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Planning Statement
Energy Modelling Report
6 Albert Terrace Mews

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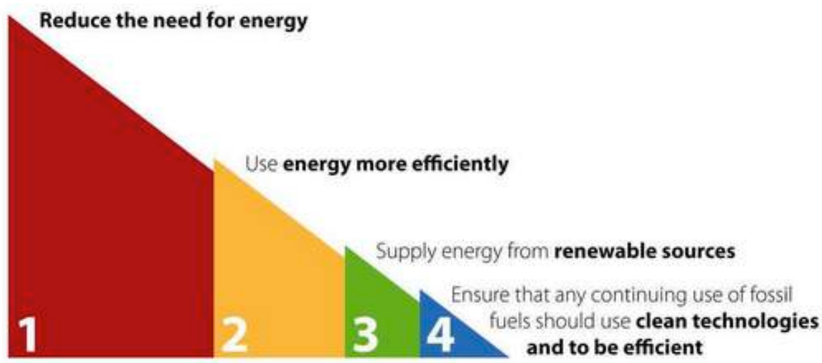
About the Scheme:	The scheme comprises the refurbishment of a residential dwelling, located in the London Borough of Camden, with a total gross internal area of approximately 143 m^2.
Planning Policy	In accordance with the Sustainable, Design and Construction SPG, the scheme is required to achieve a 19% 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 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.
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)	3.74	2.94	-	-
CO_2 emissions saving (Tonnes CO_2/yr)	-	0.80	-	-
Saving from each stage (%)	-	21.3	-	-
Total CO_2 emissions saving (Tonnes CO_2/yr)	0.80			

21.3% Total carbon emissions savings over Part L 1B of the Building Regulations 2013 achieved

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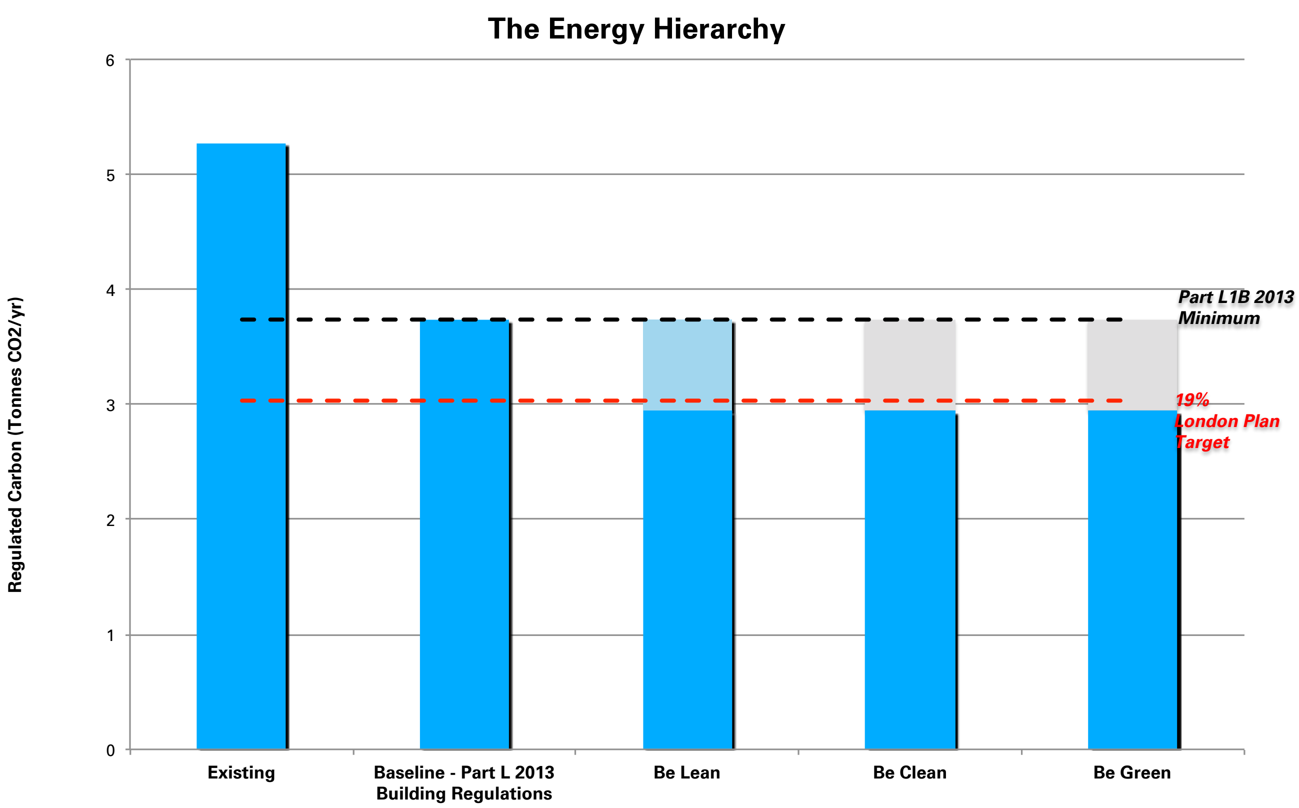
GLA's Energy Hierarchy – Regulated Carbon Emissions:

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

Site Layout Passive Design measures

The windows to façade area ratio is 15.7%.

Figure:



Summary:

As demonstrated above the development will reduce total carbon dioxide emissions by 21.3% from the fabric energy efficiency measures described in the 'Be Lean' section in comparison with the Baseline – Part L 2013 Building regulations, and will also reduce total carbon dioxide emissions by 44.3% in comparison with the existing building.

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Total Carbon Emissions:

Both regulated and unregulated emissions of the development should 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	3.74	1.39	5.13
Be Lean: After demand reduction	2.94	1.39	4.33
Be Clean: After CHP	-	-	-
Be Green: After Renewable energy	-	-	-

Introduction
Energy Modelling Report
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Aim of this study:

The purpose of this 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 2015)"

Under the GLA's guidance and the London Borough of Camden's policy document CPG3, applications for 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 and any active cooling would be electrically powered.

- 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.

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Establishing Emissions: The Carbon Profile

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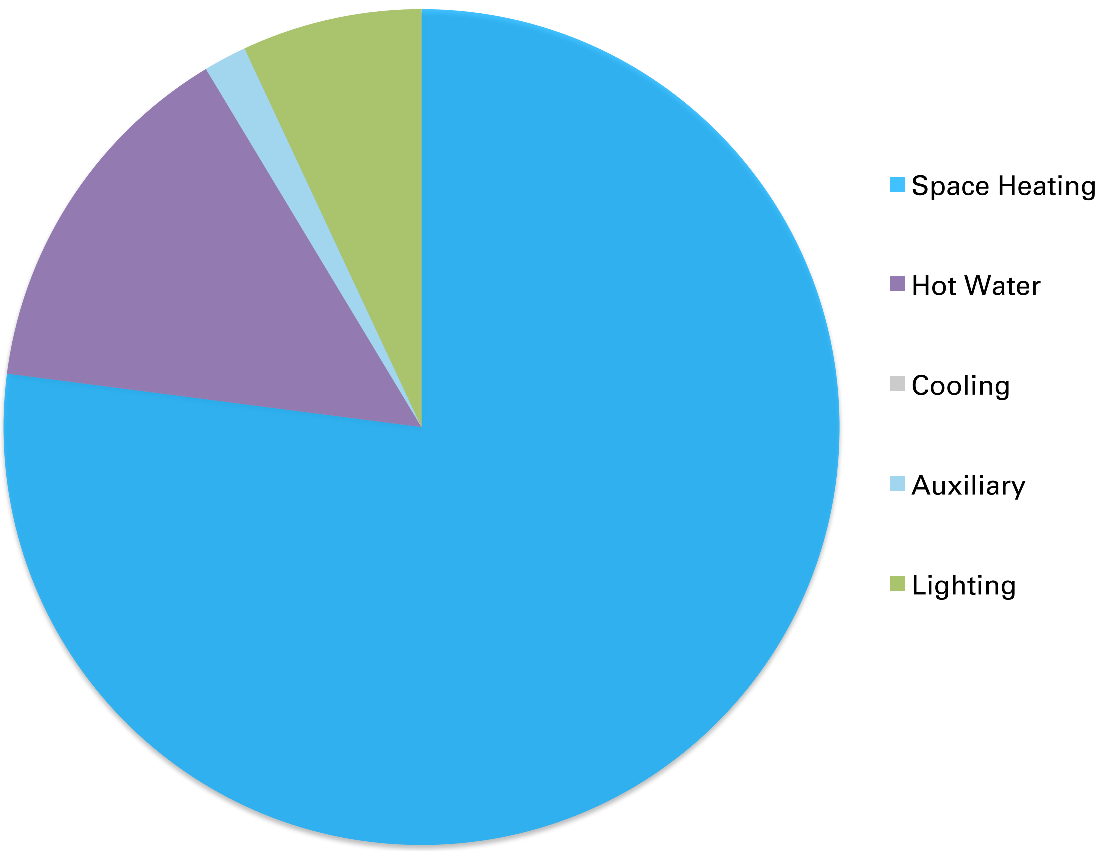
Building Regulations Part L 2013 Minimum Compliance:

The 'baseline' carbon emissions for the development are 3.74 Tonnes CO_2/yr.

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

Carbon Emissions in Tonnes CO_2/yr	Heating	Hot Water	Cooling	Auxiliary	Lighting
3.74	2.88	0.54	0.00	0.06	0.26

Baseline CO_2 Breakdown for residential areas



Overview:

The chart above shows that heating is the primary source of carbon emissions, and hot water is the second largest.

'Be Lean': Demand Reduction Measures

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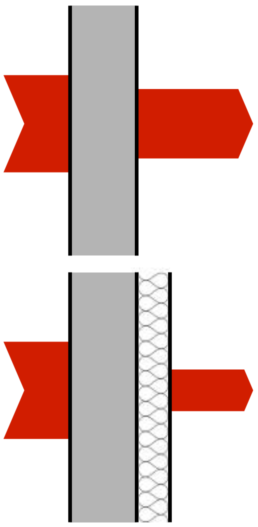
Be Lean - Summary:

Demand reduction measures have reduced the scheme's carbon emissions by 21.3% over the minimum Part L 2013 Building Regulations baseline.

Building Fabric
Passive Design measures:



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

U Values:

Element	Minimum Building Regulations U value W/m^{2}K	Proposed U value W/m^{2}K
Existing external wall	0.30	0.30
Existing external wall upgraded	0.30	0.18
Ground floor	0.25	0.25
Upgraded roof	0.18	0.12
Windows	1.60 (g-value 0.63)	1.60 (g-value 0.55)
Doors	1.80	1.60

Airtightness:

The target air permeability for the scheme has been modelled as 4m^3/(hr.m^2) @ 50 pa.

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 caused by poor perpends in blockwork inner leafs. 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 scheme has been indicatively modelled with the default thermal bridge y-values for all junction types, 0.15W/m^{2}K.

Thermal Mass:

Thermal mass of the scheme has been indicatively modelled as 250 kJ/m^{2}K (medium).

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'Be Lean': Demand Reduction Measures

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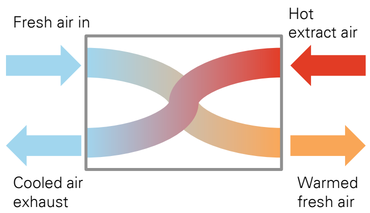
Energy Efficient Services
Active Design measures:



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 condensing combi boiler with automatic ignition, featuring time and temperature zone control and delayed thermostat. The heat will be distributed via radiators. The gas boiler will have a minimum efficiency of 89.5%.

Ventilation:
Balanced mechanical ventilation with heat recovery (89% efficiency) will be provided to the dwelling with a specific fan power of 0.61 W/l/s.

Air Conditioning:
No cooling system has been specified for the dwelling. Natural ventilation through openable windows will be used as a passive cooling measure.

Lighting:
High efficiency lighting has been specified for the development, with a luminous efficacy of more than 70 lumens/W.

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'Be Clean': Heating Infrastructure & CHP

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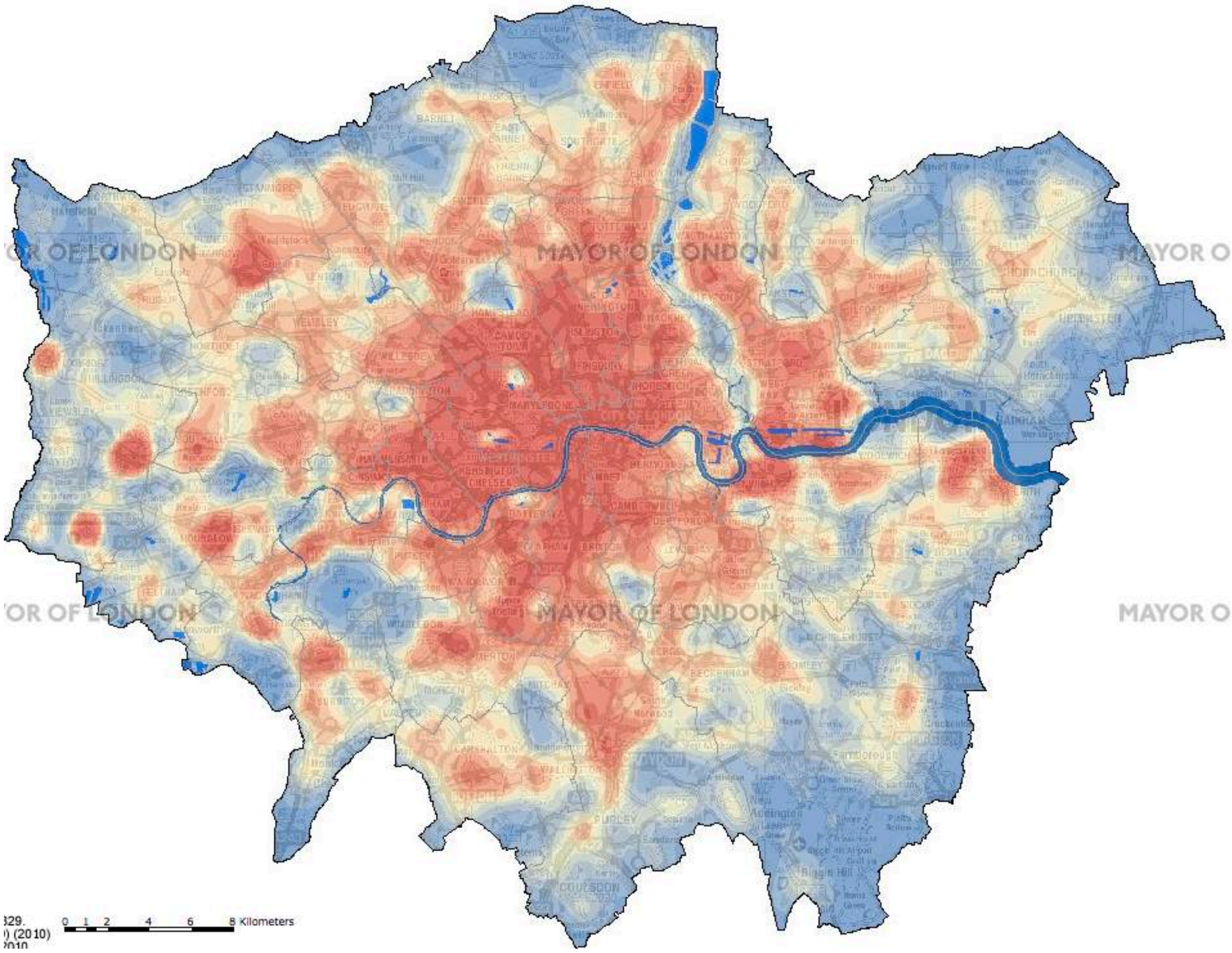
Heating Infrastructure including CHP:

Once demand for energy has been minimised, schemes should demonstrate how their energy systems have been selected. 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

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‘Be Clean’: Connection to Existing and Planned Networks

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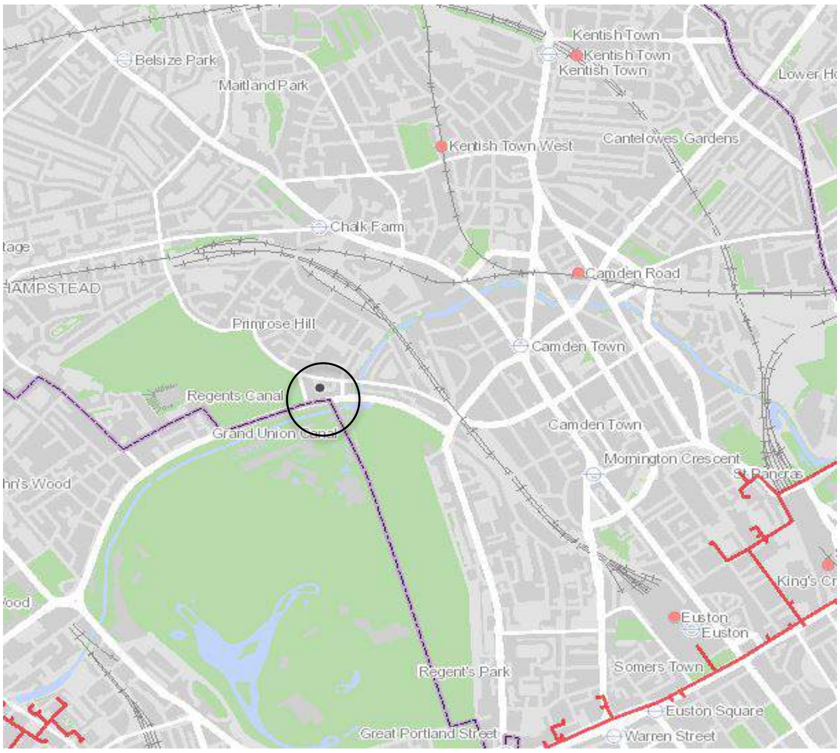
Existing and Planned Networks:

Existing DH Networks

Potential DH 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.



There are no existing DH networks within the vicinity of the scheme, therefore a connection is not possible.

'Be Clean': Site Wide Networks and CHP
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Site-wide Heat Networks:

A site wide network will not be adopted because the dwelling on site will not have adequate density 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.

‘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.

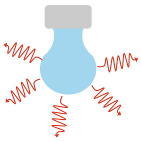
Where appropriate, the cooling strategy should investigate the opportunities to improve cooling efficiencies through the use of locally available sources such as ground cooling and river/dock water-cooling.

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.

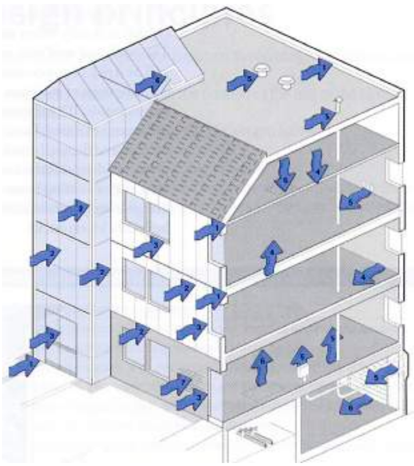
The following measures have been taken in accordance with the cooling hierarchy to reduce overheating and the need for cooling:

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, with higher values than 70 lumens/W.

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:

- Orientation of building – the scheme is orientated East/West, which will reduce excessive solar gain, and openable windows have been specified to facilitate natural ventilation.
- 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 0.55 have been specified.

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

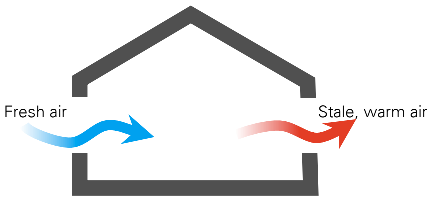
- Insulation levels have been maximised and the resulting u-values are lower than required by Building Regulations. The build-ups therefore prevent the penetration of heat as much as practically possible.
- A reduced air permeability rate of 3 $m^3/(hr.m^2)$ @ 50 pa has been targeted to minimise uncontrolled air infiltration. This will require attention to detailing and sealing.

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:

- 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 floor to ceiling heights of approximately 2.5m. As the roof will be well insulated to achieve a U-value of 0.12 W/m^2K, there will be minimal penetration of heat through the roof.

Avoiding Overheating
Measures taken:



Typical building section demonstrating passive cross ventilation.

- Green roofs – a green roof has been specified for the scheme. This will act as an insulation barrier and the ecological processes will reduce the amount of solar energy absorbed by the roof membrane, so will reduce temperatures below the surface and cool the building areas directly below.

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. 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.

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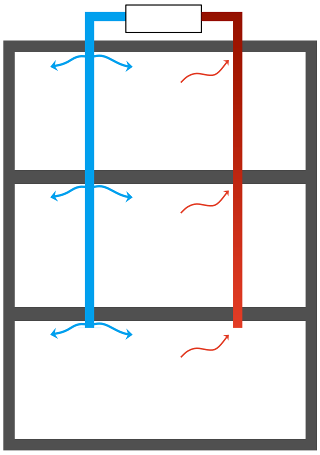
Avoiding Overheating Measures taken:



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

5) Mechanical ventilation

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

- Heat recovery units will also be specified to reduce energy demand, optimal performance will be achieved by the reduced air permeability rate of 3 $m^3/(hr.m^2)$ @ 50 pa.
- Mechanical systems will have the following efficiencies which are in compliance with the Domestic Building Services Compliance Guide:
  - ✓ Specific fan power of 0.61 W/l/s for whole ventilation systems with a heat recovery efficiency of 89%

Overheating Risk:

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

Dwelling	Overheating risk according to SAP
6 Albert Terrace Mews	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 Green’: Renewable Energy

Energy Modelling Report

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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
	✔✔✔✔	✔✔✔✔	✔✔✔✔✔	✔✔✔	✔✔✔✔✔ ✔✔✔✔✔

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'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 CO_2 emissions reduction a biomass boiler would need to be installed. The likely installed cost would be circa £10,000. 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.

'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.

Photovoltaic panels 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 18 m^2, however, the roof slopes towards Regent's Park Road to the north, and therefore it wouldn't be possible to install PV panels efficiently, facing south or west. Another fact to consider is the northern boundary of the property, which is marked by a row of large mature lime trees that effectively keeps the property in shade year round.

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 has concerns for part of the site, no noise issues.	✔✓✓✓ 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.

'Be Green': Renewable Energy

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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. The proposed site has a potential useable roof area of approximately 18 m^2, however, the roof slopes towards Regent's Park Road to the north, and therefore it wouldn't be possible to install PV panels efficiently, facing south or west. Another fact to consider is the northern boundary of the property, which is marked by a row of large mature lime trees that effectively keeps the property in shade year round.

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 has concerns for part of the site, no noise issues.	✔ 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.

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.

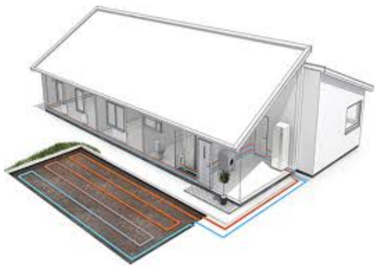
Typically a 1.5 kW turbine can provide 4,000 kWh of electrical power annually. To achieve the required CO_2 emissions reduction target approximately 1 turbine would be required as a standalone solution. The indicative cost of a smaller roof mounted turbine is £2,000/kW so achieving the required CO_2 emissions reduction would cost approximately £3,000.

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

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.

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.

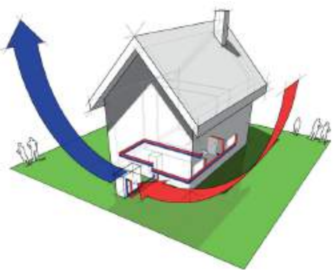
From the bores pre-insulated pipework is laid in the ground to the heat exchanger device. The system is filled with water and antifreeze. The cooled water is pumped around the loop / bore gathering energy as it circulates. The water that has been heated to 10-12°C is returned to the ground source heat 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 £20,000 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.	✔✔✓✓ 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.

Air Source Heat Pump (ASHP):

Rejected



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 £10,000 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	✔✔✔✔ (3 of 4) No local air quality impacts, use of unutilised roof space, conservation officer may have minor concerns over visual impact, no noise issues.	✔✔✔✔ (3 of 4) Can be added to the roof, good air-flow on roof, increased buildability issues for pipework and heating emitters internally.	✔✔✔✔✔ (2 of 5) Medium- high capital costs of installation, typical payback >15 years where gas is displaced, Renewable Heat Incentive available.	✔✔✔ (2 of 3) Limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✔✔✔✔✔✔✔✔✔✔ (6 of 10) 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

Energy Modelling Report

6 Albert Terrace Mews

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	✔✔✓✓	✔✓✓✓	✔✔✔✓✓	✔✔✓	✔✔✔✔✔ ✔✔✓✓✓	15 out of 26
Solar Thermal	✔✔✓✓	✔✓✓✓	✔✔✔✓✓	✔✔✔	✔✔✔✔✔ ✓✓✓✓✓	14 out of 26
Wind Energy	✔✓✓✓	✔✔✓✓	✔✔✔✔✓	✔✔✔	✔✔✔✔✔ ✔✔✓✓✓	17 out of 26
GSHP	✔✔✓✓	✔✔✓✓	✔✓✓✓✓	✔✔✓	✔✔✔✔✔ ✔✔✓✓✓	14 out of 26
ASHP	✔✔✔✓	✔✔✔✓	✔✔✓✓✓	✔✔✓	✔✔✔✔✔ ✔✓✓✓✓	16 out of 26

Renewable Technology Conclusion & Specification:

Air source heat pumps and wind energy have scored the best. It is assumed that wind energy would be considered unsuitable for the area by conservation criteria and that the local residents would raise concerns over potential noise and turbulence.

Due to the lack of space to place the air source heat pump within the dwelling, this option has been rejected. A ground source heat pump is the most suitable option for providing adequate space heating, although it would need to be supplemented by a gas boiler to achieve the required output. This, added to the fact that is an existing building, makes a GSHP economically less attractive and extends the normal payback period. Therefore, photovoltaic panels have been considered to be the optimum balance of sustainable and economic objectives.

However, the property is located within the Primrose Hill Conservation Area. It is a very prominent building at the junction of Albert Terrace Mews and Regent's Park Road. The dwelling is noted within the Conservation Area Statement as being an unlisted building that makes "a positive contribution to the special character and appearance of the area”. It is therefore considered a building of note where PV panels would be highly visible on the roof and therefore would not preserve the character of the conservation area. For this reason and the ones described in the photovoltaic section, PV panels have been considered unsuitable for the scheme.

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Conclusion

Energy Modelling Report

6 Albert Terrace Mews

Summary

The baseline carbon emissions for the scheme are 3.74 Tonnes CO_2/yr.

As demonstrated, the development will reduce carbon emissions by 21.3% from the fabric energy efficiency measures described in the "Be Lean" section. After studying the possibility of inclusion of low and zero carbon technologies, it has been decided that they are not deemed appropriate for this development.

GLA's Energy Hierarchy – Regulated Carbon Emissions				
	Baseline:	Be Lean:	Be Clean:	Be Green:
CO_2 emissions (Tonnes CO_2/yr)	3.74	2.94	-	-
CO_2 emissions saving (Tonnes CO_2/yr)	-	0.80	-	-
Saving from each stage (%)	-	21.3	-	-
Total CO_2 emissions saving (Tonnes CO_2/yr)	0.80			
21.3% Total carbon emissions savings over Part L 1B of the Building Regulations 2013 achieved				

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Appendix
Energy Modelling Report
6 Albert Terrace Mews

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

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Appendix
Energy Modelling Report
6 Albert Terrace Mews

Baseline Scenario

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:
Stroma Number:
Software Name: Stroma FSAP 2012
Software Version: Version: 1.0.4.10

Property Address: 6 Albert Terrace Mews Baseline

Address : , London, NW1 7TA

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	77.59	(1a) x	2.97	(2a) =	230.44	(3a)
First floor	65.04	(1b) x	2.45	(2b) =	159.35	(3b)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	142.63	(4)				
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =	389.79	(5)

2. Ventilation rate:

	main heating		secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							0	x 10 =	0	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

DRAFT

			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	0	÷ (5) =	0	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction		0	(11)

if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35

If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		15	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.75	(18)

Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used

Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.92	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.69	(21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7

Wind Factor (22a)m = (22)m ÷ 4

(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.88	0.87	0.85	0.76	0.75	0.66	0.66	0.64	0.69	0.75	0.78	0.82

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside

if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft

if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.89	0.88	0.86	0.79	0.78	0.72	0.72	0.71	0.74	0.78	0.8	0.83	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.89	0.88	0.86	0.79	0.78	0.72	0.72	0.71	0.74	0.78	0.8	0.83	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Doors Type 1			5.1	x	1.8	=	9.179999			(26)
Doors Type 2			2.78	x	1.8	=	5.004			(26)
Windows Type 1			5.17	x1/[1/(1.6)+ 0.04]		=	7.77			(27)
Windows Type 2			1.87	x1/[1/(1.6)+ 0.04]		=	2.81			(27)
Windows Type 3			2.4	x1/[1/(1.6)+ 0.04]		=	3.61			(27)
Windows Type 4			1.95	x1/[1/(1.6)+ 0.04]		=	2.93			(27)
Windows Type 5			5.63	x1/[1/(1.6)+ 0.04]		=	8.47			(27)
Windows Type 6			0.69	x1/[1/(1.6)+ 0.04]		=	1.04			(27)
Windows Type 7			0.47	x1/[1/(1.6)+ 0.04]		=	0.71			(27)
Windows Type 8			1.19	x1/[1/(1.6)+ 0.04]		=	1.79			(27)
Windows Type 9			0.95	x1/[1/(1.6)+ 0.04]		=	1.43			(27)
Floor			77.59	x	0.25	=	19.3975			(28)
Walls Type1	134.23	30.79	103.44	x	0.3	=	31.03			(29)
Walls Type2	3.24	0	3.24	x	0.3	=	0.97			(29)
Roof	76.93	0	76.93	x	0.18	=	13.85			(30)
Total area of elements, m²			291.99							(31)
Party wall			55.57	x	0	=	0			(32)

DER WorkSheet: New dwelling design stage

Party floor	65.04			(32a)
Party ceiling	65.7			(32b)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*
*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U)	(26) (30) + (32) =	113.88	(33)
Heat capacity Cm = S(A x k)	((28) (30) + (32) + (32a) (32e) =	30100.98	(34)
Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K	Indicative Value: Medium	250	(35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K		43.8	(36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss	(33) + (36) =	157.68	(37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	114.64	112.68	110.77	101.77	100.09	92.25	92.25	90.8	95.27	100.09	103.49	107.05	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	272.32	270.36	268.45	259.45	257.77	249.93	249.93	248.48	252.95	257.77	261.17	264.73	

Average = Sum(39)1…12 /12= 259.44 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.91	1.9	1.88	1.82	1.81	1.75	1.75	1.74	1.77	1.81	1.83	1.86	

Average = Sum(40)1…12 /12= 1.82 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N — 2.92 (42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)
if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 — 103.6 (43)
Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(44)m=	113.96	109.81	105.67	101.52	97.38	93.24	93.24	97.38	101.52	105.67	109.81	113.96

Total = Sum(44)1…12 = 1243.15 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	168.99	147.8	152.52	132.97	127.59	110.1	102.02	117.07	118.47	138.07	150.71	163.66

Total = Sum(45)1…12 = 1629.97 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	25.35	22.17	22.88	19.95	19.14	16.51	15.3	17.56	17.77	20.71	22.61	24.55	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel — 0 (47)

If community heating and no tank in dwelling, enter 110 litres in (47)
Otherwise if no stored hot water (this includes instantaneous combi boilers) enter ‘0’ in (47)
Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day):		0	(48)
Temperature factor from Table 2b		0	(49)
Energy lost from water storage, kWh/year	(48) x (49) =	0	(50)
b) If manufacturer's declared cylinder loss factor is not known:			
Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
If community heating see section 4.3			
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	(47) x (51) x (52) x (53) =	0	(54)
Enter (50) or (54) in (55)		0	(55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	0	0	0	0	0	0	0	0	0	0	0	0	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	0	0	0	0	0	0	0	0	0	0	0	0	(57)

Primary circuit loss (annual) from Table 3 — 0 — (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m

(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	50.96	46.03	50.96	49.32	49.62	45.98	47.51	49.62	49.32	50.96	49.32	50.96	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	219.95	193.83	203.48	182.28	177.21	156.08	149.53	166.7	167.79	189.02	200.02	214.62	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)

(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	219.95	193.83	203.48	182.28	177.21	156.08	149.53	166.7	167.79	189.02	200.02	214.62

Output from water heater (annual)$_{1 \ldots 12}$ — 2220.51 — (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	68.93	60.65	63.45	56.54	54.83	48.1	45.8	51.33	51.72	58.65	62.44	67.16	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

(67)m=	28.38	25.21	20.5	15.52	11.6	9.79	10.58	13.76	18.46	23.44	27.36	29.17	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	312.38	315.62	307.46	290.07	268.11	247.48	233.7	230.46	238.63	256.02	277.97	298.6	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

(69)m=	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	(69)

Pumps and fans gains (Table 5a)

(70)m=	0	0	0	0	0	0	0	0	0	0	0	0	(70)

DER WorkSheet: New dwelling design stage

Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	(71)

Water heating gains (Table 5)

(72)m=	92.65	90.25	85.29	78.53	73.69	66.81	61.56	69	71.83	78.83	86.72	90.26	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	500.24	497.92	480.07	450.94	420.24	390.92	372.67	380.04	395.75	425.12	458.88	484.86	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:		Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
North	0.9x	0.77	x	0.95	x	10.63	x	0.63	x	0.8	=	10.58	(74)
North	0.9x	0.77	x	0.95	x	20.32	x	0.63	x	0.8	=	20.23	(74)
North	0.9x	0.77	x	0.95	x	34.53	x	0.63	x	0.8	=	34.37	(74)
North	0.9x	0.77	x	0.95	x	55.46	x	0.63	x	0.8	=	55.21	(74)
North	0.9x	0.77	x	0.95	x	74.72	x	0.63	x	0.8	=	74.37	(74)
North	0.9x	0.77	x	0.95	x	79.99	x	0.63	x	0.8	=	79.62	(74)
North	0.9x	0.77	x	0.95	x	74.68	x	0.63	x	0.8	=	74.33	(74)
North	0.9x	0.77	x	0.95	x	59.25	x	0.63	x	0.8	=	58.98	(74)
North	0.9x	0.77	x	0.95	x	41.52	x	0.63	x	0.8	=	41.33	(74)
North	0.9x	0.77	x	0.95	x	24.19	x	0.63	x	0.8	=	24.08	(74)
North	0.9x	0.77	x	0.95	x	13.12	x	0.63	x	0.8	=	13.06	(74)
North	0.9x	0.77	x	0.95	x	8.86	x	0.63	x	0.8	=	8.82	(74)
East	0.9x	1	x	5.17	x	19.64	x	0.63	x	0.8	=	35.47	(76)
East	0.9x	1	x	1.87	x	19.64	x	0.63	x	0.8	=	12.83	(76)
East	0.9x	1	x	2.4	x	19.64	x	0.63	x	1	=	20.58	(76)
East	0.9x	1	x	5.17	x	38.42	x	0.63	x	0.8	=	69.38	(76)
East	0.9x	1	x	1.87	x	38.42	x	0.63	x	0.8	=	25.09	(76)
East	0.9x	1	x	2.4	x	38.42	x	0.63	x	1	=	40.26	(76)
East	0.9x	1	x	5.17	x	63.27	x	0.63	x	0.8	=	114.25	(76)
East	0.9x	1	x	1.87	x	63.27	x	0.63	x	0.8	=	41.33	(76)
East	0.9x	1	x	2.4	x	63.27	x	0.63	x	1	=	66.3	(76)
East	0.9x	1	x	5.17	x	92.28	x	0.63	x	0.8	=	166.63	(76)
East	0.9x	1	x	1.87	x	92.28	x	0.63	x	0.8	=	60.27	(76)
East	0.9x	1	x	2.4	x	92.28	x	0.63	x	1	=	96.69	(76)
East	0.9x	1	x	5.17	x	113.09	x	0.63	x	0.8	=	204.22	(76)
East	0.9x	1	x	1.87	x	113.09	x	0.63	x	0.8	=	73.87	(76)
East	0.9x	1	x	2.4	x	113.09	x	0.63	x	1	=	118.5	(76)
East	0.9x	1	x	5.17	x	115.77	x	0.63	x	0.8	=	209.05	(76)
East	0.9x	1	x	1.87	x	115.77	x	0.63	x	0.8	=	75.61	(76)
East	0.9x	1	x	2.4	x	115.77	x	0.63	x	1	=	121.31	(76)

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East	0.9x	1	x	5.17	x	110.22	x	0.63	x	0.8	=	199.03	(76)
East	0.9x	1	x	1.87	x	110.22	x	0.63	x	0.8	=	71.99	(76)
East	0.9x	1	x	2.4	x	110.22	x	0.63	x	1	=	115.49	(76)
East	0.9x	1	x	5.17	x	94.68	x	0.63	x	0.8	=	170.96	(76)
East	0.9x	1	x	1.87	x	94.68	x	0.63	x	0.8	=	61.84	(76)
East	0.9x	1	x	2.4	x	94.68	x	0.63	x	1	=	99.2	(76)
East	0.9x	1	x	5.17	x	73.59	x	0.63	x	0.8	=	132.88	(76)
East	0.9x	1	x	1.87	x	73.59	x	0.63	x	0.8	=	48.06	(76)
East	0.9x	1	x	2.4	x	73.59	x	0.63	x	1	=	77.11	(76)
East	0.9x	1	x	5.17	x	45.59	x	0.63	x	0.8	=	82.32	(76)
East	0.9x	1	x	1.87	x	45.59	x	0.63	x	0.8	=	29.78	(76)
East	0.9x	1	x	2.4	x	45.59	x	0.63	x	1	=	47.77	(76)
East	0.9x	1	x	5.17	x	24.49	x	0.63	x	0.8	=	44.22	(76)
East	0.9x	1	x	1.87	x	24.49	x	0.63	x	0.8	=	15.99	(76)
East	0.9x	1	x	2.4	x	24.49	x	0.63	x	1	=	25.66	(76)
East	0.9x	1	x	5.17	x	16.15	x	0.63	x	0.8	=	29.16	(76)
East	0.9x	1	x	1.87	x	16.15	x	0.63	x	0.8	=	10.55	(76)
East	0.9x	1	x	2.4	x	16.15	x	0.63	x	1	=	16.92	(76)
West	0.9x	0.77	x	1.95	x	19.64	x	0.63	x	0.5	=	8.36	(80)
West	0.9x	0.77	x	5.63	x	19.64	x	0.63	x	0.8	=	38.62	(80)
West	0.9x	0.77	x	0.69	x	19.64	x	0.63	x	0.8	=	9.47	(80)
West	0.9x	0.77	x	0.47	x	19.64	x	0.63	x	0.8	=	3.22	(80)
West	0.9x	0.77	x	1.19	x	19.64	x	0.63	x	0.8	=	8.16	(80)
West	0.9x	0.77	x	1.95	x	38.42	x	0.63	x	0.5	=	16.35	(80)
West	0.9x	0.77	x	5.63	x	38.42	x	0.63	x	0.8	=	75.55	(80)
West	0.9x	0.77	x	0.69	x	38.42	x	0.63	x	0.8	=	18.52	(80)
West	0.9x	0.77	x	0.47	x	38.42	x	0.63	x	0.8	=	6.31	(80)
West	0.9x	0.77	x	1.19	x	38.42	x	0.63	x	0.8	=	15.97	(80)
West	0.9x	0.77	x	1.95	x	63.27	x	0.63	x	0.5	=	26.93	(80)
West	0.9x	0.77	x	5.63	x	63.27	x	0.63	x	0.8	=	124.42	(80)
West	0.9x	0.77	x	0.69	x	63.27	x	0.63	x	0.8	=	30.5	(80)
West	0.9x	0.77	x	0.47	x	63.27	x	0.63	x	0.8	=	10.39	(80)
West	0.9x	0.77	x	1.19	x	63.27	x	0.63	x	0.8	=	26.3	(80)
West	0.9x	0.77	x	1.95	x	92.28	x	0.63	x	0.5	=	39.28	(80)
West	0.9x	0.77	x	5.63	x	92.28	x	0.63	x	0.8	=	181.46	(80)
West	0.9x	0.77	x	0.69	x	92.28	x	0.63	x	0.8	=	44.48	(80)
West	0.9x	0.77	x	0.47	x	92.28	x	0.63	x	0.8	=	15.15	(80)
West	0.9x	0.77	x	1.19	x	92.28	x	0.63	x	0.8	=	38.35	(80)
West	0.9x	0.77	x	1.95	x	113.09	x	0.63	x	0.5	=	48.14	(80)
West	0.9x	0.77	x	5.63	x	113.09	x	0.63	x	0.8	=	222.39	(80)
West	0.9x	0.77	x	0.69	x	113.09	x	0.63	x	0.8	=	54.51	(80)

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West	0.9x	0.77	x	0.47	x	113.09	x	0.63	x	0.8	=	18.57	(80)
West	0.9x	0.77	x	1.19	x	113.09	x	0.63	x	0.8	=	47.01	(80)
West	0.9x	0.77	x	1.95	x	115.77	x	0.63	x	0.5	=	49.28	(80)
West	0.9x	0.77	x	5.63	x	115.77	x	0.63	x	0.8	=	227.65	(80)
West	0.9x	0.77	x	0.69	x	115.77	x	0.63	x	0.8	=	55.8	(80)
West	0.9x	0.77	x	0.47	x	115.77	x	0.63	x	0.8	=	19	(80)
West	0.9x	0.77	x	1.19	x	115.77	x	0.63	x	0.8	=	48.12	(80)
West	0.9x	0.77	x	1.95	x	110.22	x	0.63	x	0.5	=	46.92	(80)
West	0.9x	0.77	x	5.63	x	110.22	x	0.63	x	0.8	=	216.73	(80)
West	0.9x	0.77	x	0.69	x	110.22	x	0.63	x	0.8	=	53.12	(80)
West	0.9x	0.77	x	0.47	x	110.22	x	0.63	x	0.8	=	18.09	(80)
West	0.9x	0.77	x	1.19	x	110.22	x	0.63	x	0.8	=	45.81	(80)
West	0.9x	0.77	x	1.95	x	94.68	x	0.63	x	0.5	=	40.3	(80)
West	0.9x	0.77	x	5.63	x	94.68	x	0.63	x	0.8	=	186.17	(80)
West	0.9x	0.77	x	0.69	x	94.68	x	0.63	x	0.8	=	45.63	(80)
West	0.9x	0.77	x	0.47	x	94.68	x	0.63	x	0.8	=	15.54	(80)
West	0.9x	0.77	x	1.19	x	94.68	x	0.63	x	0.8	=	39.35	(80)
West	0.9x	0.77	x	1.95	x	73.59	x	0.63	x	0.5	=	31.33	(80)
West	0.9x	0.77	x	5.63	x	73.59	x	0.63	x	0.8	=	144.71	(80)
West	0.9x	0.77	x	0.69	x	73.59	x	0.63	x	0.8	=	35.47	(80)
West	0.9x	0.77	x	0.47	x	73.59	x	0.63	x	0.8	=	12.08	(80)
West	0.9x	0.77	x	1.19	x	73.59	x	0.63	x	0.8	=	30.59	(80)
West	0.9x	0.77	x	1.95	x	45.59	x	0.63	x	0.5	=	19.41	(80)
West	0.9x	0.77	x	5.63	x	45.59	x	0.63	x	0.8	=	89.65	(80)
West	0.9x	0.77	x	0.69	x	45.59	x	0.63	x	0.8	=	21.97	(80)
West	0.9x	0.77	x	0.47	x	45.59	x	0.63	x	0.8	=	7.48	(80)
West	0.9x	0.77	x	1.19	x	45.59	x	0.63	x	0.8	=	18.95	(80)
West	0.9x	0.77	x	1.95	x	24.49	x	0.63	x	0.5	=	10.42	(80)
West	0.9x	0.77	x	5.63	x	24.49	x	0.63	x	0.8	=	48.16	(80)
West	0.9x	0.77	x	0.69	x	24.49	x	0.63	x	0.8	=	11.8	(80)
West	0.9x	0.77	x	0.47	x	24.49	x	0.63	x	0.8	=	4.02	(80)
West	0.9x	0.77	x	1.19	x	24.49	x	0.63	x	0.8	=	10.18	(80)
West	0.9x	0.77	x	1.95	x	16.15	x	0.63	x	0.5	=	6.88	(80)
West	0.9x	0.77	x	5.63	x	16.15	x	0.63	x	0.8	=	31.76	(80)
West	0.9x	0.77	x	0.69	x	16.15	x	0.63	x	0.8	=	7.78	(80)
West	0.9x	0.77	x	0.47	x	16.15	x	0.63	x	0.8	=	2.65	(80)
West	0.9x	0.77	x	1.19	x	16.15	x	0.63	x	0.8	=	6.71	(80)

Solar gains in watts, calculated for each month (83)m = Sum(74)m … (82)m

(83)m=	147.29	287.66	474.79	697.53	861.56	885.45	841.52	717.97	553.55	341.4	183.52	121.25	(83)

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	647.53	785.57	954.86	1148.48	1281.8	1276.36	1214.19	1098.01	949.3	766.52	642.4	606.11	(84)

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7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) | 21 | (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	1	1	0.99	0.98	0.95	0.86	0.74	0.8	0.95	0.99	1	1	(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	18.74	18.93	19.29	19.82	20.3	20.7	20.88	20.84	20.5	19.87	19.25	18.76	(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.39	19.4	19.41	19.46	19.46	19.5	19.5	19.51	19.49	19.46	19.45	19.43	(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	1	1	0.99	0.97	0.92	0.77	0.56	0.63	0.9	0.99	1	1	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	16.46	16.74	17.27	18.06	18.75	19.29	19.46	19.44	19.05	18.15	17.23	16.5	(90)

fLA = Living area ÷ (4) = | 0.46 | (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	17.52	17.75	18.2	18.87	19.47	19.94	20.12	20.09	19.72	18.94	18.16	17.55	(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	17.37	17.6	18.05	18.72	19.32	19.79	19.97	19.94	19.57	18.79	18.01	17.4	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, hm:													
(94)m=	1	1	0.99	0.97	0.91	0.79	0.62	0.69	0.9	0.98	1	1	(94)
Useful gains, hmGm , W = (94)m x (84)m													
(95)m=	645.98	781.79	943.58	1110.08	1168.18	1009.83	758.62	758.86	856.42	753.18	639.8	605.01	(95)
Monthly average external temperature from Table 8													
(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2	(96)
Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]													
(97)m=	3557.85	3434.16	3101.37	2548.95	1963.94	1298.19	841.84	879.54	1383.14	2112.15	2850.33	3493.22	(97)
Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m													
(98)m=	2166.43	1782.39	1605.4	1035.99	592.05	0	0	0	0	1011.08	1591.58	2148.83	

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = | 11933.74 | (98)

Space heating requirement in kWh/m²/year | 83.67 | (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system		0	(201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1	(202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1	(204)
Efficiency of main space heating system 1		89.5	(206)
Efficiency of secondary/supplementary heating system, %		0	(208)

DER WorkSheet: New dwelling design stage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year	
Space heating requirement (calculated above)														
	2166.43	1782.39	1605.4	1035.99	592.05	0	0	0	0	1011.08	1591.58	2148.83		
(211)m = {[(98)m x (204)] } x 100 ÷ (206)														(211)
	2420.59	1991.5	1793.74	1157.53	661.5	0	0	0	0	1129.69	1778.3	2400.92		
Total (kWh/year) =Sum(211)1...5,10...12 =													13333.79	(211)
Space heating fuel (secondary), kWh/month = {[(98)m x (201)] } x 100 ÷ (208)														
(215)m=	0	0	0	0	0	0	0	0	0	0	0	0		
Total (kWh/year) =Sum(215)1...5,10...12 =													0	(215)

Water heating

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year	
Output from water heater (calculated above)	219.95	193.83	203.48	182.28	177.21	156.08	149.53	166.7	167.79	189.02	200.02	214.62		
Efficiency of water heater													89.5	(216)
(217)m=	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5		(217)
Fuel for water heating, kWh/month (219)m = (64)m x 100 ÷ (217)m														
(219)m=	245.76	216.57	227.35	203.67	198	174.39	167.08	186.25	187.47	211.2	223.49	239.8		
Total = Sum(219a)1...12 =													2481.02	(219)

Annual totals		**kWh/year**	**kWh/year**	
Space heating fuel used, main system 1			13333.79	
Water heating fuel used			2481.02	
Electricity for pumps, fans and electric keep-hot				
central heating pump:		120		(230c)
Total electricity for the above, kWh/year	sum of (230a)...(230g) =		120	(231)
Electricity for lighting			501.24	(232)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year	**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x	0.216	=	2880.1	(261)
Space heating (secondary)	(215) x	0.519	=	0	(263)
Water heating	(219) x	0.216	=	535.9	(264)
Space and water heating	(261) + (262) + (263) + (264) =			3416	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.519	=	62.28	(267)
Electricity for lighting	(232) x	0.519	=	260.14	(268)
Total CO2, kg/year		sum of (265)...(271) =		3738.42	(272)
Dwelling CO2 Emission Rate		(272) ÷ (4) =		26.21	(273)
EI rating (section 14)				73	(274)

Appendix
Energy Modelling Report
6 Albert Terrace Mews

LEAN Scenario

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name: **Stroma Number:**

Software Name: Stroma FSAP 2012 **Software Version:** Version: 1.0.4.10

Property Address: 6 Albert Terrace Mews Lean

Address : , London, NW1 7TA

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	77.59	(1a) x	2.97	(2a) =	230.44	(3a)
First floor	65.04	(1b) x	2.45	(2b) =	159.35	(3b)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	142.63	(4)				
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =	389.79	(5)

2. Ventilation rate:

	main heating		secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							0	x 10 =	0	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	0	÷ (5) =	0	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction		0	(11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35			
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		4	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.2	(18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used			
Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.92	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.19	(21)

Infiltration rate modified for monthly wind speed

Monthly average wind speed from Table 7

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7

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Wind Factor (22a)m = (22)m ÷ 4

(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.24	0.23	0.23	0.2	0.2	0.18	0.18	0.17	0.19	0.2	0.21	0.22

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0.5 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0.5 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 75.65 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0.36	0.35	0.35	0.33	0.32	0.3	0.3	0.29	0.31	0.32	0.33	0.34	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside

if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft

if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.36	0.35	0.35	0.33	0.32	0.3	0.3	0.29	0.31	0.32	0.33	0.34	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Doors Type 1			5.1	x	1.6	=	8.16			(26)
Doors Type 2			2.78	x	1.6	=	4.448			(26)
Windows Type 1			5.17	x1/[1/(1.6)+ 0.04]		=	7.77			(27)
Windows Type 2			1.87	x1/[1/(1.6)+ 0.04]		=	2.81			(27)
Windows Type 3			2.4	x1/[1/(1.6)+ 0.04]		=	3.61			(27)
Windows Type 4			1.95	x1/[1/(1.6)+ 0.04]		=	2.93			(27)
Windows Type 5			5.63	x1/[1/(1.6)+ 0.04]		=	8.47			(27)
Windows Type 6			0.69	x1/[1/(1.6)+ 0.04]		=	1.04			(27)
Windows Type 7			0.47	x1/[1/(1.6)+ 0.04]		=	0.71			(27)
Windows Type 8			1.19	x1/[1/(1.6)+ 0.04]		=	1.79			(27)
Windows Type 9			0.95	x1/[1/(1.6)+ 0.04]		=	1.43			(27)
Floor			77.59	x	0.25	=	19.3975			(28)
Walls Type1	134.23	30.79	103.44	x	0.18	=	18.62			(29)
Walls Type2	3.24	0	3.24	x	0.3	=	0.97			(29)
Roof	76.93	0	76.93	x	0.12	=	9.23			(30)
Total area of elements, m²			291.99							(31)
Party wall			55.57	x	0	=	0			(32)

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Party floor	65.04				(32a)
Party ceiling	65.7				(32b)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*
*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U)	(26) (30) + (32) =	95.28	(33)
Heat capacity Cm = S(A x k)	((28) (30) + (32) + (32a) (32e) =	30100.98	(34)
Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K	Indicative Value: Medium	250	(35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K		43.8	(36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss	(33) + (36) =	139.08	(37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	46	45.41	44.81	41.84	41.24	38.27	38.27	37.67	39.46	41.24	42.43	43.62	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	185.08	184.48	183.89	180.92	180.32	177.35	177.35	176.75	178.54	180.32	181.51	182.7	

Average = Sum(39)1…12 /12= 180.77 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.3	1.29	1.29	1.27	1.26	1.24	1.24	1.24	1.25	1.26	1.27	1.28	

Average = Sum(40)1…12 /12= 1.27 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 2.92 (42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)
if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 103.6 (43)
Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)													
(44)m=	113.96	109.81	105.67	101.52	97.38	93.24	93.24	97.38	101.52	105.67	109.81	113.96	

Total = Sum(44)1…12 = 1243.15 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	168.99	147.8	152.52	132.97	127.59	110.1	102.02	117.07	118.47	138.07	150.71	163.66	

Total = Sum(45)1…12 = 1629.97 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	25.35	22.17	22.88	19.95	19.14	16.51	15.3	17.56	17.77	20.71	22.61	24.55	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 0 (47)

If community heating and no tank in dwelling, enter 110 litres in (47)
Otherwise if no stored hot water (this includes instantaneous combi boilers) enter ‘0’ in (47)
Water storage loss:

DER WorkSheet: New dwelling design stage

a) If manufacturer's declared loss factor is known (kWh/day):		0	(48)
Temperature factor from Table 2b		0	(49)
Energy lost from water storage, kWh/year	(48) x (49) =	0	(50)
b) If manufacturer's declared cylinder loss factor is not known:			
Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
If community heating see section 4.3			
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	(47) x (51) x (52) x (53) =	0	(54)
Enter (50) or (54) in (55)		0	(55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	0	0	0	0	0	0	0	0	0	0	0	0	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	0	0	0	0	0	0	0	0	0	0	0	0	(57)

Primary circuit loss (annual) from Table 3 — 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m

(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	50.96	46.03	50.96	49.32	49.62	45.98	47.51	49.62	49.32	50.96	49.32	50.96	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	219.95	193.83	203.48	182.28	177.21	156.08	149.53	166.7	167.79	189.02	200.02	214.62	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)

(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	219.95	193.83	203.48	182.28	177.21	156.08	149.53	166.7	167.79	189.02	200.02	214.62

Output from water heater (annual)1 12 — 2220.51 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	68.93	60.65	63.45	56.54	54.83	48.1	45.8	51.33	51.72	58.65	62.44	67.16	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	146.1	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

(67)m=	28.38	25.21	20.5	15.52	11.6	9.79	10.58	13.76	18.46	23.44	27.36	29.17	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	312.38	315.62	307.46	290.07	268.11	247.48	233.7	230.46	238.63	256.02	277.97	298.6	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

(69)m=	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	37.61	(69)

Pumps and fans gains (Table 5a)

(70)m=	0	0	0	0	0	0	0	0	0	0	0	0	(70)

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Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	-116.88	(71)

Water heating gains (Table 5)

(72)m=	92.65	90.25	85.29	78.53	73.69	66.81	61.56	69	71.83	78.83	86.72	90.26	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	500.24	497.92	480.07	450.94	420.24	390.92	372.67	380.04	395.75	425.12	458.88	484.86	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:		Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
North	0.9x	0.77	x	0.95	x	10.63	x	0.55	x	0.8	=	9.24	(74)
North	0.9x	0.77	x	0.95	x	20.32	x	0.55	x	0.8	=	17.66	(74)
North	0.9x	0.77	x	0.95	x	34.53	x	0.55	x	0.8	=	30.01	(74)
North	0.9x	0.77	x	0.95	x	55.46	x	0.55	x	0.8	=	48.2	(74)
North	0.9x	0.77	x	0.95	x	74.72	x	0.55	x	0.8	=	64.93	(74)
North	0.9x	0.77	x	0.95	x	79.99	x	0.55	x	0.8	=	69.51	(74)
North	0.9x	0.77	x	0.95	x	74.68	x	0.55	x	0.8	=	64.9	(74)
North	0.9x	0.77	x	0.95	x	59.25	x	0.55	x	0.8	=	51.49	(74)
North	0.9x	0.77	x	0.95	x	41.52	x	0.55	x	0.8	=	36.08	(74)
North	0.9x	0.77	x	0.95	x	24.19	x	0.55	x	0.8	=	21.02	(74)
North	0.9x	0.77	x	0.95	x	13.12	x	0.55	x	0.8	=	11.4	(74)
North	0.9x	0.77	x	0.95	x	8.86	x	0.55	x	0.8	=	7.7	(74)
East	0.9x	1	x	5.17	x	19.64	x	0.55	x	0.8	=	30.96	(76)
East	0.9x	1	x	1.87	x	19.64	x	0.55	x	0.8	=	11.2	(76)
East	0.9x	1	x	2.4	x	19.64	x	0.55	x	1	=	17.97	(76)
East	0.9x	1	x	5.17	x	38.42	x	0.55	x	0.8	=	60.57	(76)
East	0.9x	1	x	1.87	x	38.42	x	0.55	x	0.8	=	21.91	(76)
East	0.9x	1	x	2.4	x	38.42	x	0.55	x	1	=	35.15	(76)
East	0.9x	1	x	5.17	x	63.27	x	0.55	x	0.8	=	99.75	(76)
East	0.9x	1	x	1.87	x	63.27	x	0.55	x	0.8	=	36.08	(76)
East	0.9x	1	x	2.4	x	63.27	x	0.55	x	1	=	57.88	(76)
East	0.9x	1	x	5.17	x	92.28	x	0.55	x	0.8	=	145.47	(76)
East	0.9x	1	x	1.87	x	92.28	x	0.55	x	0.8	=	52.62	(76)
East	0.9x	1	x	2.4	x	92.28	x	0.55	x	1	=	84.41	(76)
East	0.9x	1	x	5.17	x	113.09	x	0.55	x	0.8	=	178.28	(76)
East	0.9x	1	x	1.87	x	113.09	x	0.55	x	0.8	=	64.49	(76)
East	0.9x	1	x	2.4	x	113.09	x	0.55	x	1	=	103.45	(76)
East	0.9x	1	x	5.17	x	115.77	x	0.55	x	0.8	=	182.5	(76)
East	0.9x	1	x	1.87	x	115.77	x	0.55	x	0.8	=	66.01	(76)
East	0.9x	1	x	2.4	x	115.77	x	0.55	x	1	=	105.9	(76)

East	0.9x	1	x	5.17	x	110.22	x	0.55	x	0.8	=	173.75	(76)
East	0.9x	1	x	1.87	x	110.22	x	0.55	x	0.8	=	62.85	(76)
East	0.9x	1	x	2.4	x	110.22	x	0.55	x	1	=	100.82	(76)
East	0.9x	1	x	5.17	x	94.68	x	0.55	x	0.8	=	149.25	(76)
East	0.9x	1	x	1.87	x	94.68	x	0.55	x	0.8	=	53.98	(76)
East	0.9x	1	x	2.4	x	94.68	x	0.55	x	1	=	86.61	(76)
East	0.9x	1	x	5.17	x	73.59	x	0.55	x	0.8	=	116.01	(76)
East	0.9x	1	x	1.87	x	73.59	x	0.55	x	0.8	=	41.96	(76)
East	0.9x	1	x	2.4	x	73.59	x	0.55	x	1	=	67.32	(76)
East	0.9x	1	x	5.17	x	45.59	x	0.55	x	0.8	=	71.87	(76)
East	0.9x	1	x	1.87	x	45.59	x	0.55	x	0.8	=	25.99	(76)
East	0.9x	1	x	2.4	x	45.59	x	0.55	x	1	=	41.7	(76)
East	0.9x	1	x	5.17	x	24.49	x	0.55	x	0.8	=	38.61	(76)
East	0.9x	1	x	1.87	x	24.49	x	0.55	x	0.8	=	13.96	(76)
East	0.9x	1	x	2.4	x	24.49	x	0.55	x	1	=	22.4	(76)
East	0.9x	1	x	5.17	x	16.15	x	0.55	x	0.8	=	25.46	(76)
East	0.9x	1	x	1.87	x	16.15	x	0.55	x	0.8	=	9.21	(76)
East	0.9x	1	x	2.4	x	16.15	x	0.55	x	1	=	14.77	(76)
West	0.9x	0.77	x	1.95	x	19.64	x	0.55	x	0.5	=	7.3	(80)
West	0.9x	0.77	x	5.63	x	19.64	x	0.55	x	0.8	=	33.72	(80)
West	0.9x	0.77	x	0.69	x	19.64	x	0.55	x	0.8	=	8.26	(80)
West	0.9x	0.77	x	0.47	x	19.64	x	0.55	x	0.8	=	2.81	(80)
West	0.9x	0.77	x	1.19	x	19.64	x	0.55	x	0.8	=	7.13	(80)
West	0.9x	0.77	x	1.95	x	38.42	x	0.55	x	0.5	=	14.28	(80)
West	0.9x	0.77	x	5.63	x	38.42	x	0.55	x	0.8	=	65.96	(80)
West	0.9x	0.77	x	0.69	x	38.42	x	0.55	x	0.8	=	16.17	(80)
West	0.9x	0.77	x	0.47	x	38.42	x	0.55	x	0.8	=	5.51	(80)
West	0.9x	0.77	x	1.19	x	38.42	x	0.55	x	0.8	=	13.94	(80)
West	0.9x	0.77	x	1.95	x	63.27	x	0.55	x	0.5	=	23.51	(80)
West	0.9x	0.77	x	5.63	x	63.27	x	0.55	x	0.8	=	108.62	(80)
West	0.9x	0.77	x	0.69	x	63.27	x	0.55	x	0.8	=	26.62	(80)
West	0.9x	0.77	x	0.47	x	63.27	x	0.55	x	0.8	=	9.07	(80)
West	0.9x	0.77	x	1.19	x	63.27	x	0.55	x	0.8	=	22.96	(80)
West	0.9x	0.77	x	1.95	x	92.28	x	0.55	x	0.5	=	34.29	(80)
West	0.9x	0.77	x	5.63	x	92.28	x	0.55	x	0.8	=	158.42	(80)
West	0.9x	0.77	x	0.69	x	92.28	x	0.55	x	0.8	=	38.83	(80)
West	0.9x	0.77	x	0.47	x	92.28	x	0.55	x	0.8	=	13.22	(80)
West	0.9x	0.77	x	1.19	x	92.28	x	0.55	x	0.8	=	33.48	(80)
West	0.9x	0.77	x	1.95	x	113.09	x	0.55	x	0.5	=	42.03	(80)
West	0.9x	0.77	x	5.63	x	113.09	x	0.55	x	0.8	=	194.15	(80)
West	0.9x	0.77	x	0.69	x	113.09	x	0.55	x	0.8	=	47.59	(80)

West	0.9x	0.77	x	0.47	x	113.09	x	0.55	x	0.8	=	16.21	(80)
West	0.9x	0.77	x	1.19	x	113.09	x	0.55	x	0.8	=	41.04	(80)
West	0.9x	0.77	x	1.95	x	115.77	x	0.55	x	0.5	=	43.02	(80)
West	0.9x	0.77	x	5.63	x	115.77	x	0.55	x	0.8	=	198.74	(80)
West	0.9x	0.77	x	0.69	x	115.77	x	0.55	x	0.8	=	48.72	(80)
West	0.9x	0.77	x	0.47	x	115.77	x	0.55	x	0.8	=	16.59	(80)
West	0.9x	0.77	x	1.19	x	115.77	x	0.55	x	0.8	=	42.01	(80)
West	0.9x	0.77	x	1.95	x	110.22	x	0.55	x	0.5	=	40.96	(80)
West	0.9x	0.77	x	5.63	x	110.22	x	0.55	x	0.8	=	189.21	(80)
West	0.9x	0.77	x	0.69	x	110.22	x	0.55	x	0.8	=	46.38	(80)
West	0.9x	0.77	x	0.47	x	110.22	x	0.55	x	0.8	=	15.8	(80)
West	0.9x	0.77	x	1.19	x	110.22	x	0.55	x	0.8	=	39.99	(80)
West	0.9x	0.77	x	1.95	x	94.68	x	0.55	x	0.5	=	35.18	(80)
West	0.9x	0.77	x	5.63	x	94.68	x	0.55	x	0.8	=	162.53	(80)
West	0.9x	0.77	x	0.69	x	94.68	x	0.55	x	0.8	=	39.84	(80)
West	0.9x	0.77	x	0.47	x	94.68	x	0.55	x	0.8	=	13.57	(80)
West	0.9x	0.77	x	1.19	x	94.68	x	0.55	x	0.8	=	34.35	(80)
West	0.9x	0.77	x	1.95	x	73.59	x	0.55	x	0.5	=	27.35	(80)
West	0.9x	0.77	x	5.63	x	73.59	x	0.55	x	0.8	=	126.33	(80)
West	0.9x	0.77	x	0.69	x	73.59	x	0.55	x	0.8	=	30.97	(80)
West	0.9x	0.77	x	0.47	x	73.59	x	0.55	x	0.8	=	10.55	(80)
West	0.9x	0.77	x	1.19	x	73.59	x	0.55	x	0.8	=	26.7	(80)
West	0.9x	0.77	x	1.95	x	45.59	x	0.55	x	0.5	=	16.94	(80)
West	0.9x	0.77	x	5.63	x	45.59	x	0.55	x	0.8	=	78.26	(80)
West	0.9x	0.77	x	0.69	x	45.59	x	0.55	x	0.8	=	19.18	(80)
West	0.9x	0.77	x	0.47	x	45.59	x	0.55	x	0.8	=	6.53	(80)
West	0.9x	0.77	x	1.19	x	45.59	x	0.55	x	0.8	=	16.54	(80)
West	0.9x	0.77	x	1.95	x	24.49	x	0.55	x	0.5	=	9.1	(80)
West	0.9x	0.77	x	5.63	x	24.49	x	0.55	x	0.8	=	42.04	(80)
West	0.9x	0.77	x	0.69	x	24.49	x	0.55	x	0.8	=	10.3	(80)
West	0.9x	0.77	x	0.47	x	24.49	x	0.55	x	0.8	=	3.51	(80)
West	0.9x	0.77	x	1.19	x	24.49	x	0.55	x	0.8	=	8.89	(80)
West	0.9x	0.77	x	1.95	x	16.15	x	0.55	x	0.5	=	6	(80)
West	0.9x	0.77	x	5.63	x	16.15	x	0.55	x	0.8	=	27.73	(80)
West	0.9x	0.77	x	0.69	x	16.15	x	0.55	x	0.8	=	6.8	(80)
West	0.9x	0.77	x	0.47	x	16.15	x	0.55	x	0.8	=	2.31	(80)
West	0.9x	0.77	x	1.19	x	16.15	x	0.55	x	0.8	=	5.86	(80)

Solar gains in watts, calculated for each month (83)m = Sum(74)m … (82)m

(83)m=	128.59	251.13	414.5	608.96	752.16	773.01	734.66	626.8	483.26	298.05	160.21	105.85	(83)

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	628.83	749.05	894.57	1059.9	1172.4	1163.92	1107.33	1006.84	879.01	723.17	619.09	590.71	(84)

DER WorkSheet: New dwelling design stage

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) — 21 (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	1	1	1	0.98	0.93	0.81	0.66	0.73	0.93	0.99	1	1	(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.42	19.57	19.86	20.26	20.63	20.88	20.97	20.95	20.73	20.25	19.77	19.41	(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.84	19.85	19.85	19.87	19.87	19.89	19.89	19.89	19.88	19.87	19.86	19.86	(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	1	1	0.99	0.97	0.9	0.73	0.51	0.59	0.88	0.99	1	1	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	17.73	17.96	18.38	18.97	19.48	19.8	19.87	19.87	19.64	18.97	18.26	17.72	(90)

fLA = Living area ÷ (4) = 0.46 (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	18.51	18.7	19.06	19.56	20.01	20.3	20.38	20.37	20.14	19.56	18.96	18.5	(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	18.36	18.55	18.91	19.41	19.86	20.15	20.23	20.22	19.99	19.41	18.81	18.35	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, hm:													
(94)m=	1	1	0.99	0.97	0.9	0.75	0.56	0.63	0.89	0.99	1	1	(94)
Useful gains, hmGm , W = (94)m x (84)m													
(95)m=	628.1	747	887.15	1027.79	1058.14	872.46	621.73	637.29	782.08	713	617.65	590.21	(95)
Monthly average external temperature from Table 8													
(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2	(96)
Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]													
(97)m=	2602.61	2519.02	2282.42	1902.26	1471.01	983.82	643.46	674.38	1052.21	1588.72	2125.37	2584.79	(97)
Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m													
(98)m=	1469.03	1190.79	1038.08	629.62	307.18	0	0	0	0	651.53	1085.56	1483.97	

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 7855.75 (98)

Space heating requirement in kWh/m²/year — 55.08 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system		0	(201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1	(202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1	(204)
Efficiency of main space heating system 1		89.5	(206)
Efficiency of secondary/supplementary heating system, %		0	(208)

DER WorkSheet: New dwelling design stage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year	
Space heating requirement (calculated above)	1469.03	1190.79	1038.08	629.62	307.18	0	0	0	0	651.53	1085.56	1483.97		
(211)m = {[(98)m x (204)] } x 100 ÷ (206)	1641.38	1330.49	1159.87	703.48	343.21	0	0	0	0	727.97	1212.91	1658.06		(211)
Total (kWh/year) =Sum(211)$_{1...5,10...12}$=													8777.38	(211)
Space heating fuel (secondary), kWh/month = {[(98)m x (201)] } x 100 ÷ (208)														
(215)m=	0	0	0	0	0	0	0	0	0	0	0	0		
Total (kWh/year) =Sum(215)$_{1...5,10...12}$=													0	(215)

Water heating

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year	
Output from water heater (calculated above)	219.95	193.83	203.48	182.28	177.21	156.08	149.53	166.7	167.79	189.02	200.02	214.62		
Efficiency of water heater													89.5	(216)
(217)m=	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5	89.5		(217)
Fuel for water heating, kWh/month (219)m = (64)m x 100 ÷ (217)m														
(219)m=	245.76	216.57	227.35	203.67	198	174.39	167.08	186.25	187.47	211.2	223.49	239.8		
Total = Sum(219a)$_{1...12}$ =													2481.02	(219)

Annual totals		**kWh/year**	**kWh/year**	
Space heating fuel used, main system 1			8777.38	
Water heating fuel used			2481.02	
Electricity for pumps, fans and electric keep-hot				
mechanical ventilation - balanced, extract or positive input from outside		362.6		(230a)
central heating pump:		120		(230c)
Total electricity for the above, kWh/year	sum of (230a)...(230g) =		482.6	(231)
Electricity for lighting			501.24	(232)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year	**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x	0.216	=	1895.91	(261)
Space heating (secondary)	(215) x	0.519	=	0	(263)
Water heating	(219) x	0.216	=	535.9	(264)
Space and water heating	(261) + (262) + (263) + (264) =			2431.81	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.519	=	250.47	(267)
Electricity for lighting	(232) x	0.519	=	260.14	(268)
Total CO2, kg/year		sum of (265)...(271) =		2942.43	(272)
Dwelling CO2 Emission Rate		(272) ÷ (4) =		20.63	(273)
EI rating (section 14)				79	(274)