatures across the year considering human comfort adaptability. The comfort band graph is based upon 1989 historic weather data:

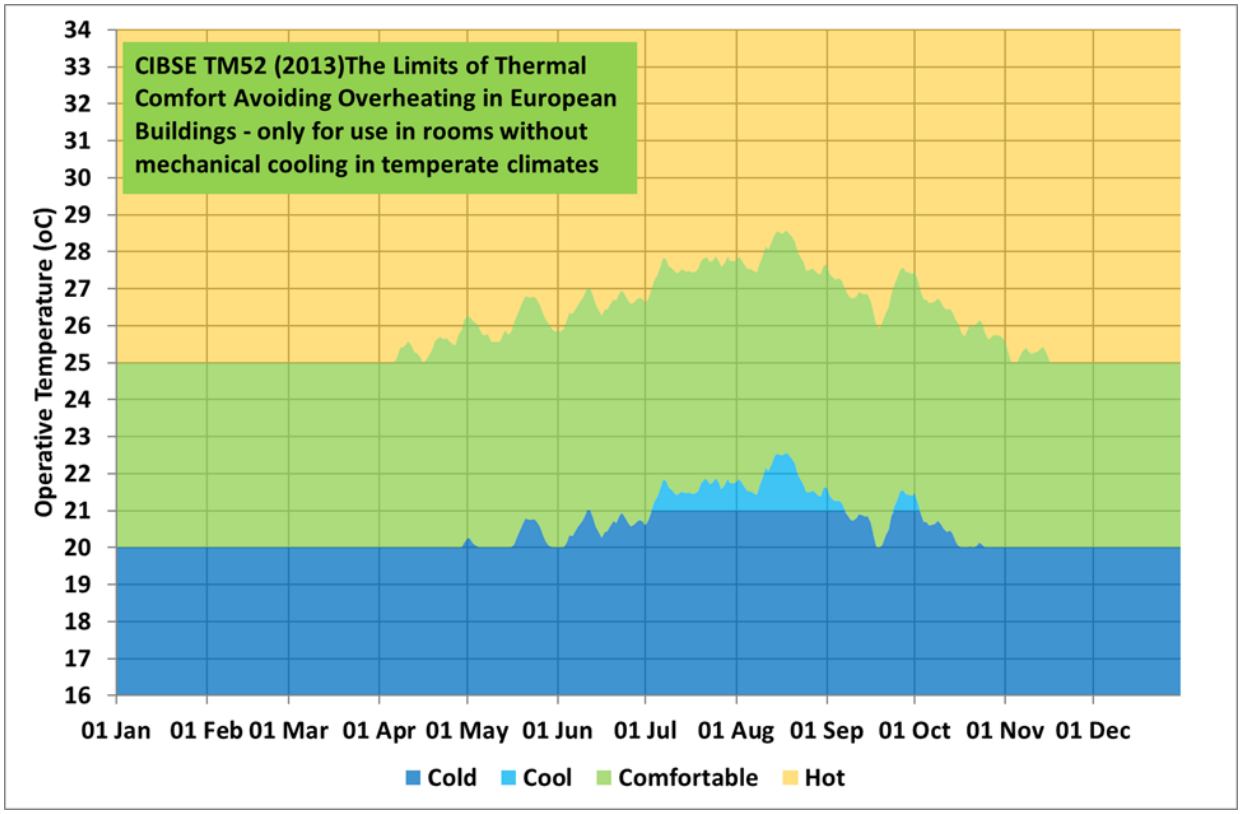


Figure 8—6—14 CIBSE TM 52 comfort band chart based upon baseline weather data

Climate change

Adaptability to climate change has been assessed using a time period 2050s, the graph below shows the comfort band in green used to test the thermal comfort.

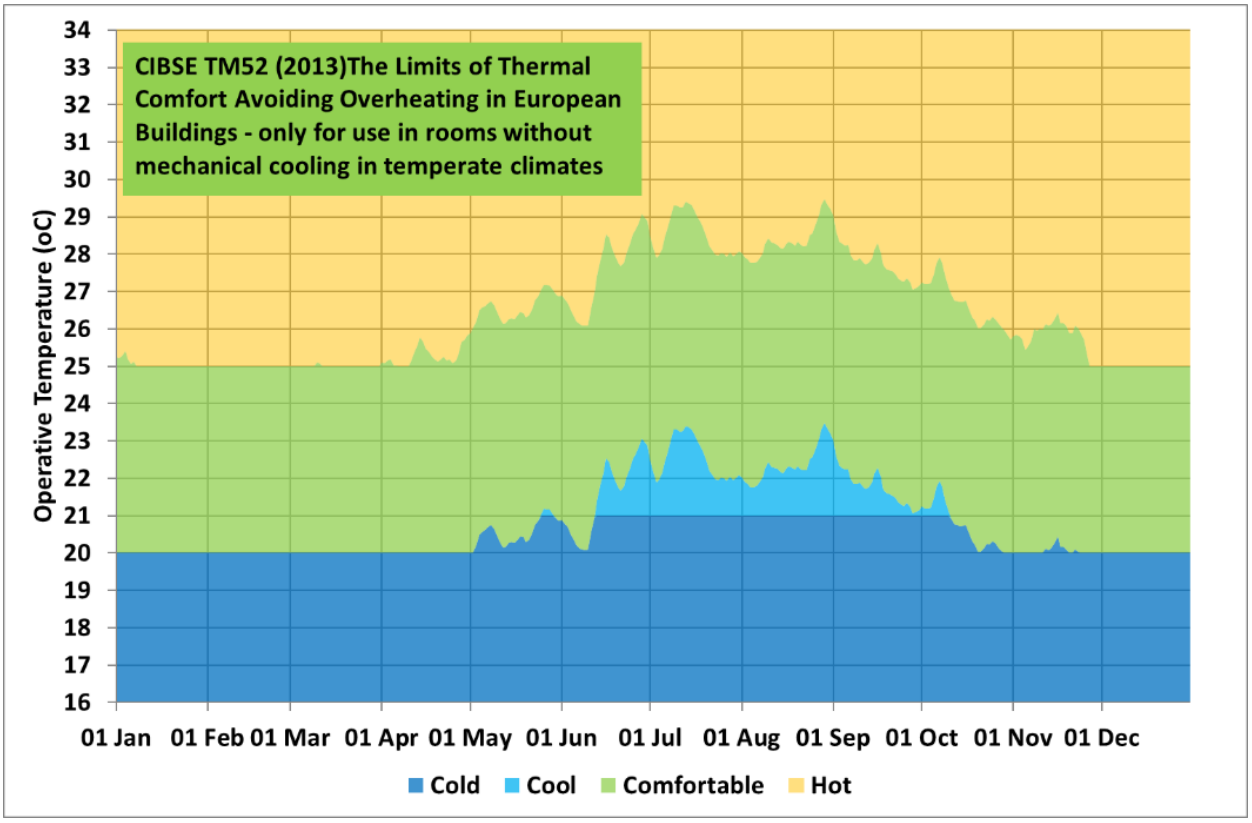


Figure 8—6—15 CIBSE TM 52 comfort band chart based upon 1989 projected in 2050 weather data

E.8 Conclusions

The CIBSE TM52 comfort standard was achievable under the current and future scenario in all occupied natural ventilated spaces at level 3-4 related to the new entrances and study/break out rooms at level 4.
The overheating risk is minimised if the following features are adopted:

Level 3:

- Proposed ventilation strategy applied in occupied spaces based on provision of flow rate through four high level equal openings (73% openable area) and fully glazed circle sliding doors integrated with BMS (50% openable area)
- Exposed concrete soffit only for the perimeter zones (café and circulation space).
- The glass properties for the new pavilion must meet g-value 0.26-0.31 and light transmission LT 41% to reduce the solar gains that might incur in the hottest days,

Level 4:

- Integration of fully glass façade with internal shading elements, the vertical fins must be 600-800 mm deep and adjustable to suit sun angle. Tilt angle might be controlled by incident solar radiation to drop the solar gains.
- Integration of external greenery screens in front of the west façade and offset 1000 mm from the wall,
- The existing glazing related to zone 6 (breakout) will be retained, however the solar transmission must be reduced with the above recommendations,

- Replace the 4 rooflights which will be installed with a set of temperature controlled and connected to BMS to raise air flow out from the central atrium and to decrease the room operative temperatures in summer,
- New fully glazed sliding doors controlled by indoor temperature and relative humidity to enhance air movement in reception-circulation and study spaces.
- Ceiling strategy with exposed concrete soffit only for perimeter zones (break out space, reception, entrance),
- It shall be noted that the thermal upgrades and waterproofing to Level 4 roof was not included in the assessment as it is out of Phase 2 scope, however the improved insulation is recommended for boosting the thermal comfort in the student occupied spaces.

The mitigation features described for level 3-4 have been coordinated with the architects and developed in the IoE design for Phase 2. Refer to document 726-06A-IOE-Phase2-Level3&4-DesignDevelopment.

E.9 Modelling inputs for Phase 2C level 3-4 entrances

Natural ventilation parameters

In line with the current London Plan (2016), Policy 5.9 addresses overheating and cooling the developments should reduce potential overheating and reliance on air conditioning systems and demonstrate this is accordance with the following cooling hierarchy:

1. Minimise internal heat generation through energy efficient design,
2. Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls,
3. Manage the heat within the building through exposed internal thermal mass and high ceilings,
4. Passive ventilation,
5. Mechanical ventilation,
6. Active cooling systems (ensuring they are the lowest carbon options).

This design note addresses item 4 in the hierarchy to assess the feasibility of natural ventilation. The study concludes that the passive design measures in Table 6—1 should be implemented into the building design for naturally ventilated:

Table 6—1 passive design parameters

	Parameters	Value	Comments
New Pavilion Level 3	Window U-value W/m^{2}K (including framing)	1.80 W/m^{2}K or better	Finish and form of framing to match existing glazing
	Type of glazing	Double glazing	
	G-Value of glass	0.26-0.31	
	Visible light transmittance	41%	
	Openable area for top level inward top hung openings linked to BMS (opening control system based on CO_2 level and temperature)	73% with max openable angle 40 degree	
New Pavilion Level 3	Window U-value W/m^{2}K (including framing)	1.80 W/m^{2}K or better	Fully glazed curved sliding doors to match original glazing system
	Type of glazing	Double glazing	
	G-Value of glass	0.26-0.31	
	Visible light transmittance	41%	
	Openable area for curved sliding door openings	50%	
Café Level 3	Window U-value W/m^{2}K (including framing)	5.7 W/m^{2}K	
	Type of glazing	Single glazing	
	G-Value of glass	0.47	
	Visible light transmittance	41%	
	Openable area	0%	
Level 4 – new rooflights	Window U-value (including framing)	1.80 W/m^{2}K or better	
	Type of glazing	Double glazing	
	G-Value of glass	0.25	
	Visible light transmittance	41%	
	Openable area %	82% with max openable angle 40 degree	

		(opening control system based on CO_2 level and temperature)	
Level 4 – West façade	Existing Window U-value (including framing)	5.7 W/m^{2}K	
	Type of glazing	Single glazing	
	G-Value of glass	0.47	
	Visible light transmittance	41%	
	Openable window area	0%	
	External greenery screen with 0.20 transmittance and to provide a light transmission 30%	LT 30%	
	Internal timber louvres to glazing for Level 4 group study space: 600 mm vertical fin projection		

Level 4 _ Rooflights

In the section below has been detailed the design parameters for the rooflight as considered in the overheating model:

- Frame factor: 10%
- Max angle openable 40°
- Effective 82% openable area for a single top hung panel: IES VE model allow to input as percent of gross opening panel without the frame. The panel is openable with max angle 40° to allow airflow movement and to exhaust the warm air flow out from the central atrium when the indoor temperature is higher than the outdoor temperature and the CO_2 concentration exceeds 800 ppm,
- Opening profile: actuated panels controlled by internal operative temperature & outdoor temperature or linked to CO_2 concentration in the occupied space – below the profile in a typical summer day.

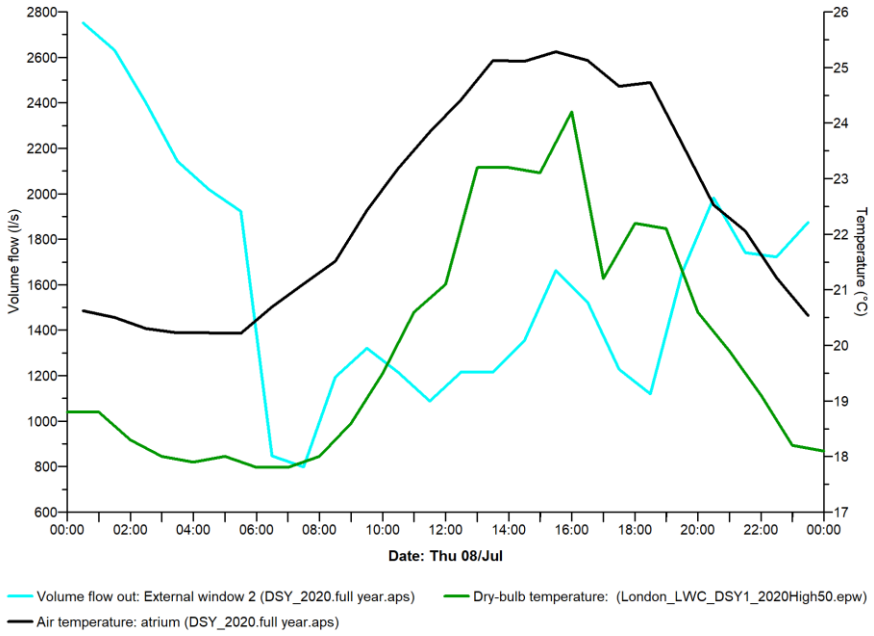


Figure 6—16 macro flow opening profile in IES thermal model for the rooflights above the central atrium at level 4

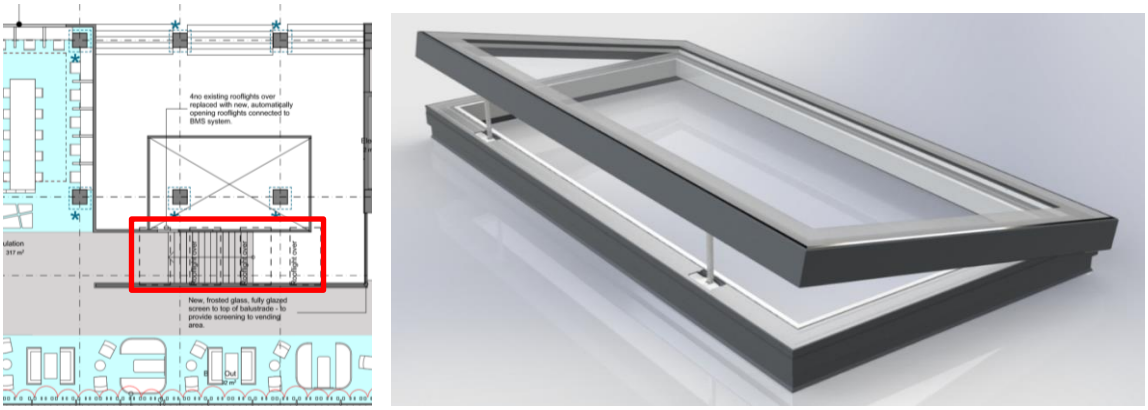


Figure 6—17 rooflight location and typical details of skylight

Main entrance Level 3 _ top hung opening profiles:

High-level opening windows above the new entrance pavilion.

Figure 6—18 proposed Bedford Way Entrance - internal view with top-level vents

Modelling inputs:

- Frame factor: 10%
- Max angle open 40°
- Effective 73% openable area for a single inward top hung panel: Macroflo in IESVE model allow to input as percent of gross opening panel without the frame. The panel is openable with max angle 40° to allow airflow movement in and out of the room.
- Opening profile: actuated panels controlled by internal operative temperature & outdoor temperature or linked to CO_2 concentration in the occupied space – below the profile in a typical summer day.

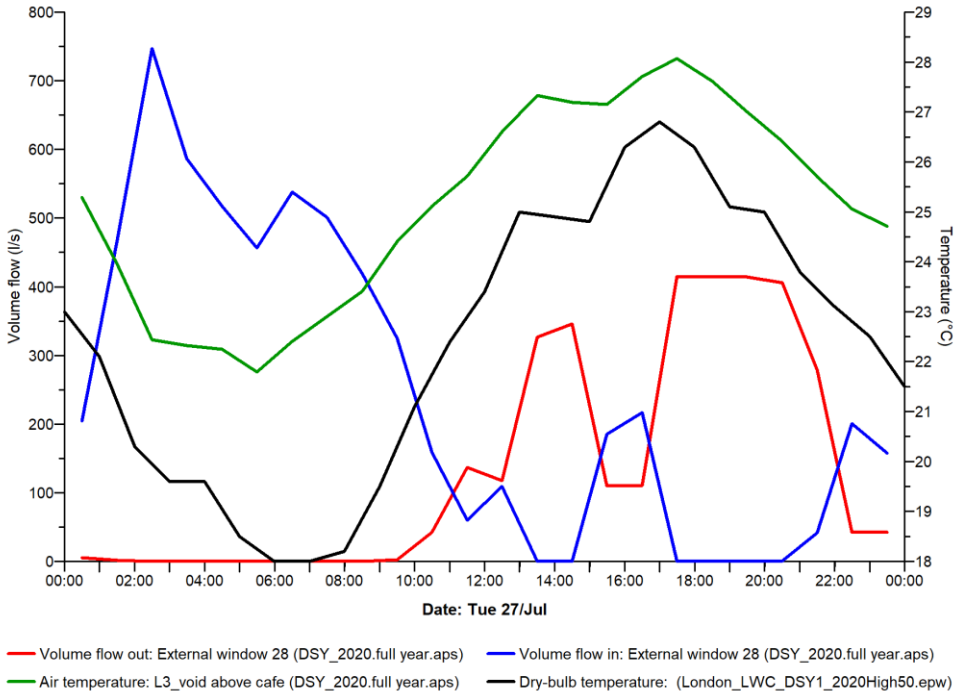


Figure 6—19 macro flow opening profile in IES thermal model for the top hung window main entrance at level 3

The analysis has considered the spaces as naturally ventilated in summer and with heating provision in winter based on MEP design strategy. In accordance with the MEP concept new warm air curtains will be installed and integrated in the drum doors at level 3 to provide adequate comfort in the reception area and new trench heaters or low-profile radiators will be provided along the perimeter zone of café and circulation space.

Additionally, at level 4 the design strategy specifies new low-profile radiators in the reception and fan coil units for providing only heating located on the exposed ceiling. The table below outlines the set points used for the study.

Table 6—2 heating set-points per space function

Space use	Assumed Heating set-point (°C)
cafe	22 ±2
circulation	22 ±2
Social Break out	22 ±2

E.10 Occupancy Density, Equipment and Lighting Gains

Inputs for people, equipment and lighting heat gains are given in Table 6—3. It is assumed that most of the equipment gains in the study spaces will be from personal laptop use by students, whereas in the reception there is likely to be a mix of screens and additional facilities such as photocopiers.

Table 6—3

Thermal template	Occupancy (m^2/p)	Load/Person	Lighting (W/m2)	Equipment (W/m2)	Radiant fraction	Diversity factor
L3_entrance/lobby	9	Sens. Load (85 W/p) Lat. Load (55 W/p) Standing, light work, walking	10	13 (heat losses from pipework's in the ceiling)	Heat losses from pipelines ceiling 22%	1
L3_reception – Zone 1	6.6	Sens. Load (80 W/p) Lat. Load (60 W/p) Seated light work	9	25	Desktop radiative heat gains 10%	0.80
L3_circulation	9	Sens. Load (85 W/p) Lat. Load (55 W/p) Standing, light work, walking	10	13 (heat losses from pipework's in the ceiling)	Heat losses from pipelines ceiling 22%	1
L3_circulation	-	-	10	13 (heat losses from pipework's in the ceiling)	Heat losses from pipelines ceiling 22%	1
L3_Social cafe	1.6	Sens. Load (85 W/p) Lat. Load (75 W/p) Standing, light work, walking	10	25	Laptop radiative hat gain 25%	0.50
L4_central study	2.3	Sens. Load (80 W/p) Lat. Load (60 W/p) Seated light work	10	25	Laptop radiative heat gain 25%	0.80
L4_break out zone	2.50	Sens. Load (80 W/p) Lat. Load (60 W/p) Seated light work	10	25	Laptop radiative heat gain 25%	0.80
L4_reception	6.80	Sens. Load (80 W/p) Lat. Load (60 W/p) Seated light work	9	25	Desktop radiative heat gains 10%	0.80
L4_Circulation	9	Sens. Load (85 W/p) Lat. Load (55 W/p) Standing, light work, walking	10	13 (heat losses from pipework's in the ceiling)		1
Profile	80% 9AM to 7PM, 0% at night		100% 8AM to 10PM, 10% at night	100% 9AM to 7PM, 10% at night		

	30% 8AM to 9AM 50% 9AM to 9.30AM 100% 9.30AM to 6PM 50% 6PM to 7PM 30% 7PM to 10PM					In summer months the panel fully opens when internal temperature is over 22 °C and fully open above 24°C, Night ventilation might be achieved when indoor temperature is over 16°C and outdoor T °C, and when outdoor temperature is above 15°C.

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