QODA

Yiewsley Sites, London Borough of Hillingdon

GLA Energy Statement

20204.R4

QODA

Revision Summary

Issue	Document prepared			Document checked		
	Name	Signature	Date	Name	Signature	Date
R4	Joel Callow	[signature]	13/09/2021	Chris Swinburn	[signature]	13/09/2021

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1 Introduction

QODA Consulting has been appointed by London Borough of Hillingdon to carry out the energy and sustainability requirements of the GLA for the two sites within the Yiewsley planning application.

1.1 Design brief

The Greater London Authority (GLA) London Plan has challenging sustainability targets for new buildings. For the Yiewsley development, a key requirement is an on-site reduction in operational CO2 emissions of at least 35% over building regulations, measured using the Part L methodology. In addition, the policy requires a target of 100% reduction, also known as ‘net zero carbon’ using either onsite measures, or by paying a financial offset for any residual emissions. This is among the most onerous of regulatory requirements anywhere in the UK at the moment. This requires a whole-team rigorous approach to design that focuses on passive and active measures to reduce in-use energy consumption. The GLA recommends a ‘lean, clean, green’ hierarchy of measures, which the team has followed in our approach.

1.2 Energy & Comfort Targets

Part L of the UK Building Regulations requires an assessment of overheating under summer conditions. QODA generally recommend going beyond the basic requirements of Part L to ensure that buildings will work effectively under future climate-change scenarios – the CIBSE TM59 methodology is recommended for robust design. Buildings must be designed to regulate summer solar gains effectively and provide sufficient ventilation to control temperature both in the day and night periods, to ensure that occupants are comfortable.

1.3 Approach to sustainability

QODA have worked in close partnership with Hunters and the rest of the design team to combine the above sustainability requirements with the many other design requirements and constraints.

The building envelope leads the design, as it is here that passive savings can be made for the lifetime of the envelope and at reasonable capital and whole-life cost. Savings built into the envelope can be expected to last 50+ years, whereas savings made through building services systems tend to have a lifespan of 10-20 years. In addition, building envelope measures tend to be low or zero maintenance. It is also much, much harder and sometimes impossible to retrofit efficiency measures to a building envelope at a later date, meaning that the point of construction is a unique opportunity to reduce energy demand and increase comfort at low investment cost.

The team has approached the envelope via a number of essential parameters:

- Solar gains
- Daylight
- Fabric heat loss (U-value)
- Window heat loss (U-value)
- Infiltration heat loss (airtightness)
- Ventilation rates in both winter and summer, including provision of heat recovery
- Thermal mass

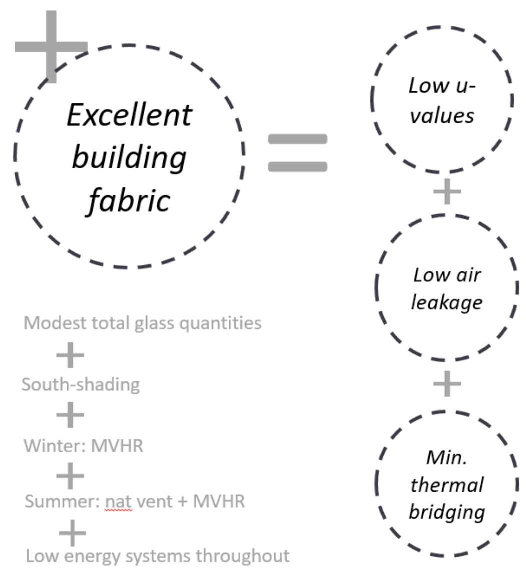


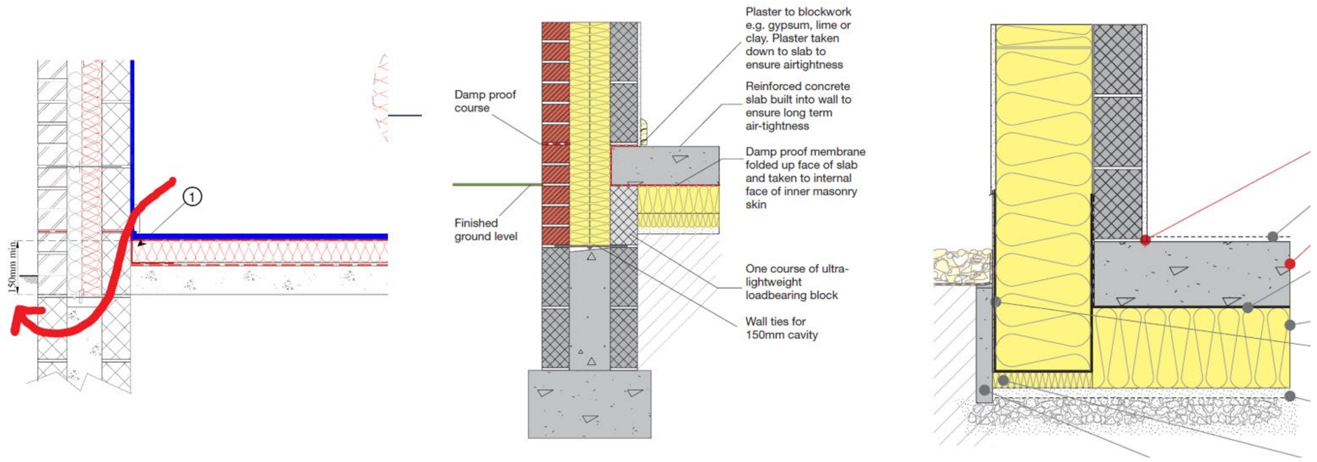
Figure 1: Graphical description of QODA approach to energy consumption

Thermal mass can be an important contributor to summer thermal comfort by both offering radiant ‘coolth’ to occupants if the mass surface is exposed, and by slowing down the response of the building to external temperature changes. This latter effect means that daytime heat is absorbed by the mass of the building and can then be purged through night time ventilation when temperatures are lower. This feature, when combined intelligently with other aspects of design, can offer reductions in overheating, improved thermal comfort, and reduced cooling loads and associated energy consumption where a mechanical cooling system is present.

The Yiewsley Development is planned to have a concrete frame structural solution and a piled foundation, along with some structural steel. This structural method gives several advantages for low energy buildings, specifically a thermally massive building, and a clean external structural surface on which to attach insulation materials in an uninterrupted way. This structural solution is not yet confirmed and needs to be agreed as the design is progressed.

1.3.1 Thermal bridging and airtightness – high performance envelope

Along with lower U-values, low air leakage and continuous insulation, a key difference between Part L1A compliant buildings and high-performance buildings is the attention to detail in the latter design that minimises thermal bridging. Thermal bridging is the leakage of conducted heat through aspects of the building envelope not covered by U-values. It is often avoidable and can always be reduced by careful design – particularly by careful coordination between the architect, energy specialist and structural engineer. While Stage 2 is too early to begin detailed calculations for the Yiewsley Development, some early design direction has been undertaken with the aim of minimising thermal bridging.



Part L accredited | Passivhaus LEB | Passivhaus Classic

Figure 2: Thermal bridging at three levels of energy performance

While the above three details are only indicative, they give the design team some targets to aim for with the Yiewsley Development design. Our aim would be thermal bridging minimized to the level labelled above as ‘Passivhaus LEB’. This target should result in thermal bridging losses that are roughly 50% lower than the Part L accredited details, but with little or no extra cost. This level of performance is in keeping with the 35% CO2 reduction target from LBH and is not as onerous and expensive as the ‘Passivhaus Classic’ detail shown above. Note that the project is not being designed to either the Passivhaus LEB or Classic standards, but the details above give a helpful steer and indication of intended performance levels. Building regulations & design criteria

All relevant legislation, regulations, standards, guidance, and good practice shall be adhered to – see below.

The design criteria will be in accordance with the recommendations of the following:

- This planning report
- CIBSE Guides
- Statutory undertakings
- Health and Safety Executive (HSE) Guidance and all relevant legislation
- CDM regulations
- Pressure system safety regulations
- Relevant British Standards
- LBH sustainability criteria

1.3.2 Ventilation design

Providing fresh air to occupants throughout the year is vital for health and wellbeing and presents the challenge of the energy required to heat the incoming air during the heating season. In order to achieve levels of energy consumption in line with the sustainability aspirations, heat recovery systems are a part of our strategy for winter ventilation, and with high efficiency fans.

The design and selection of the ventilation system for Yiewsley has been considered very carefully and is detailed in the Building Services section of the QODA Stage 2 report.

Summer ventilation must provide the same fresh air functionality as in the winter, but with the additional requirement to maintain temperatures. Details of the natural ventilation design for the scheme are given in the section on control of summer overheating.

2 Building design analysis

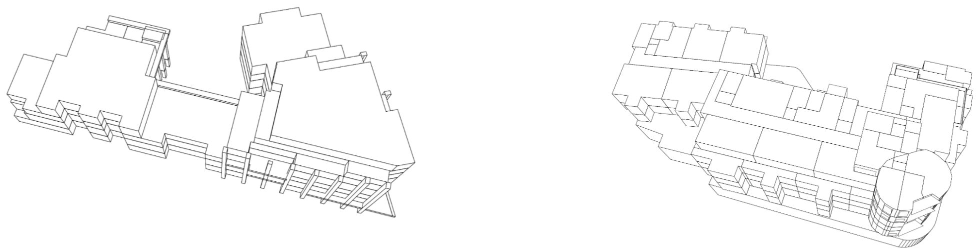


Figure 3: IES VE Thermal model for overheating analysis

Analysis has been conducted on the proposed design of the Yiewsley Development building on a number of key areas:

1. Internal daylight levels (using LightStanza and DeLuminae)
2. Compliance with the CO2 emissions criterial of Building Regulations Part L and the additional 35% saving needed by the LBH sustainability requirements (using approved software IES Virtual Environment)
3. Summer overheating – thermal comfort study in compliance with TM59

These wide-ranging design issues were considered using appropriate assumptions listed in the Appendices, and also considered on aggregate: where issues in one part of the analysis affect another design parameter. The aim is to achieve a holistic building design that embodies high performance in all the above categories.

2.1 Internal daylight levels – typical apartments

Figure 4: View of Sketchup 3D model used for natural daylight assessments

To validate and optimize the proposed elevation design and room layouts by Hunters, QODA modelled a number of typical bedrooms and living spaces to evaluate annual access to natural light. This was based on local weather historic averages and calculated using Climate Based Daylight Modelling – a method used within a number of non-binding sustainability assessments such as BREEAM and LEED. For the Yiewsley Development this gave annual average illuminance in the study area, shown in the figure above. Natural daylight illuminance was typically 500-2000 lux in a South-facing bedroom, and much higher near the window. This would qualify as very well lit, but please see sections about avoidance of summer overheating. The North-West bedroom assessed showed values of around 250 lux on average at the rear of the room.

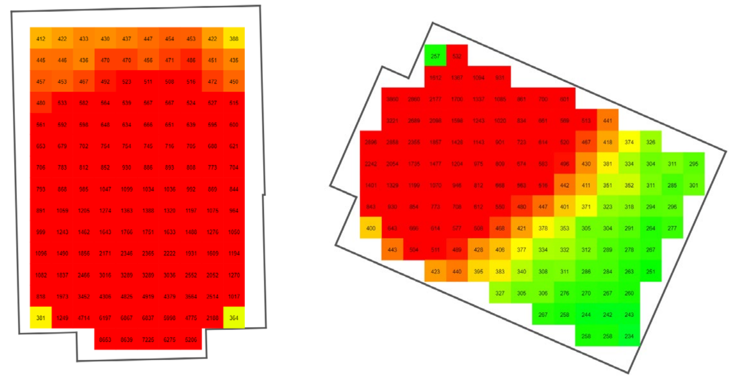


Figure 5: Annual average illuminance, South bedroom and North-West bedroom

A number of metrics are available to assess natural daylight, including average annual illuminance shown above, and Usable Daylight Illuminance (UDI). These more recent metrics better allow for the variable nature of natural light than older metrics such as the daylight factor, which assume a single sky condition throughout the year. Despite this, regulations still tend to focus on the daylight factor, and in keeping with planning policy, QODA have below assessed some sample apartment spaces against the requirements of the BRE guidance document 'Site layout planning for daylight and sunlight'. At this stage we have focused particularly on the average daylight factor requirements quoted from BS-8206-2, which are 1.0% for bedrooms, 1.5% for living rooms and 2.0% for kitchens.

Table 1: Results of preliminary daylight analysis for sample apartment spaces

Room name	Floor area	Average Daylight Factor assessed	Target ADF from BS 8206-2	Result
1BedA	14.4 m^2	2.6%	1.0%	PASS
1BedB	15.8 m^2	2.4%	1.0%	PASS
1BedC	16.3 m^2	2.4%	1.0%	PASS
1BedD	16.4 m^2	2.5%	1.0%	PASS
3bed-bed1	14.1 m^2	2.9%	1.0%	PASS
3bed-bed2	9.1 m^2	1.7%	1.0%	PASS
3bed-bed3	17.6 m^2	2.1%	1.0%	PASS
Lounge1BedA	10.6 m^2	1.5%	1.5%	PASS
Lounge1BedB	10.7 m^2	1.5%	1.5%	PASS
Lounge1BedC	10.3 m^2	2.0%	1.5%	PASS
LoungeKitch1Bed	27.4 m^2	2.9%	1.5%	PASS
Loungekitch3bed	40.1 m^2	3.2%	1.5%	PASS

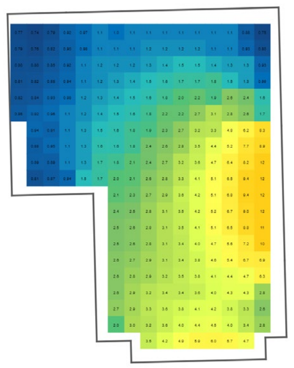


Figure 6: Average Daylight Factor results – dual aspect kitchen/living room

Dual aspect spaces such as the one above were found to have particularly good results – this room scored an ADF of 2.9%, including the kitchen space at the rear. Some apartments had a separate living space and a kitchen to the rear of the space, without access to natural light. In this instance, only the naturally lit space was assessed. An example of this from the table above is 'Lounge1BedA', which scores exactly 1.5% ADF and passes the requirement.

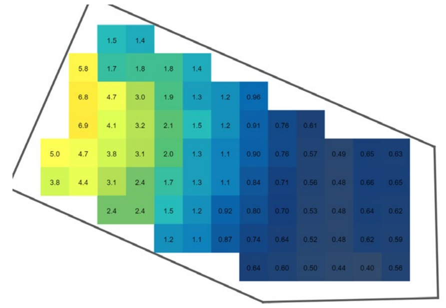


Figure 7: Average Daylight Factor results – single aspect North-West bedroom

Even the bedrooms with the least light such as the one shown above still scored well beyond the minimum of 1.0% ADF required. Many spaces scored higher than 2.0% ADF and would be considered well daylit.

Overall, the spaces assessed had excellent daylight levels when assessed using the Average Daylight Factor, and all spaces analysed passed the requirements of the BRE guidance document. Rear-positioned kitchens did not receive natural light, but these are not part of the regulatory requirements.

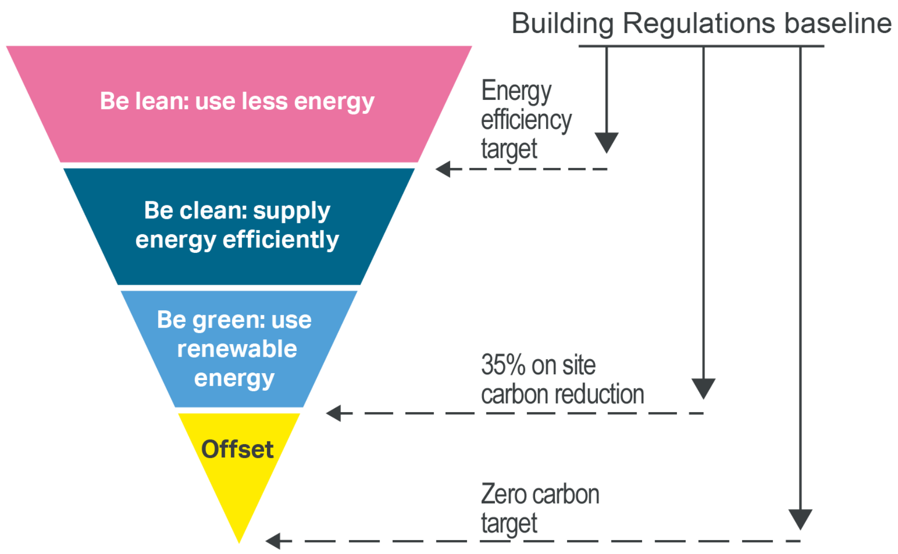
During Stage 3 design, QODA will analyse a wider range of rooms within the building to ensure good natural light access.

2.2 Compliance with Part L1A and Greater London Authority (GLA) Requirements

For newly designed and constructed residential buildings, a balance needs to be achieved between improving energy efficiency by designing low-energy dwellings at the lowest feasible running cost and providing healthy environments that ensure high thermal comfort levels for their occupants.

The regulatory framework for new residential buildings sets very demanding energy and CO_2 targets for new residential buildings, pushing developers and designers to go above and beyond common practice in order to achieve them. The current London Plan requires all new major domestic developments to achieve *'zero-carbon homes'*. '*Zero-carbon homes'* as defined by GLA require all major residential developments to achieve minimum of 35% CO_2 reduction over the Building Regulations (Part L 2013), by following the Energy Hierarchy of *'Be Lean', 'Be Clean' and 'Be Green'* and a cash-in-lieu contribution to the council to offset the remaining carbon emissions towards 100%.

On the basis of a dwelling-types modelling approach, the proposed design for Yiewsley goes above and beyond compliance with the mandatory 35% CO_2 reduction target and pushes design boundaries to achieve the highest feasible carbon dioxide offset.



Source: Greater London Authority

Figure 8: Energy Hierarchy Diagram (source: Great London Authority)

The new 'GLA Energy Assessment Guidance' that was released in March 2021, requires all new domestic developments to exceed Building Regulations requirements through demand reduction measures alone. It is noted that the new London Plan has set a target of 10% CO_2 improvement from energy efficiency measures alone. The design team for the proposed site has gone to significant efforts to find a range of measures that will deliver the required savings, without introducing unnecessary operational complexity or punitive costs. This effort results in a 20% CO_2 reduction at the *'Be Lean'* stage, demonstrating a very robust energy strategy that prioritises energy efficiency and a right mindset regarding future energy and carbon London targets.

2.3 Design Methodology

The challenging targets mentioned above require a range of design measures working in tandem. The energy design breaks into the following areas:

- Architectural design
- Building services
- Renewable energy systems

The design team has addressed these areas holistically. A number of key aspects that give rise to reduced demand and have been taken into consideration are highlighted below:

Be Lean

- Good fabric specification and air tightness
  - Increased insulation levels to opaque envelope (U-values of 0.15W/m^{2}K)
  - Double-glazed windows with low overall heat loss (U-value of 1.40W/m^{2}K and g-value of 0.50)
  - High efficiency mechanical ventilation with heat recovery for winter (Specific Fan Powers of <0.9 W/l/s and heat recovery efficiencies >93%)
  - Low thermal bridging losses (total dwelling Y-value of 0.075 W/K)
  - Low air leakage (<2 m3/h/m2)
- Communal gas boilers for space heating and domestic hot water (89.5% efficiency)
- Waste Water Heat recovery units in bathrooms with showers
- 100% Low-energy light fittings

Figure 9: Likely wall build-up to generate low U-values

The figure above illustrates a suitable method for achieving a U-value of 0.15W/m^{2}K, which is likely to be adopted for the design. This uses partial-fill mineral wool of around 200mm in thickness and represents a considerable upgrade in thermal performance over a regulations-compliant building, while maintaining the robust inner finish necessary, and allowing a brick outer leaf for architectural and durability reasons.

A variety of fabric upgrades have been designed into the scheme to ensure long-term energy savings, and further measures, such as triple glazing, will be investigated as the design progresses. This is reflected in Figure 10, where an 8.8% compliance with the Target Fabric Energy Efficiency is demonstrated on the proposed design.

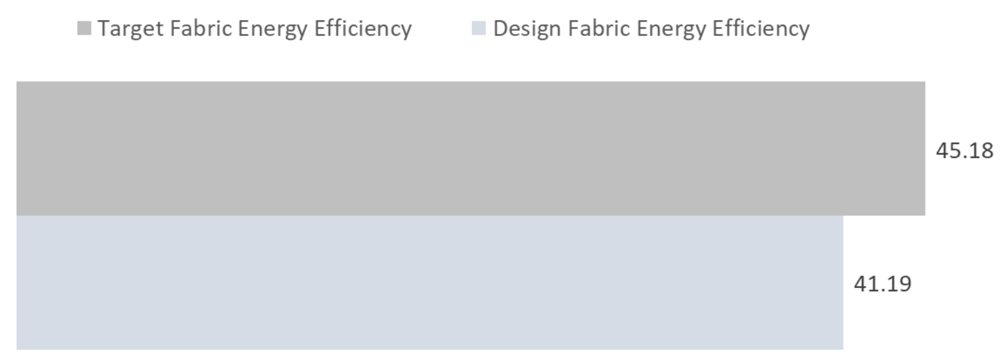


Figure 10: Fabric Energy Efficiency Compliance Graph (kWh/m²)

Be Green

- As above, plus…
- Communal highly efficient ground source heat pump for space heating and hot water (SCoP of 3.0)
- Additional immersion cylinder for top-up hot water in each dwelling
- 50kWp of south-facing PV panels to maximise the potential of on-site electricity production through renewable sources

Unfortunately, the UK Building Regulations Part L are known to allow a 'performance gap' between design intent (often stated in Stage 2 reports), and the resulting energy consumption experienced by building users after completion of construction. This is for a variety of reasons that have been widely discussed in the specialist press. For Yiewsley, the required carbon savings are measured against Part L, meaning that the design must be assessed rigorously against a limited or inaccurate baseline.

The proposed design was assessed using approved SAP software against the Part L1A requirements. Under this scheme of calculation, the Building Emission Rate (BER) must be more than 35% below the Target Emission Rate (TER) and as close as possible to 100%, in order to comply with the Part L requirements, set by GLA.

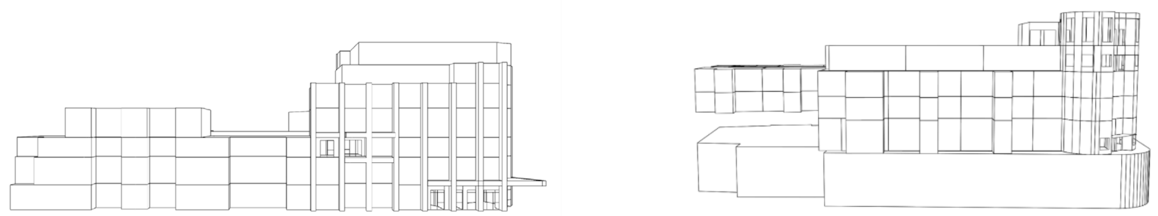


Figure 11: Visual of 3d Thermal Model of Representative Units of Yiewsley sites

SAP model replicate the geometrical characteristics of representative dwelling types of the proposed building, taking into consideration ground floor, midfloor and top floor units, different number of occupants and orientations. The design parameters that are fed in the SAP calculations include U-value fabric standards, building services systems and efficiencies (see full modelling assumptions in Appendix A at the end of this report). The SAP methodology excludes unregulated energy consumption as it only reports on regulated energy consumption on space heating, domestic hot water, ventilation lighting and electricity from pumps and circulation systems.

2.4 Overheating assessment

An initial thermal comfort assessment has been conducted on the proposed building design to assess the risk of summertime overheating. CIBSE TM59 *Design Methodology for the Assessment of Overheating Risk in Homes* (2017) has been used as a guide for what is regarded as acceptable thermal conditions.

Criterion 1 sets a limit on the number of hours the operative temperature can exceed the maximum comfort temperature:

T_{op} should not exceed T_{max} by more than 1 degree for more than 3% of occupied hours during the months of May to September.

Criterion 2 sets a daily limit on the length and severity the operative temperatures:

T_{op} should not exceed T_{max} by more than 6 degree-hours.

This means that, for example, T_{op} could exceed T_{max} by 1 degree for a maximum of 6 hours each day (i.e. 1 degree x 6 hours = 6 degree-hours), or by 2 degrees but only for 3 hours (i.e. 2 degrees x 3 hours = 6 degree-hours).

Criterion 3 sets an absolute upper temperature limit:

T_{op} should never exceed T_{max} by more than 4 degrees.

CIBSE TM59 is based on CIBSE TM52 in that it uses the "adaptive thermal comfort" methodology, which is based on research which shows that people adapt to the indoor temperature. This means that throughout the year there is no single fixed temperature that most people feel comfortable at, and instead the maximum comfort temperature (T_{max}) varies according to daily average outdoor temperatures.

For rooms that are predominantly **naturally ventilated**, compliance with TM59 is based on reference to the operative temperature (T_{op}), and the following two criteria must be met;

Criterion 1: for living rooms, kitchens and bedrooms

T_{op} should not exceed T_{max} by more than 1 degree for more than 3% of occupied hours during the months of May to September.

Criterion 1 will show which rooms frequently overheat. This is likely to happen in rooms where heat gains are not dissipated sufficiently and heat accumulates over several days. This is often the case for rooms which do not have a night cooling/ventilation strategy.

Criterion 2: For bedrooms only

T_{op} should not exceed 26°C for more than 1% of occupied hours from 10pm to 7am. 1% of annual hours between 10pm and 7am is 32 hours, so 33 or more hours above 26°C will be recorded as a fail.

Note that this standard does not seek to *prevent* overheating, but to limit it to within acceptable levels.

3 Results: CO2 emissions

The figures presented below are based on Hunters architectural drawings and are subject to change during detailed design.

As per the Part L1A calculations, the baseline Target Emissions Rate (TER) and Building Emissions Rate (BER) for each step of the energy hierarchy are as below separated by site:

Otterfield Road:

- TER = 15.9 $kgCO_2/m^2$ (54.8 tonnes/annum)
- BER (Be Lean) = 12.8 $kgCO_2/m^2$ (44.1 tonnes/annum)
- BER (Be Green) = 2.8 $kgCO_2/m^2$ (9.6 tonnes/annum)

Falling Lane:

- TER = 14.6 $kgCO_2/m^2$ (49.9 tonnes/annum)
- BER (Be Lean) = 11.5 $kgCO_2/m^2$ (39.3 tonnes/annum)
- BER (Be Green) = 2.3 $kgCO_2/m^2$ (7.8 tonnes/annum)

Table 2: Carbon Emission Rates and Reductions per Energy Hierarchy Step, Otterfield Road

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	54.8	-	
Be Lean	44.1	10.7	20%
Be Clean	44.1	0	0%
Be Green	9.6	34.5	63%
Cash contribution/Total reduction	£17,280		82%

Table 3: Carbon Emission Rates and Reductions per Energy Hierarchy Step, Falling Lane

	Total regulated emissions (Tonnes CO2 / year)	CO2 savings (Tonnes CO2 / year)	Percentage savings (%)
Part L 2013 baseline	49.9	-	
Be Lean	39.3	10.6	21%
Be Clean	39.3	0	0%
Be Green	7.8	31.5	63%
Cash contribution/Total reduction	£14,006		84%

In residential schemes, space heating and hot water are the most predominant of the total energy demand. Addressing these loads in a technically appropriate and economically feasible manner can provide substantial economic benefits and carbon savings.

An electric ground source heat pump operating on a community level with a shared loop has been examined. The latest GLA methodology allows for the use of recent carbon factors for grid electricity, which substantially changes the most cost-effective and carbon-offsetting route to achieve the above. With the significant decarbonization of the electricity grid, moving towards a predominantly electric space heating and hot water option would be beneficial.

Replacing gas boilers in the Be Green step of the Energy Hierarchy with a highly efficient ground source heat pump can provide substantial CO_2 savings, allowing the residential block to achieve an overall 82-84%% carbon dioxide reduction as opposed to the 37% reduction that was initially predicted by utilizing gas boilers for hot water at early-stage calculations.

Overall, for both sites together, the predicted carbon emissions drop from a TER value of 104.7 tonnes/annum to just 17.4 tonnes/annum for the designed scheme, using the Building Regulations assessment method SAP10. The total cash contribution to achieve net zero is £31,286.

4 Results: Summer overheating assessment using CIBSE TM59

Thermal modelling shows that restricted opening of windows 24-7 during summer periods, with the combination of mechanical background ventilation and internal shading is generally effective at controlling overheating.

The potential of omitting openable windows all together due to noise and air pollution levels of the site led us to investigate options that don’t allow for openable windows. This study has shown that even in such a scenario which is unlikely, the introduction of 300W of cooling can give a significant boost in the thermal comfort of the dwellings.

At this stage it is demonstrated that cooling is not a necessity to achieve compliance with the TM59 overheating criteria. However, this is subject to change, depending on the details of the acoustic and air quality reports of the site. As an additional point, it is commonly acknowledged that the UK climate is shifting vastly towards warmer levels, with future projections allowing for more extreme summers with extended heatwave occurrences and higher overall temperatures. In order to future-proof the dwellings for this scenario, we would suggest introducing cooling via cooling coils in the MVHR supply system which could be introduced in the current design or easily retrofitted in the future in the existing system if required.

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Appendix A: Energy and modelling assumptions

A.1 Fabric Assumptions:

Element	Description (Outside to Inside)	Cm Value	U-Value
Ground Floor	*TBC*	TBC	0.15 W/m².K
Exposed Floor	*TBC*	TBC	0.15 W/m².K
External Wall	*TBC*	TBC	0.15 W/m².K
Internal Wall	*TBC*	TBC	1.79 W/m².K
Internal Wall between heated and unheated space	*TBC*	TBC	0.15 W/m².K
Flat Roof	*TBC*	TBC	0.15 W/m².K
Windows/glazed door	*Double glazing (g-value 0.50, Tr= 0.6)*	-	1.4 W/m².K
Solid door to unheated space	*Composite door*	-	1.0 W/m².K
Thermal Mass	-	Medium	
Air tightness	*Air test required at end of construction*	2.0 m³/h.m² @50Pa	
Thermal bridging	*All junction*	ACD PSI value performance. Total Y-value of 0.075 W/K	

A.2 Mechanical Assumptions (Be Green):

Heating/Cooling	Proposed Design
Type	Community heating via Ground Source Heat Pump
Fuel	Electricity
ASHP efficiency	300
Distribution loss	Piping system => 1991, pre-insulated, low temp, variable flow
Controls	Charging system linked to use of community heating, programmer and at least two room thermostats
Domestic Hot Water	**Proposed Design**
Generator Type	From main heating with Immersion Cylinder
Fuel	Electricity
Generator Efficiency	300
Storage Volume	200
Cylinder Insulation	70mm
Waste Water Heat Recovery	RECOUP Pipe+HE Efficiency: 61.5%
Ventilation - MVHR	**Proposed Design**
MVHR	Zehnder ComfoAir 200 in each flat
MVHR Heat recovery	93%
Specific fan power (SFP)	0.91
Ductwork	Zehnder Comfotube Semi rigid

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A.3 Electrical Assumptions:

Lighting	Proposed Design
Efficiency	100% Low Energy fitting

A.4 Renewables:

Low/Zero Carbon Technology	Proposed Design
Photovoltaic panels	Power: 50 kWp fitted on Yiewsley per site Estimated output: 60 450 kWh/year Orientation: South Inclination: 30 Overshading: None or very little Moderately ventilated Modules

A.5 Solar and daylight assumptions

Element	Reflectance/Transmittance
Floors	*0.2*
Internal walls	*0.5*
Ceilings	*0.8*
Windows	*0.6 visible transmittance*
External elements	*0.4*

Appendix B: Overheating modelling assumptions and options

B.1 IES Dynamic Simulation

The following results of the overheating assessment have been derived from the dynamic simulation modelling software IES Virtual Environment which includes the CIBSE TM59 calculation tool. The model replicates the geometry of the proposed building design and parameters including U-value fabric standards, window openings and usage profiles were applied to the model. CIBSE Design Summer Year weather data for Swindon (the nearest suitable dataset) was used to represent a year with a hot summer, as defined by the TM52 and TM59 methodologies.

At this stage we have modelled 4 worst case dwellings including dwellings with single-aspect rooms, highly glazed south-facing areas and dwellings with limited shading from design elements such as balconies and vertically and horizontally extruded column and slab elements, as these are likely to have the highest risk of overheating.

These units include Unit 01, Unit 26, Unit 29 and Unit 33 as shown in Figure 12 and Figure 13.

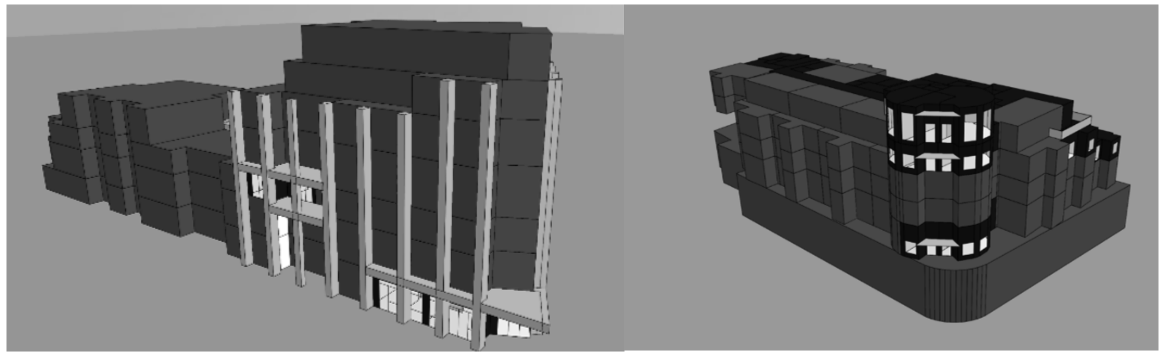


Figure 12: Sample Dwellings Selected for Overheating Modelling (southwest)

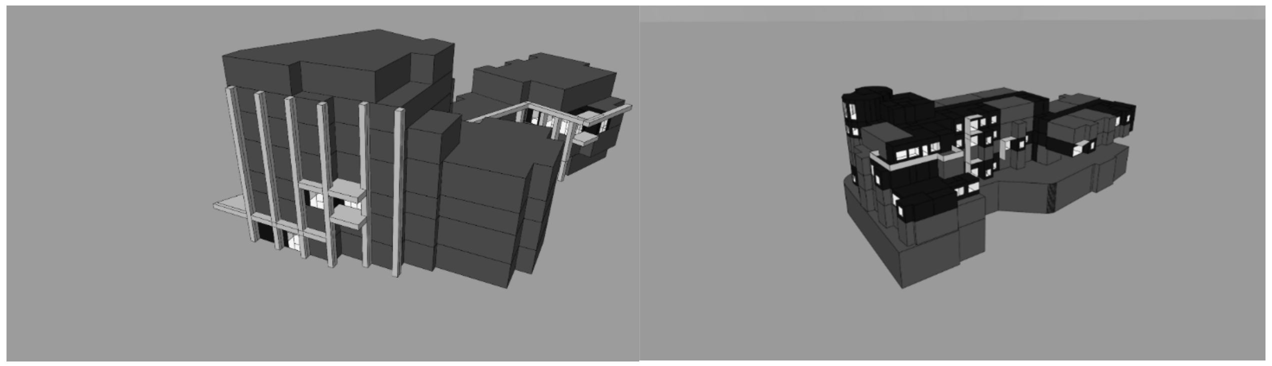


Figure 13: Sample Dwellings Selected for Overheating Modelling (south)

B.1.1 Fabric Performance

The fabric properties within the model are equivalent to the proposed performance standards given in the appendices. Notably, a concrete frame construction has been assumed, with cast concrete walls, floors and roof. Separating walls between flats and corridors are also assumed to be cavity walls with concrete blocks towards the residential side. This provides significant thermal mass to the building which will help alleviate overheating risk.

B.1.2 Internal Heat Gains

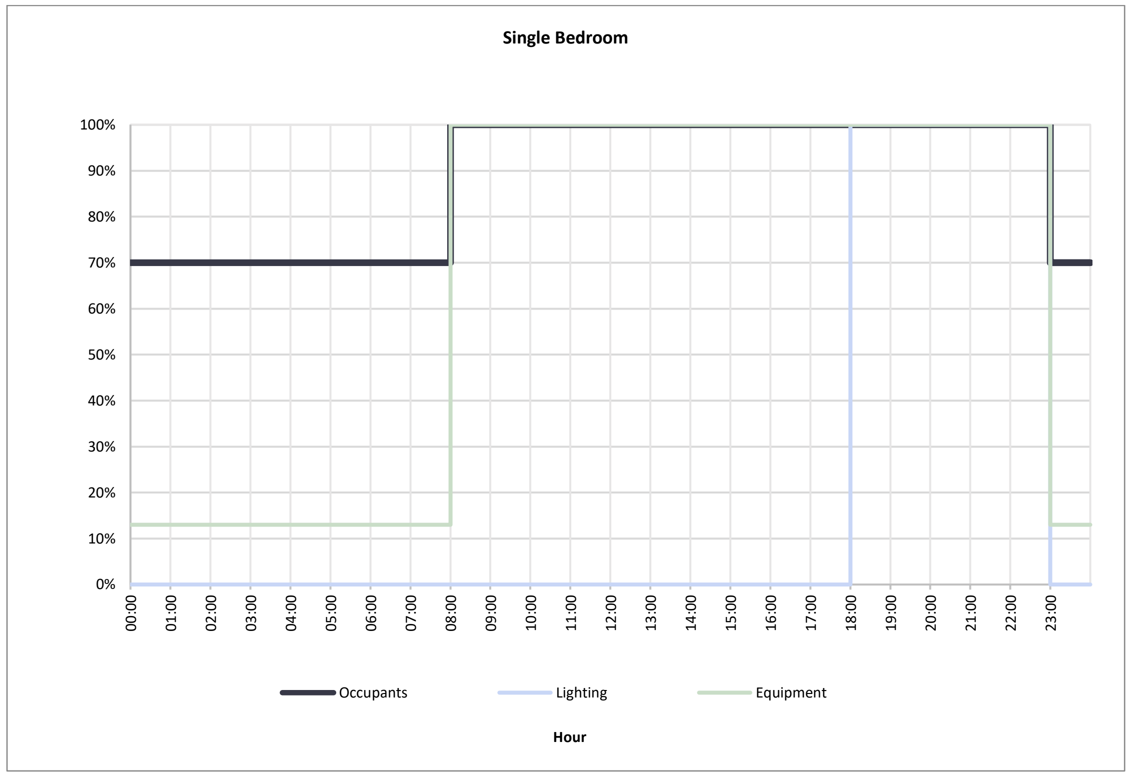
To undertake a thermal comfort assessment the internal heat gains of each room need to be accounted for. Heat gains from occupants, lighting and equipment have been calculated based on the intended usage of each room. Below is a breakdown of what has been assumed in each room:

Table 4: Assumed occupancy, lighting and equipment heat gains

Room Type	Occupancy # people	Lighting W/m²	Equipment W
Single Bedroom	1	TM59=2	TM59=80
Double Bedroom	2	TM59=2	TM59=80
1-Bedroom Apartment Living-room/Kitchen	2	TM59=2	TM59=450
2-Bedroom Apartment Living-room/Kitchen	2	TM59=2	TM59=450
3-Bedroom Apartment Living-room/Kitchen	3	TM59=2	TM59=450

*Heat losses from pipework running through first floor corridors have not been accounted for

The internal heat described above have been applied as profiles (based on TM59 standards) as shown below, to account for the variation in room use across the day.



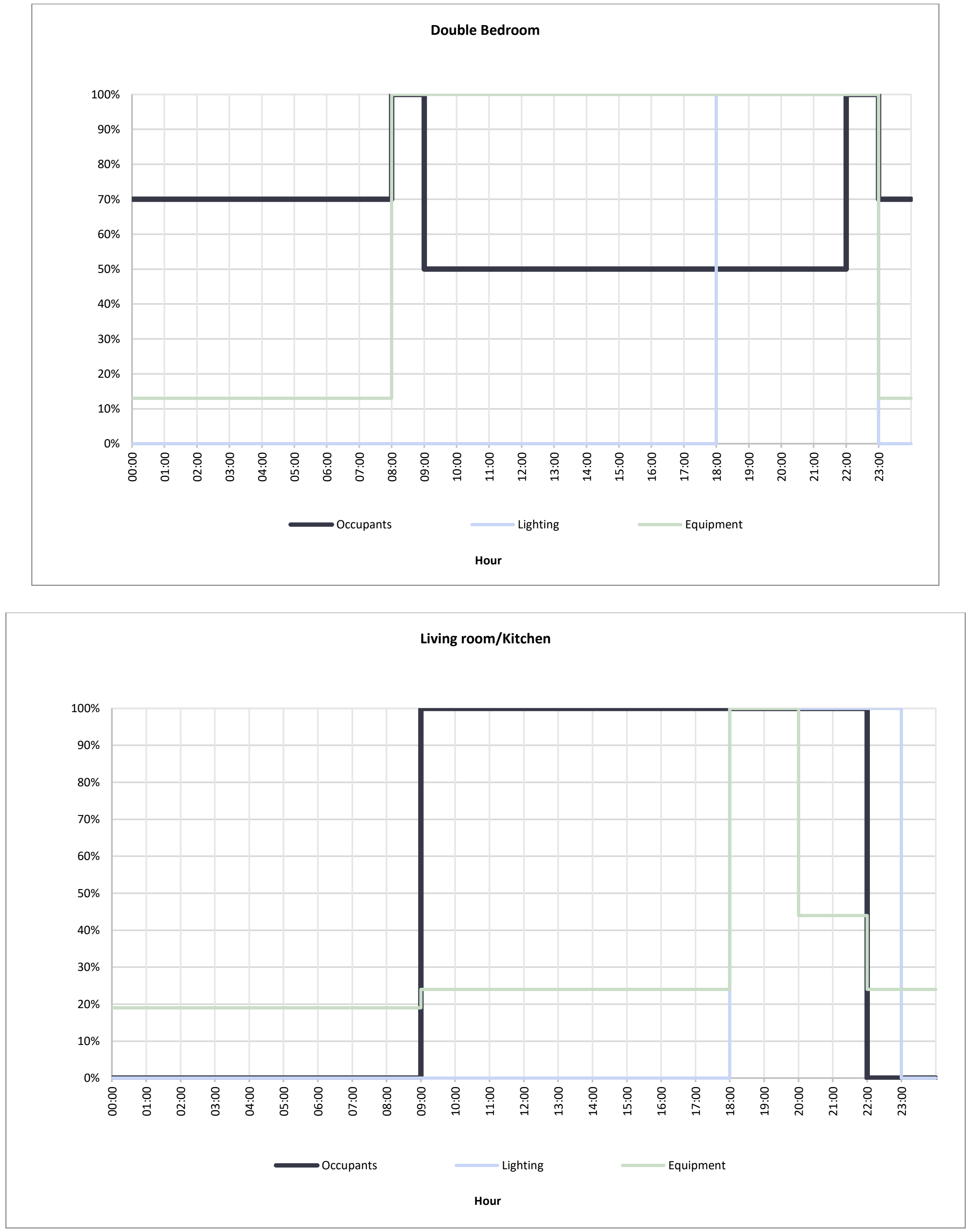


Figure 14: Standard daily profiles used in comfort modelling

B.1.3 Ventilation Strategy

The ventilation strategy for the building is;

- Mechanical ventilation with heat recovery (MVHR) providing fresh air for air quality
- Natural ventilation via opening windows to control summertime overheating.

The MVHR will also help in controlling overheating, but the significantly larger air flows are achievable by naturally ventilation.

Locations of opening windows are highlighted in yellow on **Error! Reference source not found.** overleaf. Windows are generally arranged as shown in Figure 16 below, with a bottom-hung opening above a fixed lower panel and fully openable balcony doors. This maximises the effective free area of the opening, since the open side of the window is not restricted by a sill.

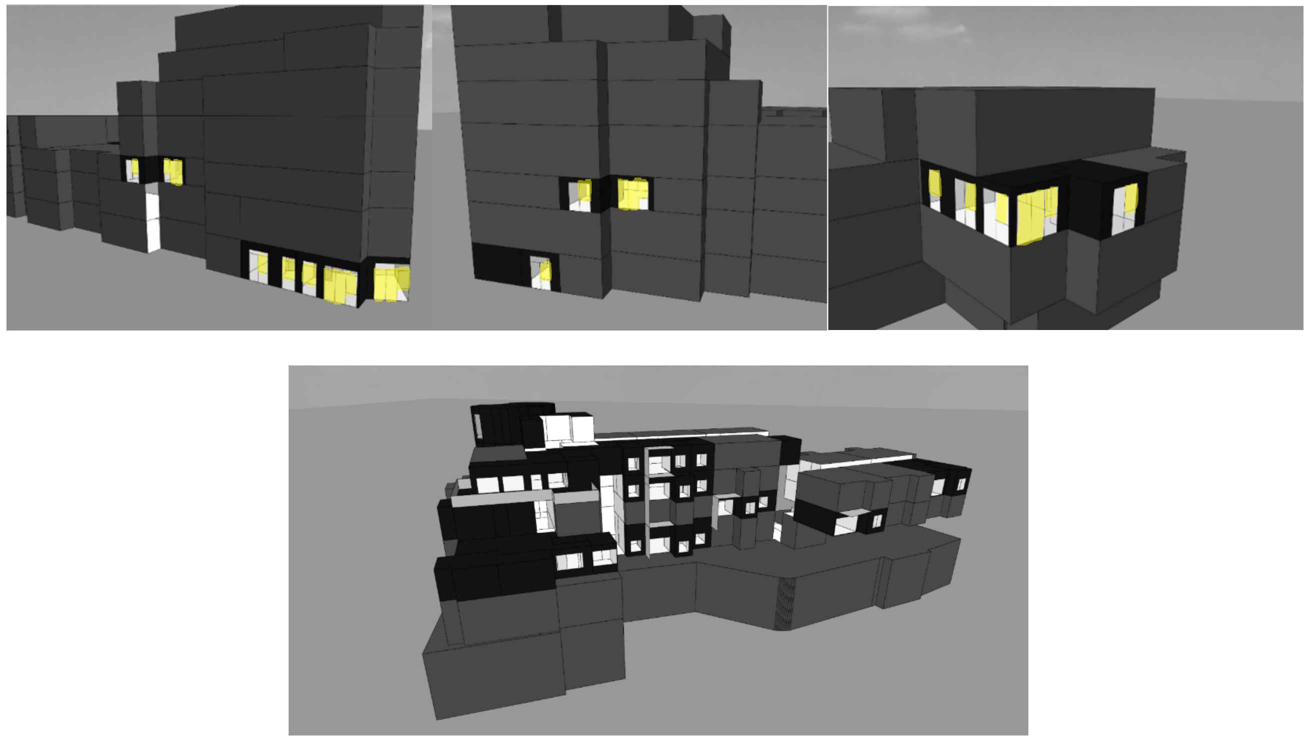


Figure 15: Locations of opening windows

Opening windows are modelled as follows:

- A 200mm restrictor has been assumed for all openable windows, giving an equivalent to a free area of around 25% to 29% depending on the dimensions of the windows.
- Balcony doors have also been assumed to open with a 200mm restrictor, giving an equivalent to a free area of 21%.
- Can be opened only when external temperature exceeds 12degC. This limits window opening during cooler weather, when cold draughts would result.
- Open when temperature exceeds 22degC internally.
- Are opened 24-7.

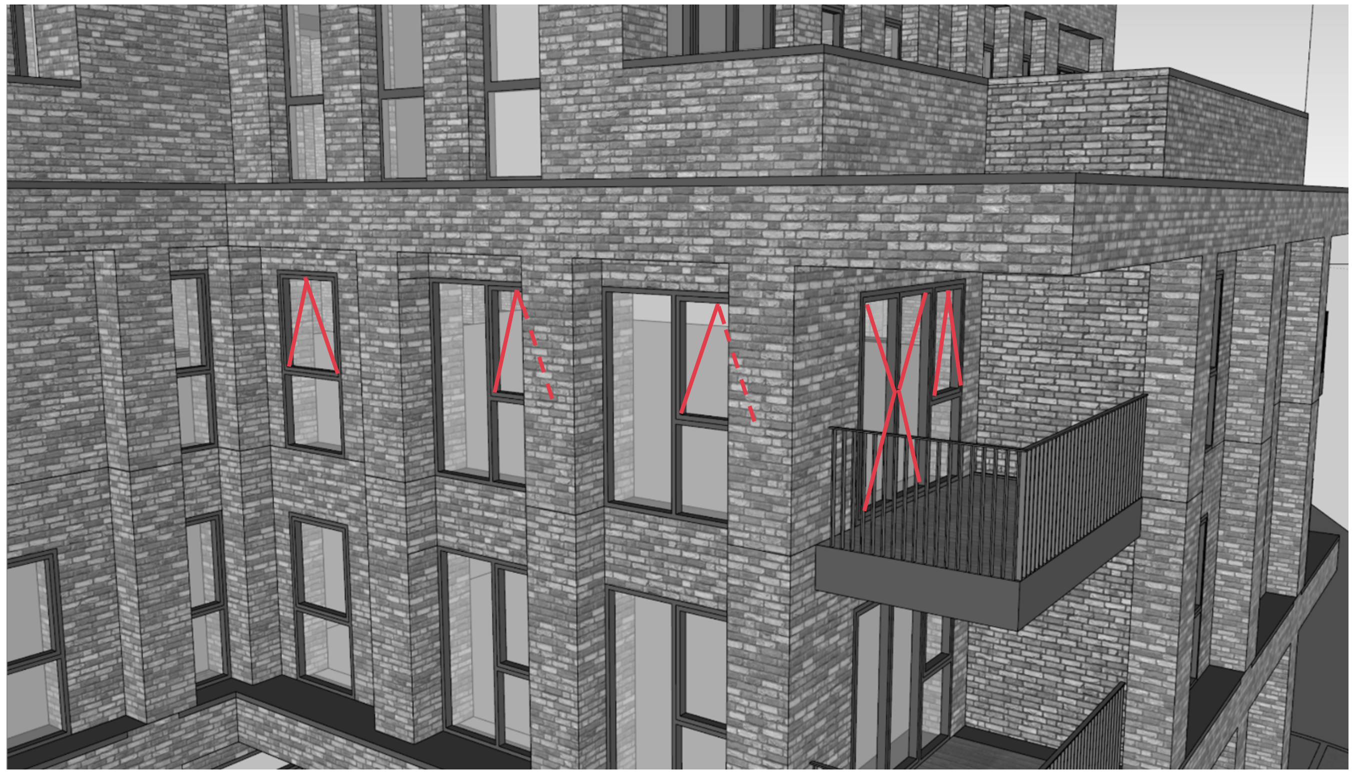


Figure 16: Window opening style

Figure 17: architectural render of facade shading measures

Facades have been designed with great care to allow control of solar gain and prevention of overheating, alongside the window opening and ventilation strategy.

Falling Lane:

A horizontal array of fixed brise-soleil on the top floor blocks high angle summer sun to prevent overheating but allows penetration of winter solar gains at lower angles for occupant health and wellbeing, as well as passive solar gains. External sliding shutters on the south-east and south facades allow occupants to control solar gain levels, for example blocking sun out on a hot summer day, or when they plan to be out of the building for a period of time.

Otterfield Road:

Similarly, Otterfield Road has external sliding shutters on south elevations, again allowing occupant control of solar gain and comfort levels.

Note on Window Openings

All openable windows have 950mm high fixed panels beneath them, and all balcony doors are protected by balcony balustrades. We have assumed that windows can be opened with a 200mm restrictor mainly for security reasons, in order to allow for windows being opened 24-7- as windows left open could present opportunities for intruders.

Other issues that need to be considered are:

- Blinds should be provided for glare control but should not hinder airflow through opening windows. This can be achieved by mounting the blinds to the frame of the opening casement, rather than the fixed frame element. Currently blinds have been excluded from the analysis.
- Curtains- can restrict airflow at night, preventing effective night purge and air movement within bedrooms.

We note that the inset balconies along with the vertical and horizontal design features on the facades that can be seen in Figure 16, allow for additional shading that is beneficial to the overall thermal performance. The majority of the worst-case dwellings that have been modelled, do not have the benefit of these design features, meaning that the solar exposure is greater, leading to significantly more solar gains within the occupied zones, as shown in Figure 17 below.

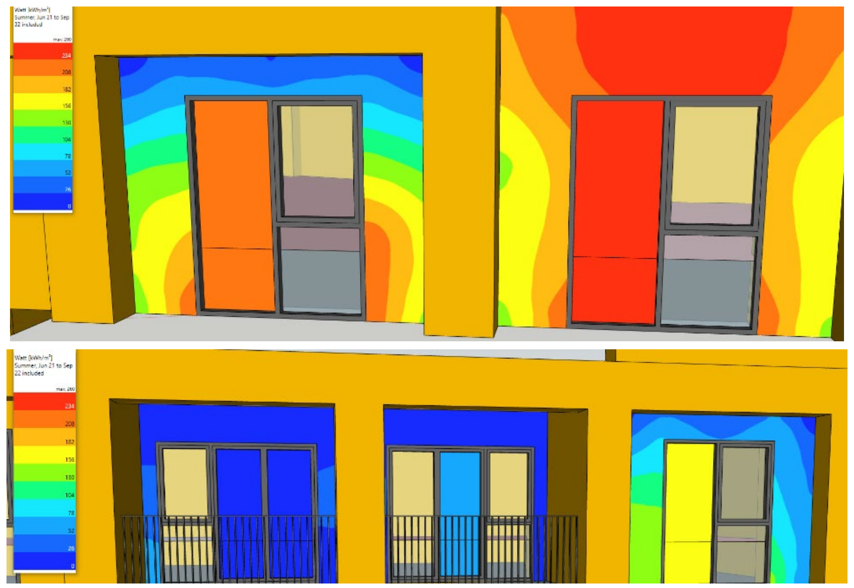


Figure 18: Summer Solar Exposure of Facades with and without Shading Features

B.1.4 Impact of External noise & air quality

There are several roads near to the Falling Lane site, which will require further acoustic investigation during detailed design to ensure occupant comfort. Due to the proximity of the site to Heathrow airport, it is expected that throughout the day there will be incidents of high decibel levels. On that basis we have allowed for partly openable windows, in order to reduce the external noise levels that penetrate the occupied spaces. Once details noise and air quality reports have been received, the strategy will be updated to address further potential restrictions.

In the case where noise levels exceed the acceptable thresholds, fully opening windows, especially during occupied hours would be restricted for the purposes of the overheating mitigation exercise. If this is insufficient, some possible solutions would be:

- Provision of acoustically attenuated openings.
- Cooling introduced through the ventilation system- although this is unlikely to be enough on its own.
- Full comfort cooling- something to be avoided because of the high capital costs, maintenance and implications for building energy use.

External air pollution is not expected to be at high levels, due to the absence of heavy traffic roads in the proximity of the site. Appropriate filtration would be specified in all mechanical ventilation systems to ensure good air quality.

B.1.5 Results, Simulation 1: Natural Ventilation (200mm Restrictors), 40l/s Mechanical Ventilation

With the design parameters outlined above (no internal blinds), and the introduction of 40l/s of mechanical ventilation, four out of eleven tested rooms failed against the TM59 criteria, as shown on Figure 18. The rooms are listed below:

- Unit 01_Bedroom 3 (8 hours above threshold for Criterion 2)
- Unit 01_Livingroom/Kitchen (0.8% above threshold for Criterion 1)
- Unit 29_Bedroom 1 (2 hours above threshold for Criterion 2)
- Unit 33_Livingroom/Kitchen (0.5% above threshold for Criterion 1)

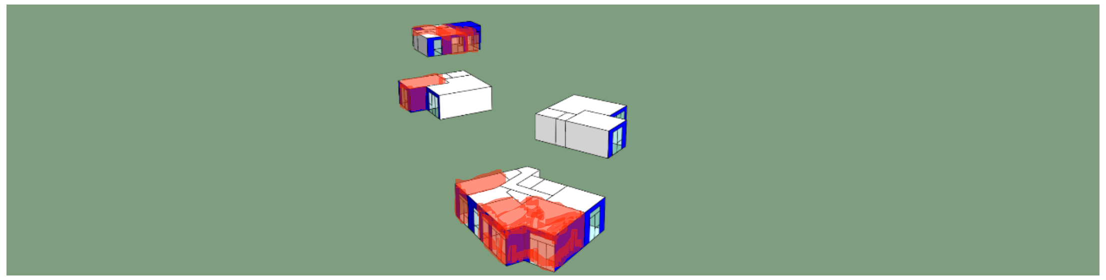


Figure 19: Failing Rooms for Overheating Simulation 1

B.1.6 Results, Simulation 2: Natural Ventilation (200mm Restrictors), 80l/s Mechanical Ventilation

With the design parameters outlined above (no internal blinds), and the introduction of 80l/s of mechanical ventilation, two out of eleven tested rooms failed against the TM59 criteria, as shown on Figure 19. The rooms are listed below:

- Unit 01_Livingroom/Kitchen (0.9% above threshold for Criterion 1)
- Unit 33_Livingroom/Kitchen (0.4% above threshold for Criterion 1)

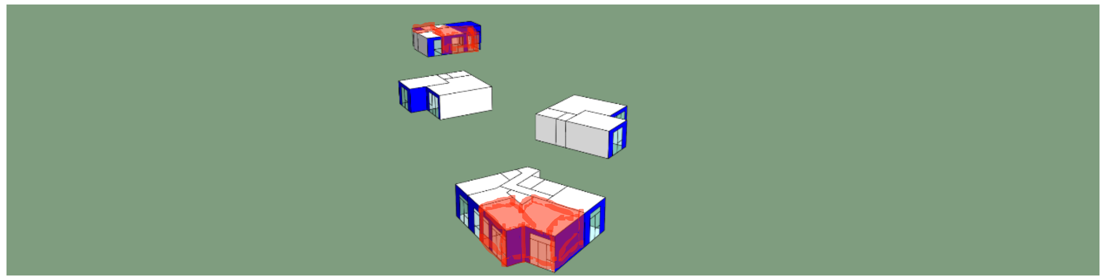


Figure 20: Failing Rooms for Overheating Simulation 2

B.1.7 Results, Simulation 3: 40l/s Mechanical Ventilation and 300W of Cooling

In this scenario we have reverted back to 40l/s of mechanical ventilation without any natural ventilation or internal blinds and introduced 300W of cooling for the entire dwelling. As a result, eight out of eleven tested rooms failed against the TM59 criteria, as shown on Figure 20Figure 18.

- Unit 01_Bedroom 1 (52 hours above threshold for Criterion 2)
- Unit 01_Bedroom 2 (1.5% above threshold for criterion 1 and 22 hours above threshold for Criterion 2)
- Unit 01_Bedroom 3 (2.7% above threshold for criterion 1 and 62 hours above threshold for Criterion 2)
- Unit 01_Livingroom/Kitchen (13.4% above threshold for Criterion 1)
- Unit 26_Bedroom 1 (14 hours above threshold for Criterion 2)
- Unit 29_Bedroom 1(1.8% above threshold for criterion 1 and 38 hours above threshold for Criterion 2)
- Unit 33_Bedroom 1 (33 hours above threshold for Criterion 2)
- Unit 33_Livingroom/Kitchen (5.6% above threshold for Criterion 1)

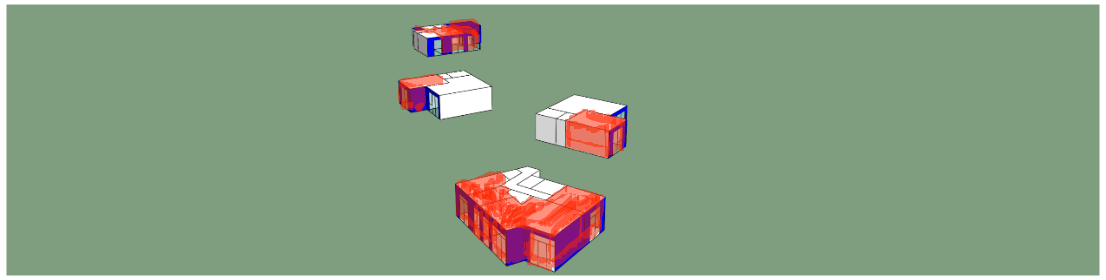


Figure 21: Failing Rooms for Overheating Simulation 3

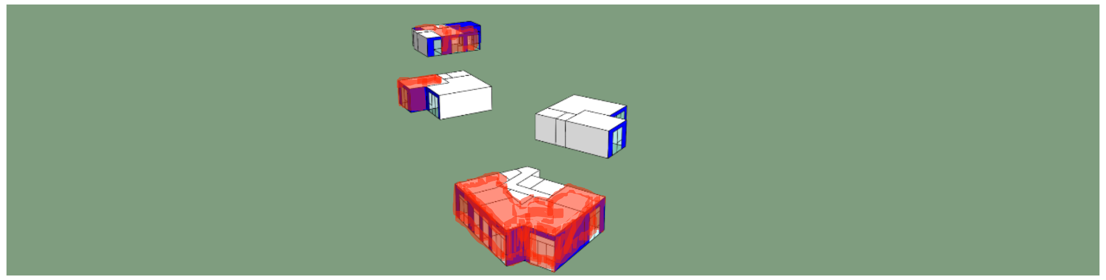
B.1.8 Results, Simulation 4: 40l/s Mechanical Ventilation and 600W of Cooling

In this scenario we have reverted kept mechanical ventilation levels at 40l/s of again without any natural ventilation or internal blinds and introduced 600W of cooling for the entire dwelling. As a result, six out of eleven tested rooms failed against the TM59 criteria, as shown on Figure 21.

- Unit 01_Bedroom 1 (24 hours above threshold for Criterion 2)
- Unit 01_Bedroom 2 (0.1% above threshold for criterion 1)
- Unit 01_Bedroom 3 (2.3% above threshold for criterion 1 and 42 hours above threshold for Criterion 2)
- Unit 01_Livingroom/Kitchen (8.7% above threshold for Criterion 1)
- Unit 29_Bedroom 1(1.5% above threshold for criterion 1 and 12 hours above threshold for Criterion 2)

- Unit 33_Livingroom/Kitchen (1% above threshold for Criterion 1)

Figure 22: Failing Rooms for Overheating Simulation 4



B.1.9 Results, Simulation 5: 40l/s Mechanical Ventilation, 300W of Cooling and Internal Blinds

All of the scenarios presented above were tested with internal blinds as well. The addition of internal shading in all of these scenarios had as a result all of the simulated rooms to pass both Criteria of the TM59 methodology.

As an example we have presented a case with 40l/s of mechanical ventilation without any natural ventilation but with internal blinds and 300W of cooling for the entire dwelling. The results for this scenario are presented below:

- Unit 01_Bedroom 1 (0.1% Criterion 1, 19 hours Criterion 2)
- Unit 01_Bedroom 2 (0.2% Criterion 1, 13 hours Criterion 2)
- Unit 01_Bedroom 3 (0.4% Criterion 1, 22 hours Criterion 2)
- Unit 01_Livingroom/Kitchen (0.1% Criterion 1, Criterion 2 n/a)
- Unit 26_Bedroom 1 (0.2% Criterion 1, 12 hours Criterion 2)
- Unit 26_Livingroom/Kitchen (0% Criterion 1, Criterion 2 n/a)
- Unit 29_Bedroom 1 (0.3% Criterion 1, 13 hours Criterion 2)
- Unit 29_Livingroom/Kitchen (0% Criterion 1, Criterion 2 n/a)
- Unit 33_Bedroom 1 (0.2% Criterion 1, 18 hours Criterion 2)
- Unit 33_Bedroom 2 (0.1% Criterion 1, 10 hours Criterion 2)
- Unit 33_Livingroom/Kitchen (0.2% Criterion 1, Criterion 2 n/a)

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