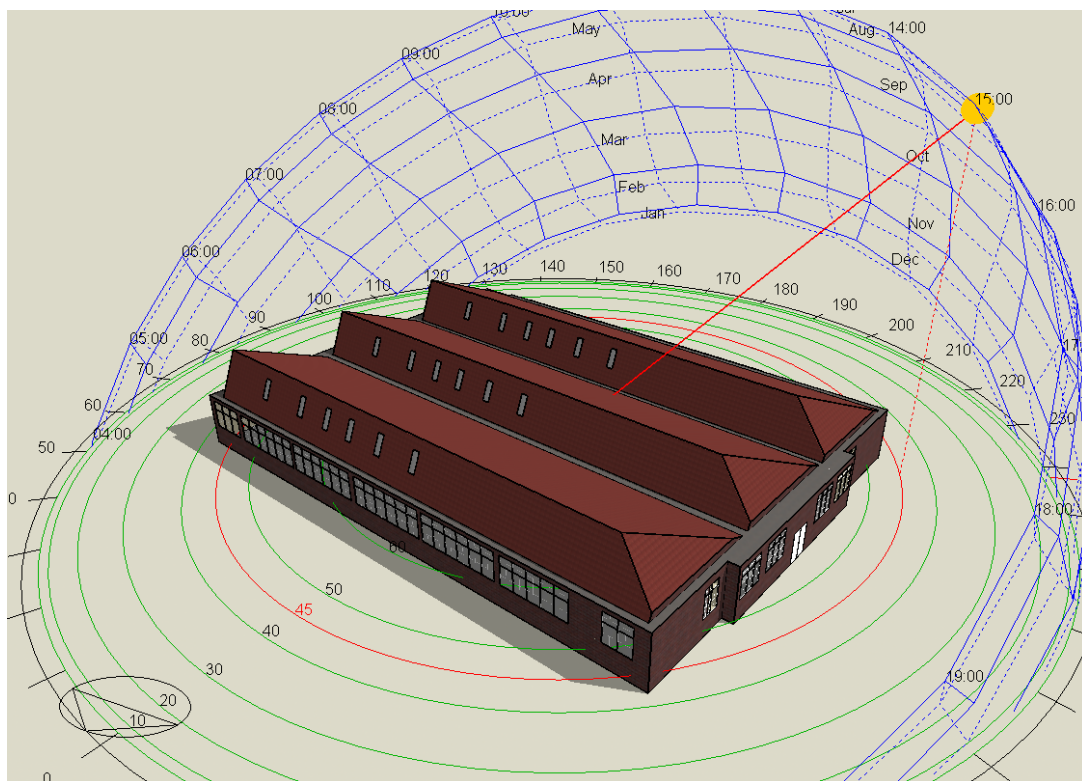


Analysis of Thermal Comfort

BREEAM Hea 04

**Proposed light industrial building at:
27-31 Garman Road, Haringey, London, N17 0YU**



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1. Executive Summary

This report details the methodology and findings of a thermal comfort analysis of a proposed light industrial building at 27-31 Garman Road, Haringey, London, N17 0YU using dynamic simulation modelling.

The reason for undertaking the work is to investigate the potential overheating risk within the building and to provide possible mitigation strategies for current and future climate change scenarios.

The proposed building design incorporates high standards of thermal insulation and fabric efficiency and high-performance glazing which serves to reduce the solar gain to the rooms.

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

Thermal analysis of the building has been carried out using DesignBuilder dynamic simulation modelling software. This software is fully accredited and compliant with CIBSE AM11 methodology.

It should be noted that as occupancy and building use is based on set parameters outlined in the BRE National Calculation Methodology and CIBSE TM52, the temperatures estimated may not match the actual building temperatures as the 'real' building may have differing operations and heat gain patterns with external weather conditions not normal to the historical data provided by the standard CIBSE weather files.

BREEAM Hea 04 credits achieved:

- One credit - Thermal modelling; and
- One credit - Design for future thermal comfort.

1.1. Justification for cooling

The mechanical and electrical specification for this building includes air to air heat pumps within the offices. Air to air heat pumps can provide both heating and cooling, are exceptionally high efficiency and low carbon. The primary use of these heat pumps will be to provide heating. For the purpose of this assessment two of the offices have been assessed without the benefit of active cooling. The third office, which is entirely enclosed and has no benefit from natural ventilation, has been assessed with active cooling. In all cases mechanical ventilation has been included at a rate of 1 l/s/m².

Based on this assessment the offices with natural ventilation have been found to be at low risk of overheating, and do not require active cooling for the DSY 1 2020 weather file:

CIBSE TM52					
Export CSV					
Block	Zone	Criterion 1 (%)	Criterion 2 (K.hr)	Criterion 3 (hr)	Pass/Fail
00	OFFICE	1.40	7.83	0.00	Pass
00	OFFICE1	2.88	8.83	0.00	Pass
00	UNITA	0.77	6.33	0.00	Pass
00	UNITB	0.00	0.00	0.00	Pass

For the 2050 weather file all offices will need cooling in order to maintain thermal comfort during the hottest periods.

CIBSE TM52					
Export CSV					
Block	Zone	Criterion 1 (%)	Criterion 2 (K.hr)	Criterion 3 (hr)	Pass/Fail
00	OFFICE	6.69	16.17	0.00	Fail
00	OFFICE1	12.17	22.00	0.00	Fail
00	UNITA	2.59	14.17	0.00	Pass
00	UNITB	0.12	1.50	0.00	Pass

Illustration of office requirements:



2. Operative temperature ranges

For air conditioned buildings summer and winter operative temperature ranges in occupied spaces are to be in accordance with the criteria set out in CIBSE Guide A Environmental design, Table 1.5; or other appropriate industry standard (where this sets a higher or more appropriate requirement/level for the building type). For naturally ventilated/free running buildings the same applies to winter operative temperature ranges only.

CIBSE Guide A Environmental Design, Table 1.5: Recommended comfort criteria for specific applications:

Building/room type	Customary winter operative temperatures for stated activity and clothing levels*			Customary summer operative temperatures (air conditioned buildings†) for stated activity and clothing levels*			Suggested air supply rate / (L·s ⁻¹ per person unless stated otherwise)	Filtration grade‡	Maintained illuminance¶ / lux	Noise criterion§		
	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§
Airport terminals:												
– baggage reclaim	12–19	1.8	1.2	21–25	1.3	0.6	10	F6-F7	200	45	50	75
– check-in areas	18–20	1.4	1.2	21–25	1.3	0.6	10	F6-F7	500	45	50	75
– concourse (no seats)	19–24	1.8	1.2	21–25	1.3	0.6	10	F6-F7	200	45	50	75
– customs area	18–20	1.4	1.2	21–25	1.3	0.6	10	F6-F7	500	45	50	75
– departure lounge	19–21	1.3	1.2	22–25	1.2	0.6	10	F6-F7	200	40	45	70
Art galleries – see Museums and art galleries												
Banks, building societies, post offices:												
– counters	19–21	1.4	1	21–25	1.3	0.6	10	F6-F7	500	35–40	40–45	65–70
– public areas	19–21	1.4	1	21–25	1.3	0.6	10	F5-F7	300	35–45	40–45	65–70
Bars/lounges	20–22	1.3	1	22–25	1.3	0.6	10	F5-F7	100–200	30–40	35–45	60–70
Bus/coach stations - see Railway/coach stations												
Churches	19–21	1.3	1.2	22–25	1.3	0.6	10	G4-F6	100–200	25–30	30–35	55–60
Computer rooms	19–21	1.4	1	21–25	1.3	0.6	10	F7-F9	300	35–45	40–50	65–75
Conference/board rooms	22–23	1.1	1	23–25	1.1	0.6	10	F6-F7	300/500	25–30	30–35	55–60
Drawing offices	19–21	1.4	1	21–25	1.3	0.6	10	F7	750	35–45	40–50	65–75

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Building/room type	Customary winter operative temperatures for stated activity and clothing levels*			Customary summer operative temperatures (air conditioned buildings†) for stated activity and clothing levels*			Suggested air supply rate / (L·s ⁻¹ per person unless stated otherwise)	Filtration grade‡	Maintained illuminance¶ / lux	Noise criterion§		
	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§
Dwellings:												
– bathrooms	20–22	–	–	23–25	–	–	15 L·s ⁻¹	G2–G4 (extract)	150	–	–	–
– bedrooms	17–19	0.9	2.5	23–25	0.9	1.2	0.4–1 ACH to control moisture	G2–G4	100	25	30	55
– hall/stairs/landings	19–24	–	–	21–25	–	–	–	–	100	–	–	–
– kitchen	17–19	1.6	1	21–25	1.5	0.5	60 L·s ⁻¹	G2–G4 (extract)	150–300	40–45	45–50	70–75
– living rooms	22–23	1.1	1	23–25	1.1	0.6	0.4–1 ACH to control moisture	G2–G4	50–300	30	35	60
– toilets	19–21	–	–	21–25	–	–	>5 ACH	G2–G4	100	–	–	–
Educational buildings:												
– corridor	19–21	1.4	1	21–25	1.3	0.6	10	–	100	35–45	40–50	65–75
– gymnasium	–	–	–	–	–	–	–	–	300	35–45	40–50	65–75
– laboratory	19–21	1.4	1	21–25	1.3	0.6	10	–	100	35–40	40–45	65–70
– lecture halls	19–21	1.4	1	21–25	1.3	0.6	10	G4–G5	500	25–30	30–40	55–65
– seminar rooms	19–21	1.4	1	21–25	1.3	0.6	10	G4–G5	300	25–35	30–40	55–65
– teaching spaces	19–21	1.4	1	21–25	1.3	0.6	10	G4–G5	300	25–35	30–40	55–65
– workshop	16–19	1.8	0.9	–	–	–	–	Depends on use	–	35–40	40–45	65–70
Exhibition halls	19–21	1.4	1	21–25	1.3	0.6	10	G3–G4	300	40	45	60
Factories:												
– heavy work	11–14	2.5	0.9	–	–	–	–	Depends on use	–	50–65	55–70	60–85

Building/room type	Customary winter operative temperatures for stated activity and clothing levels*			Customary summer operative temperatures (air conditioned buildings†) for stated activity and clothing levels*			Suggested air supply rate / (L/s-1 per person unless stated otherwise)	Filtration grade‡	Maintained illuminance¶ / lux	Noise criterion§		
	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§
- light work	16-19	1.8	0.9	-	-	-	-	Depends on use	-	45-55	50-60	70-80
- sedentary work	19-21	1.4	1	21-25	1.3	0.6	-	Depends on use	-	45	50	75
Fire/ambulance stations:												
- recreation rooms	20-22	1.3	1	22-25	1.3	0.6	10	F5	300	35-40	40-45	65-70
- watchroom	22-23	1.1	1	24-26	1.1	0.6	10	F5	200	35-40	40-45	65-70
Garages:												
- parking	-	-	-	-	-	-	6 ACH (extract)	-	75/300	55	60	85
- servicing	16-19	1.8	0.9	-	-	-	-	G2-G3	300/500	45-50	50-55	75-80
General building areas:												
- corridors	19-21	1.4	1	21-25	1.3	0.6	10	-	100	40	45	70
- entrance halls/lobbies	19-21	1.4	1	21-25	1.3	0.6	10	-	100/200	35-40	40-45	65-70
- kitchens (commercial)	15-18	1.8	1	18-25	1.6	0.6	-	G2-G4	500	40-45	45-50	70-75
- toilets	19-21	-	-	21-25	-	-	>5 ACH	G4-G5	200	35-45	40-50	65-75
- waiting areas/rooms	19-21	1.4	1	21-25	1.3	0.6	10	-	200	30-35	35-40	60-65
Hospitals and health care buildings:												
- audiometric rooms	-	-	-	-	-	-	-	-	-	20-25	20-25	50-55
- bedheads/wards	22-24	0.9	1.4	23-25	0.9	1.2	10	F7-F9	-	30	35	60
- circulation spaces (wards)	19-24	1.8	0.8	21-25	1.8	0.6	10	F7-F9	-	35	40	65
- consulting/treatment rooms	22-24	1.4	0.6	23-25	1.4	0.4	10	F7-F9	300/500	30	35	60
- corridors	19-21	1.4	1	21-25	1.3	0.6	10	-	100	35-40	40-45	65-70
- kitchens	-	-	-	-	-	-	-	-	3	35-40	40-45	65-70
- laboratories	19-21	1.4	1	21-25	1.3	0.6	10	-	100	35-40	40-45	65-70

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	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§
- nurses' station	19-22	1.4	0.9	21-25	1.3	0.6	10	F7-F9	-	35	40	65
- operating theatres	17-19	1.8	0.8	17-19	1.8	0.8	0.65-1.0 m³/s-1	F9	-	30-35	35-40	60-65
- staffroom, recreation room	19-21	1.4	1	21-25	1.3	0.6	10	G4-G5	300	30-40	35-45	55-65
- washroom/toilet	19-21	-	-	21-25	-	-	>5 ACH	G4-G5	200	35-45	40-45	65-70
Hotels:												
- ballroom	-	-	-	-	-	-	-	-	-	30-35	35-40	60-65
- banquet room	-	-	-	-	-	-	-	-	-	30-35	35-40	60-65
- bathrooms	20-22	-	-	23-25	-	-	12	F5-F7	150	40	45	65
- bedrooms	19-21	1	1	21-25	1	1.2	10	F5-F7	50/100	20-30	25-35	50-60
- corridor, lobby	19-21	1.4	1	21-25	1.3	0.6	10	-	100	35-40	40-45	65-70
- kitchen	-	-	-	-	-	-	-	-	-	40-45	45-50	70-75
- laundry	-	-	-	-	-	-	-	-	300	40-45	45-50	70-75
Ice rinks	12	-	-	-	-	-	3 ACH	G3	-	40-50	45-55	70-80
Laundries:												
- commercial	16-19	1.8	0.9	-	-	-	-	G3-G4	300/500	45	50	75
- laundrettes	16-18	1.6	1.2	20-25	1.4	0.6	-	G2-G3	300	45-50	50-55	70-75
Law courts	19-21	1.4	1	21-25	1.3	0.6	10	F5-F7	300	25-30	30-35	55-60
Libraries:												
- lending/reference areas	19-21	1.4	1	21-25	1.3	0.6	10	F5-F7	200	30-35	35-40	60-65
- reading rooms	22-23	1.1	1	24-25	1.1	0.6	10	F5-F7	500	30-35	35-40	60-65
- store rooms	15	-	-	-	-	-	-	F6-F8	200	-	-	-
Museums and art galleries:												
- display	19-21	1.4	1	21-25	1.3	0.6	10	F7-F8	200	30-35	35-40	60-65

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	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§
- storage	19-21	1.4	1	21-25	1.3	0.6	10	F7-F8	50	30-35	35-40	60-65
Offices:												
- board room, large conference room	21-23	1.2	0.9	22-25	1.2	0.7	10	F7	300-500	30	35	60
- general, small conference room, executive office	21-23	1.2	0.9	22-25	1.2	0.7	10	F6-F7	300-500	30	35	60
- open-plan	21-23	1.2	0.9	22-25	1.2	0.7	10	F6-F7	300-500	35	35	60
Places of public assembly:												
- concert hall, theatre	21-23	1	1	24-25	1.1	0.6	10	F5-F7	100-150	20-30	25-35	50-60
- cinema	21-23	1	1	24-25	1.1	0.6	10	F5-F7	100-150	20-30	25-35	50-60
- changing/dressing rooms	21-23	-	-	22-25	1.4	0.4	10	F5-F7	300	35	40	65
- circulation spaces	13-20	1.8	1	21-25	1.8	0.6	10	G4-G5	200	40	45	70
- foyers	13-20	1.8	1	21-25	1.8	0.6	10	F5-F7	200	40	45	70
- multi-purpose halls	-	-	-	-	-	-	10	G4-G5	300	-	-	-
Prison cells	19-21	1	1.5	21-25	1	1.1	10	F5	100	25-30	30-35	55-60
Railway/coach stations:												
- concourse (no seats)	12-19	1.8	1.2	21-25	1.8	0.6	10	G4-G5	200	45	50	75
- ticket office	18-20	1.4	1.2	21-25	1.3	0.6	10	G4-G5	300	40	45	70
- waiting room	21-22	1.1	1.2	24-25	1.1	0.6	10	G4-G5	200	40	45	70
Restaurants/dining rooms	21-23	1.1	1	24-25	1.1	0.6	10	F5-F7	50-200	35-40	40-45	65-70
- night club, public	19-21	1.4	1	21-25	1.3	0.6	10	F5-F7	200	40-45	45-50	70-75
Retailing:												
- shopping malls	12-19	1.8	1.2	21-25	1.8	0.6	10	G4-G5	50-300	40-50	45-55	70-80
- small shops, department stores	19-21	1.4	1	21-25	1.3	0.6	10	F5-F7	500	35-40	40-45	65-70
- department stores (upper floors)	19-21	1.4	1	21-25	1.3	0.6	10	F5-F7	500	35-40	40-45	65-70

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	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§
– supermarkets	19–21	1.4	1	21–25	1.3	0.6	10	F5–F7	750/1000	40–45	45–50	70–75
Sports halls:												
– changing rooms	21–24	–	–	22–25	–	–	6–10 ACH	G3	100	35–45	40–45	65–75
– hall	13–16	3	0.4	14–16	3	0.3	10	G3–F5	300	40–50	45–55	70–80
Squash courts	10–12	4	0.3	–	–	–	4 ACH	G3	–	50	55	80
Swimming pools:												
– changing rooms	21–24	–	–	22–25	–	–	10 ach	G3	100	35–45	40–50	65–75
– pool halls	23–26	1.6	< 0.1	23–26	1.6	< 0.1	0–15 L·s ⁻¹ ·m ⁻² (of wet area)	G3	–	40–50	45–55	70–80
Television studios	19–21	1.4	1	21–25	1.3	0.6	10	F5–F7	–	25	30	55
– sound broadcasting (drama)	19–21	1.4	1	21–25	1.3	0.6	10	F5–F7	–	15	20	45
– sound broadcasting (general)	19–21	1.4	1	21–25	1.3	0.6	10	F5–F7	–	20	25	50
– television (audience studio)	19–21	1.4	1	21–25	1.3	0.6	10	F5–F7	–	25	30	55

Building/room type	Customary winter operative temperatures for stated activity and clothing levels*			Customary summer operative temperatures (air conditioned buildings†) for stated activity and clothing levels*			Suggested air supply rate / (L·s ⁻¹ per person unless stated otherwise)	Filtration grade‡	Maintained illuminance¶ / lux	Noise criterion§		
	Temp / °C	Activity / met	Clothing / clo	Temp / °C	Activity / met	Clothing / clo				NR	dBA§	dBC§

Notes: The values of met and clo yield a PMV of zero (neutral) within the range of the operative temperatures. See CIBSE Guide A section 1.3.1.4 and 1.3.1.5 for additional data and for variations due to different activities and levels of clothing. Calculation assumes RH= 50% and ventilation rate = 0.15 m·s⁻¹. Insulation value of chair assumed to be 0.15 clo for all applications except dwellings, for which 0.3 has been assumed.

* The daily mean operative temperature for comfort (the current comfort temperature) is likely to be somewhere within the ranges given. A variation of ±1K within the day would attract little notice, while a variation of ±2 K would be noticed and might cause some complaint at the extremes. More active people are more tolerant of temperature variations. Day-on-day change should follow the guidance given in CIBSE Guide A section 1.4.1.

† Higher temperatures may be acceptable if air conditioning is not present, see CIBSE Guide A section 1.3.1.

‡ See CIBSE Guide A chapter 8, Table 8.4.

¶ Illumination levels given thus: 200–500 indicates that the required level varies through the space depending on function and/or task. Illumination levels given thus: 300/500, indicate that one or the other level is appropriate depending on exact function. Illumination levels in this table give only a general indication of requirements. Reference must be made to the table of recommended illuminances in the SLL Code for Lighting (SLL, 2012) and CIBSE/SLL Lighting Guides for design guidance on specific applications.

§ Suggested maximum permissible background noise levels generated by building services installations. See also CIBSE Guide A Table 1.22.

3. Fanger: PMV (predicted mean vote) and PPD (predicted percentage of dissatisfied)

Fanger's comfort model was the first thermal comfort model to be developed. Originally published in 1967, the Fanger comfort model helped set the stage for future models.

Predicted Mean Vote

The Predicted Mean Vote (PMV) refers to a seven-point thermal scale that runs from Cold (-3) to Hot (+3). Fanger developed his model based on data collected by subjecting a large number of people to different conditions within a climate chamber and having them select a position on the scale that best described their comfort sensation. A mathematical model of the relationship between all the environmental and physiological factors considered was then derived from the data.

Predicted Mean Vote sensation scale

Value	Sensation
-3	Cold
-2	Cool
-1	Slightly cool
0	Neutral
1	Slightly warm
2	Warm
3	Hot

The recommended acceptable PMV range for thermal comfort within an interior space is between -0.5 and +0.5 (ASHRAE 55).

Predicted Percentage of Dissatisfied

Predicted Percentage of Dissatisfied (PPD) predicts the percentage of occupants that will be dissatisfied with the thermal conditions. PPD is a function of PMV, given that as PMV moves further from 0, or neutral, PPD increases. The maximum number of people dissatisfied with their comfort conditions is 100% and, as you can never please all of the people all of the time, the recommended acceptable PPD range for thermal comfort within an interior space is less than 10% persons dissatisfied (ASHRAE 55).

4. CIBSE TM52 “The Limits of Thermal Comfort: Avoiding Overheating in European Buildings 2013”

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

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

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

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

1. **Criterion 1 (Hours of Exceedance)** sets a limit of 3% on the number of occupied hours that the operative temperature can exceed the threshold comfort temperature, T_{max} , by 1K or more during the occupied hours of a typical non-heating season – 1 May to 30 September. T_{max} is a function of the outdoor running-mean temperature.
2. **Criterion 2 (Daily Weighted Exceedance)** deals with the severity of overheating within any one day, which can be as important as its frequency. This is a function of both temperature above T_{max} and its duration. This criterion sets a daily limit for acceptability. If each hour (or part-hour) in which the temperature exceeds T_{max} by at least 1K is multiplied by the number of degrees by which it is exceeded, then this ‘excess’ should not be more than six degree-hours.
3. **Criterion 3 (Upper Limit Temperature)** sets an absolute maximum temperature of $(T_{max} + 4)$ °C for a room (T_{upp}), beyond which the level of overheating is unacceptable. The overheating risk is assessed between the 1st of May and the 30th of September.

To show compliance with TM52 at least two out of three of the criteria must be met in all occupied rooms.

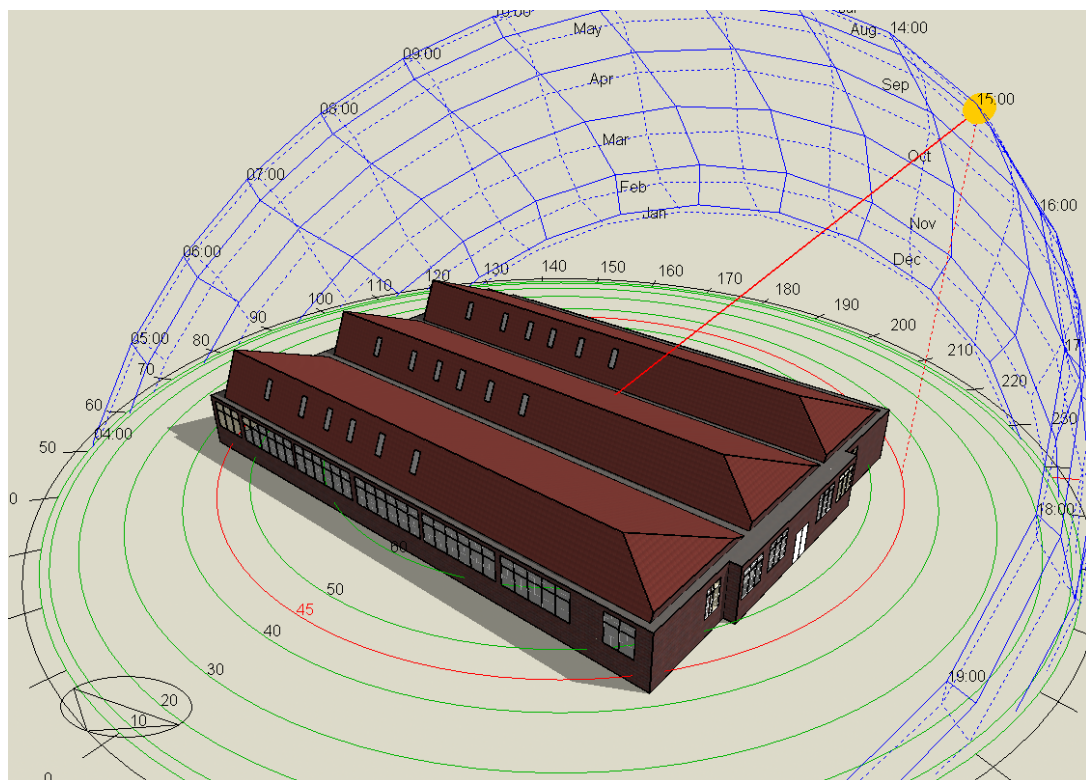
It is to be noted that the TM52 overheating criteria applies to “free-running” buildings only, i.e. buildings where the peak internal temperature is not controlled by air-conditioning.

5. The Building

This analysis has been undertaken on a single-story light industrial building with the following zones:

- Office
- Circulation areas
- Store rooms
- Toilets
- Warehouse / light industrial storage
- Kitchen
- Plant rooms

Figure 1 - Graphical Image of Building Simulation Model:



6. The Model

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

- i. Mean outdoor temperatures.
- ii. Geometry.

- iii. External shading.
- iv. Internal shading.
- v. Fabric.
- vi. Glazing.
- vii. Infiltration.
- viii. Internal gains: occupancy.
- ix. Internal gains: lighting.
- x. Internal gains: equipment.
- xi. Natural ventilation.
- xii. Mechanical ventilation.
- xiii. Active cooling.
- xiv. Occupancy schedules.

Details for each of these are provided below.

6.1. Mean outdoor temperatures

In accordance with the guidance and recommendations of CIBSE AM11 'Building Energy & Environmental Modelling', and BREEAM Hea 04, the building has been modelled against a range of CIBSE weather files to assess performance in both current and predicted future climates.

For this project, the London Weather Centre weather files were used based on them being the most representative locations.

In accordance with the guidance and recommendations of CIBSE AM11 'Building Energy & Environmental Modelling', and BREEAM Hea 04, the building has been modelled against a range of CIBSE weather files to assess performance in both current and predicted future climates.

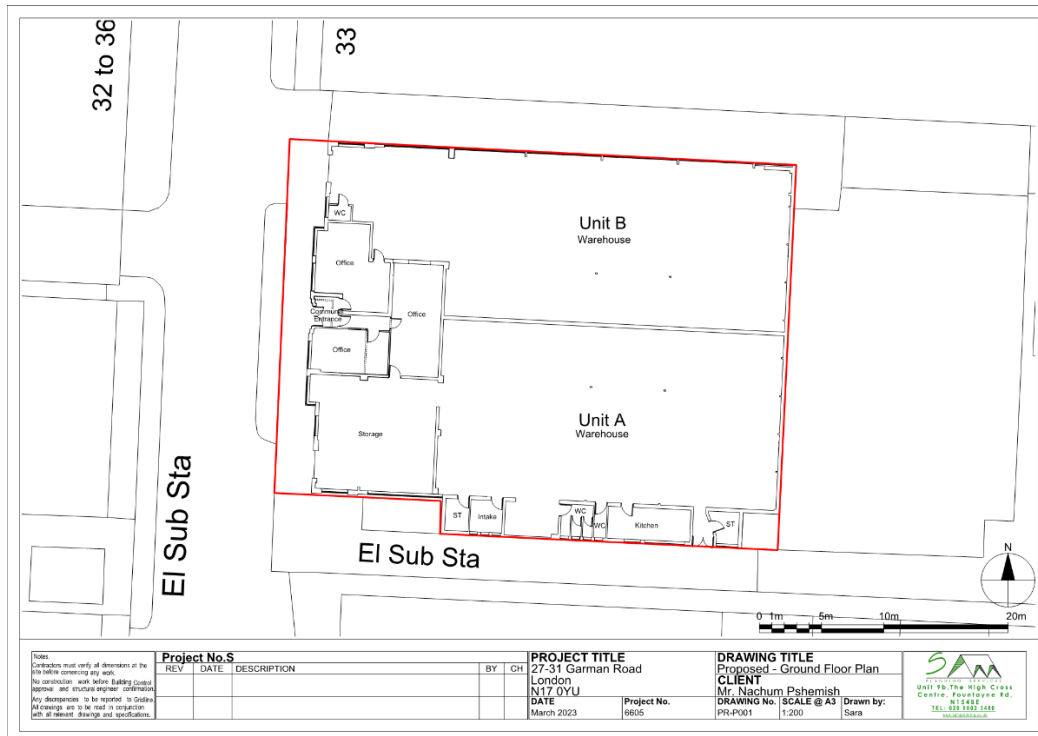
Overheating analysis has been conducted using DSY weather scenarios:

- i. Current: DSY1 weather files.
- ii. Future: DSY2 and DSY3 weather files. 2050s medium50 emissions scenario for Free Running Buildings.
- iii. Future: DSY2 and DSY3 weather files. 2020s high50 emissions scenario for Mechanically Ventilated or Mixed Mode Buildings.

6.2. Geometry

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

Figure 2 – architects drawings:



Element	U-Value (W/m ² .K)
Pitched roof	0.16
Flat roof	0.15
Vehicle access door	1.30

6.6. Glazing

Windows and fully glazed doors are to be double glazed and have been entered into the model based on the following assumed parameters: -

- Solar transmittance value (g-value) – 0.40 (solar control)
- Light transmittance value – 0.60
- U-value – 1.40 W/m²K

Frame widths have been entered at 40mm.

6.7. Infiltration

Air infiltration through the building fabric has been assigned based upon the design air permeability rate of 3m³/m².hr@50Pa. Note that air permeability can have both a positive and negative effect upon internal conditions, dependent upon the internal/external temperatures and internal set-point temperature.

6.8. Internal gains: occupancy

Heat gains arising as a result of building occupancy have been input into the simulation model based upon data from the National Calculation Methodology (NCM), and as detailed below:

Room	Occupancy density (people / m ²)	Metabolic rate (W / person)
Office	0.111	123
Warehouse / light industrial	0.05	180

6.9. Internal gains: lighting

Heat gains arising as a result of the recessed artificial lighting installation have been input into the model on the basis of the following lighting specification (lux levels for each room are based on data from the NCM):

Room	Lighting power density (watts / m ² / 100 lux)
Office	2
Warehouse / light industrial	2

6.10. Internal gains: equipment

Heat gains arising as a result of equipment located within each room have been input into the simulation model based upon data from the National Calculation Methodology (NCM), and as detailed below:

Room	Equipment gains (W/m ²)
Office	11.77
Warehouse / light industrial	5.0

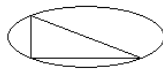
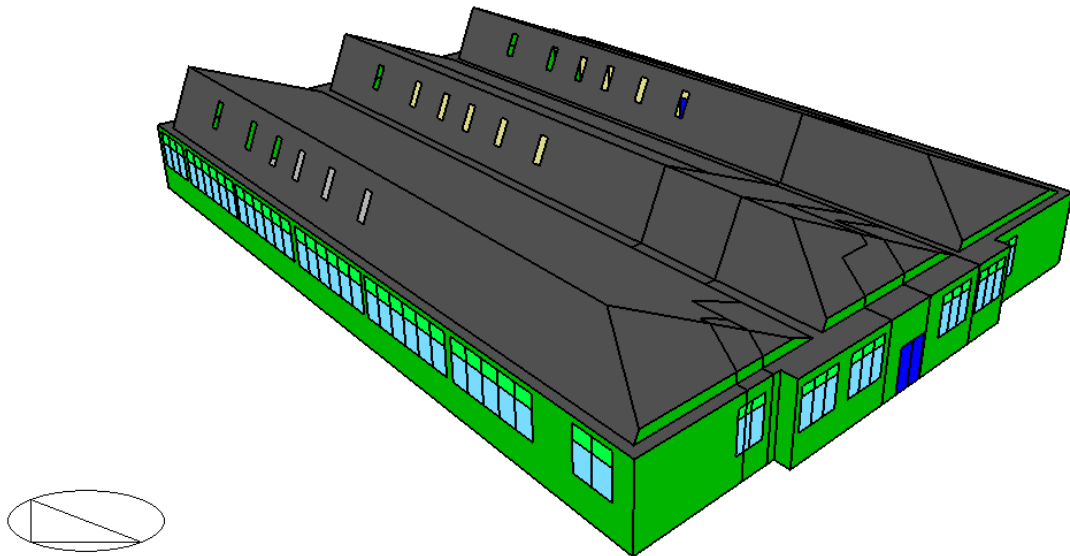
6.11. Natural ventilation

Natural ventilation is provided via openable windows and doors.

Opening areas have been entered into the simulation model in accordance with the details provided by the project architect.

Window Type	Opening Area	Opening schedule
Openable windows	100%	Based on occupancy schedule
External doors	50%	Based on occupancy schedule. 5% of the time
Non-openable windows	0%	N/A

Note: Opening areas are approximate and may vary depending on frame thickness, final window selection. Windows that are assigned as openable are highlighted in green and natural ventilation grilles are transparent within the following image:



6.12. Mechanical ventilation

Mechanical extract ventilation is to be provided to the kitchen and toilets. To reduce the need for active cooling, mechanical ventilation should be provided to the office areas at a continuous rate of 1 l/s/m².

6.13. Active cooling

Air conditioning is to be provided to the offices.

6.14. Occupancy schedules

National Calculation Methodology occupancy schedules have been applied throughout. The NCM schedules have been applied to occupancy, lighting, equipment gains, mechanical ventilation and window opening profiles.

7. Results

7.1. Operative temperatures: CIBSE Guide A

For air-conditioned buildings, summer and winter operative temperature ranges in occupied spaces are to be in accordance with the criteria set out in CIBSE Guide A Environmental design, Table 1.5; or other appropriate industry standard (where this sets a higher or more appropriate requirement/level for the building type).

For naturally ventilated/free running buildings winter operative temperature ranges in occupied spaces are to be in accordance with the criteria set out in CIBSE Guide A Environmental design, Table 1.5; or other appropriate industry standard (where this sets a higher or more appropriate requirement/level for the building type).

7.1.1. Current: DSY 1 weather file.

Room Name	Recommended winter operative temperature range: CIBSE Guide A, Table 1.5 (°C)	Heating set point (°C)	Recommended summer operative temperature range: CIBSE Guide A, Table 1.5 (°C)	Cooling set point (°C)	Operative temperatures in range
Office	21-23	23	22 - 25	24	PASS
Warehouse / light industrial	16-19	18	-	21	PASS

7.1.2. Future: DSY 2 weather file. 2020 high50 emissions scenario.

Room Name	Recommended winter operative temperature range: CIBSE Guide A, Table 1.5 (°C)	Heating set point (°C)	Recommended summer operative temperature range: CIBSE Guide A, Table 1.5 (°C)	Cooling set point (°C)	Operative temperatures in range
Office	21-23	23	22 - 25	24	PASS
Warehouse / light industrial	16-19	18	-	21	PASS

7.1.3. Future: DSY 3 weather file. 2020 high50 emissions scenario.

Room Name	Recommended winter operative temperature range: CIBSE Guide A, Table 1.5 (°C)	Heating set point (°C)	Recommended summer operative temperature range: CIBSE Guide A, Table 1.5 (°C)	Cooling set point (°C)	Operative temperatures in range
Office	21-23	23	22 - 25	24	PASS
Warehouse / light industrial	16-19	18	-	21	PASS

7.2. Fanger: DSY 1, DSY 2 and DSY 3

For air-conditioned buildings, the PMV (predicted mean vote) and PPD (predicted percentage of dissatisfied) indices as calculated by dynamic simulation modelling must be reported via the BREEAM assessment scoring and reporting tool.

Room Name	Current: DSY 1 weather file		Future: DSY 2 weather file. 2020 high50 emissions		Future: DSY 3 weather file. 2020 high50 emissions	
	PMV	PPD	PMV	PPD	PMV	PPD
Office 1	-0.34	11.0	-0.34	10.8	-0.37	11.0
Office 2	-0.29	11.1	-0.29	11.0	-0.32	10.9
Office 3	-0.39	11.6	-0.39	11.5	-0.42	11.9

7.3. CIBSE TM52

For naturally ventilated/free running buildings, the building must be designed to limit the risk of overheating, in accordance with the adaptive comfort methodology outlined in CIBSE TM52: The limits of thermal comfort: avoiding overheating in European buildings.

7.3.1. Current: DSY 1 weather file.

Room Name	Criterion 1 (%Hrs Top-Tmax>=1K)	Criterion 2 (Max Daily Deg Hrs)	Criterion 3 (Max DeltaT)	Overall Compliance
Unit A Warehouse / light industrial	1.01	7.33	0	PASS
Unit B Warehouse / light industrial	0.58	6.17	0	PASS

7.3.2. Future: DSY 2 weather file.

Room Name	Criterion 1 (%Hrs Top-Tmax>=1K)	Criterion 2 (Max Daily Deg Hrs)	Criterion 3 (Max DeltaT)	Overall Compliance
Unit A Warehouse / light industrial	2.16	24.83	0	PASS
Unit B Warehouse / light industrial	1.18	21.17	0	PASS

7.3.3. Future: DSY 3 weather file.

Room Name	Criterion 1 (%Hrs Top-Tmax>=1K)	Criterion 2 (Max Daily Deg Hrs)	Criterion 3 (Max DeltaT)	Overall Compliance
Unit A Warehouse / light industrial	2.85	16.67	0	PASS
Unit B Warehouse / light industrial	1.54	14.17	0	PASS

7.4. Fanger: DSY 1 2050 & 2080

Room Name	Future: DSY 1 2050 scenario		Future: DSY 1 2080 scenario	
	PMV	PPD	PMV	PPD
Office 1	-0.37	11.0	-0.30	10.7
Office 2	-0.26	10.9	-0.22	10.6
Office 3	-0.33	11.4	-0.33	10.9

7.5. CIBSE TM52: DSY 1 2050 & 2080

7.5.1. DSY1 2050

Room Name	Criterion 1 (%Hrs Top-Tmax>=1K)	Criterion 2 (Max Daily Deg Hrs)	Criterion 3 (Max DeltaT)	Overall Compliance
Unit A Warehouse / light industrial	2.78	15.0	0	PASS
Unit B Warehouse / light industrial	0.81	7.33	0	PASS

7.5.2. DSY1 2080

Room Name	Criterion 1 (%Hrs Top-Tmax $\geq$ 1K)	Criterion 2 (Max Daily Deg Hrs)	Criterion 3 (Max DeltaT)	Overall Compliance
Unit A Warehouse / light industrial	7.18	26.17	0	FAIL
Unit B Warehouse / light industrial	1.82	17.17	0	PASS

Retrofit strategy required in future: for example, nighttime mechanical ventilation or forced nighttime natural ventilation to cool mass of building.