Ritchie + Daffin

Chester Road Hostel
Energy Assessment
Planning
Revision B

05 March 2021

Studio D, Holborn Studios
49-50 Eagle Wharf Road
London N1 7ED
Phone +44 (0)20 7043 3417
info@ritchiedaffin.com
www.ritchiedaffin.com

Contents

This Energy Assessment has been prepared for the proposed new Hostel development at No.2 Chester Road by Camden Council. It is in the format described in *Energy Planning: GLA guidance on preparing energy assessments (October 2018).*

The project's high-level design approach is to improve the thermal performance of the building fabric to reduce heating requirements and then to supply space heating with electric underfloor heating in each dwelling. Underfloor heating saves floor and wall space in small dwelling units.

Domestic hot water will be generated by a central air-source heat pump, using environmentally-friendly CO2 refrigerant especially designed for high temperatures needed for DHW. Hot water is circulated via a traditional pipework loop to the dwellings and staff areas.

Solar Photovoltaics (PV) mounted on the flat roof will generate renewable electricity on site, this will mainly be used on site to run the heat pump.

All energy consumption of heating, power and hot water will be metered separately with the information collected centrally for management, and if necessary billing.

The energy consumption patterns will be domestic in nature and therefore Approved Document L1A and SAP have been used for the energy efficiency calculations for dwellings. The results are presented with both SAP2012 and SAP10(2020) Carbon Factors during the Regulations transition period.

In SAP2010 terms, overall a 65% Carbon reduction is proposed.

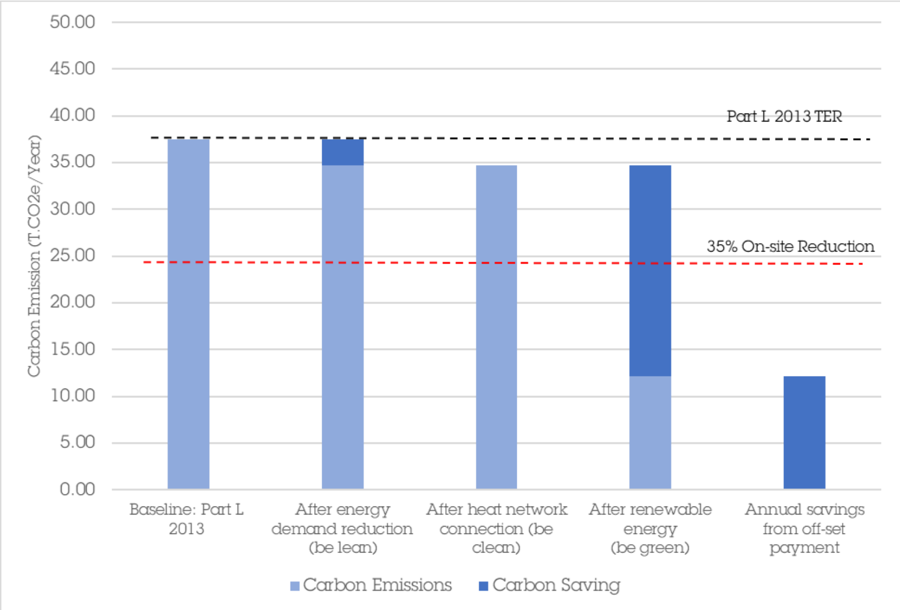
Remaining emissions are to be off-set with a payment to the local authority Carbon offset fund as required to meet a zero-carbon standard. The Offset will be calculated in terms of future SAP10 Carbon Factors.

TM59 Modelling has been carried out on the dwellings at most risk to manage the likelihood of summer overheating. The iterative steps to improve the design towards TM59 compliance are described, and the solution of external & internal shading, solar-control glass, acoustic vents and an occasional-use boost ventilation fan have been retained.

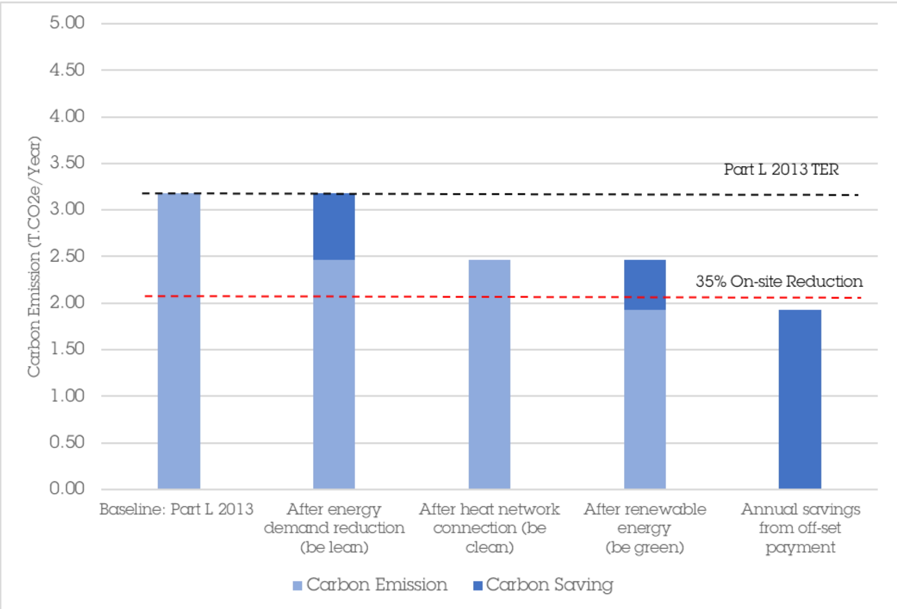
Rev B: The PV Array is enlarged to satisfy the Planning Authority request to maximise the roof coverage.
The one-off offset is based on an emissions duration of 30 years. With a carbon off-set price of £95 per tonne of CO2, this equates to 422.7 Tonnes x £95/T = **£40,157** based on SAP10 Carbon Factors.

TOTAL SITE Emissions Summary (Based on SAP10 Carbon Factors)

	Total regulated Emissions (Tonnes CO2 per annum	CO2 Savings (tonnes CO2 per annum	Percentage saving (%)
Baseline: Part L 2013 Compliant Development	40.6		
After energy demand reduction	37.1	13.5	9%
After CHP	37.1	0.0	0%
After Renewable Energy	14.1	23	57%
Annual savings from off-set payment		26.6	65%
Cumulative savings for off-set payment (30yr)		422.7	



Domestic Emissions Summary



Non-Domestic Emissions Summary

1.0 Introduction

This Energy Assessment has been prepared for the proposed new Hostel development at No.2 Chester Road by Camden Council. It is in the format described in *Energy Planning: GLA guidance on preparing energy assessments (October 2018).*

The development comprises of 50 dwelling units for temporary accommodation of homeless families.

Level	Dwelling Type	No.
Ground		
	Studio	10
	1-bed	1
	1-bed WCH	2
	1-bed corner	1
	2-bed	0
First		
	Studio	8
	1-bed	6
	1-bed corner	1
	2-bed	1
Second		
	Studio	8
	1-bed	6
	1-bed corner	1
	2-bed	1
Third		
	Studio	4
	1-bed	0
	2-bed	0
Total		50

A summary of relevant policies is listed in Section 1.2.

This assessment is then set out in three parts that explain the hierarchical approach to carbon dioxide emissions reduction.

A high-level renewable energy feasibility study summarises the choices of technology.

TM59 Overheating Modelling Iterations are described in Section 5.

The appendices include an overheating checklist and SAP & SBEM outputs.

1.2 Planning Requirements

The project takes place within the context of national, regional and local planning policy that seek to address the challenges of reducing energy use and the implications of climate change. The policies outline how Government and the Mayor of London are endeavouring to improve the way energy and other resources are used in buildings.

National Planning Policy Framework
Part 9. Meeting the challenge of climate change, flooding and coastal change.

93. Planning plays a key role in helping shape places to secure radical reductions in greenhouse gas emissions, minimising vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of renewable and low carbon energy and associated infrastructure. This is central to the economic, social and environmental dimensions of sustainable development.

94. Local planning authorities should adopt proactive strategies to mitigate and adapt to climate change,16 taking full account of flood risk, coastal change and water supply and demand considerations.

95. To support the move to a low carbon future, local planning authorities should:

- *plan for new development in locations and ways which reduce greenhouse gas emissions;*
- *actively support energy efficiency improvements to existing buildings; and*
- *when setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards.*

96. In determining planning applications, local planning authorities should expect new development to:

- *comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and*
- *take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.*

97. To help increase the use and supply of renewable and low carbon energy, local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:
- *have a positive strategy to promote energy from renewable and low carbon sources;*
- *design their policies to maximise renewable and low carbon energy development while ensuring that adverse impacts are addressed satisfactorily, including cumulative landscape and visual impacts;*

• consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources
• support community-led initiatives for renewable and low carbon energy, including developments outside such areas being taken forward through neighbourhood planning;
• identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

98. When determining planning applications, local planning authorities should:
• not require applicants for energy development to demonstrate the overall need for renewable or low carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and
• approve the application if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should also expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas.

London Plan
Policy 5.2 Minimising Carbon Dioxide emissions
A: Development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the following energy hierarchy:

Be lean: use less energy
Be clean: supply energy efficiently
Be green: use renewable energy

B: The Mayor will work with boroughs and developers to ensure that major developments meet the following targets for carbon dioxide emissions reduction in buildings. These targets are expressed as minimum improvements over the Target Emission Rate (TER) outlined in the national Building Regulations leading to zero carbon residential buildings from 2016 and zero carbon non-domestic buildings from 2019.

HOUSING SUPPLEMENTARY PLANNING GUIDANCE
Mayor of London
MARCH 2016

Definition
2.3.58 'Zero carbon' homes are homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (beyond Part L 2013) on-site (in line with policy 2.5B). The remaining regulated carbon dioxide emissions, to 100 per cent, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere (in line with policy 5.2 E).

Implementation

2.3.59 In line with the implementation date for previous increases in the London Plan carbon dioxide targets and improvements to Part L of the Building Regulations, 'zero carbon' housing will be implemented for Stage 1 schemes from 1st October 2016.
2.3.60 The technical implementation of this policy should be in line with the Mayor's Energy Planning - GLA Guidance on preparing energy assessments (March 2016). The Mayor's Housing Standard's Viability Assessment assumed a carbon off-set price of £60 per tonne of carbon dioxide for a period of 30 years. Where the borough applies a carbon dioxide off-set price of £60 per tonne, it is not considered necessary to carry out a further viability assessment of the policy approach.

ENERGY PLANNING
Greater London Authority guidance on preparing energy assessments (March 2016)

Local Planning

Camden Local Plan. Policy CC1 Climate change mitigation

The Council will require all development to minimise the effects of climate change and encourage all developments to meet the highest feasible environmental standards that are financially viable during construction and occupation.

We will:
a. promote zero carbon development and require all development to reduce carbon dioxide emissions through following the steps in the energy hierarchy;
b. require all major development to demonstrate how London Plan targets for carbon dioxide emissions have been met;
c. ensure that the location of development and mix of land uses minimise the need to travel by car and help to support decentralised energy networks;
d. support and encourage sensitive energy efficiency improvements to existing buildings;
e. require all proposals that involve substantial demolition to demonstrate that it is not possible to retain and improve the existing building; and
f. expect all developments to optimise resource efficiency.

For decentralised energy networks, we will promote decentralised energy by:
g. working with local organisations and developers to implement decentralised energy networks in the parts of Camden most likely to support them;
h. protecting existing decentralised energy networks (e.g. at Gower Street, Bloomsbury, King's Cross, Gospel Oak and Somers Town) and safeguarding potential network routes; and
requiring all major developments to assess the feasibility of connecting to an existing decentralised energy network, or where this is not possible establishing a new network.

To ensure that the Council can monitor the effectiveness of renewable and low carbon technologies, major developments will be required to install appropriate monitoring equipment.

Camden Planning Guidance: Energy efficiency and adaptation March 2019

The CPG ***Energy Efficiency and Adaptation*** has the following implications for Energy & Sustainability.

For all new build residential dwellings and flats, or multi-occupation residential buildings with 10 or more rooms/units or occupiers, or Residential refurbishments, conversions and change of user for:
5 or more dwellings, or 500sqm or more of floorspace:

1. A planning application must provide a Sustainability Statement showing how to reduce the energy, water and materials used in design and construction using BREEAM (Building Research Establishment Environmental Assessment Method). A BREEAM pre-assessment is required showing how an 'Excellent' score will be achieved. *

2. An Energy Statement should demonstrate how carbon dioxide emissions will be reduced in line with the energy hierarchy in Camden Planning Guidance and the GLA Sustainable Design and Construction SPD.

London Plan policy 5.2 requires major residential developments to achieve zero carbon (with at least 35% reduction achieved through on-site measures). The remaining regulated carbon emissions (to 100%) are to be offset through a cash in lieu contribution.

Major developments for non-domestic development will still be expected (as above) to achieve 35% reduction against Part L 2013 Building Regulations.

Camden's Policy CS13 also requires that all developments (existing and new build) achieve a 20% reduction in on-site carbon dioxide emissions through renewable technologies.

(https://www.camden.gov.uk/sustainability-statements)
Camden Council has advised the Carbon Dioxide offset cost as **£95 per tonne per year** (for 30 years).

* Refer to the separate report on Sustainability & HQM for a description of the approach to environmental assessment.

Note of Building Regulations Compliance

Part L [Conservation of Fuel & Power] will place requirements on the energy strategy.

The building arrangement and expected use has mostly dwelling-like use characteristics rather than 'rooms for residential purposes' such as student accommodation. More specifically, the proposed flats are clearly self-contained units designed to accommodate a single household. Each has its own bathroom, kitchen with washing machine, and energy and water consumption are all separately metered. The energy consumption patterns will be domestic in nature and therefore from a compliance perspective, L1A and SAP have been used for the energy efficiency calculations. The nondwelling parts of the building (approx..5% of the overall GIA) follow guidance in L2A.

SAP calculations have been carried out for each principal dwelling type using the approved FSAP2012 software (Stroma) and the summary inputs are described in Section 2. Output worksheets for each flat type are included in the Appendix.

Note on SAP 10
This proposal anticipates the forthcoming revisions to the Carbon Intensity of grid electricity.

Current SAP assumes that electricity used produces 2.4 times the carbon emissions of mains gas. The 55% reduction in the CO2 emissions factor for electricity means homes heated by direct electric systems will produce virtually the same CO2 emissions as gas, while heat pumps will produce even less.

This change has two main outcomes:

1 Carbon emissions associated with on-site electricity use will reduce by half, making it almost equivalent to gas in carbon terms.
2 The carbon savings associated with on-site electricity production will also reduce by half i.e. photovoltaic panels become less effective in offsetting carbon.

Relationship between Requirements

	SAP2012	SAP10 (2020)
	Kg CO2/kWh	**Kg CO2/kWh**
Mains Gas	0.216	0.210
Electricity	0.519	0.233

The Building Regulations and London plan each aim to achieve Carbon reduction, however they are set at different levels. The diagram below explains their respective weight. The London Plan requirement is the most onerous and this sets the design target, i.e. Zero Carbon for domestic uses and 35% reduction for non-domestic.

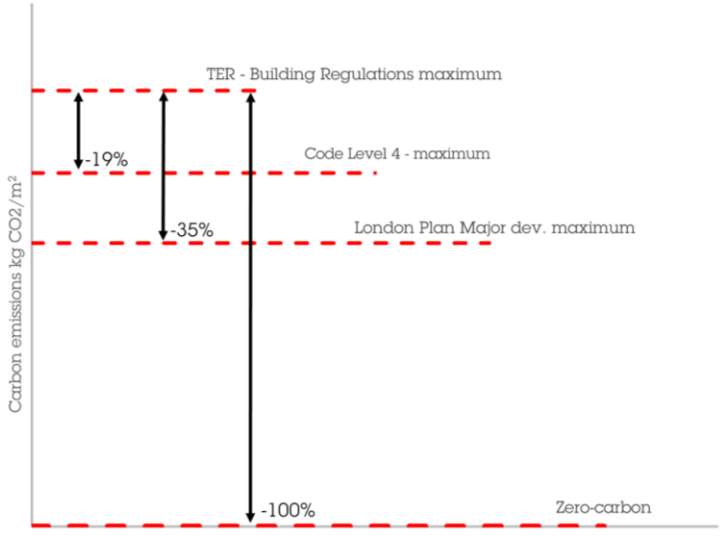


Figure 1: Carbon Reduction Requirements

2.0 Energy Demand Reduction

The first stage of the Energy Hierarchy involves focusing on improvement of the performance of the building envelope so that the energy demands for lighting, mechanical ventilation, heating and cooling are reduced or eliminated.

Thermal comfort is achieved to the greatest practical extent through the use of passive measures listed below:

- good levels of insulation with minimal thermal bridges
- passive solar gains and internal heat sources
- excellent level of airtightness
- good indoor air quality, provided by a whole house mechanical ventilation system with highly efficient heat recovery

2.1 Thermal Insulation

The proposed thermal performance of the construction elements is shown below. These are equivalent to those used in Passivhaus schemes and are better than the quoted values in the Building Regulations.

The following performance targets outline the expected standards energy efficiency for the development.

Construction Element	Building Regulations L1A Notional Spec	**Target U-Value**
External Wall	0.18 W/(m^2 K)	0.13 W/(m^2 K)
Floor	0.13 W/(m^2 K)	0.11 W/(m^2 K)
Roof	0.13 W/(m^2 K)	0.10 W/(m^2 K)
Rooflights	1.4 W/(m2 K)	1.2 W/(m2 K)
Entrance Doors (to flats)	2.00 W/(m^2 K)	1.00 W/(m^2 K)
Windows	1.4 W/(m^2 K)	1.2 W/(m^2 K)

Glazing Specification:
Solar transmittance (g-value) 0.4

Air Tightness
The design air permeability is 2.5 m^3/(hr m^2) at 50Pa.

2.2 Airtightness

This refers to limiting the uncontrolled flow of air through unintentional openings in the building envelope. The management of infiltration helps minimise building energy use. A building with high infiltration would be described as draughty.

The extent of infiltration may be determined by measuring the air permeability of the building envelope which describes the relative 'air-tightness' of a building.

The current Building Regulations 2013 requires that the air permeability of the building fabric does not exceed 10m3/h/m2 at an applied pressure difference of 50Pa.

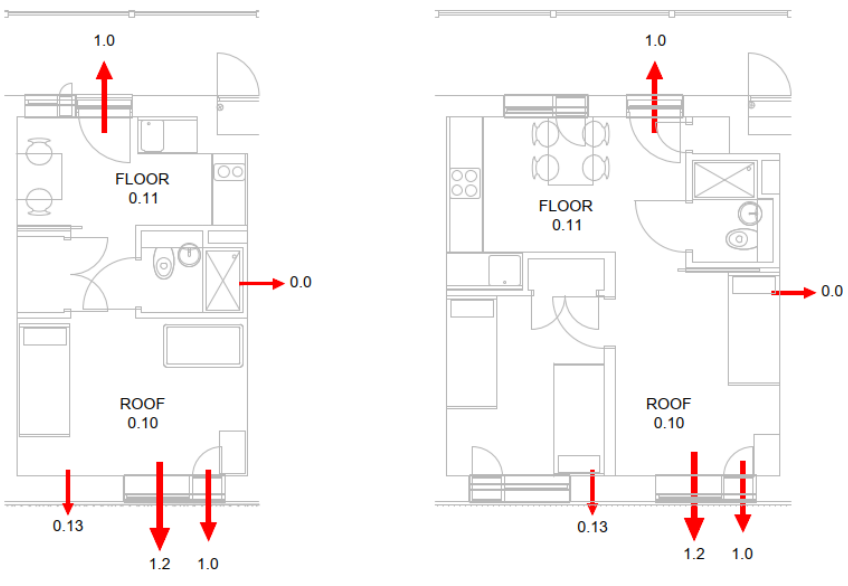
Using excellent construction details the air change rate will be no greater than 2.5m3/h/m2 at a 50Pa pressure difference which is equivalent to that of a Passivhaus.

Details of the approach to airtightness can be found in the Architect's Design & Access Statement.

Thermal Bridging

Thermal bridges represent an additional path for heat loss and are commonly present at the junctions between building constructions such as sills, jambs and wall to floor joints. Heat can be lost at these interfaces due to discontinuities in insulation.

The severity of a thermal bridge depends greatly on the construction quality of a building. For example, in Passivhaus schemes, the heat losses through such bridges are eliminated by careful design of all building joints and junctions.



Proposed U-Values (W/m2K)

2.3 SAP Parameters

Element or system	Notional Building	Proposed Building
Size and shape	Same as actual dwelling	Same as actual dwelling
Opening areas (windows and doors)	Scaled down so that total glazing area equals 25% of floor area	Same as actual dwelling
External walls	U = 0.18 W/m²K	U = 0.13W/m²K
Floors	U = 0.13 W/m²K	U = 0.11W/m²K
Roofs	U = 0.13 W/m²K	U = 0.10 W/m²K
Opaque door	U = 1 W/m²K	U = 1.0 W/m²K
Windows and glazed doors	U = 1.4 W/m²K	U = 1.2 W/m²K
	Frame factor 0.7	Frame factor 0.8
	Solar energy transmittance 0.63	Solar energy transmittance 0.4
	Light transmittance 0.80	Light transmittance 0.7
Thermal mass	Medium	Low
Living area	Same as actual dwelling	Same as actual dwelling
Shading, orientation and number of sheltered sides	Same as actual dwelling	Same as actual dwelling
Allowance for thermal bridging	Calculated from junction lengths and default psi values Refer to Appendix B	Y=0.15
Ventilation system	Natural ventilation with intermittent extract fans	Balanced MVHR (Envirovent EnergiSava)
Air permeability	5 m³/h·m² at 50 Pa	2.5 m³/h·m² at 50 Pa
Chimneys	None	None
Open flues	None	None
Extract fans	2 extract fans for a total floor area up to 70 m2, 3 for a total floor area > 70 m2 and up to 100 m2, 4 for a total floor area > 100 m2	None
Main heating fuel (space and water)	Mains gas	Electricity
Heating system	Boiler with radiators, pump in heated space	Electrical Underfloor Heating
Boiler	Combi boiler, Efficiency, SEDBUK(2009), 89.5%	N/A
Heating system controls	Programmer and room thermostat for single storey flats with living area fraction > 0.7 Otherwise time and temperature control	Programmer, room thermostat
Hot water system	From main heating system	From community heat pump
Hot water cylinder	N/A	(no cylinder in dwelling)
Primary water heating losses	N/A	N/A
Water use limited to 125 litres per person per day	Yes	Yes
Secondary space heating	None	None
Low energy light fittings	100% of fixed outlets	100% of fixed outlets

2.4 Summary

The figures below show the percentage reduction in carbon dioxide emissions as a result of the proposed energy efficiency measures per house type, and for the development as a whole. It should be noted that the TER for this first stage of the assessment is calculated with Gas-Fired Combination boilers as the baseline.

Dwelling Ref	NIA Sqm	TER	DER (Energy Efficiency)	%age Reduction
			kg CO2/m2.yr	
1-bed WCH	55.3	22.97	23.31	-1.48
1-bed	35.0	25.45	25.07	1.49
1-bed cor	35.12	27.78	27.29	1.76
Studio	25.0	30.08	28.63	4.82
2-bed	49.68	24.33	24.66	-1.36

Regulated Carbon emissions per flat type

Combined Heat and Power (CHP) is a mechanical means of producing both heat and electricity for a building. A CHP power plant usually consists of a gas-powered engine connected to a generator to produce electrical power. Waste heat given off by the engine and generator is used as a heat source. This is typically used for heating domestic hot water.

Policy 5.6 of the London Plan states:

"Major development proposals should select energy systems in accordance with the following hierarchy:

Connection to existing [off-site] heating or cooling networks

Site wide [on-site] CHP network

Communal heating and cooling."

Off-site CHP
The website http://www.londonheatmap.org.uk/Mapping/ is an interactive tool that allows users to identify opportunities for decentralised energy projects in London. The Heat Map confirms that there are no existing District Heating networks (CHP or otherwise) in the area.

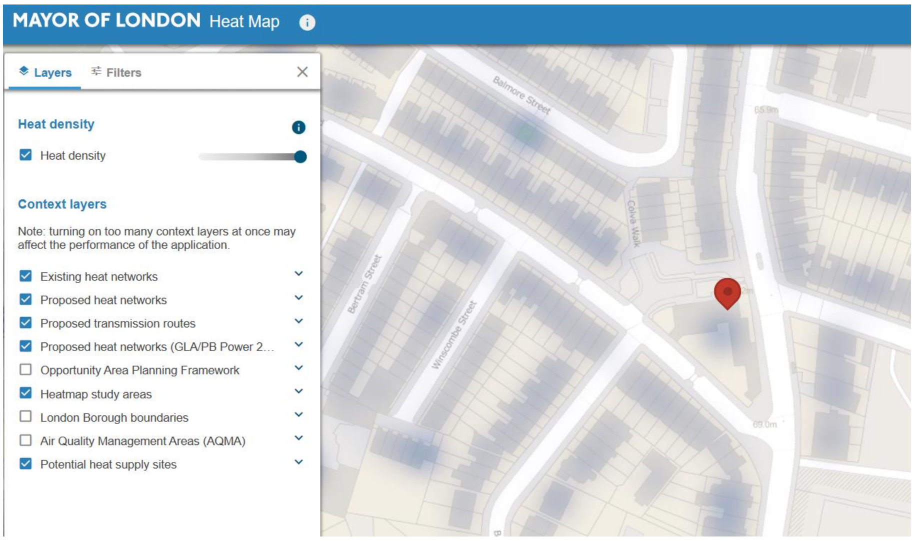


Figure 4: London Heat Map - extract

On-site CHP
This requires an on-site CHP within a communal plant room to produce heating water that would be distributed around the site through district heating pipework. Electricity would also be produced, which would then be distributed from this central plant room and used on site or exported off site.

It is judged that at the scale of 50 apartments the scheme technically and economically unfeasible due to:

a) The very low heat requirements given the measures described in Section 2.0.
b) The unnecessary technical and managerial complexity introduced to a small project.
c) Poorer Carbon performance than this proposal.

3.1 Heating & Hot Water Strategy

At the outset of the project the team proposed a highly insulated building which requires very little space heating.

On this basis a direct electric heating system was proposed as preferable using electrical resistance under-floor heating, instead of traditional 'wet' radiators.

Three options were appraised to understand the lifecycle costs.

1 Gas-fired central boilers serving an LTHW heating circuit to heat interface unit (HIU) in each apartment. HIU makes instantaneous hot water; & space heating with 'wet' underfloor heating.

2 Communal air-source heat pumps serving an LTHW heating circuit to heat interface unit (HIU) in each apartment. Hot water and space heating as option 1

3 Space heating provided by electrical underfloor heating. Communal air-source heat pumps generate domestic hot water centrally, which is distributed to apartments.

In Options 2&3 hot water is generated centrally using an air-source heat pump on the roof.

The graphs opposite illustrate the results of a Lifecyle cost and running costs per apartment type and we have drawn the following main conclusions:

Over 20 years, gas-fired central heating and electric space heating have similar overall costs.

The operational cost/year is about 12% higher for electric heating (Op3) than gas-fired central heating. The difference becomes negligible if we can build to passivhaus levels of energy efficiency.

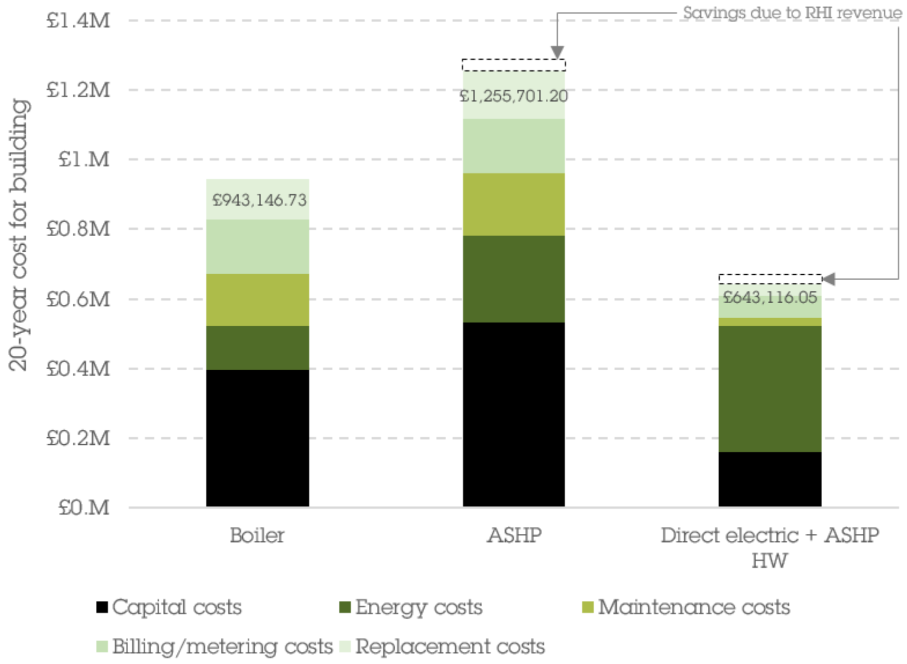
The Carbon emissions for electric heating (Op3) are 33% lower than the gas-fired option. [assuming SAP10 carbon figures for grid electricity, and these are predicted to improve further over the life of the building]

The major advantage of Option 3 is that capital costs of a conventional 'wet' heating system in the building and apartments are high and savings can be re-invested instead in insulation and renewable energy systems for the hot water. Provided the heat demand is very low, the higher cost per unit of electricity is not penalising, as can be seen from the graph opposite showing annual cost per apartment.

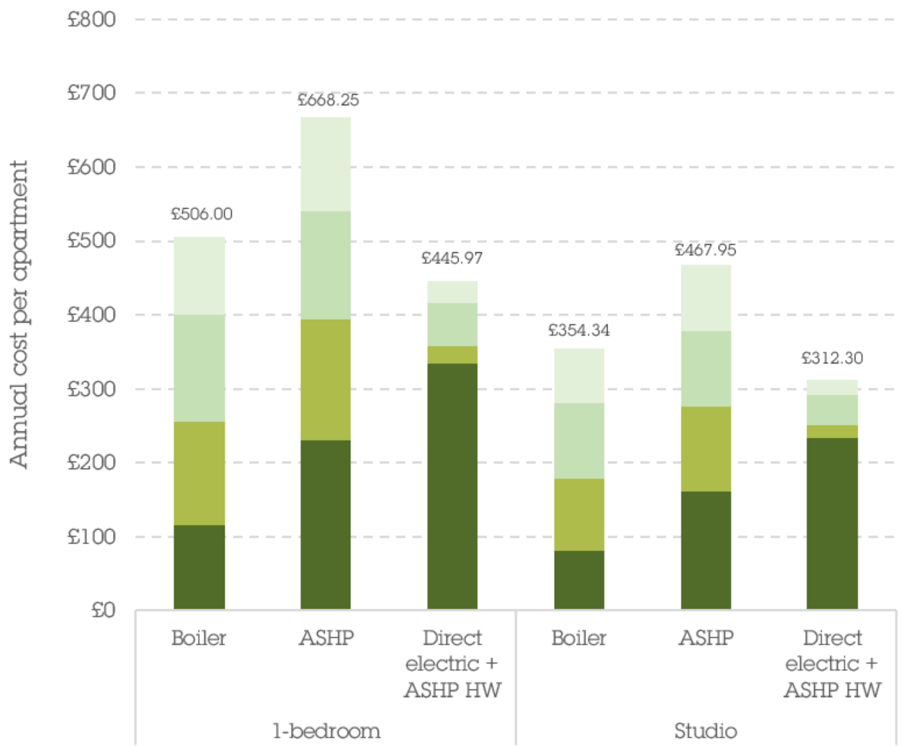
This proposal anticipates the forthcoming 2020 revisions to the Carbon Intensity of grid electricity. The carbon factor associated with electricity production has effectively halved in the last 15 years which has two main outcomes:

1 Carbon emissions associated with on-site electricity use will halve, making it almost equivalent to natural gas in carbon terms.

2 The carbon savings associated with on-site electricity production will also halve i.e. photovoltaic panels become less effective in offsetting carbon



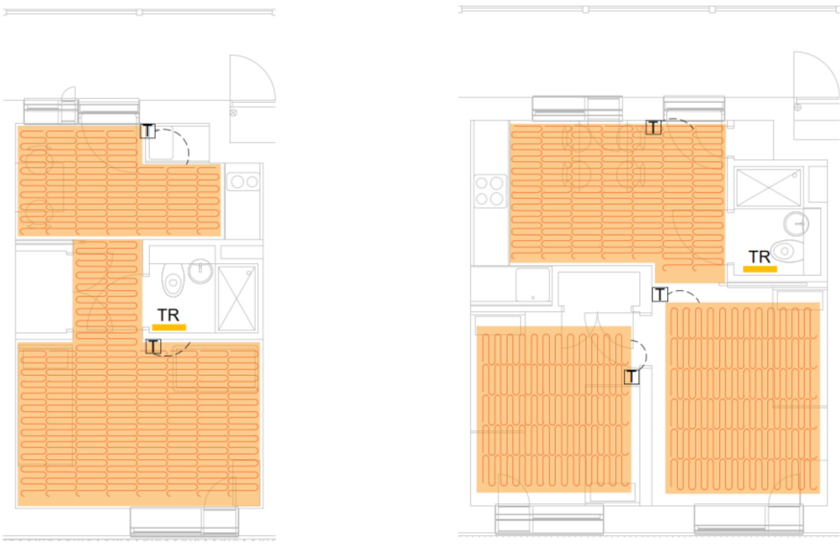
20-year Lifecycle Cost Estimate



Annual Running Cost Estimate

3.2 Space Heating System

Electrical resistance under-floor heating is proposed in each flat. Each room being separately temperature controlled with a thermostat.



Typical Electric Heating Mat in dwellings

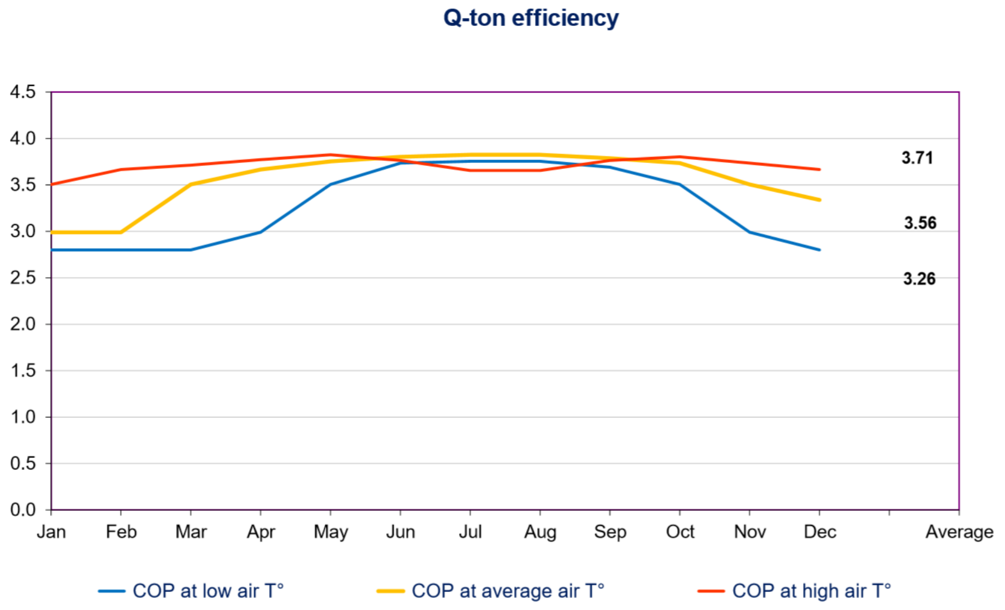
Typical Electric Heating Mat System

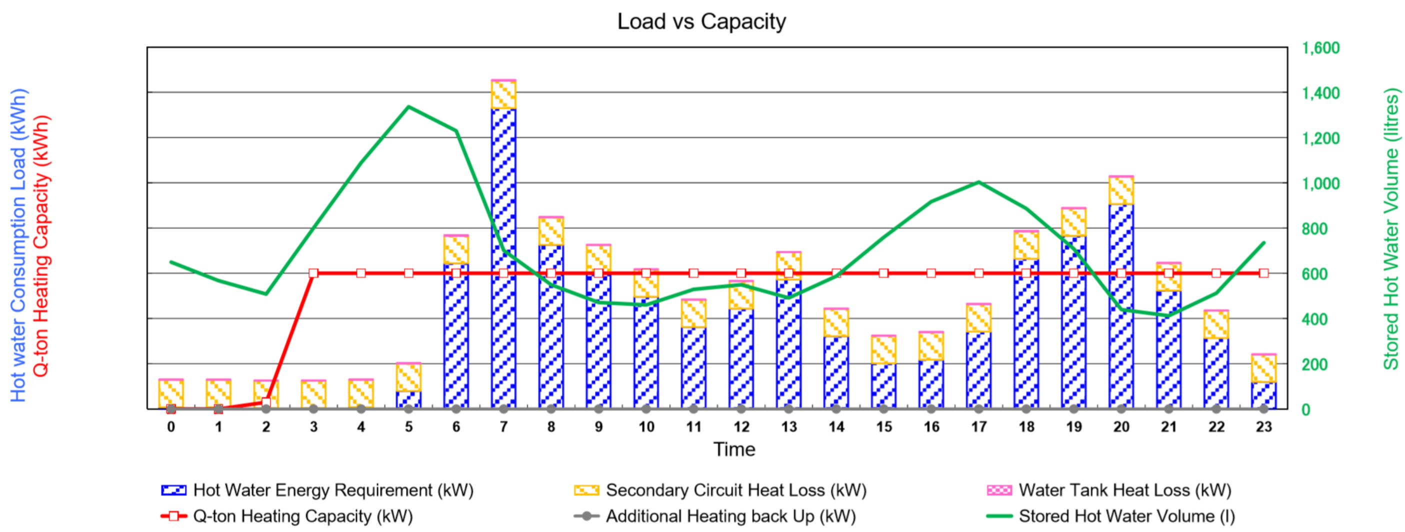
3.3 Domestic Hot Water System

Hot water will be provided via a central domestic hot water heating system. This will take the form of central air-source heat pump using safe and highly efficient CO2 as a refrigerant which is environmentally friendly as it is a natural gas and does not have harmful ecological impacts compared with standard refrigerants.

Hot water generated in the central calorifier will be delivered to each flat pipework at high level around the ground floor walkways to serve each mechanical riser where it will be distributed vertically. Tees will be incorporated onto the hot water pipework on each floor to serve individual dwellings. Flats are individually metered on each floor within the externally accessible service cupboard.

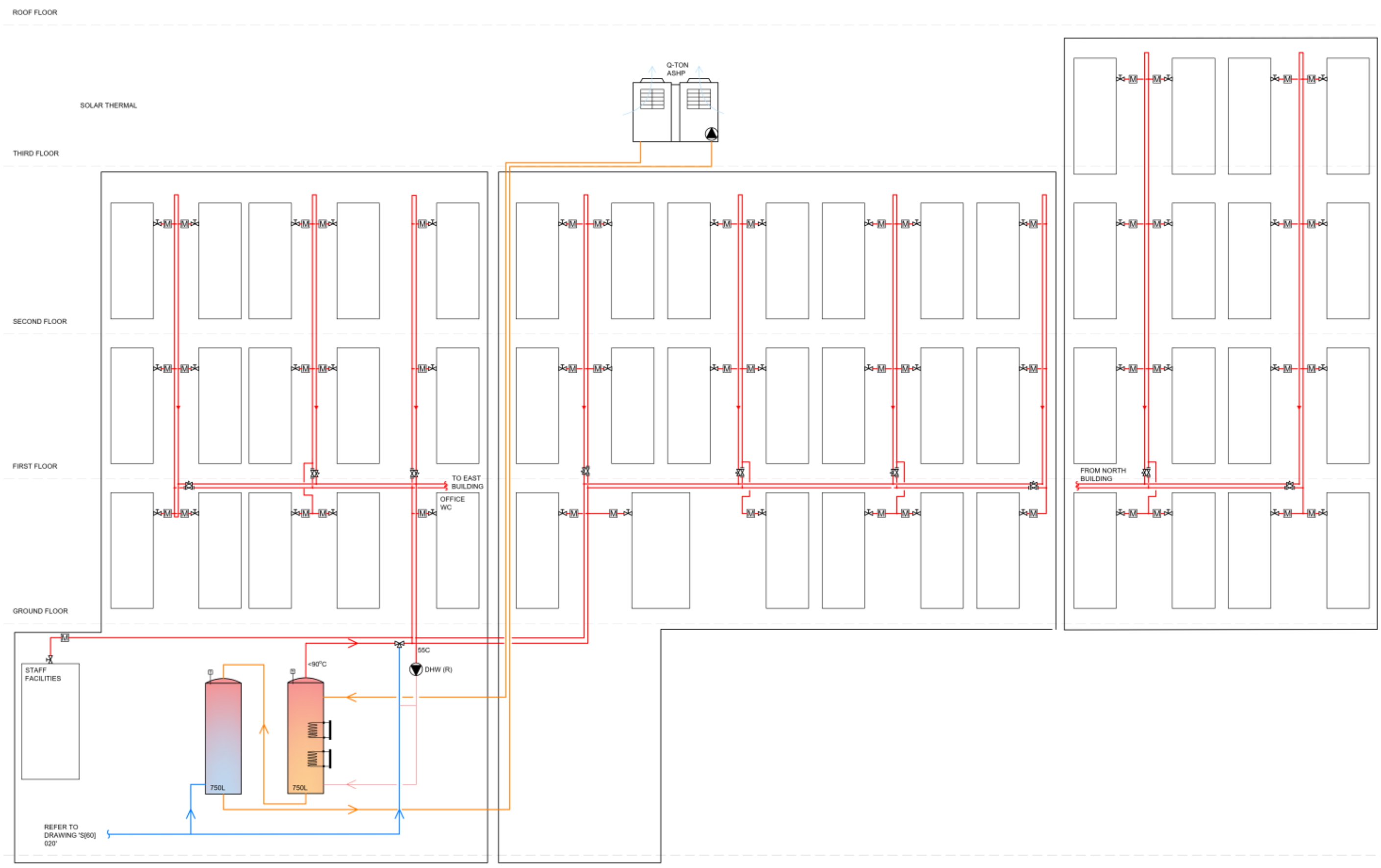
A re-circulating pipe and pump will ensure the hot water network is permanently hot, giving quick hot water delivery times at each tap and minimising legionella risk.



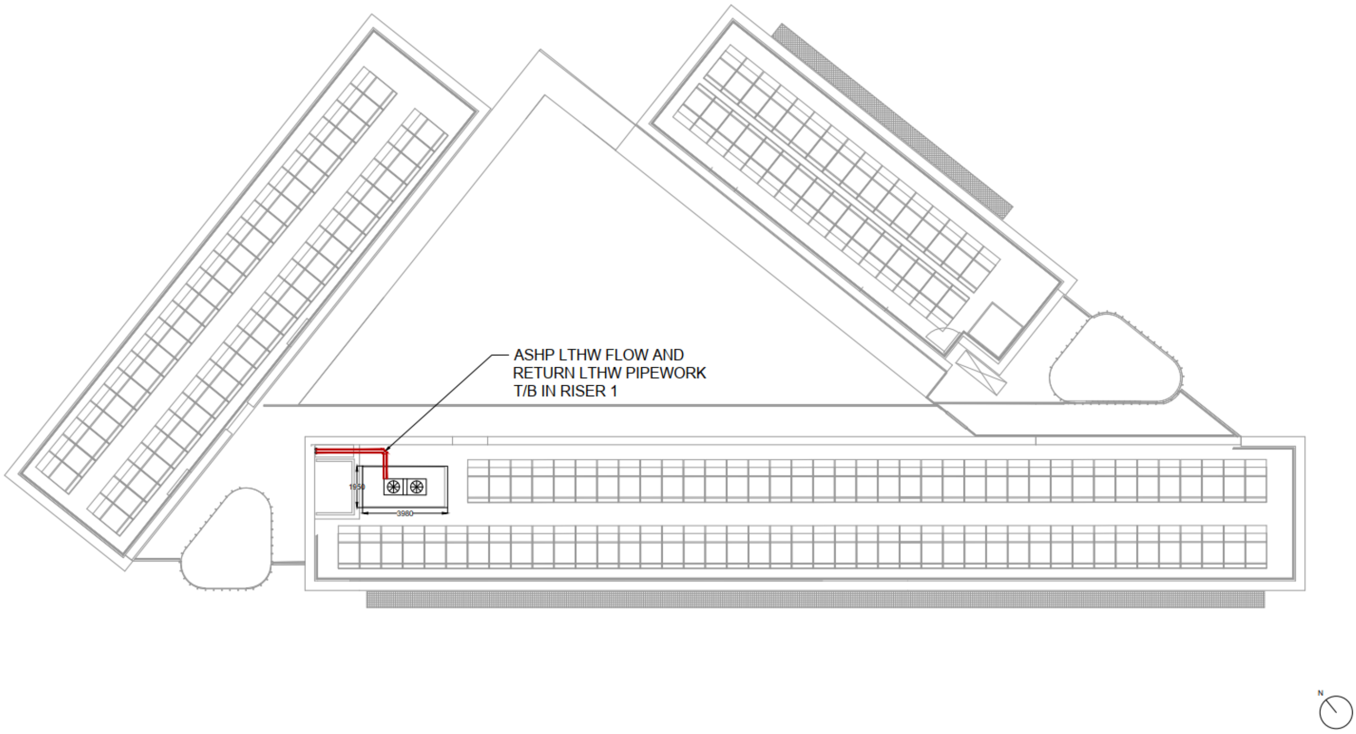


ASHP Performance Curves

A Q-Ton CO2 Heat Pump and Buffer Vessel



Schematic for Heating & Hot Water system



Roof Mounted ASHP location

A brief Renewable Energy Feasibility Study was undertaken to appraise renewable technologies and their applicability to the proposed scheme.

Building Data				
No. of dwelling units	Average unit area	Total unit area	Peak Space Heating Demand	Peak Instantaneous HWS Demand (exc. Buffer)
50	31.42 m^2	1571 m^2	50 kW	200 kW

The following renewable energy technologies were initially considered and their suitability to the scheme are as follows:

	Technology	Applicability
a	Ground Sourced heat pumps	Y
b	Air Source heat pumps	Y
c	Biomass heating	N
d	Solar Water heating	Y
e	Photovoltaics	Y
f	Wind	N

Justification for the omission of above technologies outlined in Appendix C.

Heat Pumps

Ground Source Heat Pumps

Heat from the ground is absorbed at low temperatures into a fluid inside a loop of pipe (a ground loop) buried underground. The fluid then passes through a compressor that raises it to a higher temperature, which can then heat water for the heating and hot water circuits of the building.

The cooled ground-loop fluid passes back into the ground where it absorbs further energy from the ground in a continuous process as long as heating is required.

The ground loop can be laid horizontally in a trench about a metre or so below ground. On constrained site the ground loop can be drilled vertically as boreholes to extract heat from much further down, typically 90 – 160 metres deep.

The space you need for a horizontal loop, and the depth you need for a borehole, will depend on many factors – your heat pump installer will design the collector array based on local conditions and the heat requirements of your home.

Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the ground is constantly being renewed naturally.
Since there is no cooling demand for the proposed development, the ground loops will gradually sap the heat from the surrounding earth thus reducing the effectiveness of this technology over time.

Costs are typically from £1,200 to £2,000 per kW of peak heat output.

Air Source Heat Pumps

Heat from the air is absorbed at low temperature into a fluid. This fluid then passes through a compressor where its temperature is increased and transfers its higher temperature heat to the heating and hot water circuits of the building.

Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the air is constantly being renewed naturally.

A conventional air source heat pump (using R407/R32 refrigerants) is not well suited at generating domestic hot water above 50°C. As the peak heating demand for this project is dominated by the hot water requirements, this technology would be operating insufficiently for much of its running hours. A less common heat pump using CO2 refrigerant has been developed specifically for the high temperatures required for domestic hot water production.

Costs are typically from £700 to £1,000 per kW of peak heat output.

<u>A CO2 Air Source Heat Pump has been taken forward for use on this project due to lower cost and higher seasonal efficiency for domestic hot water production.</u>

Solar Thermal

Solar thermal systems use the suns energy to supplement hot water heating in summer.

The vacuum tubes collect and trap heat from sunlight. The heat is transferred to fluid in the solar circuit pipes which in turn heats the hot water cylinder.

Vacuum tube Solar Thermal Collectors

This feasibility study assumes that a typical dwelling requires no more than 2m2 of solar thermal panels. Therefore, a residential development with 50 units would require a solar thermal array of approximately 66m^2.

While in isolation Solar Thermal is a viable technology for this project, it is not a complimentary technology with the Air Source Heat Pump because of the way CO2 refrigerants work. CO2 has a low critical point thus it needs water at a low temperature and pressure to achieve a phase change. A CO2 ASHP needs a very low temperature return (i.e. the temperature of the incoming mains cold water) and a large temperature difference to achieve their high efficiency. A solar thermal array also needs to heat the incoming mains water for highest efficiency, so both technologies are 'competing' for the same cold water.

Since we require the ASHP for year-round performance, the Solar Thermal is deemed to be technically incompatible and is not taken forward.

Solar Photovoltaics

A PV area has been determined based on the available area of roof to maximise the on-site CO_2 offset.

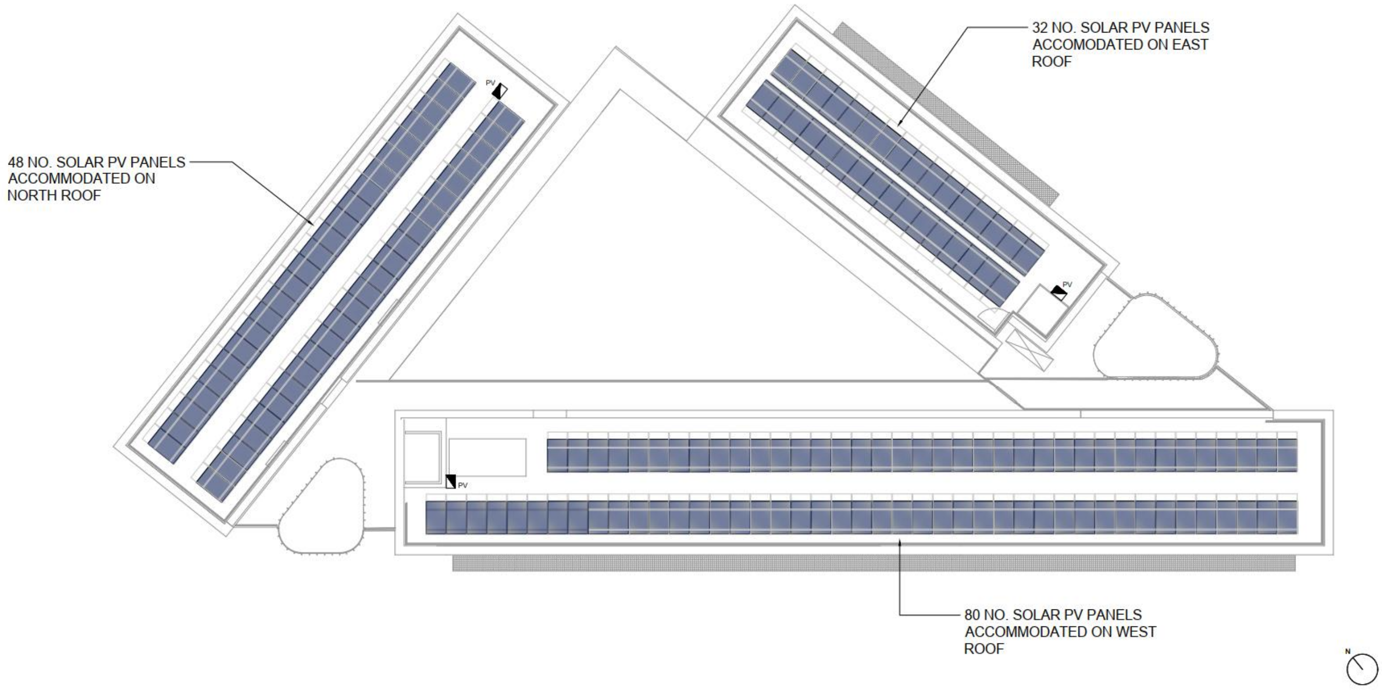
The diagram opposite shows how rooftop space can be used to provide electricity through photovoltaic panels. The electricity generated can be used on-site (to power the Hot Water Heat Pumps) or exported to the grid when there is a surplus.

Panels are positioned to enable optimal solar energy harvest and also enable a green roof to thrive below. PV arrays on the northern and south-western facing roofs will be positioned at a 30° angle facing south. The eastern rooftop will have east-west facing panels at 15° angles.

160 PV panels (at 0.34kWp each) will be used giving a total array size of 54.4kWp. (152 panels for the domestic off-set, 8 for non-domestic)

Level	Dwelling Ref	No.	FSAP type	sqm	TER	PV
						kWp/dw
Ground						
	1-bed WCH	2	A	55.3	33.39	1.88
	1-bed	1	B	35.0	37.6	1.19
	1-bed cor	1	C	35.12	40.98	1.19
	Studio	10	D	25.0	44.91	0.85
	2-bed	0	E	49.68	35.61	1.67
First						
	1-bed	6	B	35.0	37.6	1.19
	1-bed cor	1	C	35.12	40.98	1.19
	Studio	8	D	25.0	44.91	0.85
	2-bed	1	E	49.68	35.61	1.67
Second						

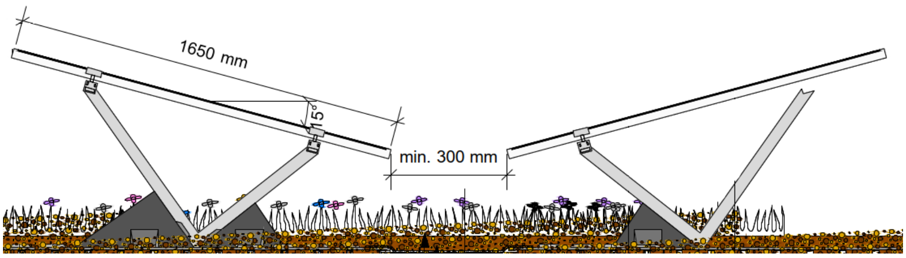
	1-bed	6	B	35.0	37.6	1.19
	1-bed cor	1	C	35.12	40.98	1.19
	Studio	8	D	25.0	44.91	0.85
	2-bed	1	E	49.68	35.61	1.67
Third						
	1-bed	0	B	35.0	37.6	1.19
	1-bed cor	0	C	35.12	40.98	1.19
	Studio	4	D	25.0	44.91	0.85
	2-bed	0	E	49.68	35.61	1.67
Total		50				51.68



PV array layout – (54.4 kWp array)

PV Modules

Photovoltaic Modules (340Wp)
Monocrystalline



PV Panel Section (East-West)

PV Panels integrated with green roofs

There is a risk of overheating in modern residential developments due to improved insulation.

In 2017 the Chartered Institute of Building Services Engineers (CIBSE) released a design methodology for the assessment of overheating in homes called TM59. It allows designers to identify high risk properties and influence the building design to avoid excessively high internal temperatures.

Compliance with TM59 for predominantly naturally ventilated homes is based on passing both of the following criteria:

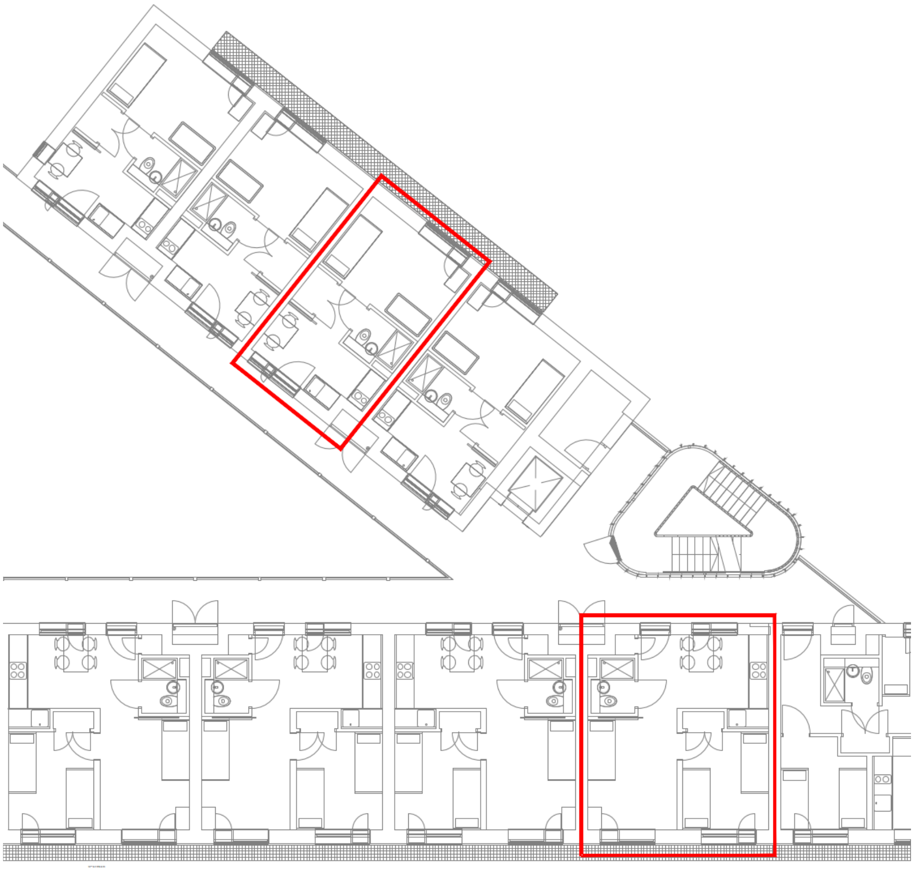
- *For living rooms, kitchens, and bedrooms:* The number of hours during which indoor temp. is greater than or equal to one degree above the outdoor temp during the period May to September inclusive shall not be more than 3 per cent of occupied hours.
- *For bedrooms only*: To guarantee comfort during sleeping hours the operative temperature in the bedroom from 10 pm to 7 am shall not exceed 26 °C for more than 32 hours annually.

Weather file
The design summer year weather files published in CIBSE's TM49 were used in this model to address for the London's urban heat island effect and account for a predicted future climate scenario.

This study employs the London Heathrow DSY1 file (2020s, high emissions, 50 percentile scenario). This was chosen in favour of the London Weather Centre file as the site lies within a low rise, suburban context and is located well outside the GLAs Central Activity Zone.

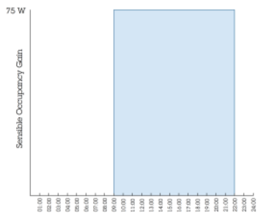
Sample Set
Two flat types were modelled in this study. They were chosen because they either feature commonly throughout the development or are considered at higher risk of overheating due to the orientation or their principal windows.

The flat plans are shown in the figures below:

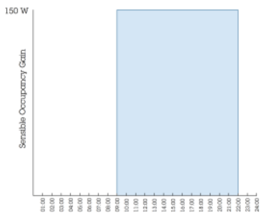


Location of Typical Dwellings

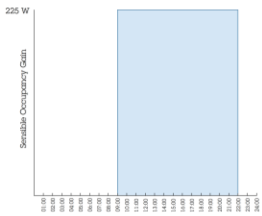
Occupancy Profiles
The occupancy profiles described in TM59 were implemented in this study which prescribes different occupancy patterns for various room types. Flats with more bedrooms are assumed to higher occupancy rates in all living rooms and kitchens. The model assumes a maximum sensible heat gain of 75 W/person and a maximum latent heat gain of 55 W/person.



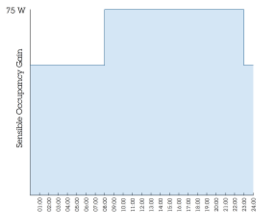
Kitchen/Living Occupancy Gain (1 Bed)



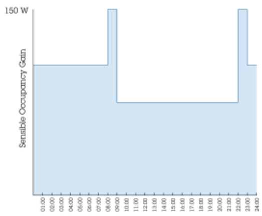
Kitchen/Living Occupancy Gain (2 Bed)



Kitchen/Living Occupancy Gain (3 Bed)



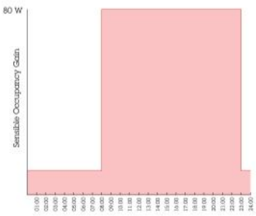
Single Bedroom Occupancy Gain



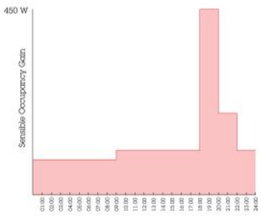
Double Bedroom Occupancy Gain

Simplified 3D model geometry used in study

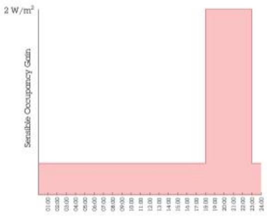
Internal Gains
Internal gains associated with lighting and equipment followed the prescribed profiles described in TM59. The graphs below summarise the internal gains associated with equipment and lighting in different room types.



Single & Double Bedroom Equipment Gain



Kitchen/Living Room Equipment Gain



Lighting Gain (All Rooms)

Simplified 3D model geometry used in study

Modelling Assumptions

The fabric performance has been using the parameter listed in the table below:

Element	U-Value (W/m².K)	
External Walls	0.10	
Roof	0.10	
	U-Value (W/m².K)	**G-Value**
Windows	1.2	0.5
Air permeability	3 $m^3/m^2.h$	

Shading

Internal blinds were also applied to all windows to help reduce solar gains to each room. The ventilation strategy is not compromised by this as all windows will were modelled shut with purge air supplied via the acoustic vents in the façade. Internal shading details used in model are shown in table below:

Parameter	Value
Shading Coefficient	0.40 (typical of white roller blinds)
Short Wave Radiant Fraction	0.3
Incident radiation to lower device	200 W/m^2
Incident radiation to raise device	100 W/m^2

External shading from overhanging balconies was also included in the model geometry.

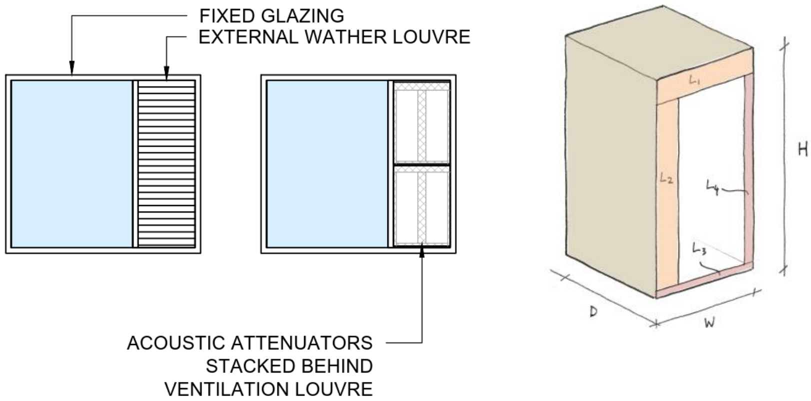
Thermal Mass details

The table below outlines the construction build-up used in the analysis. This is representative of a lightweight construction

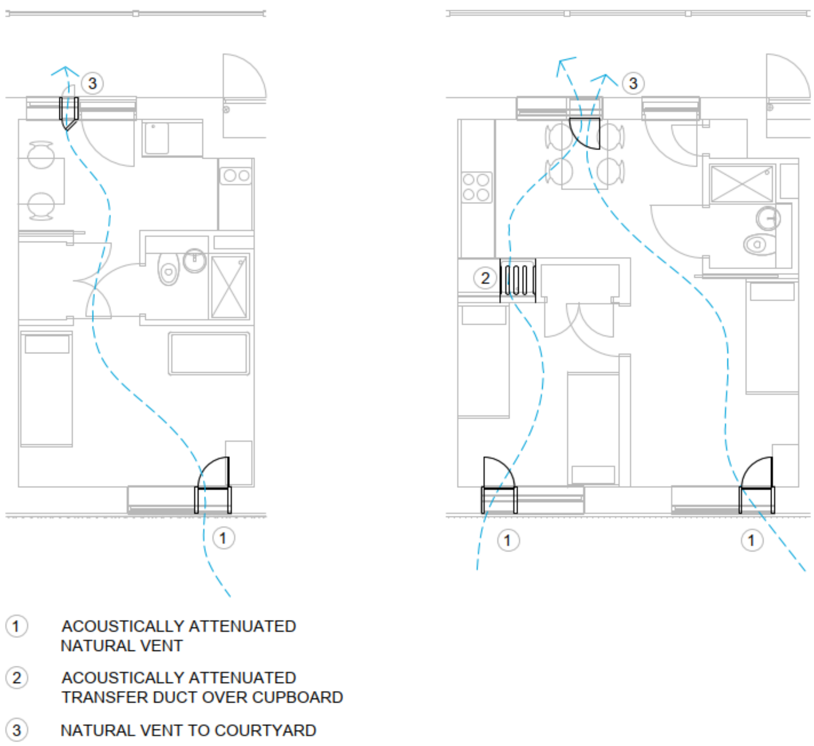
Ventilation hatches are cross-ventilation air paths are included as shown in Section 7.5.

Ventilation Strategy

Both the living rooms and bedrooms will be naturally ventilated via acoustically lined ventilation panels in the building façade. The windows should be kept shut to maintain suitable internal noise levels however can be opened should the tenant choose, and for cleaning.



Standard window/ acoustic vent arrangement



Standard window/ acoustic vent arrangement

The attenuated vents are designed to offer low resistance airflow, whilst reducing noise ingress to acceptable levels. AVO guidance suggests that night-time internal noise levels of 35-40dB(A) are unlikely to adversely affect occupants. The vents employ an external weather louvre to limit rain ingress. Ventilation is provided by opening a small thermally insulated door. Between the louvre and door is a sound absorbing lining, specially designed to provide maximum attenuation whilst maintaining a high open area.

Modelling Iterations

The following pages described the Iterative modelling process undertaken with the Architects to adapt the design and reduce the overheating risk

Iteration 1 : CLT Construction (screed floor and unlined party walls)

Element	Construction Details
External Walls	Cladding, 25mm cavity, 250mm mineral fibre slab, 200mm CLT, 20mm cavity, 25mm plasterboard
Internal Floors/Ceilings	Carpet finish, **50mm screed**, 150mm CLT, 225mm cavity, 50mm mineral wool, 12.5mm plasterboard ceiling
Party Walls	**100mm CLT, 100mm mineral wool, 100mm CLT**
Internal Walls (Flats)	25mm plasterboard, 50mm mineral wool, 25mm plasterboard
Roof	Waterproof layer, 240mm mineral wool, 100mm CLT, 225mm cavity, 12.4mm plasterboard ceiling

The results are shown below. It can be seen that the Living room criteria is met; however, the bedrooms fail to meet nigh-time criteria.

Flat Type	Room	Criteria a) (<3% to pass)	Criteria b) (<33 hours to pass)
1Bed	Living/Kitchen area	**2.6**	**43**
	Double Bedroom	**2.8**	**71**
Studio	Living/Kitchen area	**2.6**	**43**

Key:

Pass	Marginal (<+10%)	Fail

The following improvements were explored:

1. Reduction of window size
2. Provision of fixed external shading to west & west facing glazing
3. Enlargement of ventilation panels to increase ventilation rate

At this stage in the design development the Client decided to pursue a Light Gauge Steel Form of Construction for its shorter build time. Further iterations were carried out using an LGS structure.

Iteration 2: LGS Construction (lightweight steel with linings)

Element	Construction Details
External Walls	Terracotta Cladding, 25mm cavity, 250mm mineral fibre slab, 18mm board, 20mm cavity, 25mm plasterboard
Internal Floors/Ceilings	Carpet finish, 50mm insulation, 200mm slab, 225mm cavity, 50mm mineral wool, 12.5mm plasterboard ceiling
Party & Internal Walls	25mm plasterboard, 50mm mineral wool, 25mm plasterboard
Roof	Waterproof layer, 240mm mineral wool, 200mm slab, 225mm cavity, 12.4mm plasterboard ceiling
Shading	**75cm Brise Soleil**
	Kitchen vent 60cm wide, 130cm tall
	Lounge window size decreased: 60cm high sill and width reduced by 30cm

Flat Type	Room	Criteria a) (<3% to pass)	Criteria b) (<33 hours to pass)
1Bed	Living	**2.8**	**30**
	Bedroom	**2.7**	**52**
	Kitchen	**4.1**	**n/a**
Studio	Living	**2.3**	**37**
	Kitchen	**4.4**	**n/a**

Iteration 3: LGS Construction (lightweight steel with exposed concrete plank soffit)

Element	Construction Details
External Walls	Terracotta Cladding, 25mm cavity, 250mm mineral fibre slab, 18mm board, 20mm cavity, 25mm plasterboard
Internal Floors/Ceilings	Carpet finish, 50mm insulation, 200mm slab~~, **225mm cavity, 50mm mineral wool, 12.5mm plasterboard ceiling**~~
Party & Internal Walls	25mm plasterboard, 50mm mineral wool, 25mm plasterboard
Roof	Waterproof layer, 240mm mineral wool, 200mm slab, ~~**225mm cavity, 12.4mm plasterboard ceiling**~~
Shading	75cm Brise Soleil
	Kitchen vent 60cm wide, 130cm tall
	Lounge window 60cm high sill and width reduced by 30cm

Flat Type	Room	Criteria a) (<3% to pass)	Criteria b) (<33 hours to pass)
1Bed	Living	**1.6**	**35**
	Bedroom	**1.3**	**67**
	Kitchen	**3.1**	**n/a**
Studio	Living	**1.3**	**41**
	Kitchen	**3.6**	**n/a**

Iteration 4: LGS Construction (lightweight steel with alternative vertical & horizontal shading)

Element	Construction Details
External Walls	Terracotta Cladding, 25mm cavity, 250mm mineral fibre slab, 18mm board, 20mm cavity, 25mm plasterboard
Internal Floors/Ceilings	Carpet finish, 50mm insulation, 200mm slab, 225mm cavity, 50mm mineral wool, 12.5mm plasterboard ceiling
Party & Internal Walls	25mm plasterboard, 50mm mineral wool, 25mm plasterboard
Roof	Waterproof layer, 240mm mineral wool, 200mm slab, 225mm cavity, 12.4mm plasterboard ceiling
Shading	**50cm vertical fin and 50cm horizontal fin**
	Kitchen vent 60cm wide, 130cm tall
	Lounge window 60cm high sill and width reduced by 30cm

Flat Type	Room	Criteria a) (<3% to pass)	Criteria b) (<33 hours to pass)
1Bed	Living	**2.4**	**43**
	Bedroom	**2.3**	**58**
	Kitchen	**3.3**	**n/a**
Studio	Living	**2.0**	**37**
	Kitchen	**3.9**	**n/a**

Iteration 5: LGS Construction (lightweight steel with Brise Soleil, reduced g-value & summer boost ventilation)

Element	Construction Details
External Walls	Terracotta Cladding, 100mm drytherm 32 (λ = 0.032) within the wall frame 170mm Duo Slab (λ = 0.035) 20mm cavity, 25mm plasterboard
Internal Floors/Ceilings	Carpet finish, 50mm insulation, 200mm joists, 50mm mineral wool, 12.5mm plasterboard ceiling
Party & Internal Walls	25mm plasterboard, 50mm mineral wool, 25mm plasterboard
Roof	210mm Multifix in the green roof make up (λ = 0.035), 150mm drytherm (λ = 0.035), 12.4mm plasterboard ceiling
Shading	75cm Brise Soleil. White Internal Roller Blinds
	Widen vent in 1 Bed Twin Bedroom to 0.6m
	Add Glass g-value reduced to 0.4
	Add Summertime Boost Ventilation System

Flat Type	Room	Criteria 1) (Target <3%)	Criteria 2) (Target <33 hrs)	Supplementary Vent Rate
1Bed	Twin Bedroom	2.1%	33	50l/s
	Single	2.1%	30	25l/s
	Living/ Kitchen	3.0%	N/A	25l/s
Studio	Twin Room	1.8%	35	60l/s
	Living/Kitchen	3.1%	N/A	25l/s

5.1 Commentary and Proposed Contingency Measures

Iteration 5 represents the final design proposals demonstrating the integrated approach to reducing overheating risk by altering the windows, shading and materials to find a satisfactory performance.

In conjunction with Camden's client team, it was considered - given the modelling margin for error and subjectivity of overheating more generally – that in the cases shaded orange where the modelling result is a marginal 'close call' of less than 10% exceedance that the development would perform satisfactorily. The apartments selected for typological TM59 modelling were chosen as the higher risk (top floor) units with the least overshadowing. The majority of dwellings on lower floors or facing north with less solar exposure will therefore perform even better.

As a contingency measure the top-floor apartments will be fitted with wiring at the outset for the future installation of ceiling-mounted sweep fans at the centre of each room should the real conditions be considered unsatisfactory and the client decide further measures to improve air movement are desirable.

6.0 Summary

DOMESTIC Emissions Summary (Based on SAP 2012 Carbon Factors)

	Carbon dioxide emissions for **domestic** buildings (Tonnes CO2/annum)	
	Regulated	Unregulated
Baseline: Part L 2013 Compliant Development	42.0	n/a
After energy demand reduction	40.8	n/a
After CHP	40.8	n/a
After Renewable Energy (ASHP + PV)	27.1	n/a

	Regulated **domestic** carbon dioxide savings	
	Tonnes CO2 per annum	%
Savings from energy demand reduction	1.2	3
Savings from CHP	0	0
Savings from renewable energy (ASHP + PV)	13.7	33
Cumulative savings on site	14.9	36
Annual savings from off-set payment	27.1	
	Tonnes of CO2	
Cumulative savings for off-set payment (30yr)	**812**	

NON-DOMESTIC Emissions Summary (Based on SAP 2012 Carbon Factors)

	Carbon dioxide emissions for **Non-Domestic** buildings (Tonnes CO2/annum)	
	Regulated	Unregulated
Baseline: Part L 2013 Compliant Development	5.9	n/a
After energy demand reduction	5.5	n/a
After CHP	5.5	n/a
After Renewable Energy	4.3	n/a

	Regulated **Non-domestic** carbon dioxide savings	

	Tonnes CO2 per annum	%
Savings from energy demand reduction	0.4	7%
Savings from CHP	0.0	0%
Savings from renewable energy	1.2	20%
Cumulative savings on site	1.6	27%
Annual savings from off-set payment	4.3	
	Tonnes of CO2	
Cumulative savings for off-set payment (30yr)	**129**	

TOTAL SITE Emissions Summary (Based on SAP 2012 Carbon Factors)

	Total regulated Emissions (Tonnes CO2 per annum	CO2 Savings (tonnes CO2 per annum	Percentage saving (%)
Baseline: Part L 2013 Compliant Development	47.9		
After energy demand reduction	46.3	1.7	3%
After CHP	46.3	0.0	0%
After Renewable Energy	31.4	14.9	31%
Annual savings from off-set payment		16.5	35%
Cumulative savings for off-set payment (30yr)		941.6	

TOTAL SITE Emissions Summary (Based on SAP10 Carbon Factors)

	Total regulated Emissions (Tonnes CO2 per annum	CO2 Savings (tonnes CO2 per annum	Percentage saving (%)
Baseline: Part L 2013 Compliant Development	40.6		
After energy demand reduction	37.1	13.5	9%
After CHP	37.1	0.0	0%
After Renewable Energy	14.1	23	57%
Annual savings from off-set payment		26.6	65%
Cumulative savings for off-set payment (30yr)		422.7	

The remaining CO2 is to be off set through a cash in lieu contribution to the borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere.

The one-off offset is based on an emissions duration of 30 years. With a carbon off-set price of £95 per tonne of CO2, this equates to 422.7 Tonnes x £95/T = **£40,157** based on SAP10 Carbon Factors.

7.0 Appendix A: Overheating Checklist

Section 1 – Site features affecting vulnerability to overheating		Yes or No
Site location	Urban – within central London or in a high-density conurbation	Yes
	Peri-urban – on the suburban fringes of London	No
Air quality and/or Noise sensitivity – are any of following in the vicinity buildings?	Busy roads / A roads	Yes Dartmouth Park Hill
	Railways / Overground / DLR	No
	Airport / Flight path	No
	Industrial uses / waste facility	No
Proposed building use	Will any buildings be occupied by vulnerable people (e.g. elderly, disabled, young children)?	No
	Are residents likely to be at home during the day (e.g. students)?	Yes
Dwelling aspect	Are there any single aspect units?	No
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 opening of windows for ventilation?	Single storey ground floor units	Yes
	Vulnerable areas identified by the Police Architectural Liaison Officer	No
	Other	No
Section 2 - Design features implemented to mitigate overheating risk		
Landscaping	Will deciduous trees be provided for summer shading (to windows and pedestrian routes)?	No
	Will green roofs be provided?	Yes
	Will other green or blue infrastructure be provided around buildings for evaporative cooling?	Yes
Materials	Have high albedo (light colour) materials been specified?	No
Dwelling aspect	% of total units that are single aspect	0
	% single aspect with N / NE / NW orientation	0
	% single aspect with E orientation	0
	% single aspect with S / SE / SW orientation	0
	% single aspect with W orientation	0
Glazing ratio - What is the glazing ratio (glazing; internal floor area) on each facade?	N / NE / NW	0.11
	E	0.16
	S / SE / SW	0.11
	W	0.16
Daylighting	What is the average daylight factor range?	Not Calculated

Window opening	Are windows openable?	No – Vent Hatches Provided
Window opening	What is the average percentage of openable area for the windows?	0
Window opening - What is the extent of the opening?	Fully openable	No
	Limited (e.g. for security, safety, wind loading reasons)	Hatches have weather louvres
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)?	Hatches have weather louvres
Shading	Is there any external shading?	Yes
	Is there any internal shading?	Yes
Glazing specification	Is there any solar control glazing?	Yes
Ventilation - What is the ventilation strategy?	Natural – background	No
	Natural – purge	Yes
	Mechanical – background (e.g. MVHR)	Yes
	Mechanical – purge	Yes
	What is the average design air change rate	MVHR: 0.5
Heating system	Is communal heating present?	No

8.0 Appendix B 'Be Lean' SBEM Inputs

Element or system	Notional Building	Proposed Building
Size and shape	Same as actual building	Same as actual building
Opening areas		
Windows	Exposed façades have windows with area lesser of: 1.5m high x full façade width, or 40% of exposed area	Same as actual building
Doors	Same as actual building	Same as actual building
External Walls (U-Value)	0.26 W/m²K	0.13 W/m²K
Exposed Floors (U-Value)	0.22 W/m²K	0.11 W/m²K
Roofs (U-Value)	N/A	0.10 W/m²K
Entrance Door (U-Value)	2.20 W/m²K	Modelled as glazing
Glazing (U-Value)	1.60 W/m²K	1.20 W/m²K
Air permeability (m³/hm²@50Pa)	3	2.5
Glazing G-Value	0.4	0.4

System Description	WC Extract	
Kitchen extract SFP	0.5	0.4
Heat Recovery Efficiency	None	None
Demand Control?	None	None

Heating/Cooling System		
System Description	All occupied areas: Electric Resistance Heating	
Fuel Type	Electricity - Heating	Electricity - Heating
Element or system	**Notional Building**	**Proposed Building**
Heating efficiency	100%	100%

Hot Water System		
System Description	CO2 Heat Pump – Central System	
Generator type	Electric Coil, 100% efficiency	Heat Pump 356% efficiency
Hot water Cylinder	None	None
Storage losses	N/A	N/A
Secondary Circulation	None	None

9.0 Appendix C: Note about renewable energy technology

Technology	Justification for omission
c	• Biomass boilers release particulates into the atmosphere which will have an adverse effect on air quality and respiratory health in an urban environment. • Insufficient space in which to store fuel
f	• Negative visual impact. • Vibration generation for building mounted turbines. • High maintenance burden. • Wind speed at elevation of development would not be high enough justify the installation of wind turbines.

10.0 Appendix D: SAP & BRUKL Outputs