London Borough of Camden

Bacton Low Rise Redevelopment, London
Energy Strategy
29/09/2016 Revision 00
SUSTAINABILITY

Audit sheet

Rev.	Date	Description	Prepared	Verified
00	29/09/2016	For Submission	T. Wigg	R. Harper

Contents

1. Executive summary

The Application

This strategy has been prepared on behalf of London Borough of Camden (the Applicant), in support of a minor material amendment (MMA) to the original planning permission for Bacton Low Rise Redevelopment, (the Proposed Development). The Proposed Development is sited within the London Borough of Camden.

Policies & Drivers

This document summarises the pertinent policies and requirements applicable to the Proposed Development. Of these, the principal target is to achieve a reduction in regulated CO_2 emissions of 35% beyond the requirements of the Building Regulations Part L (2013), as set out in London Plan Policy 5.2 and the requirements of the Building Regulations Part L (2013) for fabric energy efficiency.

The dwellings are also aiming to achieve Part L (2013) compliance at the 'Be Lean' stage and a Code for Sustainable Homes (CfSH) score that is at the level of a 'Level 4' rating.

The credit for CO_2 emissions reductions in the CfSH requires a mandatory 19% reduction in CO_2 emissions beyond Part L1A 2013 to meet the minimum Level 4 standard. This is required for a dwelling to be certified at 'Level 4'. However, if the connection to the Royal Free network is not available at the point of CfSH certification then it cannot be used in the calculations and the required 19% will not be met through the use of high efficiency gas fired boilers. In this instance it would be necessary for the Proposed Development to be given flexibility to reduce the target appropriately in the Energy category, whilst maintaining the targeted credits in the other categories of the CfSH.

Approach

Phase 1 dwellings have been excluded from the assessment for this MMA as they are not subject to changes to the design and remain as per the approved Energy Strategy Report by Rolton Group Limited Ref 12-0083 XRP004 Issue 3 dated April 2014. The Phase 1 dwellings are to achieve a target of 32% reduction against the Part L 2010 baseline.

The residential elements of Phase 2 of the Proposed Development have been assessed using Part L1A 2013 approved SAP v9.92 (2012) methodology. Non-residential spaces have been benchmarked using Part L 2013 compliant results from similar building types.

This has provided the basis for the analysis of the designed building and services and the consideration of all applicable passive design, energy efficiency and Low or Zero Carbon (LZC) technologies.

The assessment makes use of the Mayor of London's Energy Hierarchy, shown in Figure 1.1 and the cooling hierarchy from the London Plan (MALP March 2016).

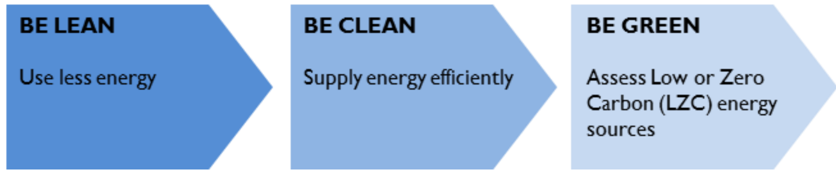

Figure 1.1: Energy Hierarchy

Be Lean - Passive Design & Energy Efficiency Measures

Passive design measures to be implemented at the Proposed Development include:

a. Suitable glazing ratio and glass g-value to balance heat losses, heat gains and daylight ingress
b. Fabric insulation levels achieving improvements over Building Regulations Part L (2013) requirements of 25% - 100%
c. Fabric air permeability achieving improvements over Building Regulations Part L (2013) requirements of 70% and 50% for dwellings and commercial spaces respectively

Energy efficiency measures to be implemented at the Proposed Development include:

a. Efficient space heating systems with zonal, programmable and thermostatic controls, with separate programmer for hot water
b. Efficient low-energy lighting throughout all dwellings. External and communal lighting will be coupled to daylight and presence detection sensors to minimise unnecessary use
c. Efficient mechanical ventilation with heat recovery which will limit the need for space heating in winter months, aid the mitigation of high internal temperatures in summer months (where openable windows cannot be used due to ambient acoustic conditions), and maintain good indoor air quality
d. Appropriately insulated pipework and ductwork (and air sealing to ductwork) to minimise losses and gains
e. Variable speed pumps and fans to minimise energy consumption for distribution of services

These measures are anticipated to achieve a **4.5%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline'.

As a result, the Proposed Development will achieve compliance with the anticipated requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

Be Clean - Infrastructure and Low-Carbon Supply of Energy

The Site is located within the vicinity of an existing heat network, specifically the Royal Free Heat Network that is operated by London Borough of Camden and is supplied with heat from the Royal Free Hospital. London Borough of Camden have advised that connection to the network will be suitable for this development and as a result this is the strategy presented at the Be Clean stage. The assumed carbon factor of heat delivered by the network is $0.11kgCO_2/kWh$.

In this mode of operation, it is expected that a reduction in regulated CO_2 emissions of 102 tonnes per annum can be achieved. This is equivalent to a further **32.4%** reduction in CO_2 emissions beyond the requirements of the Building Regulations Part L 2013 baseline.

The Proposed Development has been assessed for CO_2 emissions reductions at the Be Clean stage with a potential CHP engine on site, although Camden have advised that selection of a CHP engine is not suitable for this site due to the size of the development and the lack of non-dwelling floor areas that would make use of the electricity. The proposed development has also been assessed with centralised high efficiency gas boilers providing the thermal demand.

Be Green - On-Site Renewable Energy Generation

The inclusion of on-site renewable energy generation has been assessed. However, the nature of the current plans to service the development with the Royal Free heat network has discounted many technologies and the ability to install technologies onto the buildings is limited due to the required consideration of access to roofs of occupied dwellings for maintenance. Therefore it is currently anticipated that the proposed development will not include on-site renewable energy generation.

Overall Carbon Dioxide Emissions Reduction

A summary of the anticipated CO_2 emissions and reduction at each step of the energy hierarchy is given in Figure 1.2. The Proposed Development achieves an overall **37%** reduction in CO_2 emissions.

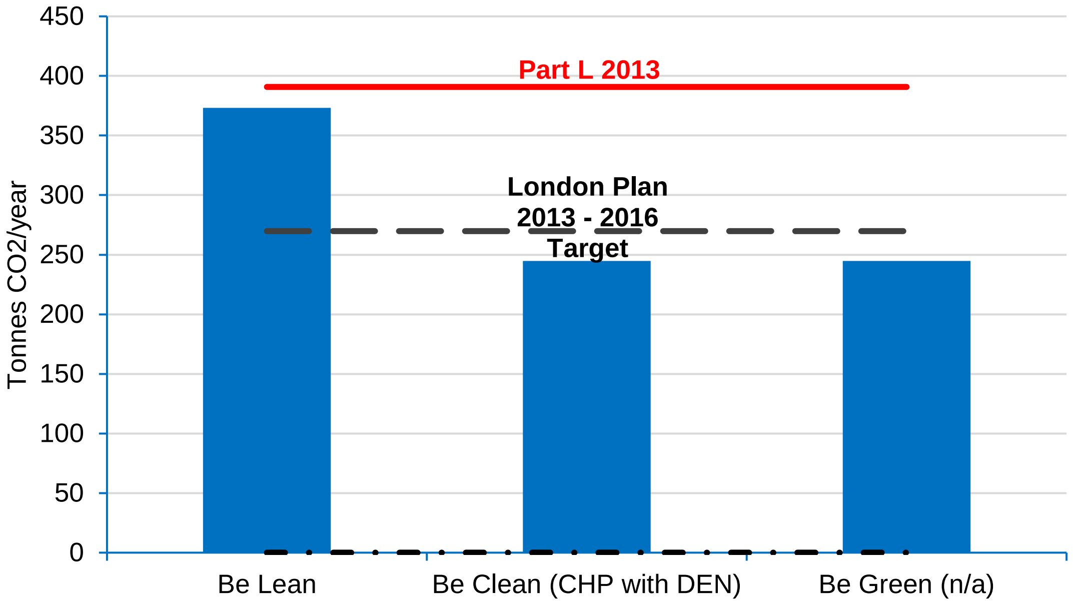

Figure 1.2: Summary of Regulated CO_2 Emissions Reduction.

Minimising Cooling Demand and Limiting the Effects of Heat Gains in Summer Months

The Proposed Development has been designed in accordance with the cooling hierarchy to minimise cooling demand and has been designed without cooling to the dwellings and to limit the likelihood of high internal temperatures. Mitigation measures such as an appropriate glazing ratio and g-value, light coloured internal blinds, high levels of insulation and minimisation of thermal heat gains are targeted.

Through these measures, the relevant areas of the Proposed Development will achieve compliance with Criterion Three of the Building Regulations Part L (2013). The cooling requirement at the Proposed Development at the non-dwellings has been minimised, representing approximately 1% of the overall energy requirement.

In addition to the Criterion 3 compliance calculations outlined above, an overheating risk assessment has been carried out for the dwellings. The risk assessments have been undertaken using the CIBSE Design Summer Year 2005 weather file and the London Heathrow Weather file (LHR) 1989 weather file, in accordance with requirements outlined in CIBSE TM49 'Design Summer Years for London'. The results for the overheating assessment are outlined in Appendix D.

CIBSE Guide A presents results of tests of a number of occupied hours during the summer months that the dwellings exceed 26ºC.

CIBSE TM52 follows the 'adaptive thermal comfort model' which works on the basis that in free running buildings (i.e. not mechanically ventilated or cooled), people will accept higher internal temperatures during parts of the year that are also hot outside.

Using mechanical ventilation alone the building exceeds the criteria of CIBSE Guide A in all dwelling areas, but CIBSE TM52 criteria is able to be met in 90% of the dwelling areas that have been assessed.

When natural ventilation is used (opening windows) 65% of the dwellings assessed meet the criteria of CIBSE Guide A and 95% meet the criteria of CIBSE TM52. In this scenario the dwellings are using opening windows with an opening of 20degrees to represent tilt and turn windows that would allow for the dwellings to remain secure whilst being ventilated. The windows are modelled to be open at all times.

Where dwellings on the site are able to make use of opening windows without disturbance from external noise they are more likely to meet the criteria of CIBSE guide A and TM52.

When using mechanical ventilation and natural ventilation the windows are modelled to be open during the day to provide ventilation whilst the occupants are out or when the sensitivity to noise is reduced. During the night when the sensitivity to noise is likely to be greater, the windows are modelled as closed and the mechanical ventilation is used. In this scenario 90% of the dwellings do not meet the CIBSE Guide A criteria. However, 90% of spaces do meet the criteria of CIBSE TM52 in this scenario.

Also presented in appendix D are the results for the 'notional baseline' model. This assumes internal gains (and profiles), occupancy schedules and building fabric of the notional building (as given by Part L1A of the building regulations and the National Calculation Methodology), results in the 'notional baseline' building significantly exceed the criteria of the various CIBSE guides, i.e. Guide A and TM52.

The results of the tests with the notional building parameters shows that none of the spaces achieve CIBSE Guide A criteria. This is the same as the actual building result. However, in the actual building results 7 spaces were only marginal fails (less than 6% of occupied hours exceeding 26ºC) compared to only 2 marginal fails with notional parameters. With notional parameters for CIBSE TM52 criteria only 6 spaces in the assessed dwellings achieve the criteria. In the actual building this was significantly higher at 25 spaces. This represents and improvement of approximately 70% over the notional building performance.

This comparison of notional and actual building results are using mechanical ventilation. Where it is possible for dwellings to make use of natural ventilation or mechanical and natural ventilation the results of the actual building are significantly better than the notional building.

Therefore, the anticipated design and servicing strategy of the Proposed Development is a significant improvement over the 'notional baseline' model and reflects the attention given to mitigate overheating risk for the building occupants.

CIBSE Guide A 2015 and CIBSE TM52	DSY 2005		LHR 1989	
	Guide A	TM52	Guide A	TM52
Notional Building	0/28 Meet Criteria	6/28 Meet criteria	0/28 Meet criteria	4/28 Meet criteria
1. Mechanical Ventilation only	0/28 Meet criteria	25/28 Meet Criteria	0/28 Meet criteria	10/28 Meet Criteria
2. Natural Vent. only	18/28 Meet criteria	27/28 Meet Criteria	18/28 meet criteria	27/28 Meet Criteria
3. Mechanical Ventilation and Natural Vent.	1/28 Meet criteria	25/28 Meet Criteria	0/28 Meet criteria	25/28 Meet Criteria

Table 4.12: Summary of Results.

In order to mitigate overheating at the proposed development the design has incorporated tilt and turn windows to allow for occupants to leave windows open during the day without concerns for security to allow natural ventilation of the dwellings when they are unoccupied or less sensitive to disturbance from external noise. These windows allow the occupants to fully open them to maximise the ventilation rate when appropriate and will likely result in further mitigation of overheating risk.

Light coloured blinds have been specified for all of the dwellings to allow occupants to reduce solar gain during the day. External shading is also provided by the inset glazing on balconies. Glazing is specified with a low g-value of 0.35 to reduce solar gain.

2. Introduction

2.1 The Application

This strategy has been prepared on behalf of London Borough of Camden (the Applicant), in support of a planning application for Bacton Low Rise Redevelopment, (the Proposed Development). The Proposed Development is sited within the London Borough of Camden.

Development Description

Variation of conditions 3 (detailed drawings), 7 (refuse & recycling), 9 (cycle storage), 10 (car parking), 11 (Electric vehicle charging points), 12 (car club bay), 13 (motorcycle parking), 23 (Wheelchair units), 25 (contaminated land measures), 26 (biodiverse roofs), 27 (bird and bat details), 28 (lighting strategy), 29 (landscaping details), 32 (building foundations), 34 (drainage details), 36 (CCTV strategy), 37 (car club parking), 40 (re-appraisal of financial viability), 43 (energy efficiency), 44 (code for sustainable homes), 45 (car free), 47 (construction management plan) and 58 and 59 (approved plans) of planning permission 2012/6338/P dated 25/04/2013 (as amended by planning permissions 2014/3633/P and 2015/1189/P) (for the redevelopment of Bacton Low Rise Estate, Gospel Oak District Housing Office and Vicar's Road workshops following the demolition of all existing buildings, to provide a total of 294 residential units and associated works), namely to; provide 20 additional Class C3 residential units (19 market and 1 intermediate units), alter the housing mix, reconfigure the employment floorspace, deliver the outstanding parts of the development as a single phase, various external alterations and reconfigurations, revise the on-site car parking provision and the amount of cycle storage, and associated works.

Site Context

The site is located in north London, within the London Borough of Camden and within the Gospel Oak ward. The site is bound to the north by the mainline railway line which runs between Kentish Town and West Hampstead, to the east by Vicars Road and Wellesley Road, to the south by Wellesley Road and to the west by Haverstock Road.

Aim

The aim of this strategy is to detail a robust energy demand reduction and supply strategy to enable the Proposed Development to meet the targets set out in the Proposed Development Plan.

Approach

This strategy follows the Mayor's energy hierarchy: 'be lean - be clean - be green'.

Calculations demonstrating the energy requirements and associated CO_2 emissions for dwellings have been carried out using Building Regulations Part L1A approved SAP 2012 v9.92 methodology. A sample of typical dwelling types have been assessed to represent the whole development.

Calculations demonstrating the energy requirements and associated CO_2 emissions for commercial uses have been carried out using benchmarks from similar Part L2A 2013 compliant buildings.

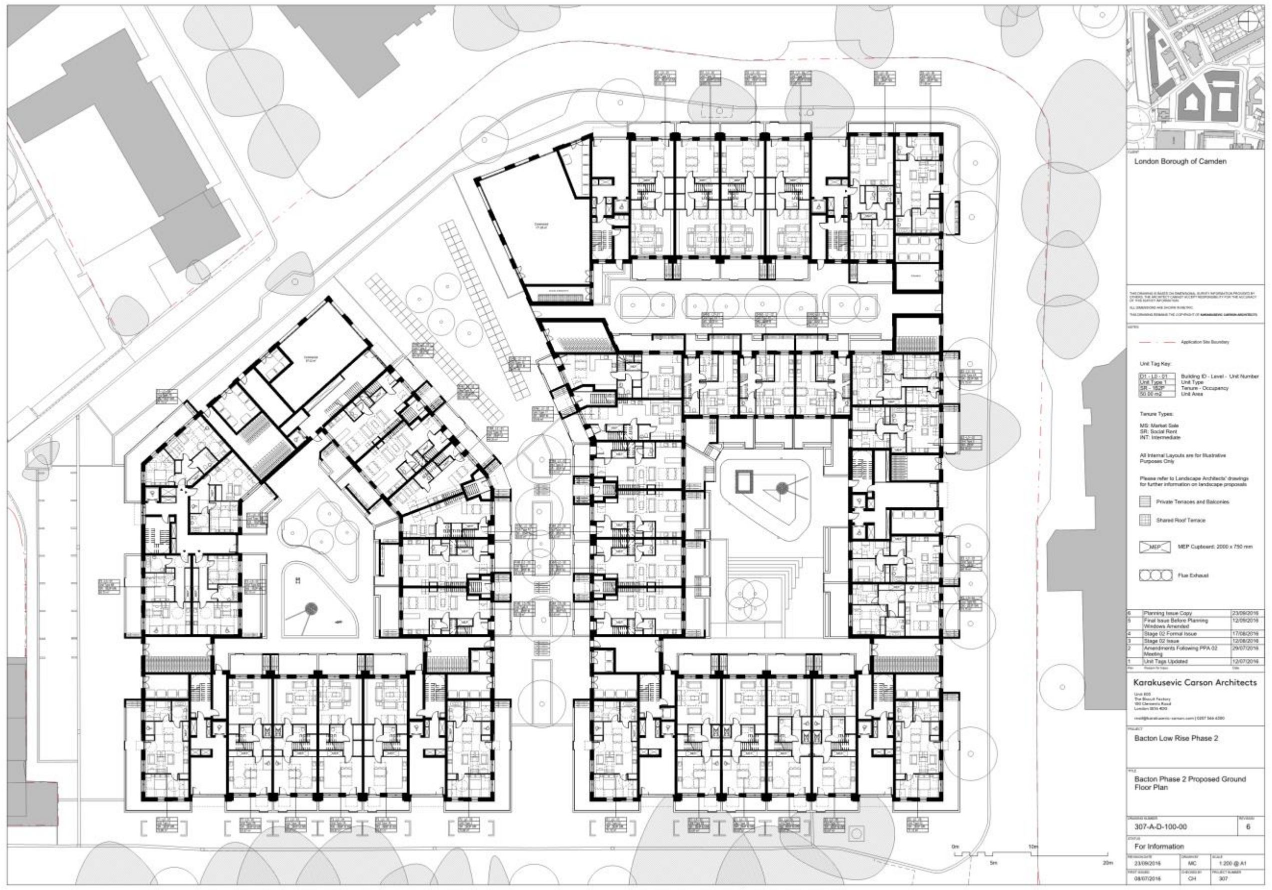

Figure 2.1: Ground Floor Plan

3. Approach and Methodology

3.1 Definitions and Limitations

Definitions

The following definitions should be understood throughout this strategy:

- **Energy demand** – the 'room-side' amount of energy which must be input to a space to achieve comfortable conditions. In the context of space heating, this is the amount of heat which is emitted by a radiator, or other heat delivery mechanism.
- **Energy requirement** – the 'system-side' requirement for energy (fuel). In the context of a space heating system using a gas boiler, this is the amount of energy combusted (e.g. gas) to generate useful heat (i.e. the energy demand).
- **Regulated CO_2 emissions** – the CO_2 emissions emitted as a result of the combustion of fuel, or 'consumption' of electricity from the grid, associated with regulated sources (those controlled by Part L of the Building Regulations).

Limitations

The appraisals within this strategy are based on Part L calculation methodology and should not be understood as a predictive assessment of likely future energy requirements or otherwise. Occupants may operate their systems differently, and / or the weather may be different from the assumptions made by Part L approved calculation methods, leading to differing energy requirements.

3.2 Energy Hierarchy

This strategy outlines how the Proposed Development could have a reduced effect on climate change by reducing CO_2 emissions associated with energy use in buildings.

Figure 3.1 outlines the route followed by the Proposed Development when reducing CO_2 emissions and defines the structure of this statement.

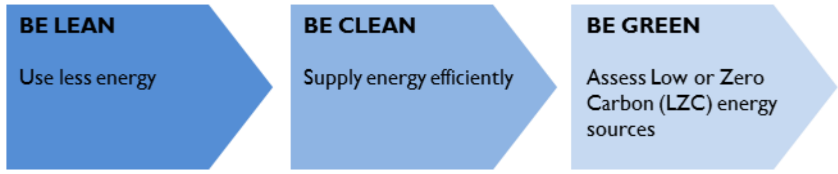

Figure 3.1: Energy Hierarchy.

The strategic approach to the design of the Proposed Development has been to reduce demand for energy prior to the consideration of integrating Low or Zero Carbon (LZC) technologies, since controlling demand is the most effective way of reducing energy requirements and CO_2 emissions.

Further reductions are ensured through the specification of high-efficiency building services to limit losses in energy supply, storage and distribution.

After the inclusion of passive design and energy efficiency measures, various options have been investigated to reduce CO_2 emissions associated with energy supply.

The feasibility of LZC technologies has been investigated in line with the policy aspirations and as part of the Energy Strategy submitted in support of the outline applications.

3.3 Methodology

The areas outlined in Table 3.1 have been used to undertake the appraisals described within this strategy. These areas relate to Phase 2 of the development. Phase 1 has been excluded as it is largely complete and is not the subject of any changes related to Energy Strategy in the MMA.

Use	Area (m^2)
Private Residential (C3)	25,857
Office (B1)	259
Total	**26,116**

Table 3.1: Area Schedule.

The following Part L 2013 compliant carbon factors in table 3.2 were used to convert the energy consumption figures into CO_2 emissions for the Proposed Development.

Fuel	Emission Factor ($kgCO_2/kWh$)
Gas	0.216
Electricity	0.519

Table 3.2: Building Regulations Part L 2013 CO_2 Emission Factors.

Phase 1 dwellings have been excluded from the assessment for this MMA as they are not subject to changes to the design and remain as per the approved Energy Strategy Report by Rolton Group Limited Ref 12-0083 XRP004 Issue 3 dated April 2014. The Phase 1 dwellings are to achieve a target of 32% reduction against the Part L 2010 baseline.

The ability of the Phase 1 dwellings to be serviced by the connection to the Royal Free Heat Network is likely to result in a greater reduction in CO_2 emissions.

4. Appraisal

4.1 Be Lean – Approach

The following sections detail the considerations of the passive design and energy efficiency measures that have been considered, and those which would be implemented at the Proposed Development.

Passive Design Measures

Passive design measures are those which reduce the demand for energy within buildings, without consuming energy in the process.

These are the most effective and robust measures for reducing CO_2 emissions as the performance of the solutions, for example wall insulation, is unlikely to deteriorate significantly with time, or be subject to change by future property owners. In this sense, we can be confident that the benefits of the measures will continue at a similar level for the duration of their installation.

Glazing Ratio

The Proposed Development has taken a 'fabric first' approach to reducing energy demand and CO_2 emissions. The early focus of the design-team was on the amount of glazing, and how this relates to the total external wall area (i.e. the glazing ratio).

With the glass technology currently available on the market, glazing ratio is an important metric to drive efficiency, whilst carefully balancing design and daylight / sunlight requirements.

Through experience of calculating the energy performance of similar developments, the design-team was advised at concept stage that glazing ratio should generally target the following ranges:

- 30% – 45% on north facing elevations;
- 30% – 50% on north-east and north-west facing elevations; and
- 40% - 60% on east, west, south-east, south-west and south facing elevations.

This recognises the sun path, and the benefit that solar gains can bring in winter months on southerly orientations. However, for northerly orientations, heat loss becomes a more critical consideration as these dwellings do not benefit from solar gains in winter.

The upper threshold of the range also considers the effect of solar gains on the potential for high internal temperatures in summer months. In designing the elevations at the Proposed Development, the architectural team has been mindful of these targets.

Commercial floor space at the Proposed Development are less sensitive to the extent of glazing as generally the demand for energy in commercial applications is driven by lighting as opposed to heating. As such, commercial uses will benefit from increased glazing ratios to promote good daylight ingress.

Glazing Energy & Light Transmittance

In designing the elevations with a moderate approach to fenestration, the design team has also been mindful to balance the solar energy transmittance and light transmittance values of the glass, to control solar gains and to maximise daylight respectively.

Solar gains are beneficial in winter months as a means of avoiding the need for active heating to maintain comfortable internal temperatures. However, in summer months excessive solar gains can lead to high internal temperatures.

In tandem with the glazing ratio targets, the solar energy transmittance (g-value) of the glass has been targeted to allow solar gains in winter, but control solar gains in summer. A value of 0.35 is targeted, i.e. transmitting only 35% of the incident solar gains into the dwelling. This has primarily been driven by the need to limit the likelihood of high internal temperatures in summer months.

The glazing g-value is linked to light transmittance. For g-values less than those targeted it is likely that the light transmittance of the glass is significantly reduced, owing to the need for highly reflective outer surfaces, or body-tints to control solar energy transmittance.

As such, the g-value and the glazing ratio selected will not have a detrimental effect on daylight ingress, allowing natural light to penetrate into the dwellings in order to limit the demand for electric lighting.

Thermal Insulation

Demand for space heating can be dominant in dwellings. However, demand can be significantly reduced through the provision of an effective thermal envelope.

It is intended that dwellings at the Proposed Development would be provided with insulation to meet the U-value targets outlined in Table 4.1, exceeding the requirements of the Building Regulations Part L1A 2013 criterion two by 40% - 100%. Values for curtain walling are preliminary and will be refined during detailed design stages once advice from façade contractors can be obtained.

Element	U-value ($W/m^2.K$)		
	Part L1A 2013 Requirement	Proposed Development Target	Anticipated Improvement
Roof	0.20	0.10 0.15 for Terraces	50%
External Walls	0.35	0.13	65%
Floor	0.25	0.10	40%
Windows	2.20	1.34 - Window	40%
Party Wall	0.20	0.00	100%
Sheltered Wall	0.30	0.18	40%

Table 4.1: U-value Targets.

Fabric Energy Efficiency
For residential dwellings, Part L 2013 includes a mandatory metric, called the Target Fabric Energy Efficiency (TFEE). The TFEE is calculated independently for each dwelling, based upon an elemental recipe of efficiency parameters, applied to the geometry of the dwelling in question. This generates a notional value which is then relaxed by 15% to generate the TFEE.

Thermal Mass
Thermal mass is the term given to describe the ability of a structure to absorb and emit heat. It is a product of the physical properties of materials e.g. Concrete can store and emit a greater quantity of heat than timber.

The 'Thermal Mass Parameter' (TMP) is a value used when calculating the annual CO_2 emissions and the likelihood of high internal temperatures for compliance with the Building Regulations Part L1A 2013. This is a measure of the amount of thermal mass per square metre of gross internal area (kJ/m^2.K).

A low TMP would mean there is little thermal mass within a dwelling. This would mean that internal heat gains and solar gains are not absorbed by the fabric. However, in this scenario gains can be more easily exhausted through ventilation.

A high TMP would lead to the 'response' of heating systems being reduced, as the heating system would need to heat both the air within the dwelling, and the fabric of the dwelling in order to increase the internal temperature.

Innovative solutions such as phase change ceiling panels will also be considered. The design-team will consider during the detailed design stages how best to achieve the target.

Fabric Air Permeability
Fabric air permeability is a measure of the volume of air that can penetrate through the fabric of a building, leading to ventilation heat loss and gain.

High air permeability can lead to uncomfortable draughts and dramatically increase the demand for space heating in winter, and space cooling in summer, when the air-flow works in reverse i.e. cool air escaping from the building.

The Proposed Development has been designed, and would be constructed, to achieve a low fabric air permeability. The target permeability for dwellings is 3 m^3/(m^2.h) at 50Pa, a 70% reduction below the requirements of the Building Regulations Part L1A 2013.

The target permeability for commercial uses is 5 m^3/(m^2.h at 50Pa, a 50% reduction below the requirements of the Building Regulations Part L2A 2013.

Energy Efficiency Measures

Energy efficiency measures are those which seek to service the demand for energy (i.e. the remaining demand after implementation of passive design measures) in the most efficient way.

Heating
Heating to dwellings at the Proposed Development would be provided by a Low Temperature Hot Water (LTHW) heat network driven by connection to the Royal Free District Heat Network backed up by high efficiency gas fired boilers. Dwellings would connect to the network via Heat Interface Units (HIU) comprising of a plate heat exchanger.

Figure 4.2: Typical Heat Interface Unit.

HIUs will be insulated in accordance with the guidelines in the Building Regulations and the Mayor of London's District Heating Manual for London (2013). This will maximise system efficiency by reducing as far as practically possible the heat loss from the pipework

Hot Water
To limit the demand for hot water, dwellings would be provided with water-efficient fixtures and fittings, to limit overall water consumption to 105 litres per person per day (l/p/d), 30% less than the average UK water consumption.

All dwellings will be provided with a plate heat exchanger within the HIU.

The fit-out of commercial floor space would be the responsibility of each tenant. Tenants would be encouraged to select water-efficient fixtures and fittings wherever possible, and would be required to meet the performance stipulations within the Building Regulations Part G.

Cooling
Dwellings at the proposed development are not to be provided with cooling. Cooling within the fit-out of commercial floor space would be the responsibility of each tenant. Tenants would be encouraged to select high-efficiency services wherever possible, and would be required to meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013).

Lighting

Dwellings would be provided with low-energy, efficient light fittings throughout, to achieve an efficacy of at least 45 lamp lumens per circuit Watt (lml/Wc) and total output of greater than 400 lamp lumens. External lighting for dwelling amenity areas will also be low-energy efficient fittings, and will be linked to daylight sensors and / or presence detectors to prevent unnecessary use.

The fit-out of commercial floor space would be the responsibility of each tenant. Tenants would be encouraged to select high-efficiency lighting systems wherever possible, and would be required to meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013).

Considering the importance of efficient lighting in terms of reducing CO_2 emissions from commercial uses, tenants would be advised of the targets quoted in luminaire lumens per circuit Watt (lml/Wc) in Table 4.3 as follows:

Lighting	Lighting Efficacy (lm/W_c)	
	'Good Practice' Requirement	'Best Practice' Option
General	55	70
Display	22	80

Table 4.3: Commercial Lighting Efficacy.

Best practice lighting systems can achieve overall efficiency of 1.8 - 2.0 W/m²/100lux. Tenants would be encouraged to design efficient lighting systems to meet these targets. Alternatively, tenants could target the requirements of Part L 2013 which includes a new metric called the Lighting Energy Numeric Indicator (LENI) which measures lighting energy requirement per annum (kWh/yr).

Ventilation

Dwellings at the Proposed Development would be provided with high-efficiency Mechanical Ventilation and Heat Recovery (MVHR) units.

MVHR units are an important addition to the building services to maintain good indoor air quality, by providing fresh air to living rooms and bedrooms and extracting vitiated air from bathrooms and kitchens.

Providing fresh air minimises the risk of stale and stagnant air, and limits the risk of condensation and mould growth.

Coupled to a heat exchanger, the warmth in extracted air can be recovered and delivered to the supply air. In this mode, the MVHR unit reduces space heating demand. The heat recovery mechanism will be provided with a bypass to avoid returning hot air to the dwellings in summer months.

The MVHR units will be capable of delivering 'trickle' 'boost' and 'purge' ventilation rates. It is anticipated that the 'purge' rate will deliver up to 100 litres per second (l/s) of fresh air, which would aid the mitigation of high internal temperatures in summer months where required.

The target Specific Fan Power (SFP) is 0.40-0.93W/l/s (55%-63% better than Part L 2013) with a heat recovery efficiency of 92%-94% (22%-24% better then Part L 2013).

The fit-out of commercial floor space would be the responsibility of each tenant. Tenants would be encouraged to select high-efficiency ventilation systems wherever possible, and would be required to meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013).

Tenants would be advised of SFP and heat recovery targets as outlined in Table 4.4 as follows:

Type	Ventilation Targets			
	'Good Practice' Requirement		'Best Practice' Option	
	SFP (W/l/s)	HR (%)	SFP (W/l/s)	HR (%)
Centralised Mechanical Ventilation	1.7	50	1.3	75
Zonal Supply and Extract System	2.3	50	1.7	75

Table 4.4: Commercial Ventilation Targets.

Metering & Controls

During detailed design, further consideration would be given to providing dwellings with energy monitoring devices that would allow occupants to instantaneously view the energy requirement within the dwelling. It is anticipated that this may be linked to the incoming electricity supply and heat supply.

The basis for the charging mechanism by the Management Company (ManCo) and / or Energy Services Company (ESCo) is under consideration and may include the HIU being provided with a heat meter, which will record, based on incoming water supply temperature and outgoing water return temperature, the heat requirement in kWh. The meters may be linked via a wireless network, or SIM card to provide automatic meter readings.

Heating systems would be provided with zonal, programmable thermostatic controls linked to a master control panel which would allow occupants to control zones within their dwellings independently for maximum flexibility. Hot water would be separately programmable.

The MVHR system would operate in 'trickle' mode continuously to maintain good indoor air quality, however an over-ride control panel would be provided to allow occupants to switch off the system, or increase the ventilation rate to 'boost' or 'purge'.

Lighting in communal areas would generally be linked to daylight and presence detection to minimise unnecessary use.

The fit-out of commercial floor space would be the responsibility of each tenant, and would be required to meet the performance stipulations within the Non-Domestic Building Services Compliance Guide (2013).

Tenants would be encouraged to provide adequate metering and controls to ensure efficient operation of their plant installations.

In terms of central plant, metering and controls would be provided in accordance with the requirements of the Building Regulations and other pertinent guidance.

Pipework & Ductwork Insulation

Heating, hot water and cooling distribution pipework would be insulated in accordance with the requirements of the Building Regulations and guidance in the Mayor of London's District Heating Manual for London (2013).

This would serve to minimise heat gains and losses to / from distribution pipework, and maximise system efficiency.

The heating, hot water and cooling services would utilise insulated pipework. Careful attention would be paid to insulating joints and knuckles to minimise standing heat losses.

Variable Speed Pumping

Services would be circulated using variable speed pumps through the Proposed Development. Variable speed pumps mean that when demand for a service is low, e.g. water consumption at night, the pump can 'turn-down' to reduce flow rate whilst maintaining adequate pressure in the system. This serves to reduce the energy requirement associated with pumping.

Operation & Maintenance Manuals

In accordance with the requirements of the Building Regulations, detailed Operation and Maintenance (O&M) manuals would be provided to all residents at the Proposed Development.

The guides would be written in plain and clear English, and it is intended that guidance would be provided to indicate where residents may procure a version of the guide in other languages, large type text or braille.

The guides would provide both an overview of the systems and their intended operation, and relevant engineering details of the installations. The guides would also contain information from the ManCo / ESCo regarding the charging mechanisms for heat and electricity. Commercial tenants will be responsible for provision of O&M manuals in accordance with the relevant Building Regulations.

Summary of Passive Design & Energy Efficiency Measures

Table 4.5 summarises the passive design and table 4.6 summarises the energy efficiency measures that would be targeted, at the Proposed Development.

	Parameter	Dwellings	Non-Dwellings
Passive Design	Windows g-value	0.35	0.4
	Window U-value ($W/m^2.K$)	1.34	2.2
	Roof U-value ($W/m^2.K$)	0.10 0.15 on terraces	n/a
	External Wall U-value ($W/m^2.K$)	0.13	
	Floor U-value ($W/m^2.K$)	0.10	0.25
	Party Wall U-value ($W/m^2.K$)	No heat loss (fully filled cavity walls with effective edge sealing)	-
	Shelter Wall U-value ($W/m^2.K$)	0.18	-
	Thermal Mass ($kJ/m^2.K$)	Low	N/A
	Fabric Air Permeability (($m^3/m^2.h$) at 50 Pa)	3.00	5.00

Table 4.5: Passive Design Measures.

	Parameter	Dwellings	Non-Dwellings
Energy Efficiency	Space Heating	Connection to Royal Free District Heat Network and High-efficiency condensing gas boilers (>90% efficiency) with Heat Interface Units (HIU) per dwelling coupled to hot water systems and radiators	By Tenant during fit-out. Connection to landlords LTHW network will be available.
	Hot Water	Water efficient fixtures and fittings to minimise water demand. Low heat loss HIU / water cylinder.	By Tenant during fit-out. Connection to landlords LTHW network will be available.
	Space Cooling	No Cooling	By Tenant during fit-out.
	Lighting	High efficiency lighting with efficacy >45 lamp lumens per circuit Watt. Daylight and presence detection in common areas / roof terraces.	To be provided in accordance with the requirements of the Building Regulations.
	Ventilation	High efficiency MVHR with specific fan power of 0.40-0.93W/l/s and HR of 92%-94%.	By Tenant during fit-out.
	Metering & Controls	Zonal, programmable thermostatic controls for heating. Separate programmable control for hot water. Electricity meter and heat meter with potential link to energy display device.	To be provided in accordance with the requirements of the Building Regulations.
	Pipework & Ductwork Insulation	To be provided in accordance with the requirements of the Building Regulations.	To be provided in accordance with the requirements of the Building Regulations
	Variable Speed Pumping	To be provided.	To be provided.
	O&M Manuals	Systems overview and detailed descriptions in plain and clear English.	In accordance with Building Regulations.

Table 4.6: Energy Efficiency Measures.

4.2 Be Lean – Energy Requirement & CO_2 Emissions Appraisal

The following is an appraisal of the likely energy requirements and resultant CO_2 emissions that are likely to arise as a result of the Proposed Development, after the inclusion of the passive design and energy efficiency measures described in this strategy.

The appraisal is based on approved calculation methodology and should not be understood as a predictive assessment as occupants may operate their systems differently, and / or the weather may be different from the assumptions made within the calculations.

Regulated Sources

Regulated sources of energy requirement are those controlled by the Building Regulations, as follows:

a. space heating
b. hot water
c. space cooling
d. lighting
e. auxiliary (combining fans, pumps and controls)

Unregulated Sources

Unregulated sources of energy requirement include small power electricity use (computers, plug in devices) and cooking. Currently, unregulated energy is not included within the Building Regulations Part L assessment requirements. It is anticipated that the proportion of unregulated energy will gain in significance when compared to regulated energy as each revision of Building Regulations Part L comes into force and regulated energy is reduced.

It is therefore foreseeable that energy efficiency and the rising cost of energy will play an increasing role when future residents and building occupants are deciding which appliances to purchase and the frequency of their use. However, it is not possible at present to quantify the extent of this potential reduction.

Given the uncertainty, measures to educate the future building users on how they can reduce their equipment energy requirements will be encouraged. This can be provided in the form of building user guides and tenant fit-out guides. The guidance measures detailed within these types of documents will consider:

a. use of A / A+ rated white goods
b. energy star rated computers and flat screen monitors
c. energy efficient lifts
d. voltage optimization and power factor correction

Results

The energy requirement and CO_2 emissions appraisal has been based on benchmarked compliant Part L 2013 buildings for the commercial spaces and compliant Part L 2013 SAP calculations undertaken on the dwellings. It is anticipated that commercial uses will be modelled for submission to Building Control at a later date.

Please refer to sample SAP compliance reports in Appendix B. These SAP reports demonstrate compliance at the Be Lean stage of the Mayors Energy Hierarchy.

The calculations summarised overleaf, demonstrate that prior to the implementation of any ‘be clean’ or ‘be green’ measures, the annual regulated energy requirement of the Proposed Development to be approximately **1,477MWh** with associated regulated CO_2 emissions of **373 tonnes**.

The majority of the regulated energy requirement, approximately 46% is as a result of hot water requirement.

It is anticipated that overall, a **4.5%** reduction in annual regulated CO_2 emissions will be made beyond the requirements of the Building Regulations Part L 2013 through passive design and energy efficiency measures.

Therefore, the Proposed Development achieves Part L 2013 compliance via Be Lean measures, i.e. prior to the consideration of any LZC technologies.

Summary Tables & Charts

Table 4.7, Table 4.8, Figure 4.4 and Figure 4.5 indicate the annual energy requirement and associated CO_2 emissions by service and space use at the Proposed Development, rounded to the nearest hundred.

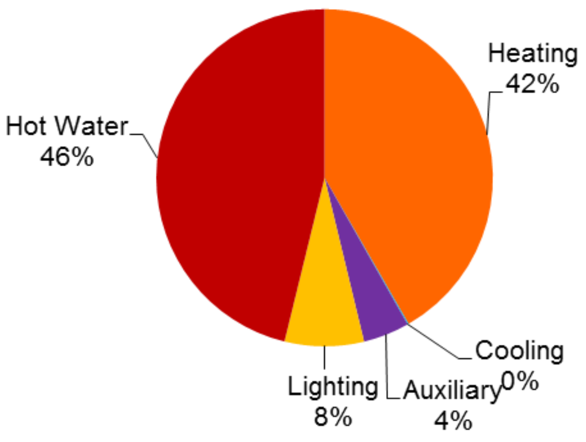

Figure 4.4: Annual Energy Requirement.

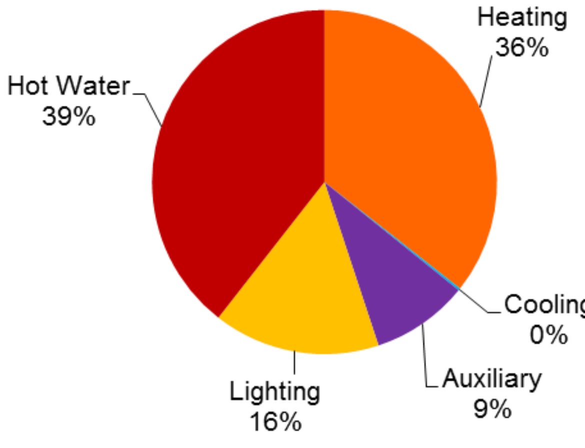

Figure 4.5: Annual CO_2 Emissions

Figure 4.6 demonstrates that the majority of the CO_2 emissions that would arise from the Proposed Development are associated with thermal sources (heating and hot water).

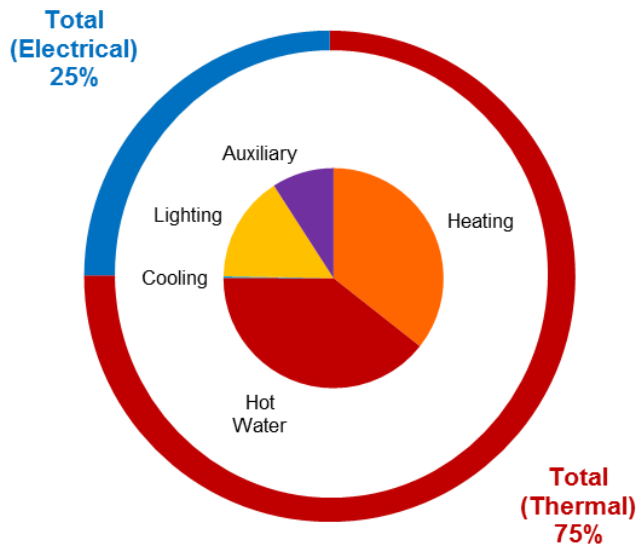

Figure 4.6: Annual CO_2 Emissions by Type.

Use	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total (Regulated)	Unregulated
	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)	(kWh/yr)
Private Residential (C3)	613,700	0	61,300	107,500	680,100	1,462,600	771,500
Office (B1)	1,800	1,400	4,200	4,900	1,700	14,000	10,600
TOTAL	**615,500**	**1,400**	**65,500**	**112,400**	**681,800**	**1,476,600**	**782,100**

Table 4.7: Annual Energy Requirement.

Use	Heating	Cooling	Auxiliary	Lighting	Hot Water	Total (Regulated)	Unregulated
	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)	($kgCO_2$/yr)
Private Residential (C3)	132,600	0	31,800	55,800	146,900	367,100	400,400
Office (B1)	400	700	2,200	2,500	400	6,200	5,500
TOTAL	**133,000**	**700**	**34,000**	**58,300**	**147,300**	**373,300**	**405,900**

Table 4.8: Annual CO_2 Emissions.

4.3 Be Clean

The following sections detail considerations of the infrastructure and low-carbon energy supply measures that have been considered, and those which would be implemented at the Proposed Development.

Infrastructure

Infrastructure at the Proposed Development would be the key to achieving the target reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L 2013.

Decentralised Energy Networks

By reference to the London Heat Map (http://www.londonheatmap.org.uk), the proposed Development is located within the vicinity of this existing heat network.

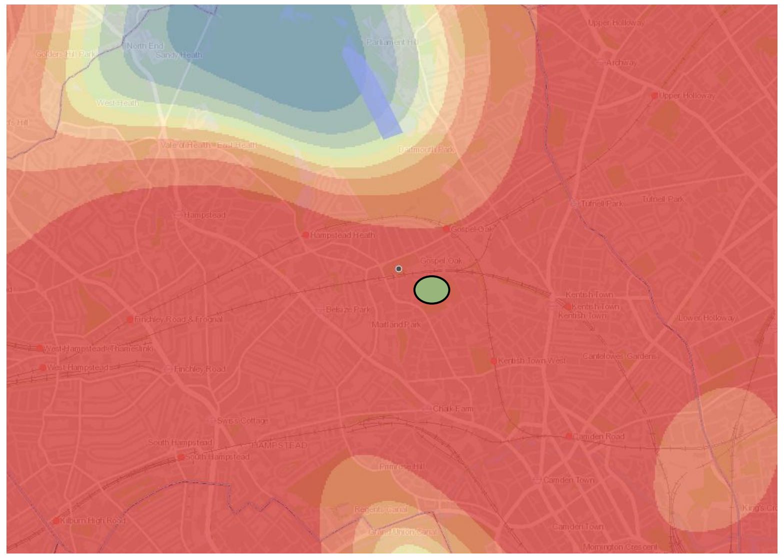

Figure 4.7: Extract from London Heat Map.

Royal Free District Heat Network

The Royal Free District Heat Network is located to the North of the site and there is a proposed route through the pedestrianised centre of the site. The network supplies heating and hot water to a number of developments in Camden. Communications have been taking place via London Borough of Camden with the network operators. London Borough of Camden have informed the design team that there is capacity on the network to connect the development to it but on the understanding that the development must be able to support itself through gas fired boilers.

The council have informed the design team that the network will supply all of the heat required by the proposed development. The date that a connection to the network will be made is not yet known but it is anticipated that it may be within 5 years.

As a result, the Proposed Development will be provided with gas fired boilers to serve all of Phase 1 and 2 and a connection to the Royal Free Network will be established at a date that is to be determined.

Communications with London Borough of Camden as the main contact for connections to the network are included in Appendix C.

The carbon factor of heat from the network has been requested from the operator but at this time is unknown. As a result an assumed carbon factor of approximately 0.11kgCO2/kWh has been used in the calculations of CO_2 emissions reductions at the ‘Be Clean’ stage.

This carbon factor is approximately twice that of the average carbon factor set out in the DECC report ‘Assessment of the Costs, Performance and Characteristics of UK Heat Networks (2015)’ which sets out an average carbon factor of 0.05kgCO_2/kWh.

The connection to the Royal Free heat network with this assumed carbon factor could reduce regulated CO_2 emissions by approximately **128.5 tonnes** per annum. This is equivalent to a reduction of **32.9%** beyond the Building Regulations Part L 2013 ‘baseline’

Technology Appraisal

This section considers the relative merits of providing a stand-alone on-site heat network served by a dedicated energy centre with either CHP or CCHP.

Considering the high proportion of CO_2 emissions arising from thermal sources at the Proposed Development (approximately 75%), a Combined Heat and Power (CHP) or Combined Cooling, Heat and Power (CCHP) system could be suitable.

Figure 4.8 and Figure 4.9 demonstrate that these systems can work more efficiently than their traditional counterparts, i.e. grid electricity and gas boilers. It is estimated that where thermal demand is adequate, CHP and CCHP can achieve reductions in primary energy demand relative to traditional sources of approximately 30%.

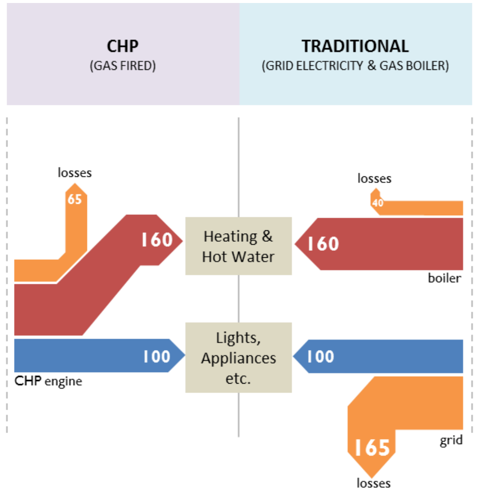

Figure 4.8: CHP Efficiency.

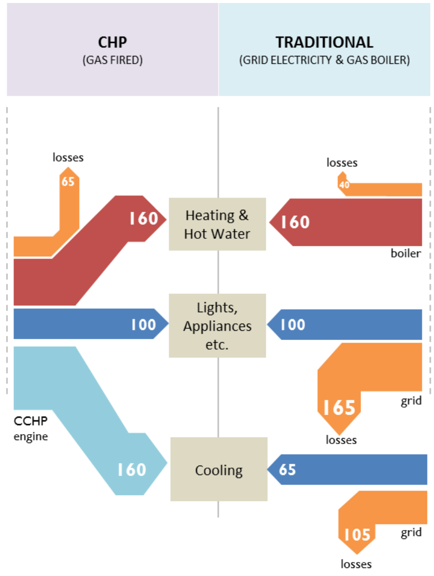

Figure 4.9: CCHP Efficiency.

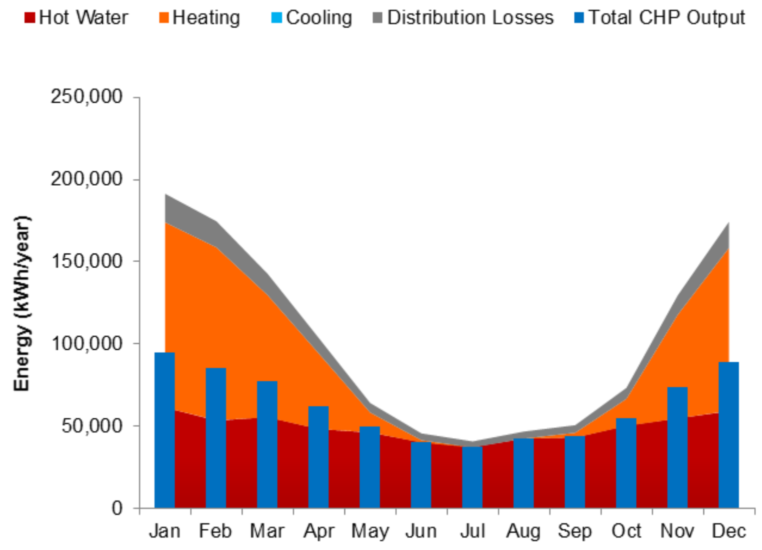

Figure 4.10: Annual Thermal Load Profile and Potential CHP Contribution.

Combined Heat and Power

The Proposed Development is not seeking to utilise a Combined Heat and Power Unit as the lead generator as this will be provided by the connection to the Royal Free Heat Network. However, the ability of an on-site CHP to deliver CO_2 emissions savings has been assessed for the purposes of this energy strategy. This would be backed up by high efficiency gas fired condensing boilers. This would provide for the heating and hot water needs of all uses at the Proposed Development, including the amenities, dwellings and commercial spaces.

Using the energy appraisal calculations, a CHP engine coupled to the DEN has been considered. Selecting a CHP engine to deliver 100% of the annual hot water requirement and up to 30% of the annual space heating requirement would require an engine of 90kW$_e$.

It is estimated that a CHP engine of this size, allowing for losses and pumping associated with the heat network, could reduce regulated CO_2 emissions by approximately **57.1 tonnes** per annum. This is equivalent to a reduction of **14.6%** beyond the Building Regulations Part L 2013 'baseline'.

Combined Cooling Heat and Power

Selecting a CHP engine and matched absorption chiller (CCHP) to deliver 100% of the annual hot water requirement, 30% of the annual space heating requirement and 100% of the annual space cooling would require an engine with a peak output of approximately 91kW$_e$. The cooling demand is very low and therefore is unlikely to provide significant demand on the CHP engine.

Figure 4.10 demonstrates the annual thermal load profile of the Proposed Development, overlaid with the potential output from a CCHP system. An allowance for distribution losses has also been made.

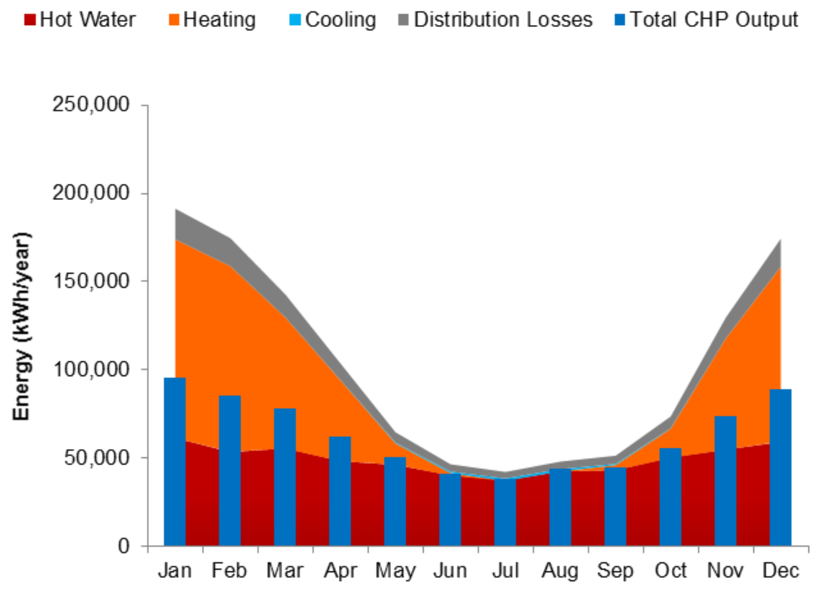

Figure 4.11: Annual Thermal Load Profile and Potential CCHP Contribution.

It is estimated that a CCHP system of this nature, allowing for losses and pumping associated with the DEN, could reduce regulated CO_2 emissions by approximately **56.6 tonnes** per annum.

This is equivalent to a reduction of **14.5%** beyond the Building Regulations Part L 2013 'baseline'.

Summary

In comparing the technology options, as summarised in Table 4.9, it is noteworthy that the savings that can be achieved by installation of CHP rather than a CCHP are greater.

System	Peak Output (kW)		Annual Output (kWh)		CO_2 Emissions Reduction		Notes
	Electrical	Thermal	Electrical	Thermal	Total (tonnes)	% Beyond 'Baseline'	
Connection to Royal Free Heat Network	-	-	-	-	128.5	32.9%	100% HW 100% SH
CHP	90	161	419,738	750,864	57.1	14.6%	100% H/W 30% S/H
CCHP	90	161	423,512	757,616	56.6	14.5%	100% H/W 30% S/H 100% S/C

Table 4.9: CHP and CCHP Appraisal Summary.

Key:
(h) heating and hot water output
(c) cooling output
h/w hot water
s/h space heating
s/c space cooling

It is considered that the Proposed Development will not utilise a CHP or CCHP engine to supply heating and hot water, as the capacity for connection to the Royal Free district heat network is available and will provide for significantly greater CO_2 emissions reductions that provision of an on-site CHP.

4.4 Be Green

The following sections detail the renewable energy generation measures that have been considered, and those which would be implemented at the Proposed Development.

Renewable technologies harness energy from the environment and convert this to a useful form. Many renewable technologies are available. However, not all of these are commercially viable, suitable for city-centre locations or appropriate for the Proposed Development.

Technologies considered include:

a. heat pumps (ground-source / air-source)
b. biomass boilers
c. photovoltaic
d. solar thermal
e. wind turbines

Renewable Technology Appraisal

Air / Ground Source Heat Pumps

Air Source Heat Pumps (ASHP) and Ground Source Heat Pumps (GSHP) work to extract heat from the air or the ground. Generally, GSHPs are more efficient as the ground temperature is more stable over the course of the year relative to the air temperature.

GSHPs have three common varieties:

a. horizontal, closed loop
b. vertical, closed loop
c. vertical, open loop

ASHPs have two common varieties:

d. air to water
e. air to air

The performance characteristics and technical requirements of each vary. Typically however, vertical open loop GSHP systems operate at the highest efficiencies and are capable of producing the most thermal output.

Open loop boreholes require an abstraction license from the Environment Agency. To gain a licence, a scheme is typically required to operate in balance such that over the year, the amount of heat extracted from the ground is equivalent to the amount of heat rejected to the ground.

Given the low amount of cooling at the Proposed Development (approximately 1% of the overall regulated energy requirement), if a large amount of heat were to be extracted in winter there would be a large imbalance between amount of heat extracted and heat rejected to the ground over a yearly cycle, which could lead to permafrost, rendering the system unusable and potentially damaging nearby structures and local ecology.

Impacts to ground conditions are also valid considerations for all GSHP technologies, meaning a balanced heating and cooling strategy should be applied.

When assuming a GSHP could operate at Seasonal Energy Efficiency Ratio (SEER) of 4.0 (i.e. five units of useful heat for every unit of electricity consumed), to deliver 100% of space cooling and balanced to deliver an equivalent amount of heating (approx. 4% of requirement) but no hot water, it is estimated that a reduction in CO_2 emissions of **2.6 tonnes** per annum could be achieved.

This is equivalent to a reduction in regulated CO_2 emissions of **0.7%** beyond the Building Regulations Part L (2013) 'baseline'.

Considering the low potential CO_2 emissions reduction, the use of GSHP will not be implemented at the Proposed Development.

ASHPs do not operate as efficiently as GSHPs. Moreover, during times of peak demand (i.e. during winter months) the ambient air temperatures are at their minimum, meaning the ASHP needs to work harder to extract the desired amount of heat. Systems have been noted to perform poorly in operation, in particular those systems which are also providing hot water.

To accommodate the demands at the Proposed Development, large external condenser units would be required. These would have a significant visual impact on-site, and would be a source of noise.

When assuming an ASHP could operate at Seasonal Energy Efficiency Ratio (SEER) of 4.0 (i.e. four units of useful heat for every unit of electricity consumed), to deliver 100% of space heating, and 100% of space cooling, but no hot water, it is estimated that a reduction in CO_2 emissions of **63.8 tonnes** per annum could be achieved.

This is equivalent to a reduction in regulated CO_2 emissions of **16.3%** beyond the Building Regulations Part L (2013) 'baseline'. However, this is far below the CO_2 emissions reductions offered by the connection to the Royal Free Heat Network.

Therefore, due to the low CO_2 emissions reduction offered by ASHP's relative to the connection to the Royal Free district heat network, ASHP's will not be implemented at the Proposed Development.

Biomass Heating

Biomass boilers burn wood fuel, or other bio-fuel sources, to generate heat. These boilers can operate at high efficiencies, comparable to condensing gas boilers. However, they require a large fuel store to maintain continuous operation during the winter months.

As such, area take for such plant is high. Furthermore, fuel deliveries in city-centre locations can prove difficult and security of fuel supply is an important consideration.

Biomass boilers also result in higher emission of Nitrous Oxide (NOx) in comparison with gas boilers. This can have a negative impact on the local air quality. Policies in London seek to protect and enhance local air

quality. Any proposal for biomass heating would be required to demonstrate the scheme would be 'air quality neutral'.
If a biomass boiler was to be implemented to provide 100% of the hot water demand, and 30% of the space heating demand, requiring a large fuel store, a reduction in CO_2 emissions of **143.6 tonnes** per annum could be achieved. This is equivalent to a reduction in regulated CO_2 emissions of **36.7%** beyond the Building Regulations Part L (2013) 'baseline'. This is above the CO_2 emissions reductions which would be achieved through the use of a CHP engine.

However, due to the constraints of this site, potential negative impact on air quality, biomass heating is not favoured for the Proposed Development.

Photovoltaic Panels

An appraisal of the available roof space at the Proposed Development has been undertaken. The roof layouts have been designed in response to the need to balance many factors such as:

a. area required for plant (flues from boilers and exhausts from ventilation)
b. area required for access
c. areas of sedum roof to increase ecological value
d. reducing overshading of facades and allowing for sunlight ingress

Considering the potentially available roof space and allowing for access and maintenance requirements, a total PV array size of 25kWp could be included at the Proposed Development, with a required roof area of approximately 180m².

The roof area available for a PV array would be subject to overshading from the adjacent buildings and blocks on the site. This would reduce the effectiveness of the panels and reduce the potential output. The current flat roof areas allow for inspection of the sedum roof from an elevated work platform. Therefore access for maintenance of areas of PV would require additional access consideration and man safe systems to be installed.

Based on the solar irradiance data for London, an array of this size would generate approximately 17,200kWh of electricity per annum, reducing CO_2 emissions by **8.9 tonnes** per annum. This is equivalent to a reduction in regulated CO_2 emissions of **2.3%** beyond the Building Regulations Part L (2013) 'baseline'.

Solar Thermal Panels

The appraisal of solar thermal panels has been undertaken with the same approach as for PV.
Considering the available roof space, and allowing for access and maintenance requirements, a total solar thermal system size of 86kWp could be installed at the Proposed Development.

Based on the solar irradiance data for London, an array of this size would generate approximately 78,300kWh of heat per annum. This level of thermal generation is equivalent to 2% of the annual hot water demand, reducing CO_2 emissions by **19.5 tonnes** per annum.

This is equivalent to a reduction in regulated CO_2 emissions of **5.0%** beyond the Building Regulations Part L (2013) 'baseline'.

The use of Solar Thermal panels would require additional plant and would have little benefit compared to the connection to the Royal Free heat network and therefore it is not proposed to utilise this technology in the proposed development.

Micro Wind Turbines

The installation of micro wind turbines at the Proposed Development could generate useful electricity.
On the basis of providing two 6kW vertical axis wind turbines, it is estimated that approximately 2,300kWh of electricity could be generated annually, reducing CO_2 emissions by **1.2 tonnes** per annum.

This is equivalent to a reduction in regulated CO_2 emissions of **0.3%** beyond those savings made using passive design and energy efficiency measures and beyond the Building Regulations Part L (2013) 'baseline'.

Despite manufacturer claims that vertical axis wind turbines work well in city-centre locations, turbulent air flow patterns caused by the rough and irregular urban landscape are not conducive to high annual yields from wind turbines.

Moreover, mounting wind turbines on the roofs of the Proposed Development could result in unacceptable vibration and resonance being felt within top floor apartments. This scenario is likely to result in the turbines being switched off.

As such, the use of micro wind turbines will not be implemented at the Proposed Development.

4.5 Summary

Table 4.10 provides a summary of the estimated emissions reductions associated with each of the suitable technologies identified above.

	Annual Output		Annual Regulated CO_2 Emission Reduction		Sizing Notes	Suitable?
	Thermal (kWh/yr)	Electrical (kWh/yr)	Tonnes per year	% Beyond Part L 'baseline'		
Connection to Royal Free Heat Network	-	-	128.5	32.9%	100% SH 100% HW	✓
~90kWe CHP with DEN	750,864	419,738	57.1	14.6%	30% SH 100% HW	✗
~25kWp (180sqm) Photovoltaic (PV) Panels	-	17,200	8.9	2.3%	170sqm panel area	✗
~86kWp (180sqm) Solar Thermal Heating	78,300	-	19.5	5.0%	170sqm panel area	✗
~240kW Wood Pellets Boiler	750,900	-	143.6	36.7%	100% HW 30% SH	✗
~6kW Ground Source Heat Pump	26,500	-1,300	2.6	0.7%	100% SC 4% SH 0% HW	✗
~151kW Air Source Heat Pump	538,600	-1,300	63.8	16.3%	100% SC 100% SH 0% HW	✗
2 No. 6kW Vertical axis wind turbines	-	2,304	1,200	0.3%	30m above ground level	✗

Table 4.10: Summary of LZC Technology Appraisal.

Key:
(h) heating and hot water output
(c) cooling output
hw hot water
sh space heating
sc space cooling

Energy Hierarchy

Following the energy hierarchy, reductions in regulated energy requirements and associated CO_2 emissions have been made at each stage as demonstrated by Table 4.11 as follows. The Proposed Development is targeting a 37% overall reduction.

	Regulated Carbon Dioxide Emissions Savings	
	(tonnes/yr)	(%)
Reduction from Be Lean	17	4.5%
Reduction from Be Clean	129 (using assumed carbon factor)	32.9%
Reduction from Be Green	0	0.0%
Total Reduction	**146**	**37%**
Target Reduction	137	35%
Annual Surplus / Shortfall	+9	+2%

Table 4.11: Summary of Regulated CO_2 Emissions Reduction.

The CO_2 emission savings are represented graphically in Figure 4.12 as follows:

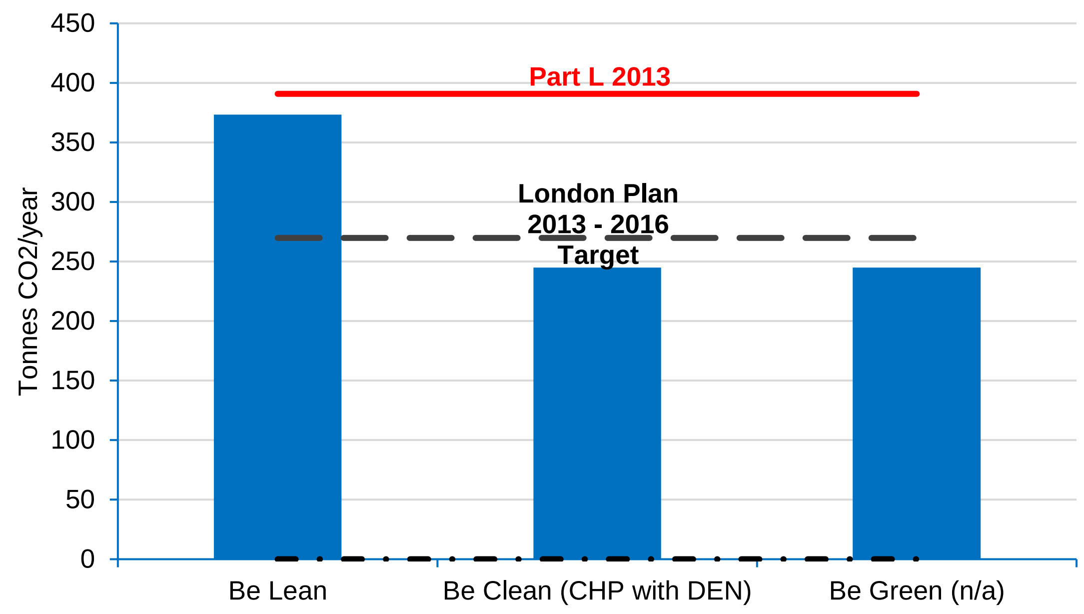

Figure 4.12: Summary of Regulated CO_2 Emissions Reduction.

4.6 Minimisation of Cooling Demand & Limiting the Effects of Heat Gains

In tandem with the energy and CO_2 emissions appraisal, an iterative approach has been undertaken to limit the effects of heat gains in summer (Part L Criterion 3) and to minimise the cooling demand.

Basis of the Assessment

The London Plan Policy 5.9 details that development proposals should reduce potential overheating and reliance on air conditioning systems. A 'cooling hierarchy' is provided and the Proposed Development has sought to follow this hierarchy.

Cooling Hierarchy

The following cooling hierarchy has been followed to limit the effects of heat gains in summer:

a. minimise internal heat generation through efficient design and efficient equipment selection
b. reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration and insulation
c. natural ventilation
d. mechanical ventilation
e. active cooling systems

Summary of Mitigation Measures

The following mitigation measures would be implemented at the Proposed Development.
Internal heat gains would be minimised by providing:

a. Energy efficient lighting (such as LED or compact fluorescent) with low heat output
b. Insulation to heating and hot water pipework and minimisation of dead-legs to avoid standing heat loss (from pipework to dwellings)
c. If applicable, selection of energy efficient white goods with low heat output

External heat gains would be minimised by providing:

a. Suitable glazing ratio
b. Glazing with internal shading (blinds, to be provided by developer) and suitable g-value (0.35) to limit solar heat gains
c. High levels of insulation and low fabric air permeability which will retain cool air within the dwellings in summer months

Where ambient acoustic conditions allow, dwellings will be able to use natural ventilation to purge heat from dwellings. Where acoustic conditions require windows to be closed to achieve target internal noise levels, it is anticipated that during the day-time, occupants could utilise openable windows for natural ventilation as the sensitivity to noise during the day is likely to be low.

At night, where windows cannot be opened as this would cause difficulty sleeping, occupants can utilise the 'purge' function of the energy efficient mechanical ventilation units. These will be designed to provide sufficient volume of air to achieve compliance with criterion three of the Building Regulations Part L1A 2013.

Summary of Results

Through the mitigation measures listed above, all dwellings at the Proposed Development achieve compliance with criterion three of the Building Regulations Part L1A 2013, and none of the corresponding SAP assessments show a 'high' likelihood of high internal temperatures in summer months.

The cooling requirement at the Proposed Development has been minimised (see energy demand and CO_2 emissions appraisal, p14), representing approximately 1% of the overall energy requirement due to the cooling requirement of the non-dwelling areas.

Fit-out of commercial spaces would be the responsibility of tenants. Tenants would be required to determine the cooling demand and Building Regulations compliance for their respective spaces. In all instances, the commercial spaces will achieve compliance with criterion three of the Building Regulations and the requirements of the Non-Domestic Building Services Compliance Guide, at the time of construction.

Summary of Overheating Assessments

In addition to the Criterion 3 compliance calculations outlined above, an overheating risk assessment has been carried out for the dwellings. The risk assessments have been undertaken using the CIBSE Design Summer Year 2005 weather file and the London Heathrow Weather file (LHR) 1989 weather file, in accordance with requirements outlined in CIBSE TM49 'Design Summer Years for London'. The results for the overheating assessment are outlined in Appendix D.

CIBSE Guide A presents results of tests of a number of occupied hours during the summer months that the dwellings exceed 26ºC.

CIBSE TM52 follows the 'adaptive thermal comfort model' which works on the basis that in free running buildings (i.e. not mechanically ventilated or cooled), people will accept higher internal temperatures during parts of the year that are also hot outside.

Using mechanical ventilation alone the building exceeds the criteria of CIBSE Guide A in all dwelling areas, but CIBSE TM52 criteria is able to be met in 90% of the dwelling areas that have been assessed.

When natural ventilation is used (opening windows) 65% of the dwellings assessed meet the criteria of CIBSE Guide A and 95% meet the criteria of CIBSE TM52. In this scenario the dwellings are using opening windows with an opening of 20degrees to represent tilt and turn windows that would allow for the dwellings to remain secure whilst being ventilated. The windows are modelled to be open at all times.

Where dwellings on the site are able to make use of opening windows without disturbance from external noise they are more likely to meet the criteria of CIBSE guide A and TM52.

When using mechanical ventilation and natural ventilation the windows are modelled to be open during the day to provide ventilation whilst the occupants are out or when the sensitivity to noise is reduced. During the night when the sensitivity to noise is likely to be greater, the windows are modelled as closed and the mechanical ventilation is used. In this scenario 90% of the dwellings do not meet the CIBSE Guide A criteria. However, 90% of spaces do meet the criteria of CIBSE TM52 in this scenario.

Also presented in appendix D are the results for the 'notional baseline' model. This assumes internal gains (and profiles), occupancy schedules and building fabric of the notional building (as given by Part L1A of the building regulations and the National Calculation Methodology), results in the 'notional baseline' building significantly exceed the criteria of the various CIBSE guides, i.e. Guide A and TM52.

The results of the tests with the notional building parameters shows that none of the spaces achieve CIBSE Guide A criteria. This is the same as the actual building result. However, in the actual building results 7 spaces were only marginal fails (less than 6% of occupied hours exceeding 26ºC) compared to only 2 marginal fails with notional parameters. With notional parameters for CIBSE TM52 criteria only 6 spaces in the assessed dwellings achieve the criteria. In the actual building this was significantly higher at 25 spaces. This comparison of notional and actual building results are using mechanical ventilation. Where it is possible for dwellings to make use of natural ventilation or mechanical and natural ventilation the results of the actual building are significantly better than the notional building.

Therefore, the anticipated design and servicing strategy of the Proposed Development is a significant improvement over the 'notional baseline' model and reflects the attention given to mitigate overheating risk for the building occupants.

CIBSE Guide A 2015 and CIBSE TM52	DSY 2005		LHR 1989	
	Guide A	TM52	Guide A	TM52
1. Mechanical Ventilation only	0/28 Meet criteria	25/28 Meet Criteria	0/28 Meet criteria	10/28 Meet Criteria
2. Natural Vent. only	18/28 Meet criteria	27/28 Meet Criteria	18/28 meet criteria	27/28 Meet Criteria
3. Mechanical Ventilation and Natural Vent.	1/28 Meet criteria	25/28 Meet Criteria	0/28 Meet criteria	25/28 Meet Criteria
Notional Building	0/28 Meet Criteria	6/28 Meet criteria	0/28 Meet criteria	4/28 Meet criteria

Table 4.12: Summary of Results.

In order to mitigate overheating at the proposed development the design has incorporated tilt and turn windows to allow for occupants to leave windows open during the day without concerns for security to allow natural ventilation of the dwellings when they are unoccupied or less sensitive to disturbance from external noise. These windows allow the occupants to fully open them to maximise the ventilation rate when appropriate and will likely result in further mitigation of overheating risk.

Light coloured blinds have been specified for all of the dwellings to allow occupants to reduce solar gain during the day. External shading is also provided by the inset glazing on balconies. Glazing is specified with a low g-value of 0.35 to reduce solar gain.

Further assessments of the acoustic conditions are currently being undertaken and this may result in an increase in the number of dwellings that can make use of natural ventilation during occupied hours.

GLA Overheating Checklist

Recently updated GLA energy policy guidance included a requirement for all developments with residential uses to respond to a 'Domestic Overheating Checklist' for use early in the design process to identify potential overheating risks and to trigger the incorporation of passive measures within the building envelope. The responses from the design team are outlined in tables 4.13 and 4.14 as follows.

Section 1 – Site Features Affecting Vulnerability to Overheating		Yes or No?
Site Location	Urban – within central London or high density conurbation	No
	Peri-urban – on the suburban fringes of London	Yes
Air Quality and/or Noise sensitivity – are any of the following in the vicinity of the building	Busy roads / A roads	No
	Railways / Overground / DLR	Yes
	Airport / Flight Path	No
	Industrial uses / waste facility	No
Proposed Building Uses	Will any buildings be occupied by vulnerable people (e.g. elderly, disabled, young children)?	Yes
	Are residents likely to be at home during the day (e.g. students)?	Yes
Dwelling Aspect	Are there any single aspect units?	Yes
Glazing ratio	Is the glazing ratio (glazing: internal floor area) greater than 25%?	No
	If yes, is this to allow acceptable levels of daylighting?	n/a
Security – Are there any security issues that could limit opening of windows for ventilation?	Single storey ground floor units	The windows will be tilt and turn allowing the occupants to leave them open for ventilation when unoccupied
	Vulnerable areas identified by the Police Architectural Liaison Officer	Areas have been identified that could be a target for anti-social behaviour.
	Other	No

Table 4.13: Overheating Checklist Section 1.

Section 2 – Site Features Affecting Vulnerability to Overheating		Yes or No?
Landscaping	Will deciduous trees be provided for summer shading (to windows and pedestrian routes)?	Trees will provide shading to some windows at lower levels. Trees are planned within the pedestrian route between the two blocks.
	Will green roofs be provided?	Sedum roofs are specified on flat roof areas.
	Will other green or blue infrastructure be provided around buildings for evaporative cooling?	No
Materials	Have high albedo (light colour) materials been specified?	Light coloured bricks are the predominant external wall finish (Approx 80%). Pitched roofs will be zinc standing seam.
Dwelling Aspect	% of total units that are single aspect	31%
	% of single aspect with N/NE/NW orientation	5%
	% single aspect with E orientation	40%
	% single aspect with S/SE/SW orientation	12%
	% single aspect with W orientation	43%
Glazing Ratio – What is the glazing ratio (glazing – internal floor area) on each façade?	N/NE/NW	~2.5%
	E	~2.2%
	S/SE/SW	~5.2%
	W	~3.0% These figures are approximate and based on a sample of selected dwellings based on total glazing area of the elevations to gross internal floor area of all dwellings.
Daylighting	What is the average daylight factor range	Unknown.

Section 2 – Site Features Affecting Vulnerability to Overheating		Yes or No?
Window Opening	Are windows openable?	Yes. All dwellings have windows that can be opened in each occupied room.
	What is the average percentage of openable area for the windows?	Windows – 100% (tilt and turn windows provided so this is variable according to occupant need). Sliding Patio Doors – 85% Balcony doors – 100%
Window Opening – what is the extent of the opening?	Fully openable	Variable openings for ventilation. Windows are fully openable to allow for cleaning.
	Limited (e.g. for security, safety, wind loading reasons)	Allowed for by specification of tilt and turn windows for security. Railings and balustrades allow for safety.
Security	Where there are security issues (e.g. ground floor flats) has an alternative night time natural ventilation method been provided (e.g. ventilation grates)?	Yes and tilt and turn will also be provided to allow for ventilation when unoccupied.
Shading	Is there any external shading?	Yes from inset and bolt on balconies.
	Is there any internal shading?	Light coloured blinds will be provided to all units.
Glazing Specification	Is there any solar control glazing?	Yes g-value 0.35.
Ventilation – what is the ventilation strategy?	Natural - background	Yes where external acoustic conditions allow.
	Natural – purge	Yes where external acoustic conditions allow.
	Mechanical – background (e.g. MVHR)	Yes in all dwellings.

Section 2 – Site Features Affecting Vulnerability to Overheating		Yes or No?
	Mechanical – purge	Yes in all dwellings.
	Average Design ACH	Sample dwellings assessed in SAP ~1.59 required to meet Criterion 3.
Heating System	Is communal heating present?	Yes
	What is the flow/return temperature?	To Be Confirmed by Royal Free heat network and designed in accordance with London Heat Network Manual.
	Have horizontal pipe runs been minimized?	Yes
	Do the specifications include insulation levels in line with the London Heat Network Manual?	Yes

Table 4.14: Overheating Checklist Section 2.

5. Conclusion

5.1 Meeting Pertinent Targets

Energy and CO_2 Emissions

This Energy Strategy has demonstrated that through implementation of passive design and energy efficiency measures and the connection to the Royal Free District Heat Network, that overall the Proposed Development is anticipated to achieve a 37% reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013) 'baseline'

Passive design measures and energy efficiency measures which would be implemented at the Proposed Development include:

a. Suitable glazing ratio and glass g-value to balance heat losses and gains and daylight ingress
b. Fabric insulation levels achieving improvements over Building Regulations Part L (2013) requirements of 25% - 100%
c. Fabric air permeability achieving improvements over Building Regulations Part L (2013) requirements of 70% and 50% for dwellings and commercial spaces respectively
d. Efficient space heating systems with zonal, programmable and thermostatic controls, with separate programmer for hot water
e. Efficient low-energy lighting throughout all dwellings. External and communal lighting will be coupled to daylight and presence detection sensors to minimise unnecessary use
f. Efficient mechanical ventilation with heat recovery which will limit the need for space heating in winter months, aid the mitigation of high internal temperatures in summer months (where openable windows cannot be used due to ambient acoustic conditions), and maintain good indoor air quality
g. Appropriately insulated pipework and ductwork (and air sealing to ductwork) to minimise losses and gains
h. Variable speed pumps and fans to minimise energy consumption for distribution of services

These passive design measures are anticipated to achieve a **4.5%** reduction in regulated CO_2 emissions beyond the requirements of the Building Regulations Part L (2013). As a result, the Proposed Development would achieve compliance with the requirements of the Building Regulations Part L (2013) through passive design and energy efficiency measures, i.e. before the use of LZC technologies.

In addition to the above, the Proposed Development would benefit from a connection to the Royal Free district heat network that would supply all of the heating and hot water demands of the dwellings and be available for the tenants of the commercial spaces. It is expected that regulated CO_2 emissions savings of **129tonnes** per annum can be achieved. This is equivalent to a **32.9%** reduction in CO_2 emissions beyond the Building Regulations Part L (2013) 'baseline'.
.

Energy Hierarchy

Following the energy hierarchy, reductions in regulated energy requirements and associated CO_2 emissions have been made at each stage as demonstrated by Table 5.1 as follows:

	Regulated Carbon Dioxide Emissions Savings	
	(tonnes/yr)	(%)
Reduction from Be Lean	17	4.5%
Reduction from Be Clean	129 (using assumed carbon factor)	32.9%
Reduction from Be Green	0	0.0%
Total Reduction	**146**	**37%**
Target Reduction	137	35%
Annual Surplus / Shortfall	+9	+2%

Table 5.1: Summary of Regulated CO_2 Emissions Reduction.

The CO_2 emissions are represented graphically in Figure 5.1 as follows:

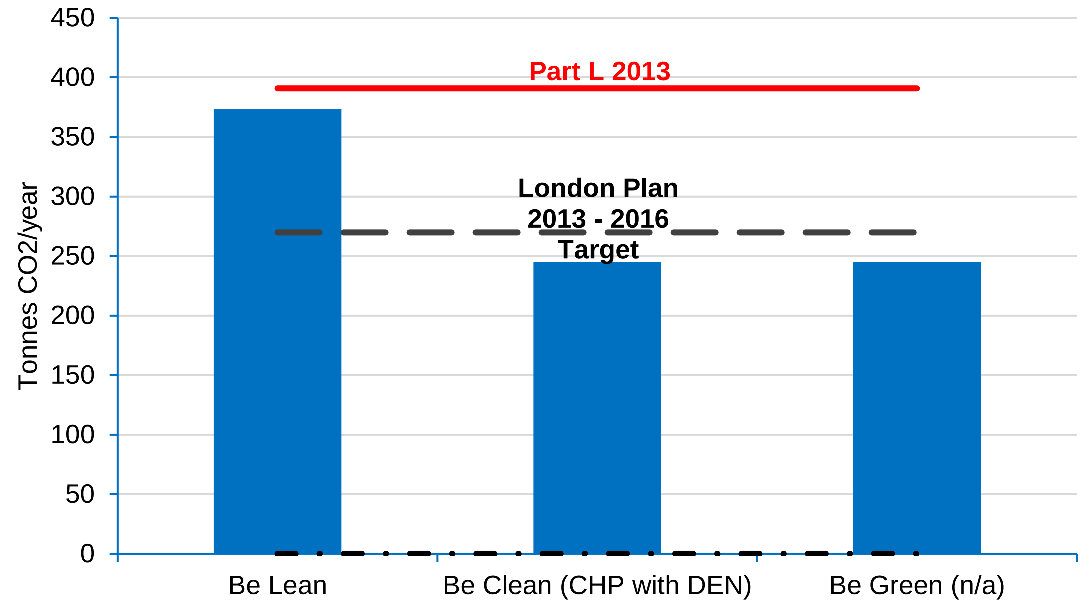

Figure 5.1: Summary of Regulated CO_2 Emissions Reduction.

Limiting the Effects of Heat Gains in Summer

Mitigation measures such as sensible glazing ratio and g-value, high levels of insulation levels and minimisation of internal heat gains will be implemented at the Proposed Development. Through these measures, all dwellings at the Proposed Development would achieve compliance with criterion three of the Building Regulations Part L1A 2013, and none of the corresponding SAP assessments show a ‘high’ likelihood of high internal temperatures in summer months. The cooling requirement at the Proposed Development has been minimised, representing approximately 1% of the overall energy requirement. Additionally, in line with policy requirements, a CIBSE overheating analysis has been undertaken.

In order to mitigate overheating at the proposed development the design has incorporated tilt and turn windows to allow for occupants to leave windows open during the day without concerns for security to allow natural ventilation of the dwellings when they are unoccupied or less sensitive to disturbance from external noise.

Light coloured blinds have been specified for all of the dwellings to allow occupants to reduce solar gain during the day. External shading is also provided by the inset glazing on balconies. Glazing is specified with a low g-value of 0.35 to reduce solar gain.

As outlined, the dwellings have been compared to a ‘notional baseline’. It is deemed that the anticipated design and servicing strategy of the Proposed Development and improvement over the ‘notional baseline’ reflects the attention given by the design team to mitigate overheating risk for the building occupants.

Please refer to appendix D for the results of the overheating assessment.

6. Appendix A: Regulatory and Policy Context

The following outlines the regulatory and planning policy requirements applicable to the Proposed Development.

6.1 National Policy

6.1.1 Current Policy Framework

The policies considered when preparing this strategy are contained in the London Plan (GLA, 2015) and the Local Development Framework (LDF) documents of LB Camden.

The Proposed Development constitutes a 'major development' (>10 dwellings and/or >1,000m^2 of commercial floor space) and is therefore subject to the policies of the GLA, contained within the London Plan.

6.1.2 Building Regulations Part L 2013

Approved Document Part L

Part L of the Building Regulations is the mechanism by which government is driving reductions in the regulated CO_2 emissions from new buildings.

Current Requirements: Part L 2013

Part L has five key criteria which must be satisfied as follows:

a. Criterion 1 - Achieving the Target Emission Rate (TER)
b. Criterion 2 - Limits on design flexibility
c. Criterion 3 - Limiting the effects of solar gains in summer
d. Criterion 4 - Building performance consistent with the Dwelling Emission Rate (DER)
e. Criterion 5 - Provision for energy efficient operation of the dwelling

Criteria one, two and three are addressed within this strategy.

Criterion one requires that the building as designed is not predicted to generate CO_2 emissions in excess of that set by the Target Emission Rate (TER) calculated in accordance with the approved Standard Assessment Procedure (SAP) 2012. Part L (2013) requires the following reductions:

a. A 6% aggregate reduction in CO_2 emissions beyond the requirements of Part L 2010 for dwellings; and
b. A 9% aggregate reduction in CO_2 emissions beyond the requirements of Part L 2010 for non-domestic buildings.

Criterion two places upper limits on the efficiency of controlled fittings and services for example, an upper limit to an external wall U-value of 0.30W/m^2.K (dwellings).

A Fabric Energy Efficiency Standard (FEES) has been introduced for new dwellings although no definitive targets have been set in this regard. Part L 2013 requires the following Fabric Energy Efficiency performance targets to be met:

a. Target Fabric Energy Efficiency (TFEE). The TFEE is calculated independently for each dwelling, based upon an elemental recipe of efficiency parameters, applied to the geometry of the dwelling in question. This would generate a notional value which would then be relaxed by 15% to generate the TFEE

Criterion three requires that dwellings are not at 'high' likelihood of high internal temperatures in summer months (June, July & August) and that zones in commercial buildings are not subject to excessive solar gains. This is demonstrated using the procedure given in SAP 2012 Appendix P for dwellings, and Simplified Building Energy Model (SBEM) or Dynamic Simulation Method (DSM) for non-residential buildings.

6.2 GLA Planning Policy

6.2.1 London Plan – Consolidated with Alterations since 2011 (March 2015)

On the 10th March 2015, Further Alterations to the London Plan was issued. The updated London Plan document is now a material consideration for planning applications. Key alterations to the document are as follows:

- A new policy is in place relating to electricity and gas supply.
- Policy guidance changes relating to increased provision of waste capacity.
- Funding to create cycle friendly 'mini Hollands' for up to four outer London Borough town centres.
- Further guidance is given which highlights the importance of demand side energy management and minimum standards for cycle parking.

6.2.2 Final Versions of the 'Minor Alterations to the London Plan' (MALP March 2016)

Final versions of the 'Minor Alterations to the London Plan (MALPs) were published and adopted in March 2016 and are current for any Stage 1 submissions to the GLA. The MALPs address parking and housing standards.

Recent alterations also include amendments to the 'Housing Supplementary Planning Guidance' (SPG) and 'Energy Planning' guidance, clarifying the CO_2 emissions reduction targets that currently apply and the changes that will be introduced from 1st October 2016 which are summarised in the table below.

Use Type	CO_2 Reduction Target (beyond Part L 2013)	
	2013 – 2016	2016 – 2019 (1st October 2016)
Residential Buildings	35%	**'Zero Carbon'**
Non-Domestic Buildings	35%	35%

Table A1: Uplift in CO_2 emissions targets

The target reduction in CO_2 emissions for 'Residential Buildings' will remain at 35% until 1st October 2016 when this will be uplifted to 'Zero Carbon' for Stage 1 applications. It should be noted that GLA has not offered a definition of 'Zero Carbon', however, in this context it is assumed to be a 100% reduction in regulated CO_2 emissions. The policy suggests that at least 35% should be achieved on site, with the remainder achieved by a combination of off-site measures and a cash in lieu payment (currently set at £2,700 per tonne of CO_2 in LB Camden of remaining emissions to achieve a total reduction of 100%).

The target reduction in CO_2 emissions for 'Non Domestic Buildings' will remain at 35% and will not be uplifted in the near future, despite the consultation document indicating that this would be set at 50%. The GLA comment that the 35% target will provide a smooth trajectory towards the upcoming requirement for 'Nearly Zero Energy Buildings' by 2020. It should be noted that the UK Government has yet to ratify the EU requirement for 'Nearly Zero Energy Buildings' and this may not occur should the UK vote to leave the EU.

The GLA have produced a 'Domestic Overheating Checklist' (Appendix 5 of the 'Energy Planning' guidance) for use early in the design process to identify potential overheating risks and to trigger the incorporation of passive measures within the building envelope. The 'Energy Planning' guidance document also includes an update to the guidance on compliance with overheating policy that design teams should be aware of when undertaking risk analysis and thermal comfort modelling for dwellings.

It is the GLA's expectation that dynamic thermal modelling should be undertaken to determine overheating risk and demonstrate compliance with London Plan Policy 5.9. This should be in addition to the Building Regulations 'Criterion 3' assessment of heat gains in summer months.

The GLA has set out that dynamic modelling should be carried out in accordance with the guidance and data sets in CIBSE TM49 'Design Summer Years' for London (2014) using the three design weather years as follows:

- 1976: a year with a prolonged period of sustained warmth.
- 1989: a moderately warm summer (current design year for London).
- 2003: a year with a very intense single warm spell.

For developments in high density urban areas (e.g. Canary Wharf) and the 'Central Activity Zone' the 'London Weather Centre' data set should be used. In lower density urban and suburban areas the 'London Heathrow' dataset should be used. These data sets have been adjusted to account for future climate effects.

The modelling should also consider the additional guidance contained in CIBSE TM52 'The Limits of Thermal Comfort: Avoiding Overheating in European Buildings'.

6.2.3 London Plan Policy

Development within London Borough of Camden is subject to the policy requirements of the London Plan 2016. The following policies of the London Plan (2016) have informed this strategy.

Policy 5.2: Minimising CO_2 Emissions

Policy 5.2 requires new-build domestic and non-domestic development to reduce CO_2 emissions by 40% beyond the Building Regulations Part L (2010) Target Emission Rate (TER).

Policy 5.6: Decentralised Energy in Development Proposals

Policy 5.6 requires development proposals to evaluate the feasibility of Combined Heat & Power (CHP) systems and where a new CHP system is appropriate, examine opportunities to extend the system beyond the Site boundary. Developments should select energy systems on the following hierarchy:

a. connection to existing heating or cooling networks
b. site wide CHP network
c. communal heating and cooling

Where future network opportunities are identified, proposals should be designed to connect to these networks.

Policy 5.7: Renewable Energy

Policy 5.7 requires that developments should provide a reduction in expected CO_2 emissions through the use of on-site renewable energy generation, where feasible.

Policy 5.9: Overheating and Cooling
Policy 5.9 requires that development proposals reduce potential overheating & reliance on air conditioning systems, demonstrated in consideration of the following cooling hierarchy:

a. minimisation of internal heat generation through efficient design
b. reduction of external heat gains through consideration of orientation, shading, albedo, fenestration, insulation, and green roofs & walls
c. management of internal heat gains through exposed thermal mass
d. passive ventilation
e. mechanical ventilation
f. active cooling

Development proposals should demonstrate how the design, materials, construction and operation of the development would minimise overheating and also meet its cooling needs

6.3 London Borough of Camden Policy

6.3.1 Camden Core Strategy (November 2010)

CS13 – Tackling climate change through promoting higher environmental standards

Reducing the effects of and adapting to climate change

The Council will require all development to take measures to minimise the effects of, and adapt to, climate change and encourage all development to meet the highest feasible environmental standards that are financially viable during construction and occupation by:

a. Ensuring patterns of land use that minimise the need to travel by car and help support local energy networks;
b. Promoting the efficient use of land and buildings;

c. Minimising carbon emissions from the redevelopment, construction and occupation of buildings by implementing, in order, all of the elements of the following energy hierarchy:
    i. Ensuring developments use less energy,
    ii. Making use of energy from efficient sources, such as the King's Cross, Gower Street, Bloomsbury and proposed Euston Road decentralised energy networks;
    iii. Generating renewable energy on-site; and
d. Ensuring buildings and spaces are designed to cope with, and minimise the effects of, climate change. The Council will have regard to the cost of installing measures to tackle climate change as well as the cumulative future costs of delaying reductions in carbon dioxide emissions.

Local Energy Generation

The Council will promote local energy generation and networks by:
a. Working with our partners and developers to implement local energy networks in the parts of Camden most likely to support them, i.e. in the vicinity of:
    - Housing estates with community heating or the potential for community heating and other uses with large heating loads;
    - The growth areas of King's Cross; Euston; Tottenham Court Road; West Hampstead Interchange and Holborn;
    - Schools to be redeveloped as part of Building Schools for the Future programme;
    - Existing or approved combined heat and power/local energy networks; and other locations where land ownership would facilitate their implementation.
b. Protecting existing local energy networks where possible (e.g. at Gower Street and Bloomsbury) and safeguarding potential network routes (e.g. Euston Road);

7. Appendix B: Sample Part L1A 2013 Compliance Report

L1A 2013 - Regulations Compliance Report
Design - Draft

NHER

This design draft submission provides evidence towards compliance with Part L of the Building Regulations, in accordance with Appendix C of AD L1A. It has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the 'as built' property. This report covers only items included within the SAP and is not a complete report of regulations compliance.

Assessor name	Mr Greg Jones	Assessor number	7740
Client		Last modified	16/09/2016
Address	Unit 34 - -, -		

Check	Evidence	Produced by	OK?
Criterion 1: predicted carbon dioxide emission from proposed dwelling does not exceed the target			
TER (kg CO_2/m^2.a)	Fuel = N/A Fuel factor = 1.00 TER = 13.01	Authorised SAP Assessor	
DER for dwelling as designed (kg CO_2/m^2.a)	DER = 12.27	Authorised SAP Assessor	
Are emissions from dwelling as designed less than or equal to the target?	DER 12.27 < TER 13.01	Authorised SAP Assessor	Passed
Is the fabric energy efficiency of the dwellling as designed less than or equal to the target?	DFEE 37.2 < TFEE 40.3	Authorised SAP Assessor	Passed
Criterion 2: the performance of the building fabric and the heating, hot water and fixed lighting systems should be no worse than the design limits			
Fabric U-values			
Are all U-values better than the design limits in Table 2?	**Element / Weighted average / Highest** Wall 0.14 (max 0.30) 0.18 (max 0.70) Party wall 0.00 (max 0.20) N/A Floor 0.10 (max 0.25) 0.10 (max 0.70) Roof 0.10 (max 0.20) 0.10 (max 0.35) Openings 1.37 (max 2.00) 1.80 (max 3.30)	Authorised SAP Assessor	Passed
Thermal bridging			
How has the loss from thermal bridges been calculated?	Thermal bridging calculated from linear thermal transmittances for each junction	Authorised SAP Assessor	
Heating and hot water systems			
Does the efficiency of the heating systems meet the minimum value set out in the Domestic Heating Compliance Guide?	Community heating scheme Secondary heating system: None	Authorised SAP Assessor	N/A
Does the insulation of the hot water cylinder meet the standards set out in the Domestic Heating Compliance Guide?	No hot water cylinder in the dwelling	Authorised SAP Assessor	
Do controls meet the minimum controls provision set out in the Domestic Heating Compliance Guide?	Space heating control: Charging system linked to use, programmer and TRVs No hot water cylinder in the dwelling	Authorised SAP Assessor	Passed
Fixed internal lighting			

URN: A version 6
NHER Plan Assessor version 6.2.3
Page 1 of 2
SAP version 9.92

Check	Evidence	Produced by	OK?
Does fixed internal lighting comply with paragraphs 42 to 44?	Schedule of installed fixed internal lighting Standard lights = 0 Low energy lights = 1 Percentage of low energy lights = 100% Minimum = 75 %	Authorised SAP Assessor	Passed
Criterion 3: the dwelling has appropriate passive control measures to limit solar gains			
Does the dwelling have a strong tendency to high summertime temperatures?	Overheating risk (June) = Slight (21.79°) Overheating risk (July) = Medium (23.49°) Overheating risk (August) = Medium (23.3°) Region = Thames Thermal mass parameter = 100.00 Ventilation rate in hot weather = 1.38 ach Blinds/curtains = Light-coloured curtain or roller blind	Authorised SAP Assessor	Passed
Criterion 4: the performance of the dwelling, as designed, is consistent with the DER			
Design air permeability ($m^3/(h.m^2)$ at 50Pa)	Design air permeability = 3.00 Max air permeability = 10.00	Authorised SAP Assessor	Passed
Mechanical ventilation system Specific fan power (SFP)	Mechanical ventilation with heat recovery: SFP = 0.53 W/(litre/sec) Max SFP = 1.5 W/(litre/sec) Heat recovery efficiency = 94.00 % Min heat recovery efficiency = 70.00 %	Authorised SAP Assessor	Passed
Have the key features of the design been included (or bettered) in practice?	The following walls have a U-value less than 0.15W/m²K: • N_1st_Wall (0.13) • N_2nd_Wall (0.13) • S_1st_Wall (0.13) • S_2nd_Wall (0.13) The following party walls have a U-value less than 0.2W/m²K: • E_1st_Wall (0.00) • E_2nd_Wall (0.00) • E_Entrance (0.00) • N_Entrance (0.00) • W_1st_Wall (0.00) • W_2nd_Wall (0.00) • W_Entrance (0.00) The following floors have a U-value less than 0.13W/m²K: • GF Entrance (0.10) The following roofs have a U-value less than 0.13W/m²K: • Roof 1 (0.10) Design air permeability of 3 $m^3/(h.m^2)$ is less than 4 $m^3/(h.m^2)$ at 50 Pa	Authorised SAP Assessor	

URN: A version 6
NHER Plan Assessor version 6.2.3
Page 2 of 2
SAP version 9.92

8. Appendix C – Correspondence with Royal Free Heat Network Operators

Richard Harper

From: Barns, David <David.Barns@camden.gov.uk>
Sent: 31 August 2016 16:35
To: Richard Harper
Cc: Poppy Carmody-Morgan; Aaron Brown; Terri Smyth; Caroline Hull; William Chan
Subject: RE: Royal Free Heat Network

Hi Richard

I believe the simplest and most reliable approach will be to use the current DECC guidance and assumed carbon factor.

Best wishes

David

David Barns
Senior Energy Performance Officer

Telephone: 020 7974 2530

From: Richard Harper [mailto:RichardHarper@hoarelea.com]
Sent: 31 August 2016 16:07
To: Barns, David
Cc: Poppy Carmody-Morgan; Aaron Brown; Terri Smyth; Caroline Hull; William Chan
Subject: RE: Royal Free Heat Network

David,

Have you been able to source any information on the carbon factor associated with the Royal Free heat network?

Thanks for your help with this.

Regards

Richard Harper
Executive Sustainability Consultant

HOARE LEA

DDI +44 1454 806 692
Tel +44 1454 201 020
Email richardharper@hoarelea.com

www.hoarelea.com

From: Richard Harper
Sent: 19 August 2016 16:38
To: 'Barns, David' <David.Barns@camden.gov.uk>

1

Cc: Poppy Carmody-Morgan <poppy.carmody-morgan@quod.com>; Aaron Brown <aaron.brown@quod.com>; Terri Smyth <terri@developingprojects.co.uk>; Caroline Hull <ch@karakusevic-carson.com>; William Chan <WilliamChan@hoarelea.com>
Subject: RE: Royal Free Heat Network

David,

Thank you for the further information. I can see how you would benefit from the use of the carbon free heat from the network and the calculation of how much carbon that saves.

In line with the DECC guidance on calculating the carbon emissions from a heat network the carbon emissions resulting from gas and electricity consumed to pump and produce the total amount of heat and electricity is off set by not using electricity from the grid that has a higher carbon intensity. This is where the benefit is derived.

The heat carbon factor will be used in our submission of calculations of CO_2 emissions for the Bacton development. At present we are using an assumed carbon factor.

Thank you for your help in this matter.

Regards

Richard Harper
Executive Sustainability Consultant

HOARE LEA

DDI +44 1454 806 692
Tel +44 1454 201 020
Email richardharper@hoarelea.com

www.hoarelea.com

From: Barns, David [mailto:David.Barns@camden.gov.uk]
Sent: 17 August 2016 17:08
To: Richard Harper <RichardHarper@hoarelea.com>
Cc: Poppy Carmody-Morgan <poppy.carmody-morgan@quod.com>; Aaron Brown <aaron.brown@quod.com>; Terri Smyth <terri@developingprojects.co.uk>; Caroline Hull <ch@karakusevic-carson.com>; William Chan <WilliamChan@hoarelea.com>
Subject: RE: Royal Free Heat Network

Hi Richard

Sorry for my slow response to this.

I will ask my manager about this tomorrow. I don't have any contacts at the Royal Free Trust directly I'm afraid.

When we spoke the other day I was saying about the complexity of the carbon intensity of heat from Camden's point of view. From our perspective the carbon intensity is the kWh of gas burned by our own boilers (or not burned because the demand is met from the waste heat supplied by the network) and electricity from running the network. I.e. the Royal Free Network reduces rather than increases the amount of carbon emitted. Getting figures from the Royal Free on the amount of gas and electricity consumed for their needs will only serve to add to the carbon intensity rather than reduce it.

Does that make sense in any way from your perspective?

I'll see where I get to with RFT contacts in the meantime.

2

Thanks

David

David Barns
Senior Energy Performance Officer

Telephone: 020 7974 2530

From: Richard Harper [mailto:RichardHarper@hoarelea.com]
Sent: 15 August 2016 17:23
To: Barns, David
Cc: Poppy Carmody-Morgan; Aaron Brown; Terri Smyth; Caroline Hull; William Chan
Subject: Royal Free Heat Network

David,

Thank you for the information you provided in our discussion on the Royal Free Heat Network on Friday.

During our conversation you mentioned that the Royal Free have all of the information on the gas consumption and electricity generation from the gas turbine.

I think I mentioned that it would be useful if you already have a contact at the health trust that could help us to understand the carbon factor of the heat that is generated for the network. In order to do this we would require the gas and electricity use and heat and electricity generation figures for the plant and heat network for a recent year.

Is this a request that you could make of the Royal Free?

Regards

Richard Harper
Executive Sustainability Consultant

HOARE LEA

DDI +44 1454 806 692
Tel +44 1454 201 020
Email richardharper@hoarelea.com

Visit our website www.hoarelea.com

Follow us

Building Services Consultancy of the Year
CIBSE Building Performance Awards 2016

3

Richard Harper

From:	Murphy, Angela <Angela.Murphy@camden.gov.uk>
Sent:	06 September 2016 15:24
To:	Richard Harper
Cc:	Poppy Carmody-Morgan; Terri Smyth; Caroline Hull; Jonathan Sparks; Phil Duerdin; Matthew Perring; Michael Walker; Greg Jones; Barns, David
Subject:	RE: Royal Free District Heat Network - Carbon Factor
Follow Up Flag:	Follow up
Flag Status:	Flagged

Richard,

We only receive the surplus heat, and so do not have a carbon factor. I believe David has explained this to you.

I have contacted the RFT and requested this on your behalf.

I also suggest, subject to confirmation from RFT, that you base your 'set point' under a range of options as there is no plan at present to expand the project nor will there be until such time as the current contract suite is finalised and other issues have been resolved with the tri-partite agreements between the Trust, Camden and Utilyx.

I would suggest modelling on connection in 5, 10 and 15 years.

regards

Angela Murphy
Sustainability Strategy Team Leader

Telephone: 020 7974 1923

From: Richard Harper [mailto:RichardHarper@hoarelea.com]
Sent: 05 September 2016 17:02
To: Murphy, Angela
Cc: Poppy Carmody-Morgan; Terri Smyth; Caroline Hull; Jonathan Sparks; Phil Duerdin; Matthew Perring; Michael Walker; Greg Jones
Subject: Royal Free District Heat Network - Carbon Factor

Angela,

I have had several discussions with David Barns on the carbon factor of the heat in the district heat network that the Bacton Low Rise development is proposing to connect to.

I spoke to David last week on receiving the carbon factor from yourselves and he suggested it would be best to speak to you about this.

In order for us to submit an energy strategy considering the connection to the district heat network and the CO_2 emissions reductions that can be attributed to this system we require a carbon factor for a unit of heat and information on the capacity of the network to deliver heat to the development.

1

The GLA will likely examine the amended energy strategy and will raise questions about the suitability of the figures we have used within the calculation of our CO_2 emissions reductions to target the CO_2 emissions reduction of 35% (100% from 1st October) beyond Part L 2013 policy. The GLA would usually expect to see evidence of our correspondence with the network operators including the carbon factor associated with the heat supplied by the network and the assumptions used to derive the carbon factor. We will also need to present a justification of the capacity of the network to provide the required heat to the development (e.g. 50%, 100% etc) to justify the calculations.

The carbon factor that we use will have a significant impact on the possible carbon offset charges that could apply to the application.

David has made me aware of how the carbon savings reported for the council through the use of the network are calculated, however, for the energy strategy the calculation of the carbon factor requires a methodology that is compliant with Building Regulations requirements to be used.

As well as the carbon factor, in order for the development to demonstrate the commitment to connect to the district heat network at the planning stage an agreed point must be set by which the development will connect. This could be set as follows:

1. A stated number of years following occupation
2. A particular date
3. An agreed trigger point (e.g. occupation of the Xth dwelling)

This needs to be agreed prior to the submission to planning.

If you have any queries on the above or would like to discuss, please let me know or get in touch on the number below.

Richard Harper
Executive Sustainability Consultant

HOARE LEA

DDI +44 1454 806 692
Tel +44 1454 201 020
Email richardharper@hoarelea.com

Visit our website www.hoarelea.com

Follow us

Building Services Consultancy of the Year
CIBSE Building Performance Awards 2016

9. Appendix D – Summary of Overheating Assessments

The following provides a summary of the overheating risk assessment carried out against the CIBSE requirements.

Results are also presented for the 'notional baseline' building. The design of the 'notional baseline' building was as per the Building Regulations Part L 2013 notional building, i.e. internal gains set according to National Calculation Methodology (NCM) profiles for dwellings. The extent of glazing was also set equivalent to the glazing types outlined within the Part L1A 2013 reference building parameters, which are used to determine the Criterion 3 benchmark when carrying out compliance assessments.

Table 4 Summary of concurrent notional dwelling specification

Element or system	Values
Opening areas (windows and doors)	Same as actual dwelling up to a maximum proportion of 25% of total floor area[1]
External walls (including opaque elements of curtain walls)	0.18 $W/(m^2 \cdot K)$
Party walls	0.0 $W/(m^2 \cdot K)$
Floor	0.13 $W/(m^2 \cdot K)$
Roof	0.13 $W/(m^2 \cdot K)$
Windows, roof windows, glazed roof-lights and glazed doors	1.4 $W/(m^2 \cdot K)$ (whole window U-value)[2]
	g-value = 0.63[3]
Opaque doors	1.0 $W/(m^2 \cdot K)$
Semi-glazed doors	1.2 $W/(m^2 \cdot K)$
Airtightness	5.0 $m^3/(h \cdot m^2)$
Linear thermal transmittance	Standardised psi values – see SAP 2012 Appendix R, except use of $y = 0.05\ W/(m^2 \cdot K)$ if the default value of $y = 0.15\ W/(m^2 \cdot K)$ is used in the actual dwelling
Ventilation type	Natural (with extract fans)[4]
Air-conditioning	None

Figure D1: Part L1A 2013 Notional Dwelling Specification

The remaining building fabric performance was applied as per the Part L 2013 Notional Building. Occupancy patterns were set according to NCM profiles, no blinds were applied and windows were closed.

Summary of Results

The units have been assessed using dynamic thermal modelling software IES 2015. The assessment has been based on the inputs as outlined within this report, accounting for gains such as those from people and equipment.

The requirement is to demonstrate that the risk of overheating has been mitigated through the incorporation of passive design measures within occupied areas.

Broadly the results can be summarised as follows:

- Based on the building as designed, the majority of units cannot achieve the CIBSE Guide A 2015 criteria for both weather files
- Applying Natural Ventilation with windows open 100% of the time demonstrates a significantly reduced risk of overheating in all dwelling spaces. The majority of the spaces meet the criteria of CIBSE guide A and CIBSE TM52 in this scenario.
- Unit C does not meet the TM52 criteria using the LHR1989 weather file based on current building design
- Based on the building as designed, openable windows enables Unit D to meet CIBSE TM52 in both weather files.
- As designed has shown improvement from the notional building using parameters set out in Approved Document Part L1A (2013). There is a significant improvement in the % of hours that the As Designed dwelling exceeds the criteria compared to the building regulations compliant building.
- Lower g-value in some of the glazing has shown a minor improvement in the % of hours that the criteria are exceeded.
- The use of solar control glazing (g-value: 0.35) and light coloured blinds has the affect of reducing the risk of the dwelling overheating.

The table below shows the results of the modelling for the different scenarios.

CIBSE Guide A 2015 and CIBSE TM52	DSY 2005		LHR 1989	
	Guide A	TM52	Guide A	TM52
1. Mechanical Ventilation only	0/28 Meet criteria	25/28 Meet Criteria	0/28 Meet criteria	10/28 Meet Criteria
2. Natural Vent. only	18/28 Meet criteria	27/28 Meet Criteria	18/28 meet criteria	27/28 Meet Criteria
3. Mechanical Ventilation and Natural Vent.	1/28 Meet criteria	25/28 Meet Criteria	0/28 Meet criteria	25/28 Meet Criteria

Table D1: Summary of Results

9.1 Results Summary for Building As Designed – Mechanical Ventilation

- Building as designed with continuous mechanical extract ventilation with an air change rate of 15l/s per bedroom and 13l/s per living room.
- Additional ventilation is provided to the living room as follows; 1 bedroom dwelling: 100 l/s, 2 bedroom dwelling: 140 l/s and 3 bedroom dwelling: 160 l/s

Results are presented against CIBSE Guide A 2015, and CIBSE TM52 criteria.

Results are presented from simulations using the Design Summer Year 2005 (DSY05) and the London Heathrow weather file 1989 (LHR 1989).

The results of the two different dwellings can be summarised as follows:

- All rooms do not meet the 2015 CIBSE Guide A criterion, by up to 22.3% when using the DSY05 weather file and 36.0% when using the LHR 1989 weather file.
- Using the LHR 1989 weather file leads to an increase in the time the dwelling is exceeding the CIBSE Guide A 2015 criteria.
- CIBSE TM52 criteria can be met for Unit C and D using the DSY05 weather file, however it does not meet the criteria when using the LHR1989 weather file.

Unit Ref.	Room	DSY05	LHR 1989	DSY05	LHR 1989
		CIBSE Guide A 2015		CIBSE TM52	
		Summer Operative Temperature (ºC) >26			
		% occupied hours >26(ºC)		Achieved Criteria?	
C	Livingroom	22.3	36.0	✓	✗
	Bedroom 1	11.9	26.9	✓	✗
D	Livingroom	8.9	16.4	✓	✗
	Bedroom 1	6.5	14.9	✓	✓
	Bedroom 2	4.1	7.0	✓	✓
	Bedroom 3	5.5	14.3	✓	✓

Table D2: Summary of results for Mech Vent.

9.2 Results Summary for Building As Designed – Natural Ventilation

- Building as designed with openable windows of an openable area 85% with a maximum angle open 20°. Windows are open for 24 hours.
- Results are presented against CIBSE Guide A 2015, and CIBSE TM52.

Results are presented according to the design summer year 2005 (DSY05) and the London Heathrow weather file 1989 (LHR 1989).

The results of the two different dwellings can be summarised as follows:

- All bedrooms meet the 2015 CIBSE Guide A criterion.
- Livingroom temperature criteria is at worst exceeded 8.5% of the occupied hours when using the DSY05 weather file and 12.8% when using the LHR 1989 weather file.
- Using the 1989 weather file leads to an increase in time that the dwelling is exceeding the CIBSE Guide A 2015 criterion.
- CIBSE TM52 criteria can be met in the majority of rooms using the LHR 1989 weather file, however the living room in Unit C does not meet the criteria.

Unit Ref.	Room	DSY05	LHR 1989	DSY05	LHR 1989
		CIBSE Guide A 2015		CIBSE TM52	
		Summer Operative Temperature (ºC) >26			
		% occupied hours>26(ºC)		Achieved Criteria?	
C	Livingroom	8.5	12.8	✓	✗
	Bedroom 1	1.2	2.0	✓	✓
D	Livingroom	5.7	8.4	✓	✓
	Bedroom 1	1.2	2.2	✓	✓
	Bedroom 2	1.2	1.8	✓	✓
	Bedroom 3	1.2	2.0	✓	✓

Table D3: Summary of Results for Nat Vent

9.3 Results Summary for Building As Designed – Mechanical Ventilation and Natural Ventilation

- Building as designed with continuous mechanical extract ventilation with an air change rate of 15l/s per Bedrooms and 13l/s per Livingroom.
- Additional ventilation is provided to the living rooms; 1 bedroom dwelling: 100 l/s, 2 bedroom dwelling: 140 l/s and 3 bedroom dwelling: 160 l/s
- Additionally with openable windows of an openable area 85% with a maximum angle open 20°. Opening from 8am – 9pm.

Results are presented against CIBSE Guide A 2015, and CIBSE TM52.

Results are presented according to the design summer year 2005 (DSY05) and the London Heathrow weather file 1989 (LHR 1989).

The results of the two different dwellings can be summarised as follows:

- All units do not comply with the 2015 CIBSE Guide A criterion when using the DSY05 and LHR 1989 weather file. However there is improvement from Mechanical Ventilation only and natural ventilation only.
- CIBSE TM52 criteria can be met in majority of rooms using the DSY05 weather file, however the living room in Unit C does not meet the criteria.
- CIBSE TM52 criteria cannot be met for Unit C and D using both DSY05 and LHR 1989 weather file.

Unit Ref.	Room	DSY05	LHR 1989	DSY05	LHR 1989
		CIBSE Guide A 2015		CIBSE TM52	
		Summer Operative Temperature (ºC) >26			
		% occupied hours>26(ºC)		Achieved Criteria?	
C	Livingroom	9.1	16.9	✗	✗
	Bedroom 1	4.5	17.3	✓	✓
D	Livingroom	6.5	10.2	✓	✗
	Bedroom 1	4.0	16.2	✓	✓
	Bedroom 2	3.5	8.6	✓	✓
	Bedroom 3	3.9	10.9	✓	✓

Table D4: Summary of results using natural ventilation and mech vent

9.4 Results Comparison of Building As Designed and Notional Building

- Notional Building – Mechanical Ventilation Only
- Building as designed follows the Approved Document Part L1A (2013), further details shown in Appendix G. Operation profiles were based on the UK NCM database for dwellings.
- Building As Designed – Mechanical Ventilation and Natural Ventilation
- Building as designed with continuous mechanical extract ventilation with an air change rate of 15l/s per Bedrooms and 13l/s per Livingroom.
- Additional ventilation is provided to the living rooms; 1 bedroom: 100 l/s, 2 bedroom: 140 l/s and 3 bedroom: 160 l/s
- Additionally with openable windows of an openable area 85% with a maximum angle open 20°. Opening from 8am – 9pm.

Results shows a comparison between the Notional and Building As Designed for CIBSE Guide A 2015.

Results are presented according to the design summer year 2005 (DSY05) and the London Heathrow weather file 1989 (LHR 1989).

The results of the two different dwellings can be summarised as follows:

- All units show a significant improvement from Notional to the building As Designed when using the DSY05 and LHR 1989 weather file.
- The difference in percentage hours exceeding the criteria are presented in Table 12.
- There is a significant improvement in the % of hours that the As Designed dwelling exceeds the criteria compared to the building regulations compliant building. This can be attributed to increased mechanical ventilation rates, reduced g-value and shading from light coloured blinds.

Unit Ref.	Room	DSY05	LHR 1989	DSY05	LHR 1989	Percentage difference of Actual to Notional
		Notional Building		Building As Designed – Mechanical Ventilation and Natural Ventilation		
		Summer Operative Temperature (ºC) >26				
		% occupied hours>26(ºC)				
C	Livingroom	95.6	100	9.1	16.9	86.5%
	Bedroom 1	59.8	93.8	4.5	17.3	55.3%
D	Livingroom	11.4	22.6	6.5	10.2	4.9%
	Bedroom 1	7.4	30.7	4.0	16.2	3.4%
	Bedroom 2	4.2	13.6	3.5	8.6	0.7%
	Bedroom 3	6.0	31.6	3.9	10.9	2.1%

Table D5: Summary of results of actual building against the notional building.

www.hoarelea.com