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Planning Statement
Energy Assessment
19 Fitzroy Square

Document information:

Prepared for:
Tamares Real Estate

Date of current issue:
01.04.2016

Issue number: 2

Our reference:
1708

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About the Scheme:

The scheme is a refurbishment of the 19 Fitzroy Square, which is to be converted into a five-bedroom house. The dwelling is located in the Camden conservation area and have a total Gross Internal Area of approximately 520 m^2.

Planning Policy

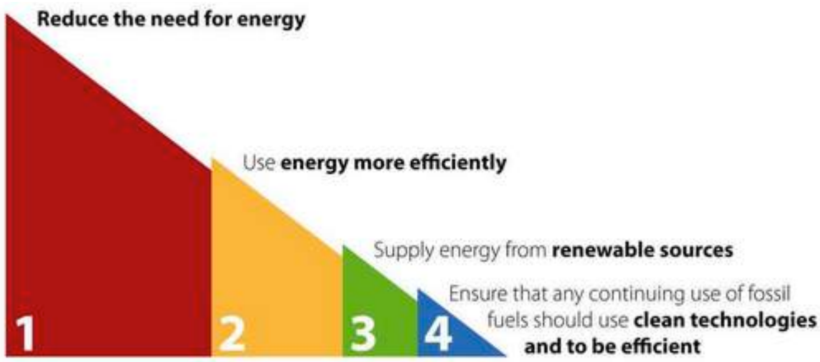
In accordance with the Sustainable, Design and Construction SPG, the scheme is required to achieve a 40% reduction in regulated carbon dioxide emissions (Beyond Building Regulations Part L 2010) as set out in The London Plan Policy 5.2. As stated in the latest guidance on preparing energy assessments, issued by the GLA in March 2016, this equates to a 35% carbon reduction target beyond Part L 2013.

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 L2B) – 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.

The Energy Hierarchy:

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



The resulting energy savings are shown below in accordance with the GLA's Energy Hierarchy:

GLA's Energy Hierarchy – Regulated Carbon Emissions				
	Baseline:	Be Lean:	Be Clean:	Be Green:
CO_2 emissions (Tonnes CO_2/yr)	22.75	16.12	-	11.80
CO_2 emissions saving (Tonnes CO_2/yr)	-	6.63	-	4.31
Saving from each stage (%)	-	29.1	-	19.0
Total CO_2 emissions saving (Tonnes CO_2/yr)	10.94			
48.1% Total carbon emissions savings over Part L of the Building Regulations 2013 achieved				

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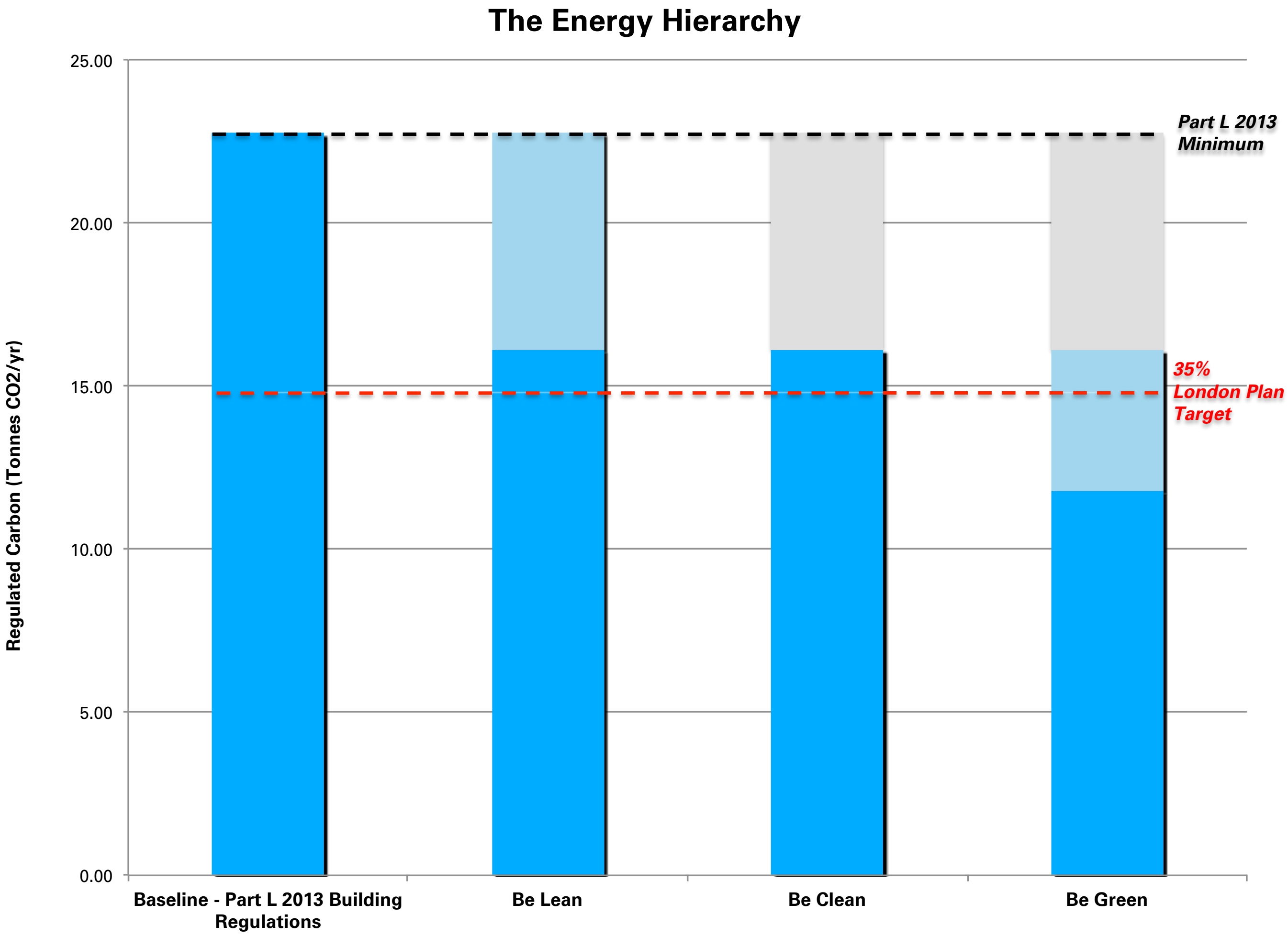
GLA's Energy Hierarchy – Regulated Carbon Emissions:

A graphical illustration of how the scheme performs in relation to Building Regulations and the Energy Hierarchy is shown below.

Figure:



Summary:

As demonstrated above the development will reduce carbon emissions by 29.1% from the fabric energy efficiency measures described in the 'Be Lean' section, and will reduce total carbon emissions by 48.1% over Building Regulations with the further inclusion of an air source heat pump.

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Shortfall in Emissions:

As set out in Policy 5.2 of the London Plan, if the development fails to meet the 35% target, the annual shortfall is determined by subtracting the overall regulated carbon dioxide savings from the target savings. The result is then multiplied by the assumed lifetime of the development's services (e.g. 30 years) to give the cumulative shortfall. The cumulative shortfall is multiplied by the carbon dioxide off-set price to determine the required cash-in-lieu contribution, as shown below.

Carbon Dioxide Emissions – Regulated (Tonnes CO_2/yr)		
	(Tonnes CO_2/yr)	%
Savings from 'Be Lean'-After energy demand reduction	6.63	29.1%
Savings from 'Be Clean'-After CHP	0.00	0.0%
Savings from 'Be Green'-After renewable energy	4.31	19.0%
Total Cumulative Savings (30years)	10.94	48.1%
Total Target Savings	7.96	35%
Annual Surplus	2.98	
	Annual Shortfall (Tonnes CO2/yr)	Cumulative Shortfall (Tonnes CO2)
Shortfall	-	-
Carbon offset contribution required: £0		

Total Carbon 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.

Carbon Dioxide Emissions – Regulated and Unregulated (Tonnes CO_2/yr)			
	Regulated Emissions	Unregulated Emissions	Total Emissions
Baseline: Part L 2013	22.75	1.58	24.33
Be Lean: After demand reduction	16.12	1.58	17.70
Be Clean: After CHP	-	-	-
Be Green: After Renewable energy	11.80	1.58	13.39

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Introduction
Energy Assessment
19 Fitzroy Square

Aim of this study:

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 development's design and evolution.

Methodology:

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 PLANNING: Greater London Authority guidance on preparing energy assessments (April 2014)"

Under the GLA's guidance and the London Borough of Camden's policy document CPG3, applications for major developments should be accompanied by an energy statement. The energy statement should provide information demonstrating how the energy hierarchy has been followed i.e. 'Lean, Clean, Green', including consideration of passive design and decentralised energy options such CHP/Community CHP.

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

- BASELINE: A calculation of the Part L 2013 Building Regulations complaint CO_2 emission baseline using approved software. The baseline assumes a gas boiler would provide heating, any active cooling would be electrically powered and minimum building requirements were assumed for fabric and services specifications where possible.

- 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, 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.

- CLEAN: in accordance with Policy 5.6 of London Plan, 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.

- GREEN: in accordance with Policy 5.7 of London Plan, 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.

Please note that these findings are currently subject to a detailed analysis from a building services design engineer and qualified quantity surveyor.

Establishing Emissions: The Carbon Profile

Energy Assessment

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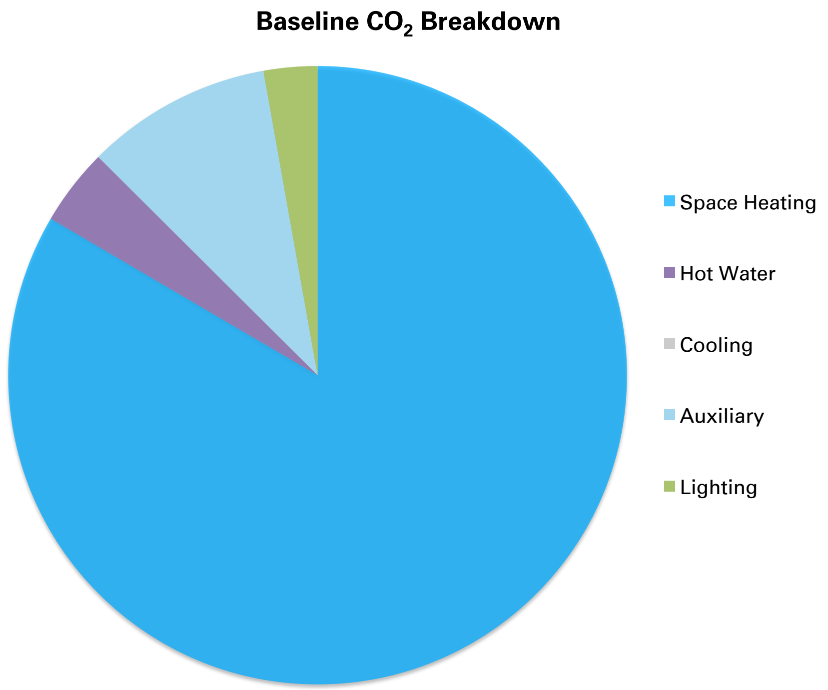
Building Regulations Part L 2013 Minimum Compliance:

The 'baseline' carbon emissions for the development are 22.75 Tonnes CO_2/yr.

The pie chart below provides a breakdown of the scheme's baseline carbon emissions by system over the course of one year.

Carbon Emissions in Tonnes CO_2/yr	Heating	Hot Water	Cooling	Auxiliary	Lighting
	18.98	0.92	0	2.21	0.64



Overview:

The chart above shows that space heating is the primary source of carbon emissions, and auxiliary is the second largest, across the scheme as a whole.

'Be Lean': Demand Reduction Measures

Energy Assessment
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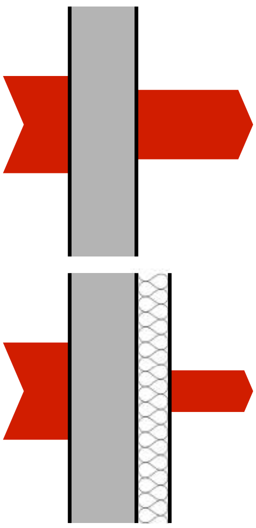
Be Lean - Summary:

Demand reduction measures have reduced the scheme's carbon emissions by 29.1 % over the minimum Part L 2013 Building Regulations baseline.

Building Fabric
Passive Design measures:

U Values:

Element	Minimum Building Regulations U value W/m^2K	Proposed U value W/m^2K
External wall – Existing (Uninsulated)	-	1.50
External wall – Upgraded (T1)	0.30	0.25
External wall – Upgraded (T2)	0.30	0.39
Basement Wall – New	0.28	0.23
Wall to plant room - New	0.28	0.28
Ground Floor – Upgraded	0.25	0.19
Exposed Floor – Upgraded	0.25	0.25
Basement Floor – New	0.22	0.25
Plant Room Floor – New	0.22	0.22
Pitched Roof – Upgraded	0.18	0.15
Flat Roof – Upgraded	0.18	0.16
Glazing – Existing (Single glazing)	-	4.8
Glazing – Existing (Secondary glazing)	-	1.95
Glazing – New (Double glazing)	1.60	1.20
Roof Glazing – New (Double glazing)	1.60	1.60
Doors - Existing	-	3.00



Graphic illustrations of the heat flow through a wall and how is it minimized with low u-value (consequence of the additional insulation).

Airtightness:
The windows and doors of the development will be 100% draught stripped.

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 and cracks in masonry walls typically this is caused by poor perpends in blockwork inner leafs. Structural leakage is hard to remedy retrospectively. Good detailing at the design stage is therefore 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 constriction.

Thermal Bridging:
The scheme has been indicatively modelled with the default thermal bridge y-values for all junction types, $0.15W/m^2K$.

Thermal Mass:
Thermal mass of the scheme has been indicatively modelled as $250\ kJ/m^2K$ (medium).

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'Be Lean': Demand Reduction Measures
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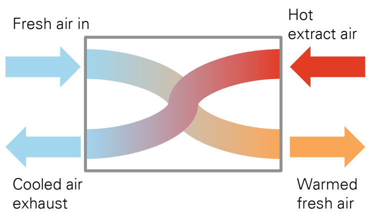
Energy Efficient Services
Active Design measures:



Graphic illustration of a heat recovery unit, which exploits the extract hot air of the room to heat the cold supply air.

Heating:
Heating will be provided by a gas boiler for the 'Be Lean' scenario, featuring time and temperature zone control, delayed thermostat and a weather compensator. The heat will be distributed via underfloor heating with pipes in screed above insulation. The gas boiler will have a minimum efficiency of 89.5%.

Ventilation:
Balanced mechanical ventilation with heat recovery (89% efficiency) will be provided to dwellings and wet rooms with a specific fan power of 0.8 W/l/s. In addition mechanical extract ventilation will be provided to wet rooms.

Air Conditioning:
Cooling will be provided to the principle four rooms by split systems, the systems will have an energy efficiency rating of 3.4.

Lighting:
High efficiency lighting has been specified for the development.

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'Be Clean': Heating Infrastructure & CHP

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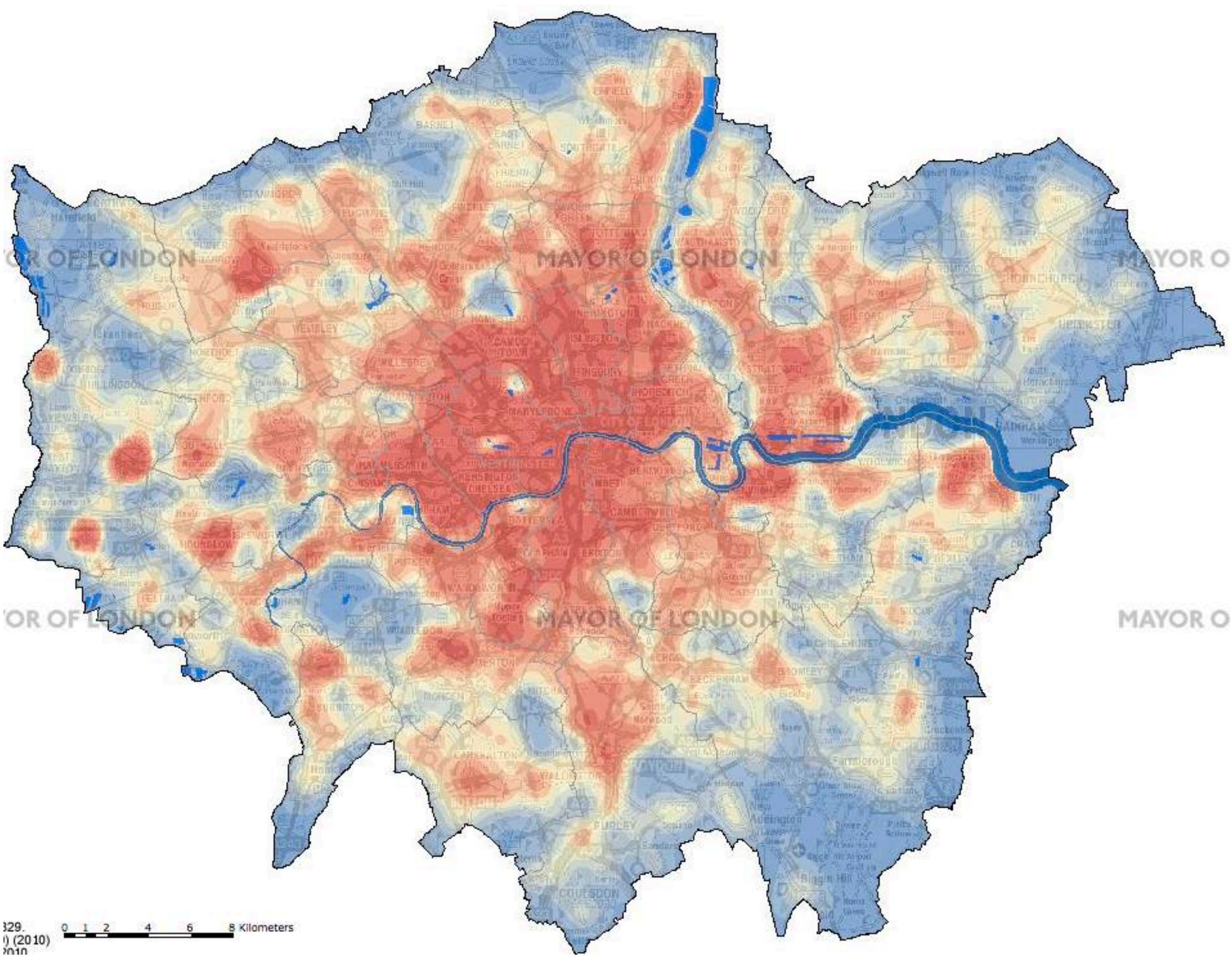
Heating Infrastructure including CHP:

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. This has involved a systematic appraisal of the potential to connect to existing or planned heating networks and on site communal and CHP systems.

Heating Infrastructure:

The London Heat Map (shown below) has been consulted to establish the possibility of connecting to heating infrastructure.



Source: http://www.londonheatmap.org.uk/Mapping

‘Be Clean’: Connection to Existing and Planned Networks

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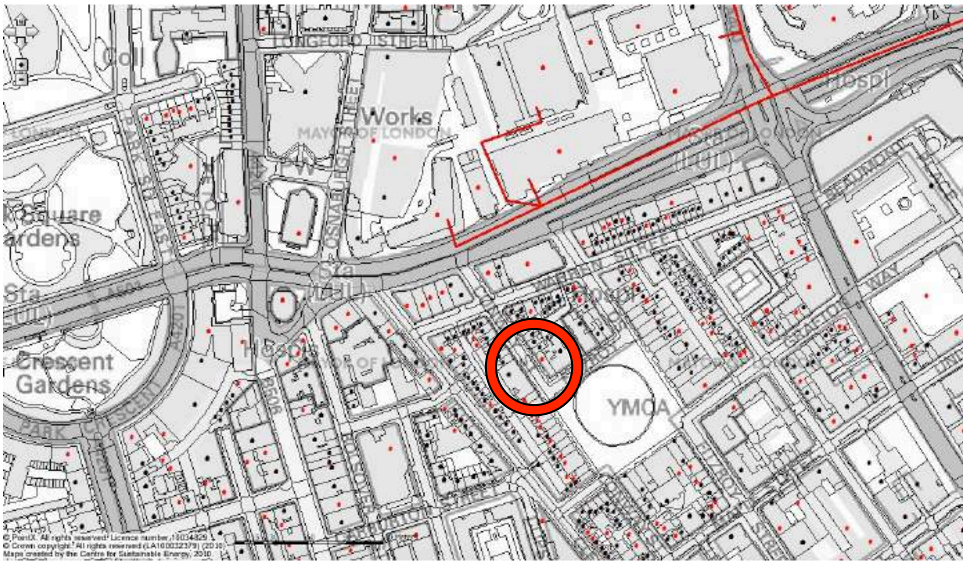
Existing and Planned Networks:

Existing networks:
A review of the London Heat Map demonstrates that there are no existing networks present within connectable range of the scheme. A map of the existing and potential networks in the scheme’s location is shown below.



Existing DH Networks
Potential DH Networks

There is one potential network within the vicinity of the scheme. However, due to the distance from the development a connection is not possible.

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'Be Clean': Site Wide Networks and CHP

Site-wide Heat Networks:

In accordance with section 8.2 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 the development is a single dwelling and 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.

Combined Heat and Power (CHP)

In accordance with section 8.3 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.

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'Be Clean': Cooling
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Policy 5.9 Overheating and Cooling:

The aim of this policy 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.

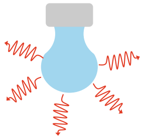
Where appropriate, the cooling strategy should investigate the opportunities to improve cooling efficiencies through the use of locally available sources such as ground cooling and river/dock water-cooling.

The Cooling Hierarchy:

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

1) **Minimise internal heat generation through energy efficient design**
2) **Reduce the amount of heat entering the building in summer (e.g. shading and fenestration)**
3) **Manage the heat within the building through thermal mass, room height and green roofs**
4) **Passive ventilation**
5) **Mechanical ventilation**
6) **Active cooling systems (ensuring the lowest carbon option)**

Avoiding Overheating Measures taken:



LED bulbs can emit 80% less heat compared to an incandescent bulb and their life span is up to 41 times more.

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

1) **Minimise internal heat generation through energy efficient design**

Internal heat gains have been minimised where possible. Energy Efficient appliances will help reduce internal heat gain and reduce the cooling requirement.

Energy efficient lighting will also be specified (>45 lumens per circuit watt). LED lighting will be specified and a power lighting density figure of 9W/m^2 will be targeted.

'Be Clean': Cooling
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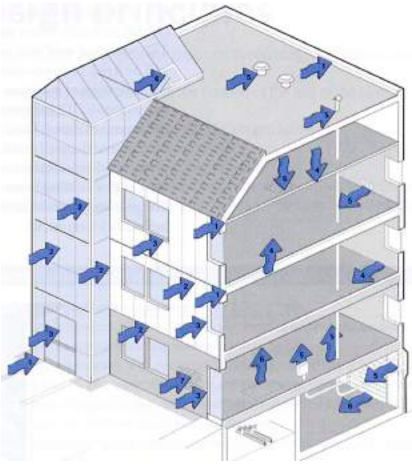
Avoiding Overheating
Measures taken:



Examples of possible air leakage points in a building

Examples of how the thermal mass absorbs heat during day and emits it during night.

2) Reduce the amount of heat entering the building in summer (e.g. shading and fenestration)

Direct solar gains will be controlled in the following ways:

- 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 windows with a g-value of 0.6 have been specified for new windows. Existing windows have a g-value of 0.85.

Heat transfer and infiltration has been controlled in the following ways:

- Insulation levels have been maximised and the resulting u-values 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.

- All windows and doors will be 100% draught stripped to minimise uncontrolled air infiltration. This will require attention to detailing and sealing. See 'Be Lean' section of this report for details of how this will be achieved.

3) Manage the heat within the building through thermal mass, room height and green roofs.

The following measures have been specified to manage heat accumulation within the building:

- 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. 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.

'Be Clean': Cooling
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Avoiding Overheating Measures taken:

- 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 existing building has an average floor to ceiling heights of approximately 3.5m. As the roof will be well insulated to achieve a U-value of 0.17 W/m^2K for the pitched roof and 0.15 W/m^2K for the flat roof, there will be minimal penetration of heat through the roof.

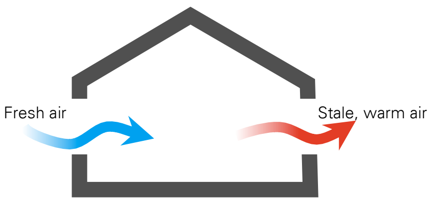
- A green roof has been considered to be unpractical by the design team. Consequently, a roof covering with a high albedo (reflective) surface has been specified in order to minimise the heat absorbed by the roof, and significant thermal insulation has been specified to prevent any heat absorbed being transferred into the building.

4) Passive ventilation

Ventilation that does not use fans or mechanical system has been specified to reduce the cooling load.

- Openable windows are specified on all facades of the building. 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 stricture during the day.



Typical building section demonstrating passive cross ventilation.

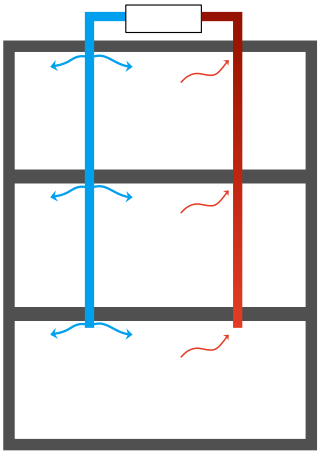
'Be Clean': Cooling
Energy Assessment
19 Fitzroy Square

Avoiding Overheating Measures taken:

5) Mechanical ventilation

Passive ventilation will not be adequate to cool the building to the required temperature. Mechanical ventilation will be utilised in the following forms:

- A mixed mode system will be implemented. This will be complimentary to the passive cooling measures taken. During summer months, mechanical ventilation using fans will circulate and remove hot air from the building. The building will also adopt a zoned design to allow natural ventilation where possible and mechanical ventilation where there are increased cooling loads.
- Fan powered ventilation: single point extracts will be used in WCs and food preparation areas. A whole building system will be specified which will use air handling units with separate supply and extract fans. Heat recovery units will also be specified to reduce energy demand, optimal performance will be achieved by the reduced air permeability rate (doors and windows will be 100% draught stripped).
- The mechanical systems will have the following efficiencies which are in compliance with the Domestic Building Services Compliance Guide:
  - ✓ Specific fan power of 0.8 W/l/s for whole ventilation systems with heat recovery
  - ✓ Heat recovery efficiency of 89%



Typical building section demonstrating a simple method of supply and extract ventilation system.

Overheating Risk:

The overheating risk considering all the above described passive measures have been assessed for the dwelling and is presented in the table below:

Dwellings	Overheating risk according to SAP
19 Fitzroy Square	Not Significant

According to the GLA guidance on preparing energy assessments (April 2015), Section 11, a dynamic modelling to assess the risk of overheating should be carried out. However, due to the overheating results of SAP showing that there is no significant risk of overheating, it has been considered that a dynamic modelling is not required.

‘Be Clean’: Cooling
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Efficiency Measures taken:

6) Active cooling systems (ensuring the lowest carbon option)

Passive design measures and the use of natural and/or mechanical ventilation were used to reduce the cooling demand. However, an air conditioning system has been specified for scheme to provide the required level of comfort and to guarantee the occupant’s comfort.

Following the methodology of the cooling hierarchy has progressively reduced the demand for cooling. The monthly cooling requirements of the development are presented in the table below.

	Monthly Cooling Requirement (kWh/m^2/year)			
Dwellings	June	July	August	Annual
19 Fitzroy Square	0	0	0	0

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 conspired carefully 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 have the following efficiencies which are in compliance with the Domestic Building Services Compliance Guide:
    - ✓ Energy Efficiency Ratio of 3.4

'Be Green': Renewable Energy
Energy Assessment
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Renewable Energy Feasibility:

In line with Policy 5.7 of the 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.

Renewable Energy Technology Comparison:

Each technology has been assessed under 5 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:

✔ ✔ ✔ ✔ ✔ = 1 scored out of a possible 5

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

- **Local, site-specific impact:** (Maximum score of 4)
  - Local planning criteria = ✔ ✔
  - Land used by all components = ✔
  - Noise impact from operation = ✔
- **Suitability and design impact:** (Maximum score of 4)
  - Interaction on the current building design = ✔ ✔
  - Building orientation suitability = ✔
  - 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 = ✔ ✔ ✔
- **Operation and maintenance:** (Maximum score of 3)
  - Servicing requirements (low or high) = ✔
  - Maintenance costs (low or high) = ✔
  - Resource use from future maintenance (low or high) = ✔
- **CO_2 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 (example below) 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.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
	✔✔✔✔	✔✔✔✔	✔✔✔✔✔	✔✔✔	✔✔✔✔✔ ✔✔✔✔✔

‘Be Green’: Renewable Energy

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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 small to meet the required CO_2 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. In order to meet the 35% CO_2 emissions reduction a biomass boiler would need to be installed. The likely installed cost would be circa £50,000. 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/access issues, and storage of the biomass fuel. A detailed feasibility study will be required to investigate the suitability.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
Biomass Boiler	✔✓✓✓ Local air quality impacts, increased transport usage on the restricted site, increased plant space.	✔✔✔✓ Increase in plant space required, orientation fine, 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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‘Be Green’: Renewable Energy

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Photovoltaic (PV):

Rejected

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 systems can be discreet through being designed as an integral part of the roof. An ‘invisible’ design using slates or shingles as opposed to an architectural statement could be preferable in a sensitive area.

Photovoltaics supply electricity to the building and are attached to electricity gird 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 potential useable roof area of approximately 36 m^2 and is orientated south-east and south-west. However, there are concerns over the suitability of this technology given the building’s listed status.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
Photovoltaic	✔✓✓✓ No local air quality impacts, use of unutilised roof space, conservation officer will have concerns given the site’s location and listed status, no noise issues.	✔✔✔✓ Can be added to the roof, good orientation, and slightly increased buildability issues for wiring and metering.	✔✔✔✓✓ Increased capital costs of installation, typical payback of 8 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.

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. The proposed site has a potential useable roof area of approximately 36 m^2 and is orientated south-east and south-west. However, there are concerns over the suitability of this technology given the building's listed status and location in a conservation area.

It is estimated that the CO_2 emissions reduction that would be produced by solar hot water as a standalone system would not be adequate to achieve the required CO_2 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.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
Solar Thermal	✔✓✓✓ No local air quality impacts, use of unutilised roof space, conservation officer will have concerns given the site's location and listed status, no noise issues.	✔✔✔✓ Can be added to the roof, good orientation, and slightly increased buildability issues for piping and cylinders.	✔✔✔✓✓ Increased capital costs of installation, typical payback of 8 years, Renewable Heat Incentive available.	✔✔✔ Limited servicing and maintenance i.e. 1 visit every two years, 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.

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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.

Typically a 1.5 kW turbine can provide 4,000 kWh of electrical power annually. To achieve the required CO_2 emissions reduction target approximately 1 turbine would be required as a standalone solution. The indicative cost of a smaller roof mounted turbine is £2,000/kW so achieving the required CO_2 emissions reduction would cost approximately £6,000.

A detailed wind resource evaluation would be required for the site to fully understand the generation potential and payback period. Also, it is likely this technology would not be approved by the local authority given the building's listed status and location within a conservation area.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
Wind Energy	✔✔✔✔ No local air quality impacts, use of unutilised roof space, conservation officer will have concerns for the site, minor noise issues.	✔✔✔✔ Can be added to the roof, relatively limited wind speeds in local area, increased buildability issues for wiring and metering.	✔✔✔✔✔ Medium capital costs of installation, typical payback < 5 years, Feed in Tariff available.	✔✔✔ Very 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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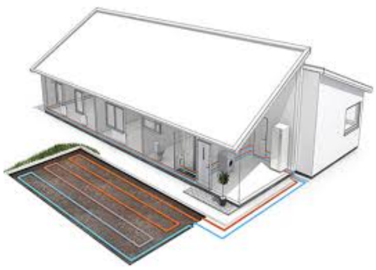
Ground Source Heat Pump (GSHP):

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 bores, 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 bores 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 was viable.

From the bores 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 / bore 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.

Typical costs for an installation this are in the region of £50,000 for a smaller commercial or domestic size installation, with general installation costs at £1200 /kW of energy produced.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
GSHP	✔✔✓✓ No local air quality impacts, not visible so conservation friendly, no noise issues, however the constrained site may prohibit its installation.	✔✔✔✓ Can be added to the roof, good air-flow on roof, increased buildability issues for pipework and heating emitters internally.	✔✓✓✓✓ High capital costs of installation, typical payback of 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.	✔✔✔✔✔ ✔✔✓✓✓ Limited 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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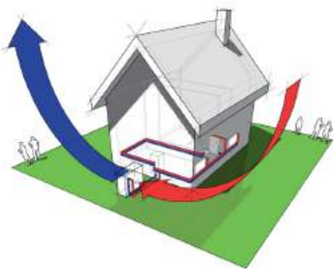
Air Source Heat Pump (ASHP):

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°C to +25°C, however, the performance will reduce to below the required 3 to 1 carbon saving ratio in winter, and the 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 are only available on a relatively small scale. If applied across a larger site a number of plant zones would be required for generation of heat, leading to increased plant space requirements. Typical costs for an installation this are in the region of £30,000 for a smaller commercial or domestic size installation.

Carbon dioxide emissions savings will typically be less than that of the ground source heat pump. Air source heat pumps may be more suitable as an HVAC solution.

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability
ASHP	✔✔✔✔ No local air quality impacts, use of unutilised roof space, conservation officer may have minor concerns over visual impact, no noise issues.	✔✔✔✔ Can be added to the roof, good air-flow on roof, 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.	✔✔✔✔✔ ✔✔✔✔✔ Limited 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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‘Be Green’: Summary of Renewable Technologies

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Summary Comparison Matrix:

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

Renewable Technology	Local, site-specific impact	Suitability and design impact	Economic viability	Operation and maintenance	CO_2 and sustainability	Total Score
Biomass Boiler	✔✓✓✓	✔✔✔✓	✔✔✔✓✓	✔✓✓	✔✔✔✔✔ ✔✔✓✓✓	15 out of 26
Photovoltaic	✔✓✓✓	✔✔✔✓	✔✔✔✓✓	✔✔✓	✔✔✔✔✔ ✔✔✓✓✓	16 out of 26
Solar Thermal	✔✓✓✓	✔✔✔✓	✔✔✔✓✓	✔✔✔	✔✔✔✔✔ ✓✓✓✓✓	15 out of 26
Wind Energy	✔✓✓✓	✔✔✓✓	✔✔✔✔✓	✔✔✔	✔✔✔✔✔ ✔✔✓✓✓	17 out of 26
GSHP	✔✔✓✓	✔✔✔✓	✔✓✓✓✓	✔✔✓	✔✔✔✔✔ ✔✔✓✓✓	15 out of 26
ASHP	✔✔✔✓	✔✔✔✓	✔✔✓✓✓	✔✔✓	✔✔✔✔✔ ✔✓✓✓✓	16 out of 26

Renewable Technology Conclusion & Specification:

Although it has achieved the highest score, it is assumed wind energy would be considered unsuitable for the building given its listed status and location in a conservation area. It is also likely that the local residents would raise concerns over potential noise and turbulence. Moreover, photovoltaic panels and solar thermal panels are not feasible for a similar reason - because of the historic value of the site. Therefore, an air source heat pump has been considered to be the optimum balance of sustainable and economic objectives.

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ASHP:

A detailed summary of the lifecycle cost, revenue and payback for the air source heat pump (ASHP) is given below.

Lifecycle Cost:

The lifecycle of the proposed system is 25 years. To calculate the lifecycle cost of the ASHP, the installation and maintenance of the system will be compared to the cost of the baseline system (gas boiler).

Costs have been taken as approximates.

Capital Cost	Baseline System		Proposed System	
	Heating	Cooling	Heating	Cooling
System Type	Base Boiler	ASHP		ASHP
Installation Cost (£)	5,000	10,000		23,000
Maintenance and Replacement Cost (£)	2,250	3,000		4,500
Total (£)		20,500		27,500
Total Extra Cost (£)				7,000
Operational Cost		Baseline System		Proposed System
Heating Demand (kWh/yr)		63,997		18,150
Cost (p/kWh)		4		12
Operational Cost (£)		2,560		2,178
Predicted Annual Savings (£/year)				382

Revenue and Payback

The dwelling has a heating demand of 63,997 kWh per year using a gas boiler. The cost of gas is 4 p/kWh, therefore he annual operational cost would be £2,560. With the use of two ASHPs with 3.31 and 3.81 EER, the heating demand is reduced to 18,150 kWh. The cost of electricity is 12 p/kWh, therefore the annual operational cost would be £2,178.

Consequently, the dwelling would have an annual saving of £382 and the simple payback time for the proposed system is 0.1 years.

Summary Performance Calculations:

The following tables summarise the reduction in carbon emissions and the life cycle cost of the ASHP system.

Energy and Carbon Performance Criteria	Value
Predicted Annual Energy Saved (kWh/yr)	45,847
Annual Carbon Emissions Reductions (kg CO_2/yr)	4,314
% CO_2 Emissions Reduction	19.0

Cost Performance Criteria	Value
Total Extra Cost Over Life Cycle (£)	7,000
Predicted Annual Savings (£)	382
Payback Period (years)	18.3

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Conclusion
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Summary

The baseline carbon emissions for the scheme are 22.75 Tonnes CO_2/yr.

As demonstrated, the development will reduce carbon emissions by 29.1% from the fabric energy efficiency measures described in the "Be Lean" section, and will reduce total carbon emissions by 48.1% over Building Regulations with the further inclusion of low and zero carbon technologies.

GLA's Energy Hierarchy – Regulated Carbon Emissions

	Baseline:	Be Lean:	Be Clean:	Be Green:
CO_2 emissions (Tonnes CO_2/yr)	22.75	16.12	-	11.80
CO_2 emissions saving (Tonnes CO_2/yr)	-	6.63	-	4.31
Saving from each stage (%)	-	29.1	-	19.0
Total CO_2 emissions saving (Tonnes CO_2/yr)	10.94			
48.1% Total carbon emissions savings over Part L of the Building Regulations 2013 achieved				

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Further Information:	As required by the GLA, 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 SAP DER Worksheets Lean – DER from the Lean SAP DER Worksheets Clean – No Clean Scenario Green – DER from the Green SAP DER Worksheets

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Baseline Scenario

Appendix
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LEAN Scenario

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GREEN Scenario