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# RIBA Stage 2

## Energy Assessment

### 6 Lindfield Gardens

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# Executive Summary

## Energy Assessment

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#### About the Scheme

The proposal comprises refurbishment and extension of an existing house to create 9 residential units with an internal floor area of approximately 711m<sup>2</sup>. The development is located in the London Borough of Camden.

#### Planning policy

The scheme has been developed in accordance with the GLA Guidance and Camden Planning Guidance Energy efficiency and adaptation (July 2020). According to the planning policies, the scheme should achieve:

- Greatest possible reduction – meeting Part L1B for retained thermal elements (London Plan 5.4, Local Plan CC1)
- 20% Reduction in CO<sub>2</sub> from onsite renewables (London Plan 5.4, 5.7, Local Plan CC1)
- BREEAM DR Excellent

#### Summary

All flats have been modelled for the purposes of the energy assessment. The scheme complies with the 2013 Building Regulations Part L and the minimum energy efficiency targets in the following documents have been followed:

- Refurbishment (Part L1B) – Consequential improvements to refurbished areas have been made to ensure that the building complies with Part L, to the extent that such improvements are technically, functionally, and economically feasible.

In addition, the CO<sub>2</sub> emissions of the scheme have been calculated using the SAP 10.0 carbon emission factors, and the scheme can achieve:

- An on-site CO<sub>2</sub> reduction of 3.5% beyond Building Regulations through energy efficiency measures. The design team has maximised the passive design measure, however, the existing wall cannot be further insulated due to interstitial condensation risk. Therefore, no further CO<sub>2</sub> improvement can be achieved.
- A CO<sub>2</sub> reduction of 27.8% from renewable technologies (ASHP and PV panels have been specified for Flat 1)
- A total on-site CO<sub>2</sub> reduction of 31.2%
- BREEAM DR 2014 Energy credits:
  - Ene 01 – 0 credits
  - Ene 02 – 3 credits (Excellent standard)
  - Ene 03 – 6.5 credits
  - Ene 04 – 2 credits for Flat 1

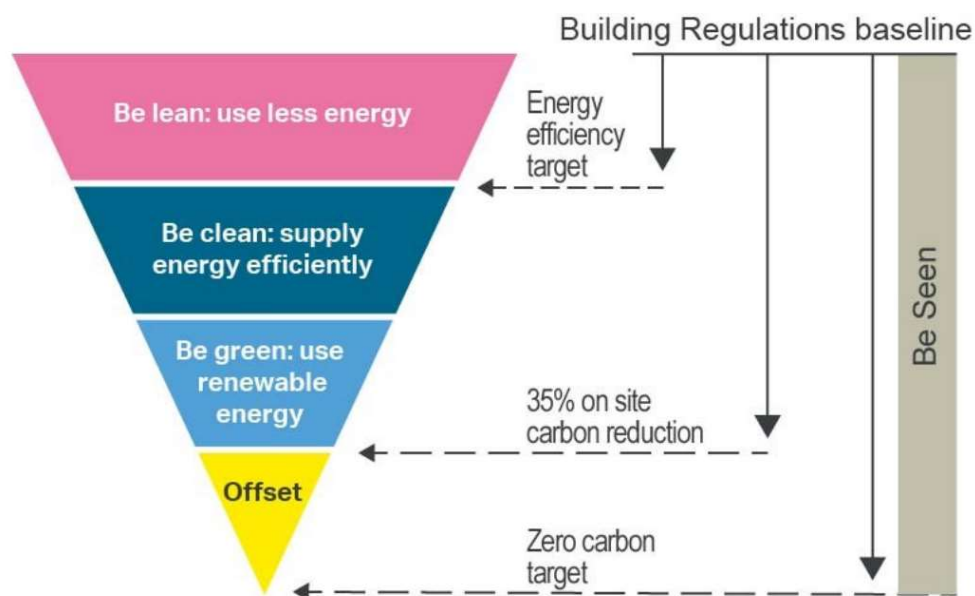
# Executive Summary

## Energy Assessment

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#### Energy hierarchy

The proposed scheme has followed the energy hierarchy that is illustrated below:



Source: Greater London Authority

#### Key measures

Key measures identified for each stage are shown below:

- Be Lean:
  - Low U-values for new opaque elements and fenestration
  - Low g-value for new windows and rooflights
  - High efficiency lighting
- Be Clean:
  - No communal heating system has been provided due to BREEAM scoring (a communal system will result in higher operational cost compared to the baseline case and therefore no credits can be awarded)
- Be Green:
  - ASHP and PV panels have been specified for Flat 1

# Executive Summary

## Energy Assessment

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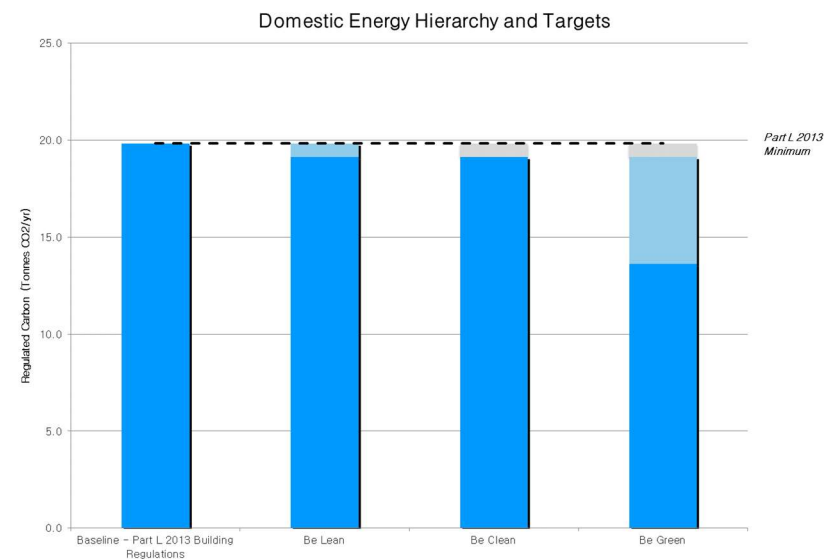
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#### GLA's Energy Hierarchy: Regulated carbon emissions

The proposed scheme has followed the energy hierarchy. A graphical illustration of how the scheme performs in relation to Building Regulations and the Energy Hierarchy is shown below. Carbon dioxide emission factors for SAP 10.0 have been used for the calculation.

As demonstrated in the figure the proposed scheme will reduce carbon emissions by 3.5% from the fabric energy efficiency measures described in the 'Be Lean' section. A total improvement of 31.2% has been achieved through the further specification of ASHP and PV panels for Flat 1.

Therefore, the scheme meets and exceeds Building Regulations and Local Plan policy.



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#### Regulated CO<sub>2</sub> emissions

Site-wide				
GLA's Energy Hierarchy: Regulated CO <sub>2</sub> – Calculated using SAP 2012 CO <sub>2</sub> factors				
	Baseline:	Be lean:	Be clean:	Be green:
CO <sub>2</sub> emissions (tCO <sub>2</sub> /yr)	21.45	20.54	–	16.66
CO <sub>2</sub> emissions saving (tCO <sub>2</sub> /yr)	–	0.91	–	3.88
Saving from each stage (%)	–	4.2	–	18.1
Total CO <sub>2</sub> emissions saving (tCO <sub>2</sub> /yr)	4.79			
22.3% total CO <sub>2</sub> savings over Building Regulations Part L achieved				
GLA's Energy Hierarchy: Regulated CO <sub>2</sub> – Calculated using SAP 10.0 CO <sub>2</sub> factors				
	Baseline:	Be lean:	Be clean:	Be green:
CO <sub>2</sub> emissions (tCO <sub>2</sub> /yr)	19.83	19.14	–	13.63
CO <sub>2</sub> emissions saving (tCO <sub>2</sub> /yr)	–	0.69	–	5.50
Saving from each stage (%)	–	3.5	–	27.8
Total CO <sub>2</sub> emissions saving (tCO <sub>2</sub> /yr)	6.20			
31.2% total CO <sub>2</sub> savings over Building Regulations Part L achieved				

# Carbon Emission Factors

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#### Emission factors:

The Greater London Authority (GLA) Guidance on Energy Assessments published in October 2018 highlights a critical development regarding carbon emission factors. Grid electricity has significantly decarbonised since the last update of Part L in April 2014 and in July 2018 the Government published updated carbon emission factors (SAP 10.0) demonstrating this. Although SAP 10.0 is not in use yet, the GLA Guidance encourages the use of SAP 10.0 carbon emission factors from January 2019 in areas where there are no opportunities to connect to existing or planned district heat networks. Any applicants proposing to use the SAP 2012 emissions factors is required to provide adequate justification.

SAP 2012 emission factors can be used where:

- The scheme is located within a Heat Network Priority area; and
- There is potential to connect to an existing network using gas-engine CHP or a new network using low-emission CHP; and
- The heat network operator has, or is in the process of developing, a strategy to decarbonise the network and has shared it with the GLA

While the proposed scheme is expected to comply with SAP 2012 for Building Regulation compliance, the assessment presents total emissions using SAP10.0 as it is required for demonstrating performance against planning policy targets. The revised factors are below:

Fuel Type	Carbon Factor (kg CO <sub>2</sub> /kWh)	
	SAP 2012	SAP10.0
Natural Gas	0.216	0.210
Grid Electricity	0.519	0.233

The carbon emissions of the scheme have been calculated using Building Regulations methodology for estimating energy performance against Part L 2013 requirements, and the outputs have been manually converted for the SAP 10.0 emission factors using a spreadsheet.

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# Establishing CO<sub>2</sub> Energy Assessment 6 Lindfield Gardens

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## Methodology

The purpose of an energy assessment is to demonstrate that climate change mitigation measures comply with London Plan energy policies, including the energy hierarchy. It also ensures energy remains an integral part of the scheme's design and evolution.

The methodology followed in this report follows the guidance set out by the Greater London Authority (GLA) for developing energy strategies as detailed in the document. "Energy Assessment Guidance: Greater London Authority guidance on preparing energy assessments as part of planning applications (April 2020)". The scheme has been developed in accordance with the Intend to Publish London Plan 2019.

This report has followed these documents and comprises the following components:

- Baseline: A calculation of the Part L 2013 Building Regulations compliant CO<sub>2</sub> emission baseline using approved software. The baseline assumes a gas boiler would provide heating and any active cooling would be electrically powered and fabric has been modelled as per Appendix 4 of GLA's Guidance.
- Be Lean: A calculation of the impact of demand reduction measures. For example, passive design measures, including optimising orientation and site layout, natural ventilation and lighting, thermal mass and solar shading, and active design measures such as high efficacy lighting and efficient mechanical ventilation with heat recovery.
- Cooling Hierarchy: In accordance with Policy 5.9 of London Plan and Intent to Publish London Plan 2019 Policy SI4, measures that are proposed to reduce the demand for cooling have been set out such as minimisation of solar and internal gains and night cooling strategies.
- Be Clean: In accordance with Policy 5.6 of London Plan and Intent to Publish London Plan 2019 Policy SI3, this report has demonstrated how the scheme has selected heating, cooling and power systems to minimise carbon emissions. This comprises an evaluation of the feasibility of connecting to existing low carbon heat networks, planned networks, site-wide and communal heat networks, and CHP.
- Be Green: In accordance with Policy 5.7 of London Plan and Intent to Publish London Plan 2019 Policy SI2, this report has conducted a feasibility assessment of renewable energy technologies. This comprised a site-specific analysis of the technologies and, if applicable, how they would be integrated into the heating and cooling strategy for the scheme.

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# Establishing CO<sub>2</sub> Energy Assessment 6 Lindfield Gardens

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## Establishing CO<sub>2</sub> emissions

As required by the GLA both the regulated and unregulated emissions of the development must be quantified and demonstrated. The total emissions for the scheme are shown below.

CO <sub>2</sub> Emissions – Regulated and Unregulated (tonnes CO <sub>2</sub> /yr) – SAP 10.0 – Residential			
	Regulated Emissions	Unregulated Emissions	Total Emissions
Baseline: Part L 2013	19.83	5.32	25.15
Be Lean: Use less energy	19.14	5.32	24.45
Be Clean: Supply energy efficiently	–	–	–
Be Green: Use renewable energy	13.63	5.32	18.95



# Baseline

## Energy Assessment

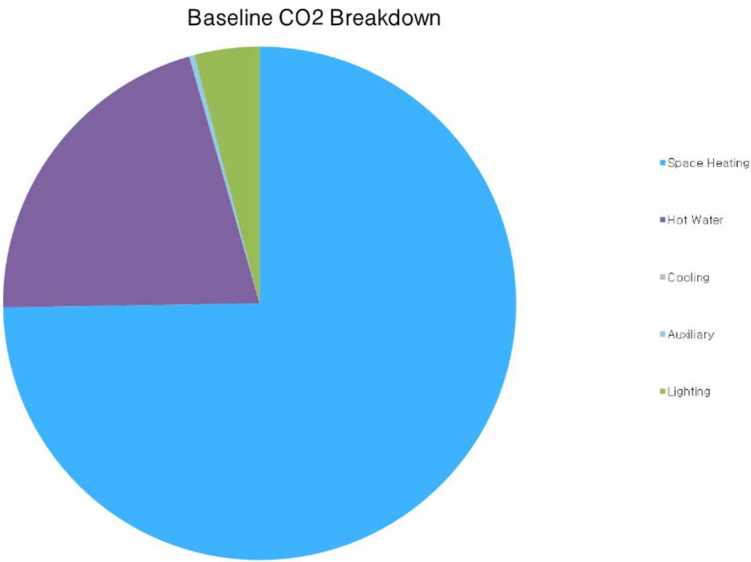
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Building regulations Part L 2013 minimum compliance

The total baseline carbon emissions for the whole scheme is 19.83 tonnes CO<sub>2</sub>/yr (using SAP 10.0 carbon dioxide emission factors).

The pie chart provides a breakdown of the specific carbon emissions by system over the course of one year. The chart shows that space heating is the primary source of carbon dioxide emissions, and hot water is the second largest.

Carbon Emissions in tonnes CO <sub>2</sub> /yr.				
Heating	Hot Water	Cooling	Auxiliary	Lighting
14.82	4.13	0.00	0.06	0.81



# Demand Reduction Energy Assessment 6 Lindfield Gardens

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## Be Lean: summary

Demand reduction measures have reduced the scheme's carbon emissions by 3.5% (using SAP 10.0 figures) over the minimum Part L 2013 Building Regulations baseline.

## U-values

Element	Minimum Building Regulations U-value W/m <sup>2</sup> K (Appendix 4 – GLA guidance)	Proposed U-value W/m <sup>2</sup> K
Flat roof – Existing	0.18	0.18*
Flat roof – New	0.18	0.14
Pitched roof – Existing	0.18	0.18*
Pitched roof – New	0.18	0.14
Wall – Existing	0.55	0.55*
Wall – New	0.25	0.14
Corridor wall	0.55	0.55*
Ground floor	0.55	0.55*
Exposed floor	0.55	0.55*
Windows – Existing	1.60 (g-value 0.63)	1.60 (g-value 0.63)
Windows – New	1.60 (g-value 0.50)	1.30 (g-value 0.50)
Rooflights – Existing	1.60 (g-value 0.63)	1.60 (g-value 0.63)
Rooflights – New	1.60 (g-value 0.50)	1.30 (g-value 0.50)
Doors	1.80	1.30

\*The Building has been fully refurbished and insulated in 2009, therefore the above values have been assumed. It has been estimated that the existing elements cannot be insulated further without increasing the interstitial condensation risk. A dynamic condensation risk analysis (using WUFI) is required in case the existing elements are thermally upgraded.

Party walls will be fully filled cavity with effective sealing at all exposed edges and in line with insulation layers in abutting elements.

## Air permeability

A reduced air permeability has been targeted as per the table below:

	Minimum Building Regulations	Proposed
Air permeability (m <sup>3</sup> /hm <sup>2</sup> @50 Pa)	10	10

This will require careful attention to two key areas:

- Structural leakage
- Services leakage

Structural leakage occurs at joints in the building fabric and around window and door openings, loft hatches and access openings. There will also be some diffusion through materials such as cracks in masonry walls typically caused by poor perpends in the blockwork or brickwork. Structural leakage is hard to remedy retrospectively therefore good detailing at the design stage is essential.

Services leakage occurs at penetrations from pipes and cables entering the building. These can be sewerage pipes, water pipes and heating pipes. As well as electricity cables there may also be telecommunication cables. Attention, therefore, needs to be paid to sealing all penetrations during construction.

## Thermal Bridging:

The default psi-value has been used for all junctions due to the existing structure.

## Thermal Mass:

Thermal mass of the scheme has been indicatively modelled as 250 kJ/m<sup>2</sup>K (medium).

# Demand Reduction Energy Assessment 6 Lindfield Gardens

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## Heating

The scheme has been modelled with a gas boiler with an efficiency of 89.5%. Heat will be provided via radiators and will be controlled with a programmer, thermostat and TRVs.

Please note that for the final “Be green” scenario, Flat 1 will be heated by an ASHP (Ecodan 14 kW). Heat will be provided via radiators and will be controlled with a time and temperature zone control by suitable arrangement of plumbing and electrical services.

## Hot Water

The hot water will be provided by the main gas heating system (gas boilers with an efficiency of 89.5%). No hot water cylinder has been specified.

Please note that for the final “Be green” scenario, Flat 1 will be heated by the main ASHP (Ecodan 14 kW). A hot water cylinder will be specified with 300l capacity and a heat loss factor of less than 1.69 kWh/day. The cylinder will be located in a heated space, with cylinder stat and primary pipework will be fully insulated.

## Ventilation

Natural ventilation with extract fans for toilet and kitchen has been specified for all dwellings.

## Cooling

The existing house has an air conditioning unit. Air conditioning will be provided for flat 1 (ground floor) to ensure occupant thermal comfort, with an energy label class of A and variable speed compressors. No cooling has been specified for the remaining flats.

## Lighting

High efficiency lighting has been specified for the development with a minimum efficacy of 75 lumens/W.

## Energy demand following energy efficiency measures (MWh/year)

Space Heating	Hot water	Lighting	Auxiliary	Cooling	Unregulated gas	Unregulated electricity
69.0	18.7	2.8	0.3	0.0	0.0	11.8

## Fabric energy efficiency

Baseline Fabric Energy Efficiency (MWh/year)	Design Fabric Energy Efficiency (MWh/year)	Improvement (%)
65.59	64.84	1%

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# Cooling and Overheating

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#### Overheating and cooling

The aim of this section is to reduce the impact of the urban heat island effect in London and encourage the design of spaces to avoid overheating and excessive heat generation, and to mitigate overheating due to the impact of climate change.

Where design measures and the use of natural and/or mechanical ventilation are not enough to guarantee the occupant's comfort, in line with the cooling hierarchy the development's cooling strategy must include details of the active cooling plant being proposed, including efficiencies, and the ability to take advantage of free cooling and/or renewable cooling sources.

Where appropriate, the cooling strategy should investigate the opportunities to improve cooling efficiencies through the use of locally available sources such as ground cooling and river/dock water-cooling.

#### The Cooling Hierarchy in Policy SI4

Developments should reduce potential overheating and reliance on air conditioning systems and demonstrate this with the Cooling Hierarchy:

1. Reduce the amount of heat entering the building through orientation, shading, high albedo materials, fenestration, insulation, and the provision of green infrastructure
2. Minimise internal heat generation through energy efficient design
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
4. Provide passive ventilation
5. Provide mechanical ventilation
6. Provide active cooling systems

#### Avoiding overheating: measures taken

The following measures have been taken in accordance with the cooling hierarchy to reduce overheating and the need for cooling:

1. Reduce the amount of heat entering the building through orientation, shading, high albedo materials, fenestration, insulation, and the provision of green infrastructure
  - Solar control – all methods controlling solar gain to within tolerable limits have been considered. The location, size, design and type of window openings and glazing have been optimised and reduced solar gain factors from low emissivity new windows have been specified.
  - Light-coloured curtain/roller blinds will be specified to limit solar gain. The shading has also been optimised to avoid substantially reducing daylighting or increasing the requirement for electric lighting.
  - High albedo materials: A high albedo (reflective) surface has been specified for the roof in order to minimise the heat absorbed by the roof, and significant thermal insulation has been specified to prevent any heat absorbed being transferred into the building.
  - Insulation levels have been maximised and the resulting U-values for the new elements are lower than required by Building Regulations. The build-ups therefore prevent the penetration of heat as much as practically possible. See the 'Be Lean' section of this report for target u values.

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# Cooling and Overheating Energy Assessment

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2. Minimise internal heat generation through energy efficient design
  - Internal heat gains have been minimised where possible. The scheme will target the BREEAM Domestic Refurbishment Energy 5: Energy Labelled White Goods. Energy efficient appliances will help reduce internal heat gain and reduce the cooling requirement.
  - Energy efficient lighting will also be specified as per the 'Be Lean' section.
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
  - High thermal mass – exposed building fabric materials such as masonry or concrete have been utilised in the form of concrete floors and dense masonry external walls. These materials act as 'thermal batteries'; they absorb heat gains during the day when the building is occupied and 'store' it for an extended period, thereby helping to stabilise daytime temperatures. At night this heat can be dissipated, which 'resets' the heating cycle. Ventilation will also be used at night to purge the stored heat within the structure. A 'ground coupled' system that uses the thermal storage capacity of the ground has not been specified as the passive ventilation option has been selected instead.
  - Room heights – high ceilings are traditionally used in hot climates to allow thermal stratification so that occupants can inhabit the lower cooler space, and to decrease the transfer of heat gain through the roof. The proposed building has floor to ceiling heights of more than 2.5m. As the roof will be well insulated to below building regulations, there will be minimal penetration of heat through the roof.
4. Provide passive ventilation
  - Openable windows are specified on all facades of the building.
  - Shallow floorplates have been specified with dual aspect units, where possible, to allow for cross ventilation. Cross ventilation will be achieved by opening windows on two facades and ensuring there is a clear path for airflow.
  - Night time cooling will also be utilised. This will work in tandem with high thermal mass materials specified. The larger temperature differential that exists between internal and external temperatures at night will allow effective stack ventilation and purging of heat accumulated within the structure during the day.
5. Provide mechanical ventilation
  - Natural ventilation with extract fans for toilet and kitchen has been specified for all dwellings.
  - The mechanical systems will comply with the Domestic Building Services Compliance Guide.

# Cooling and Overheating Energy Assessment 6 Lindfield Gardens

## Overheating risk

The overheating risk considering all the above described passive measures have been assessed for the scheme:

Areas	Overheating risk from SBEM and SAP
Flat 1	Not significant
Flat 2	Slight
Flat 3	Slight
Flat 4	Slight
Flat 5	Slight
Flat 6	Medium
Flat 7	Medium
Flat 8	Medium
Flat 9	Medium

According to the GLA guidance on preparing energy assessments (April 2020) Section 8, a dynamic modelling in line with CIBSE TM52 and TM59 should be carried out to assess the risk of overheating. The dynamic overheating analysis has been carried out by eight Associates '5207-6 Lindfield Gardens-Overheating-2009-07yp', issued on the 07/09/2020, confirms that the scheme meets the CIBSE TM52 and TM59 requirements.

## Active cooling

Air conditioning has just been specified for Flat 1 (ground floor). No cooling has been specified for other flats since the overheating analysis demonstrates there is no significant risk of overheating and the passive design measures are enough to guarantee the occupant's comfort.

For flat 1, to ensure the cooling system is the most carbon efficient possible the following parameters have been selected:

- Location: Indoor cooling units have been specified on a localised basis where internal gains are too high. The units will be fully fitted with local temperature controls for optimal usage.
- The location of the outdoor units that 'dump' the heat has been carefully considered so not to cause problems for people and the environment, and not to add to the urban heat island effect. They will be located on the roof space and will allow adequate air movement around the condensing units; this will ensure maximum operating efficiency and will limit the impacts of dumped heat on people and the environment.
- The AC systems will follow the Domestic Building Services Compliance Guide

# Heating Infrastructure Energy Assessment 6 Lindfield Gardens

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## Heating infrastructure including CHP

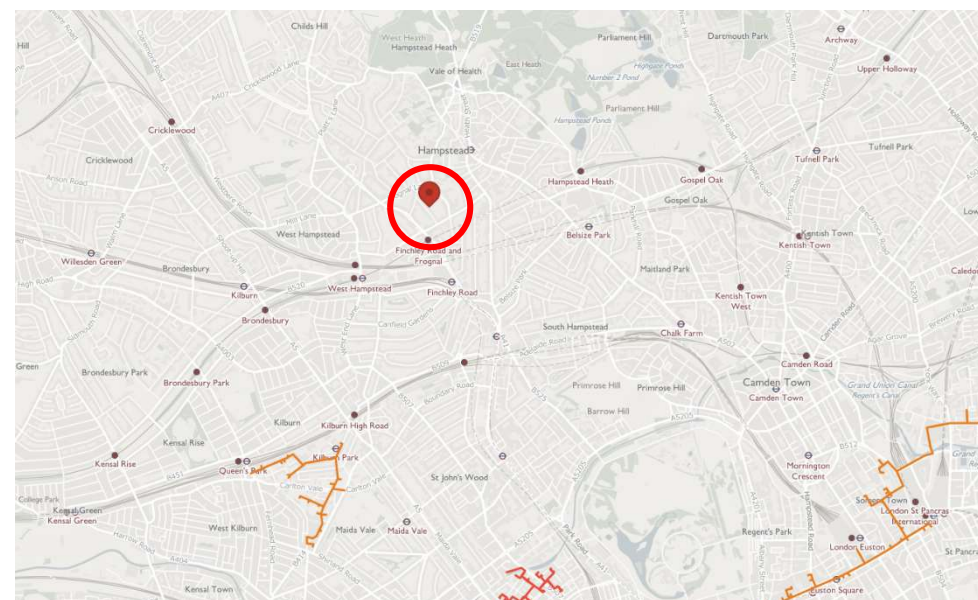
Once demand for energy has been minimised, schemes must demonstrate how their energy systems have been selected in accordance with the order of preference in Policy 5.6B of London Plan and Policy SI3 of Intended to publish London Plan. This has involved a systematic appraisal of the potential to connect to existing or planned heating networks and on site communal and CHP systems.

To comply with London Plan Policy SI 3, developments in Heat Network Priority Areas (HNPAs) should have a communal low-temperature heating system and should select a heat source in accordance with the following heating hierarchy:

- connect to local existing or planned heat networks
- use zero-emission or local secondary heat sources (in conjunction with heat pump, if required)
- use low-emission combined heat and power (only where there is a case for CHP to enable the delivery of an area-wide heat network, meet the development's electricity demand and provide demand response to the local electricity network)
- use ultra-low NOx gas boilers

## Connect to local existing or planned heat network

The illustration below shows the London heat map. Red lines are existing heat networks and orange lines are proposed heat networks. The red circle shows the location of the proposed scheme.



A review of the London Heat Map demonstrates that there are no existing networks present within connectable range of the scheme. Therefore, a connection is not possible.

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# Heating Infrastructure

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#### Use zero-emission and/or local secondary heat sources

According to the GLA and Intend to Publish London Plan Policy SI3, the exploitation of local energy opportunities to maximise the use of locally available energy sources whilst minimising primary energy demand and carbon emissions is encouraged. Secondary heat includes environmental sources such as air, water and ground; and waste sources such as heat from the sewerage system, sewage treatment plants, the tube network, data centres and chiller systems.

There are no local available waste heat sources for the scheme. The possibilities of capturing waste heat from nearby sources has been undertaken, however the amount of heat available is likely a fraction of the scheme's demand which makes its collection trivial within the context of the scheme.

#### Use low-emission combined heat and power (CHP)

In accordance with section 9 of the GLA guidance for Energy Planning where connection to an area wide heat network will not be available in the foreseeable future i.e. 5 years following completion, or the development is of such a scale that it could be the catalyst for an area wide heat network, applicants should evaluate the feasibility of on-site CHP

GLA guidance stipulates that small, or purely residential developments of less than 350 dwellings will not be expected to include on-site CHP. CHP systems are best utilised where there is a consistent and high demand for heat. Because of the small electricity supplies and demand of this scheme, a CHP installed to meet the base heat load would typically require the export of electricity to the grid. The administrative burden of managing CHP electricity sales at a small scale without an active energy service companies (ESCOs) is prohibitive for smaller operators of residential developments.

The heat demand profile of this residential scheme is not suitable to CHP. The implemented fabric improvements from the 'Be Lean' scenario have also reduced the energy demand from space heating to hot water. For CHP systems to be economically viable they need to run for at least 5,000 hours per year. Therefore, a CHP system would most likely be oversized, and as a result less efficient and economic.

#### Use ultra-low NOx gas boilers

Where it is clearly demonstrate that the above heating options (District heating, local secondary heat source and CHP) have been fully investigated and ruled out, then a site-wide heating strategy led by ultra-low NOx gas boilers can be considered.

In accordance with section 9 of the GLA guidance for Energy Planning, where it is demonstrable that a site wide network is not feasible then an individual heating strategy can be implemented. A site wide network will not be adopted because local conditions are not favourable to centralised distribution. Therefore, it is considered that distribution losses would be relatively large and the effectiveness and carbon reducing potential would be undermined when compared to an individual servicing strategy.

Moreover, the scheme is required to achieve a BREEAM Excellent rating. The score for the energy credits is calculated based on the EER (Energy efficiency rating) improvement and primary energy. The EER is based on the energy costs associated with space heating, water heating, ventilation, and lighting. Any communal system will result in distribution losses and a slightly higher cost compared to the baseline. Therefore, no energy credits can be achieved if a communal heating system is specified and a BREEAM DR 'Excellent' rating is not achievable.

Therefore, an individual heating system has been specified for each dwelling.



# Renewable Energy Energy Assessment 6 Lindfield Gardens

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## Renewable Energy Feasibility:

In line with Policy SI2 of the Intend to publish London Plan the feasibility of renewable energy technologies has been considered. A detailed site-specific analysis and associated carbon saving calculations has also been provided for renewable energy technologies considered feasible.

Each technology has been assessed under 3 broader categories. There are key criteria for each category on which the technology is evaluated. The key criteria have been given a weighting based on a tick-system, a graphical representation of this is shown below:

The weighting of each of the criteria within the categories is shown below:

- Local, site-specific impact: (Maximum score of 5)
  - Local planning criteria = ✓✓
  - Land used by all components = ✓
  - Noise impact from operation = ✓
  - Interaction on the current building design = ✓
  - Buildability of installation = ✓
- Economic viability: (Maximum score of 5)
  - Capital cost of all components = ✓
  - Grants and funding available = ✓
  - Payback periods (years) 3–5, 5–10, 10–15 = ✓
  - Servicing requirements (low or high) = ✓
  - Maintenance costs (low or high) = ✓

- CO2 and sustainability: (Maximum score of 10)
  - Carbon saving per year = ✓✓✓✓
  - Impact of future grid decarbonisation (gas vs. electric) = ✓✓
  - Local air quality/pollution = ✓✓
  - Resource use of installation = ✓✓

Key comments on each of the criteria and the corresponding score will be provided in a table for each of the technologies. The score for each of the criteria will be summed and each of the technologies will then be ranked. The assessment of each technology is undertaken on the following pages.

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## Biomass & Biofuel – Rejected

Biomass is normally considered a carbon 'neutral' fuel, as the carbon dioxide emitted on burning has been recently absorbed from the atmosphere by photosynthesis. Although some form of fossil fuel derived inputs are required in the production and transportation of the fuel.

Wood is seen as a by-product of other industries and the small quantity of energy for drying, sawing, pelleting and delivery are typically discounted. Biomass from coppicing is likely to have external energy inputs from fertiliser, cutting, drying etc. and these may need to be considered. In this toolkit, all biomass fuels are considered to have zero net carbon emissions.

Biomass can be burnt directly to provide heat in buildings. Wood from forests, urban tree pruning, farmed coppices or farm and factory waste, is the most common fuel and is used commercially in the form of wood chips or pellets. Biomass boilers can also be designed to burn smokeless to comply with the Clean Air Acts.

Boilers can be fed automatically by screw drives from fuel hoppers. This typically involves daily addition of bagged fuels.

A biomass boiler could be installed on site for supplementary LTHW heating; however, a major factor influencing the suitability of a biomass boiler is the availability of the biomass fuel. A local and reliable fuel source would be essential for the biomass boiler to be an efficient replacement for a conventional boiler system. Therefore, a very comprehensive feasibility assessment needs to be undertaken to understand the practicalities of such a system.

It is estimated that the heating and hot water demand of the site is too large to meet the required CO<sub>2</sub> emissions reduction if a biomass boiler was a standalone system. Therefore, a biomass boiler would need to be combined with energy demand reduction measures and/or CHP. The likely installed cost would be circa £30,000. The additional cost of providing and storing the bio-fuel also needs to be accounted for. The site is likely to be unsuitable for biomass boilers due to site constraints such as limited transport, and storage of the biomass fuel. A detailed feasibility study will be required to investigate the suitability.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)
✓ Local air quality impacts, increased transport usage, increased plant space, slightly increased buildability issues.	✓✓✓ Increased capital costs of installation, typical payback of 8 years, Increased maintenance relative to gas boiler, resource use not significantly increased if well serviced.	✓✓✓✓✓ Very low carbon intensity of feedstock if properly procured. Decarbonisation impact not applicable, air quality issues.

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## Photovoltaic Panels (PV) – Accepted

Photovoltaic systems convert energy from the sun into electricity through semi-conductor cells. Systems consist of semi-conductor cells connected together and mounted into modules. Modules are connected to an inverter to turn the direct current (DC) output into alternating current (AC) electricity for use in buildings.

Photovoltaic panels supply electricity to the building and are attached to electricity grid or to any other electrical load. Excess electricity can be sold to the National Grid when the generated power exceeds the local need. PV systems require only daylight, not sunlight to generate electricity (although more electricity is produced with more sunlight), so energy can still be produced in overcast or cloudy conditions.

The cost of PV cells is heavily dependent on the size of the array. There are significant cost reductions available for larger installations.

The most suitable location for mounting photovoltaic panels is on roofs as they usually have the greatest exposure to the sun. The proposed site has a very small potential roof area. PV panels have been specified to areas with low visual impact.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)
✓✓✓ No local air quality impacts, use of unutilised roof space, no noise issues, good orientation, and slightly increased buildability issues for wiring and metering.	✓✓ Increased capital costs of installation, typical payback of 10–15 years, Feed in Tariff available, limited servicing and maintenance i.e. 1 visit per year, inverter will require replacement.	✓✓✓✓✓ ✓✓✓ High carbon saving from electricity, uses minimal grid electricity, no local air impact, high embodied energy of panels.

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## Solar Thermal – Rejected

Solar water heating systems use the energy from the sun to heat water for domestic hot water needs. The systems use a heat collector, generally mounted on the roof in which a fluid is heated by the sun. This fluid is used to heat up water that is stored in either a separate hot water cylinder or a twin coil hot water cylinder inside the building. The systems work very successfully in all parts of the UK, as they can work in diffuse light conditions.

Like photovoltaic panels the most suitable location for mounting solar hot water panels is on roofs as they usually have the greatest exposure to the sun.

It is estimated that the CO<sub>2</sub> emissions reduction that would be produced by solar hot water as a standalone system would not be adequate to achieve the required CO<sub>2</sub> emissions reduction target. Therefore, a solar hot water system would need to be combined with more energy efficiency strategies, a CHP, or additional renewable technologies to achieve the carbon reduction target.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)
✓✓✓ No local air quality impacts, use of unutilised roof space, no noise issues, good orientation, slightly increased buildability issues for piping and cylinders.	✓✓✓ Increased capital costs of installation, typical payback of 8–10 years, Heat Incentive available, limited servicing and maintenance i.e. 1 visit per year, heat transfer fluid requires replacing every 10 years.	✓✓✓✓✓✓ ✓ Lower carbon saving as primarily displacing gas, uses minimal grid electricity, no local air impact, medium embodied energy of panels.

# Renewable Energy

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#### Wind Energy – Rejected

Wind energy is a cost-effective method of renewable power generation. Wind turbines can produce electricity without carbon dioxide emissions in ranges from watts to megawatt outputs. The most common design is for three blades mounted on a horizontal axis, which is free to rotate into the wind on a tall tower.

The blades drive a generator either directly or via a gearbox to produce electricity. The electricity can either be linked to the grid or charge batteries. An inverter is required to convert the electricity from direct current (DC) to alternating current (AC) for feeding into the grid.

Modern quiet wind turbines are becoming viable in low density areas where ease of maintenance and immediate connection to the grid or direct use of the electricity in a building, may make them cost effective, despite lower wind speeds than open areas.

Wind turbines are generally less suited to dense urban areas as their output will be affected by potentially lower and more disrupted wind speeds, and their use of much more cost-effective machines may be prohibited by their proximity to some building types. Small turbines can be used in inner city areas mounted on buildings, although there are relatively few installations.

A detailed wind resource evaluation would be required for the site to fully understand the generation potential and payback period. Also, it is likely that planning restrictions and resistance from groups within the local community could also affect the viability of wind energy for the project.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)
✓ No local air quality impacts, use of unutilised roof space, medium noise issues, relatively limited wind speeds in local area, increased buildability issues for wiring and metering.	✓✓✓✓ Medium capital costs of installation, typical payback of 5 years, Feed in Tariff available, limited servicing and maintenance, costs of 2–3% typical.	✓✓✓✓✓ High carbon saving from electricity, output limited from urban installation, consumes little grid electricity, no local air impact, low embodied energy of panels

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## Ground Source Heat Pump (GSHP) – Rejected

Geo-thermal energy is essentially heat collected from the ground. Heat obtained from the ground may be considered it as a source of heating and cooling within the UK by the use of a geo-thermal heat pump or ground source heat pumps.

A ground source heat pump is a device for converting energy in the form of low-level heat to heat at a usable temperature. The heat pump consists of five main parts: ground collector loop/or boreholes, heat exchanger, compressor, condenser heat exchanger and expansion valve.

At approximately 1.2–1.5 metres down below ground level the temperature is a constant 10 to 12°C. Any boreholes would need to be sunk to an effective depth of 50 – 120m and a ground feasibility report would be required to ascertain if this method of heat source were viable.

From the boreholes pre-insulated pipework is laid in the ground to the heat exchanger device. The system is filled with water and antifreeze. The cooled water is pumped around the loop / borehole gathering energy as it circulates. The water that has been heated to 10–12°C is returned to the ground source heat exchanger where the energy is transferred to the refrigerant gas. For every 1kW of energy used to compress the refrigerant, the process 'gives up' 4 kW of energy for use in the system being used to heat the building.

The installation cost for a Ground Source Heat pump is typically high compared to a gas-boiler installation. Moreover, the installation of the ground collector it will be hard due to the existing structures that are on site. Therefore, the GSHP has been rejected.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)
✓✓ No local air quality impacts, no visual impact, no noise issues, however the constrained site may prohibit its installation. Increased buildability issues for pipework and heating emitters internally.	✓ High capital costs of installation, typical payback >15 years where gas is displaced, Renewable Heat Incentive available, limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✓✓✓✓✓ ✓✓✓ Medium carbon saving from gas displacement, consumes some electricity so benefits from decarbonisation, no local air impact, high embodied energy of equipment.

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## Air Source Heat Pump (GSHP) – Accepted

Air source heat pump systems work on the same principle as a ground source heat pump although they use the outside air as the heat source.

The coefficients of performance given by air source heat pump systems are inferior to that of ground source systems due to varying air temperatures. In the depth of winter, the energy efficiency of an air source system will be lower than that of a ground source system, and it is likely that more back-up heat will be required if an air source unit is fitted. This back-up heat often comes from a direct electric heater. They operate over a varying temperatures range of  $-15^{\circ}\text{C}$  to  $+25^{\circ}\text{C}$ , however, the performance will reduce to below the required 3 to 1 carbon saving ratio in winter, and they also require a defrosting mechanism to melt ice that forms on the air heat exchanger.

ASHPs are cheaper to install than ground source heat pumps but carbon dioxide emission savings will typically be less than that of a ground source heat pump. There is limited available space in the scheme and no ASHPs can be specified on the roof due to conservation. Moreover, the heating demand of the scheme will be high compared to new builds, because of the existing wall fabric that cannot be further upgraded due to interstitial condensation risk. Therefore, an electric ASHP will increase the operational cost and would not be viable for the whole scheme. However, an ASHP has been specified for Flat 1.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)
✓✓✓ No local air quality impacts, use of unutilised roof space, over visual impact, low noise issues, increased buildability issues for pipework and heating emitters internally.	✓✓ Medium– high capital costs of installation, typical payback >15 years where gas is displaced, Renewable Heat Incentive available Limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✓✓✓✓✓ ✓✓ Medium carbon saving from gas displacement, less efficient in winter, consumes electricity so benefits from decarbonisation, no local air impact, high embodied energy of equipment.

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## Summary comparison matrix

An assessment of the feasibility of each of the technologies is shown below.

Renewable Technology	Comments	Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO <sub>2</sub> and sustainability (out of 10)	Total Score
Biomass Boiler	Rejected – High air quality impact	✓	✓✓✓	✓✓✓✓✓	9
Photovoltaic	Accepted – High CO <sub>2</sub> savings and have low visual impact	✓✓✓	✓✓	✓✓✓✓✓ ✓✓✓	13
Solar Thermal	Rejected – Low CO <sub>2</sub> savings compared to PV panels	✓✓✓	✓✓✓	✓✓✓✓✓ ✓	12
Wind Energy	Rejected – High visual and noise impact	✓	✓✓✓✓	✓✓✓✓✓	10
GSHP	Rejected – High capital cost	✓✓	✓	✓✓✓✓✓ ✓✓✓	11
ASHP	Accepted – Can provide carbon savings with minimal site impact	✓✓✓	✓✓	✓✓✓✓✓ ✓✓	12

Photovoltaic panels, solar thermal panels and ASHPs have scored the best. However, due to the limited amount of roof, visual impact and conservation criteria, PV panels and ASHP have been specified for Flat 1.



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## Air Source Heat Pump (ASHP) – Performance

The lifecycle of the proposed system is 25 years. To calculate the lifecycle cost of the ASHP, the maintenance of the system and cost of electricity to run the pumps will be included.

ASHP has been specified for Flat 1 to provide space heating and hot water.

The following table summarise the reduction in carbon emissions and the life cycle cost of the ASHP system compared to a gas boiler.

	Gas Boiler	Air Source Heat Pump
	Heating and hot water	Heating and hot water
Installation cost (£)	3,000	11,000
Maintenance and replacement cost (£)	4,000	2,000
Total (£)	7,000	13,000
Energy demand (kWh)	90,237	39,102
Cost of gas/electricity (p/kWh)	5	12.5
Annual operational cost (£)	4,963	4,888

It should be noted that the figures above are based on SAP modelling for CO<sub>2</sub> compliance. Compliance models are not well suited to investment appraisals because they do not accurately estimate energy consumption. It is estimated that the lifecycle saving for ASHP will be greater than boiler under 'real-life' operating conditions and consumption.

Moreover, the servicing strategy has been proposed based on sustainability aspirations and compliance with GLA requirements, which is intended to supersede simple economic payback appraisals for purposes of energy strategies.

Cost Performance Criteria	Value
Extra Cost Over Life Cycle (£)	6,000
Predicted Annual Savings (£)	75
Payback Period (years)	79.6
Energy and Carbon Performance Criteria	Value
Predicted Annual Energy Saved (kWh/yr)	51,135
Annual Carbon Emissions Reductions (kg CO <sub>2</sub> /year) using SAP10.0 carbon factors	522
CO <sub>2</sub> Emissions Reduction (%) with SAP10.0	23.7%

# Renewable Energy

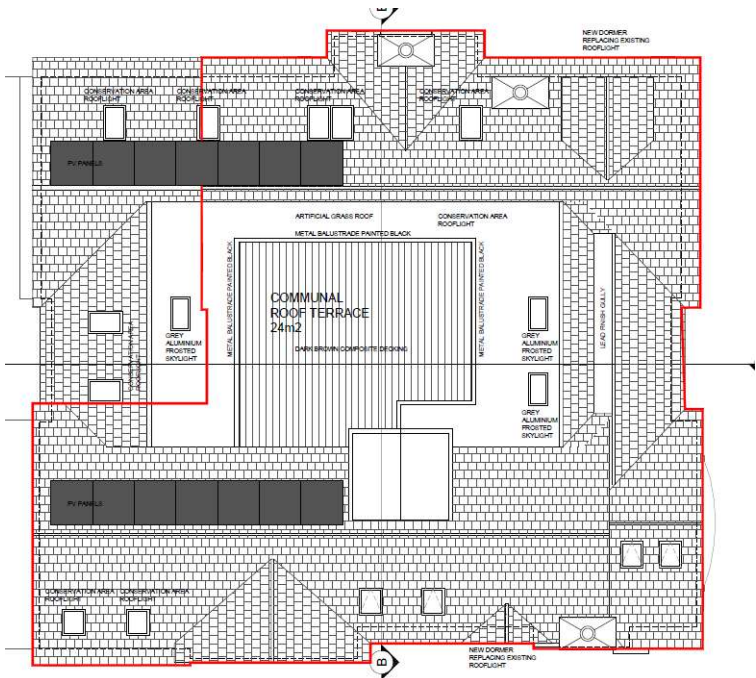
## Energy Assessment

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#### Photovoltaic panels (PV) – Performance

A photovoltaic panel system of 4.2 kWp (14 panels of 300W each) has been specified for Flat 1, a detailed summary of the lifecycle cost, revenue and payback for the photovoltaic panels is presented in this section.

PV panels will be placed with 30° tilt, oriented south-east, covering approximately 25m<sup>2</sup> of the roof.



The lifecycle of the proposed high efficiency panels is 25 years. To calculate the lifecycle cost of the panels, the maintenance of the system and replacement cost will be included. The total costs for the proposed system's lifetime is shown in the table below.

Capital cost (£)	5,000
Maintenance cost (£)	1,500
Operational cost (£)	600
Total (£)	7,100
Cost of electricity (p/kWh)	12.5
Electricity generation (kWh/yr)	3,458
% of energy used on site	50%
Savings (£)	309
Summary	
Cost Performance Criteria	Value
Extra Cost Over Life Cycle (£)	7,100
Predicted Annual Savings (£)	309
Payback Period (years)	23.0
Energy and Carbon Performance Criteria	Value
Predicted Annual Energy Saved (kWh/yr)	3,458
Annual Carbon Emissions Reductions (kg CO <sub>2</sub> /year) using SAP10.0 carbon factors	806
CO <sub>2</sub> Emissions Reduction (%) with SAP10.0	4.1%

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# Conclusion

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#### Summary

All flats have been modelled for the purposes of the energy assessment. The scheme complies with the 2013 Building Regulations Part L and the minimum energy efficiency targets in the following documents have been followed:

- Refurbishment (Part L1B) – Consequential improvements to refurbished areas have been made to ensure that the building complies with Part L, to the extent that such improvements are technically, functionally, and economically feasible.

In addition, the CO<sub>2</sub> emissions of the scheme have been calculated using the SAP 10.0 carbon emission factors, and the scheme can achieve:

- An on-site CO<sub>2</sub> reduction of 3.5% beyond Building Regulations through energy efficiency measures. The design team has maximised the passive design measure, however, the existing wall cannot be further insulated due to interstitial condensation risk. Therefore, no further CO<sub>2</sub> improvement can be achieved.
- A CO<sub>2</sub> reduction of 27.8% from renewable technologies (ASHP and PV panels have been specified for Flat 1)
- A total on-site CO<sub>2</sub> reduction of 31.2%
- BREEAM DR 2014 Energy credits:
  - Ene 01 – 0 credits
  - Ene 02 – 3 credits (Excellent standard)
  - Ene 03 – 6.5 credits
  - Ene 04 – 2 credits for Flat 1

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# Appendix A

## Energy Assessment

### 6 Lindfield Gardens

#### Total fuel consumption

The total gas and electricity consumption are shown in the table below.

Energy source	Total fuel consumption (MWh/year)
Grid electricity	14.9
Gas boilers (communal/individual)	87.7
Gas CHP	–
Connection to existing District Heating network	–
Other gas use (e.g. cookers)	–

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# Appendix B

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#### SAP and BRUKL files

The emission figures and details of the calculations and methodology used to determine the figures provided within the report can be found in the following pages:

- Baseline – DER from the Baseline scenario DER SAP worksheet
- Be Lean Residential – DER from the Be Lean scenario DER SAP worksheet
- Be Green Residential – DER from the Be Green scenario DER SAP worksheet

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# Appendix B

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Baseline Residential – DER from the Baseline scenario DER SAP worksheet

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Be Lean Residential – DER from the Be Lean scenario DER SAP worksheet

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Be Green Residential – DER from the Be Green scenario DER SAP worksheet