South Yorkshire Pensions Authority

262 High Holborn | Appendix E

Sustainability & Energy Statement

30th April 2013

Design & Access Statement Contents

Energy Statement

262 High Holborn, London

23rd April 2013

Prepared For:

South Yorkshire Pensions Authority

ENERGY STATEMENT
262 HIGH HOLBORN, LONDON

QUALITY ASSURANCE

Date	Issue	Revision	Prepared By	Checked By	Approved By	File Number
5th April 2013	1	0	Joan Senent	Ed Chan	Ed Chan	1674/Energy Statement-262 High Holborn
12th April 2013	2	1	Joan Senent	Ed Chan	Ed Chan	1674/Energy Statement-262 High Holborn
17th April 2013	3	2	Ed Chan	Martin Taylor	Martin Taylor	1674/Energy Statement-262 High Holborn
23rd April 2013	4	3	Ed Chan	Martin Taylor	Martin Taylor	1674/Energy Statement-262 High Holborn

The current report provides a brief overview of the wide range of opportunities for sustainable energy and is not intended as detailed design advice. As such data and information should only be treated as INDICATIVE at this stage of the process. Further investigation can be undertaken when more accurate and detailed information is required on specific measures.

Whilst Meinhardt endeavoured to ensure that all information contained within this document is correct, it cannot be held responsible for any inaccuracies within or problems arising out of the use of this document.

ENERGY STATEMENT
262 HIGH HOLBORN, LONDON

Table of Contents

1. Executive Summary

1.1 Development Description

The building is situated on the south side of High Holborn in London. The building is surrounded by commercial buildings and a Hotel building. 262 High Holborn is an existing 7 storey building with two levels of basement. Part of the building will be demolished, and a new extension will be built to the rear.

The proposed uses of the building are set out as below:

Basement:	Plant room, shower facilities, tenant store/office, retail areas.
Ground Floor:	Entrance/reception, toilet, BMS/security room, cycle store, refuse room and plant room.
1st to 6th floors:	Office areas
7th floor:	Office, terrace and plant
8th floor:	Office area and terrace
Roof floor:	Lift overrun, PV array, low-level plant equipment adjacent to overrun, facade access equipment

1.2 Basecase Building Energy Demand

Meinhardt has used the industry standard 'IES Virtual Environment software suite (version 2012) from Integrated Environmental Solutions Ltd. to produce a dynamic thermal simulation of the proposed 262 High Holborn building. This software is included in the CIBSE AM11.

Table 1 is a summary of the baseline building energy consumption breakdown for the 262 High Holborn building. The resulting carbon dioxide emission from the baseline building energy consumptions are shown in table 2.

Base Line Scenario Actual Building	
REGULATED	Energy Demand (MWh/year
Heating	40
Cooling	9
Auxiliary	54
Lighting	64
Hot water	4
Total regulated	171
UNREGULATED	
Equipment	313
Lifts	6
Entrance Heater	4
Total unregulated	324
Total	495

Table 1 – Baseline Building Energy Consumption (MWh/year)

Base Line Scenario Actual Building	
REGULATED	CO_2 Emissions (tonnes/year)
Heating	21
Cooling	5
Auxiliary	28
Lighting	33
Hot water	2
Total regulated	88
UNREGULATED	
Equipment	162
Lifts	3
Entrance Heater	2
Total unregulated	167
Total	256

Table 2 – Baseline Building carbon dioxide emissions (tonne CO_2/year)

1.3 Part L2A Compliance

Part L compliance studies have been undertaken to check the proposed building against the Building Regulations Part L 2010.

The Part L assessment as summarised in Table 3 below, indicates that the actual building CO_2 emissions is 25.4 % below the Part L requirement.

	Carbon Dioxide Emission (kg CO_2/m2/year)	Improvement over target building
Target Building	18.3	-
Energy Efficiency measures	16.9	7.7%
Energy Efficiency and GSHP	14.6	20.2%
Energy Efficiency and GSHP and PV panels	13.7	25.4%

Table 3 – Part L compliance summary

1.4 Energy Efficiency Measures

The following are the proposed energy efficiency measures for the building:

1. Active Chilled Beams

2. Heat Recovery with Thermal Wheels, a high efficiency heat recovery method to re-claim energy from the ventilation system.

3. High efficiency condensing boilers

4. High efficiency chillers (improved chiller efficiency due to elevated chilled water temperature for chilled beam system)

5. High efficiency lighting equipment and controls

6. Variable volume inverter controlled pumps and fans

7. High performance façades

8. A full building energy management system incorporating energy monitoring, plant monitoring and controls include optimisation and weather compensation routines. This system will also give warnings of the out of range values

1.5 Heating, Cooling, Ventilation and Renewable systems

<u>Proposed Heating System</u>

High efficiency boilers are proposed with low NOx emission modulating burners. The boilers will be condensing type to maximise energy efficiency. Water will be circulated to the building with variable volume circulating pumps located in the boiler room. Inverter drives will be fitted to all circulating pumps.

The LTHW will be distributed to serve air handling unit heater batteries, active chilled beams (heating mode), radiators and entrance trench heating. Radiators and trench heating are proposed with thermostatic radiator valves for temperature control.

Proposed Cooling System

A chilled water supply will be provided by air cooled water chillers on the 7th Floor plant space. Chilled water will be circulated to serve the air handling unit cooling coils and active chilled beams located in the office areas.

The chilled water will be circulated with variable volume circulating pumps. Inverter drives will be fitted to all circulating pumps.

The control and the sequencing of chiller units will be regulated by the inbuilt chiller unit controls and will be monitored by the building management system.

Proposed Ventilation System

The building will be provided with mechanical ventilation. The areas will be served by the following systems:

Area	**System**
Office areas / Entrance	General Supply and Extract System (with on floor shut off damper)
Toilet areas	Extract System (supply transferred from office area)
Plant rooms and Storage	General Supply and Extract System

Fresh air AHUs will provide constant discharge temperatures throughout the year. Heat will be reclaimed by the use of a thermal wheels between the supply and extract systems. On floor shut off dampers will be provided, to shut off the air supply when there is no demand. All fans will have inverter drives.

General extract from the plant rooms and storage areas will be via a low velocity ductwork system with an extract fan located at basement level. Extract systems will generally be rated at 95% of the supply systems to achieve a positive pressure regime to minimise infiltration.

All supply and fresh air intake ductwork and plenums will be insulated against heat loss and surface condensation.

All fans will be driven by high efficiency EC/DC motors.

Renewables Assessment

Potential CO_2 savings from the following low and zero carbon technology options have also been reviewed (see table 4)

1) Combined Heat and Power
2) Tri-Generation (Combined Heat and Power + Absorption Cooling)
3) Solar Thermal Heating
4) Photovoltaic
5) Wind Turbines
6) Biomass Heating
7) Ground Source Heating and Cooling

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)	Recommended
Low Carbon Options				
CHP	90 kWth, 60 kWe	0.4	1.045	No
CCHP	90 kWth, 60 kWe & 56 kW absorption cooling	0.9	2.201	No
Renewable Options				
GSHP – Heating	178 kW	1.5	3.767	Yes
GSHP – Cooling	192 kW	2.9	7.195	Yes
Solar Thermal Panels	7 m² (active panel area)	0.9	2.172	No
PV Panels	72 m² (active panel area)	1.9	4.678	Yes
Wind Turbines	4 x 1.5kW	0.4	1.264	No
Bio Mass Boiler	49 kW	1.7	4.274	No

Table 4 - Summarises the low and zero carbon technology options

The matrix (figure 1) below provides a summary of the low carbon and renewable technologies considered and how they can or cannot be integrated together. In general, those identified in the red and blue blocks are not compatible to be used together.

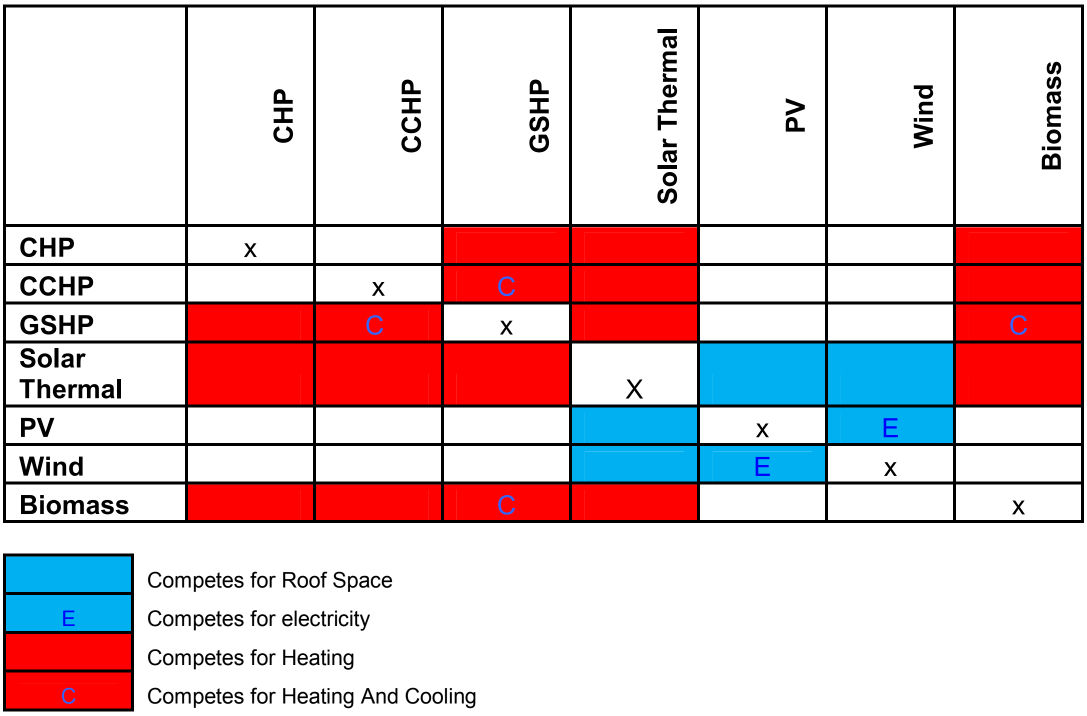


Figure 1 - Low carbon and renewable technologies integration matrix

Proposed Renewables

To optimise the potential carbon savings within the confines of the development, the recommended strategy is for GSHPs to meet a proportion of the buildings heating and cooling demand in conjunction with PV. Table 5 indicates the potential CO_2 savings from the proposed renewable technologies.

This has been estimated to provide a maximum of up to 6.3% CO_2 reduction. This will be subject to further detailed geotechnical studies and design development during the detailed design stages.

	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
Solar PV	72 m²	1.9	4.678
GSHP - Heating	178 kW	1.5	3.767
GSHP - Cooling	192 kW	2.9	7.195
Total		6.3	15.640

Table 5 - Summarises the proposed renewable technologies

The renewable energy study has indicated that the development can achieve 6.3% CO_2 saving via the application of onsite renewable energy technologies. There are technical and practical constraints that provide limitations on increasing the renewable CO_2 savings as details below:

Technical Constraints

1. Most of the Low or zero carbon emission technologies, such as GSHP, CHP, Tri-gen CHP, Bio-mass and solar thermal are targeting the heating demand of the building, and they can't be used together. The heating demand is relatively low for the development, and the building heating demand has been significantly reduced through a number of energy efficiency measures such as heat recovery system of ventilation system and high performance facade. Therefore, the carbon saving from heat targeting Low and Zero Carbon technologies are limited.

Practical Constraints

1. The proposed GSHP cooling system enhances the carbon saving of the building, however because of the site constraints; the size of the GSHP cooling system is limited. The limited site area in turn limits the number of boreholes, and hence the size of the GSHP. The number and positions of structural piles also influence the size of the GSHP as the boreholes need to be spaced apart from the structural piles.
2. Insufficient roof space limits the use of PV panels and wind turbines. The building has a small footprint, and the roof level also has a further reduced area due to the mansafe system, roof access panel, boiler flue termination and smoke vent opening. These further reduce the useable area for PV panels.
3. On the roof, the lift overrun is approximately 1.5m above the main roof level. This would result in the shading on the PV panels, and hence the output of the PV panels has been reduced. The PV panels can't be raised to 1.5m above roof level to overcome the shading issue, because of planning concerns.
4. The uncertainty of wind conditions in an urban environment, height restriction and sight lines make wind turbines an impractical renewable option for this building.

Summary

The energy demand of the building has been significantly reduced through a number of energy efficiency measures. In addition to the energy efficiency measures, the building will include renewable technologies in the form of ground source heating/cooling and PV panels to provide a saving of 6.3% of the predicted building CO_2 emissions.

2. Introduction

2.1 Background

Meinhardt has been appointed by the South Yorkshire Pensions Authority to produce an Energy Statement for 262 High Holborn in support of its planning application to the London Borough of Camden. The report outlines how the proposed development addresses the energy related policies, as set out within the London Plan, as well as the energy related Camden policies which are set out in the Camden Plan.

The report demonstrates that the project design team has given thorough consideration to all zero and low CO_2 technologies that could be technically employed to meet a proportion of the building's energy demand. The report draws on the energy demand modelling which has been undertaken by Meinhardt, as well as earlier project renewable energy feasibility studies, and sets out the potential CO_2 savings and design implications associated with each of the zero or low CO_2 options considered. Finally the report sets out the proposed energy strategy.

The report establishes the building energy demand and indicates how energy and CO_2 savings can be made through energy efficiency measures (Be Lean), efficient supply of energy (Be Clean) and incorporation of a variety of renewable energy sources (Be Green).

2.2 Description of the building

The building is situated on the south side of High Holborn in London. The building is surrounded by commercial buildings and Hotel.

262 High Holborn is an existing 7 storey height building with two levels of basement. Part of the building will be demolished, and a new extension area will be built at the back of the building.

The proposed uses of the building are set out as below:

Basement:	Plant room, shower facilities, tenant store/office, retail areas.
Ground Floor:	Entrance/reception, toilet, BMS/security room, cycle store, refuse room and plant room.
1st to 6th floors:	Office areas
7th floor:	Office, terrace and plant room
8th floor:	Office area and terrace.
Roof floor:	Lift overrun, PV array, low-level plant equipment adjacent to overrun, facade access equipment.

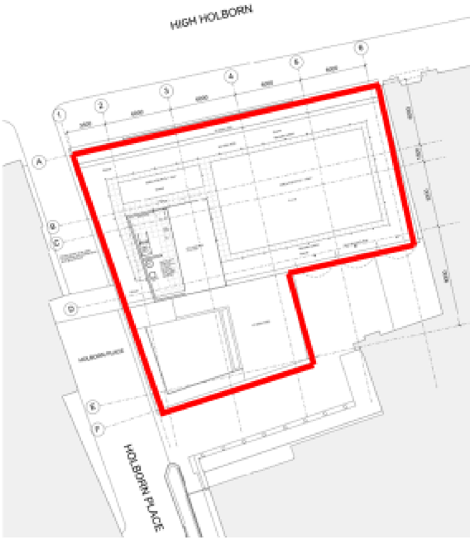


Figure 2 – 262 High Holborn located on the south side of High Holborn.

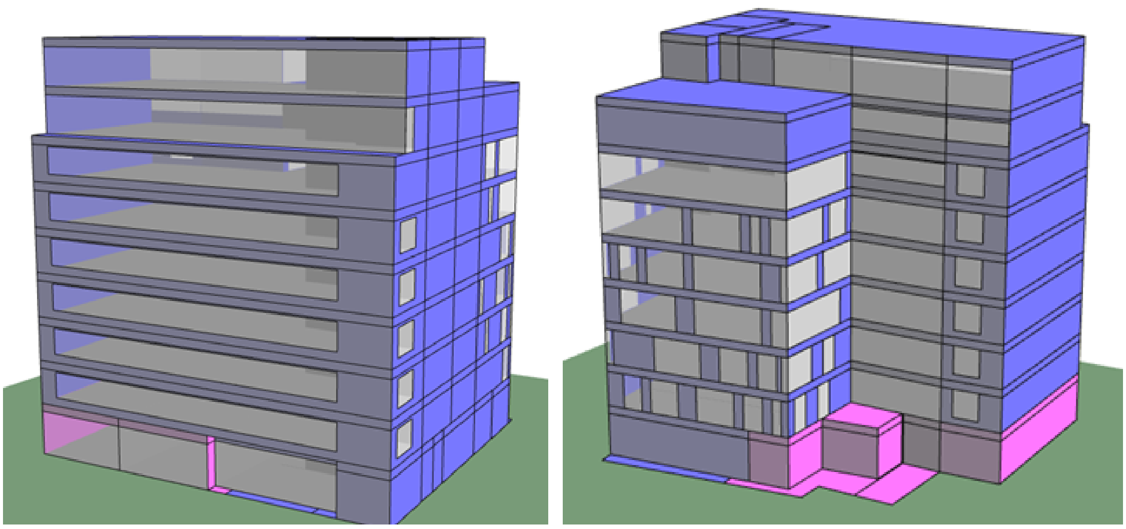


Figure 3 – 3D Image generated by the thermal modelling software.

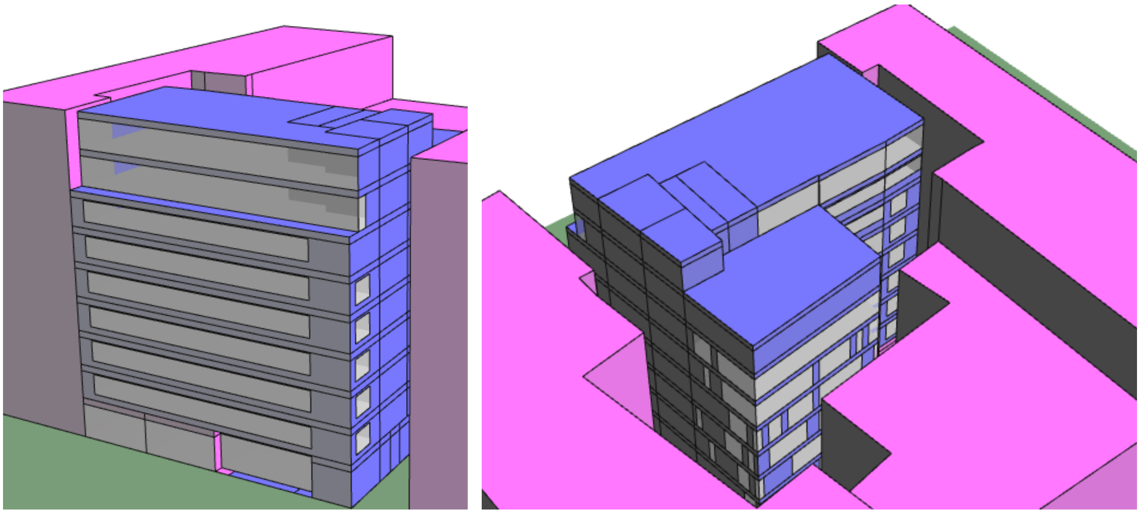


Figure 4 – 3D Image generated by the thermal modelling software.

2.3 Report contents

This report has been written to respond to the London Plan and the London Borough of Camden policies and identifies how the Energy Hierarchy has been addressed. The report includes:

1. An energy demand assessment outlining the estimated energy consumption and an overall annual carbon dioxide emissions figure.

2. A review of the design of the building with reference to the energy efficient design measures, and recommendations being considered for the development. This includes heating, cooling, ventilation, day lighting and artificial lighting, equipment and appliances.

3. A statement setting out the technical consideration of CHP and CCHP as it could be used in this development.

4. An assessment of the feasibility of each renewable energy technology, setting out the possible size of the plant that can be installed and the carbon savings that would be achieved as a result of the installation.

5. A summary identifying which of the low and zero carbon energy options have been proposed for the development.

3. Energy Assessment

3.1 Energy Model

Meinhardt has used the industry standard 'IES Virtual Environment software suite (version 2012) from Integrated Environmental Solutions Ltd to produce a dynamic thermal simulation of the proposed development. This software is included in the CIBSE AM11.

IES 2012 is an integrated suite of applications based around a 3D geometrical model. The modules used for this project include "ModelIT" for model construction and "ApacheSim" for thermal simulation.

- ModelIT is used to generate the geometry of the 3D models.
- ApacheSim is a dynamic thermal simulation program, based on first-principles mathematical modelling of the heat transfer processes occurring within and around a building. It qualifies as a Dynamic Model in the CIBSE system of model classification, and exceeds the requirements of such a model in many areas. The program provides an environment for the detailed evaluation of building and system designs, allowing them to be optimised with regard to comfort criteria and energy use. This module also houses the construction database which defines all the construction U-values for the various elements.

The models were simulated using the CIBSE test reference year (TRY) weather data for London, as required by Building Regulations Part L2A 2010. This data is based on the mean weather data from 1976 to 1995 and has a summertime peak dry bulb temperature of 30.1°C and wintertime minimum of - 4.5°C.

A full list of the thermal modelling assumptions is included within this report as Appendix B.

The Part L2A assessment of 262 High Holborn outputs include hourly kW demands for heating (DHW, mechanical ventilation and chilled beams heating), cooling (mechanical ventilation and chilled beam cooling) and electricity (including small power, lighting and electrical consumption from mechanical ventilation systems). National Calculation Methodology (NCM) has been used to work out the TER and the baseline BER. The reduction in emissions will be (1-BER/TER)*100 [%].

These outputs have allowed gas and electrical consumption and related CO_2 emissions to be calculated.

3.2 Delivered Energy Demand

Table 6 below outlines the 262 High Holborn annual site energy demands split between space heating, space cooling, Auxiliary energy (funs and pumps), Lighting, DHW, and equipment using NCM templates. The total site energy demand is 495MWh/year. This is the sum of energy calculated in Part L, regulated, and unregulated.

The energy demands outlined in the first column have been multiplied by the carbon emission factor for gas and electricity, and the resulting emissions are shown in the second column. The total site energy CO_2 consumption is 256 CO_2 tonnes/year

Base Line Scenario Actual Building		
	Energy Demand MWh/year	CO_2 Emissions tonnes/year
REGULATED		
Heating	40	21
Cooling	9	5
Auxiliary	54	28
Lighting	64	33
Hot water	4	2
Total	171	88

UNREGULATED		
Equipment	313	162
Lifts	6	3
Entrance Heater	4	2
Total	324	167
TOTAL		
Total site	495	256

Table 6: Building energy demand and carbon emissions.

Throughout this report the carbon dioxide emission factors used are as given in Table 24 (table below) of the NCM modelling guide for buildings other than dwellings in England and Wales.

Fuel	$KgCO_2$ per kWh
Gas	0.198
Electricity Grid supplied	0.517
Electricity Grid displaced	0.529

Based on the energy modelling that Meinhardt have undertaken for 262 High Holborn, the predicted CO_2 emissions from the site is 256 tones CO_2/year.

The model includes variation profiles for cooling, heating, ventilation and auxiliary energy as per the NCM guidelines.

3.3 Part L2A CO_2 Emissions

The Part L 2A compliance energy & CO_2 emissions for the actual and notional building are shown in the document below:

	Carbon Dioxide Emission (kg CO_2/m^2/year)	Improvement over target building
Target Building	18.3	-
Energy Efficiency measures	16.9	7.7%
Energy Efficiency and GSHP	14.6	20.2%
Energy Efficiency and GSHP and PV panels	13.7	25.4%

Table 7 – Part L compliance summary

The results indicate that the actual building CO_2 emission is 13.7 $kgCO_2/m^2$, while the TER (Target Emission Rate) is 18.3 $kgCO_2/m^2$. The results indicate that the building passes the Part L 2A requirement by 25.4%.

4. Energy Efficiency Measures (Be Lean).

4.1 Introduction

This section outlines how the energy demands of 262 High Holborn have been reduced in line with the first part of the Energy Hierachy: Use less energy (be lean).

Before considering renewable and Low and Zero Carbon technologies, the building has been designed to reduce energy use.

- High efficiency cooling is achieved by using chilled beams, rather than higher energy consuming fan coil units. Chilled beams are able to run at higher temperatures allowing the chilling plant to run more efficiently.

- High specification facades are to be used, limiting solar heating gains while allowing daylight, thus saving on lighting energy as well as reducing the building's heat loss during the winter season. This reduces energy consumption on lighting, heating and cooling.

- A thermal wheel is to be used to recover heat from the building and pre-heat or pre-cool the incoming air, saving heating and cooling energy. In midseason the AHU will allow air to bypass the thermal wheel providing free cooling when outside temperatures permit.

- Highly efficient boilers and chillers are to be used

- Daylight controls will ensure lighting is dimmed when day light is available at the perimeter. Occupation sensors will switch off the lighting when spaces are not occupied.

4.2 Building fabrics

High efficiency building fabric provided for 262 High Holborn includes 1) low g value glazing to reduce solar gain. 2) An improved u-value fabric to reduce heat loss. 3) Air tightness is improved beyond Part L2A minimum requirement targeting 5 $m^3/h/m^2$ @50 pa

Details of building fabric are shown in the table below.

FABRIC U values	W/m2K
Roof	0.18
Wall	0.22
Ground Floor	0.2
Windows	1.1 (G value 0.27)
Internal Wall	1.8
Internal floor/ceiling	1
Air Permeability (m3/h.m2 @50Pa)	5

4.3 Heating System

The heating system energy requirement has been reduced as a result of the following design features:

a) Thermal wheel heat recovery with high operating efficiencies is proposed to serve offices, corridors and entrance areas. This significantly reduces the heating required to warm up incoming fresh air in winter. Plant room and store rooms will also be provided with a heat recovery system.

b) LTHW circuits have variable volume flow rates, which require less pumping energy.

c) Heating will be provided by high efficiency Low NO_x, Condensing boilers. All selected plant will outperform the minimum Building Regulation Part L2A efficiency requirement.

d) Heating coils in Air Handling Units and Active Chilled Beams will be operated at lower water temperature, which will allow the proposed ground source heat pump system to work at higher efficiency.

4.4 Cooling System

The cooling system energy requirement has been reduced by introducing the following features to the design:

a) Active chilled beams operate at a higher chilled water temperature hence improving the efficiencies of the chillers

b) Cooling will be provided by high efficiency air cooled chillers. All selected plant will outperform the minimum Building Regulation Part L2A efficiency requirement.

c) Active chilled beams operate without the need of an in built fan, hence reducing energy consumption over a Fan Coil Unit design.

4.5 Ventilation System

The energy requirements have been reduced by introducing the following features to the design:

a) All fans operate with inverter control, with the air volume modulating to suit demand. And all fans will be driven by high efficiency EC/DC motors.

b) All selected plant will outperform the minimum Building Regulation Part L2A efficiency requirement.

4.6 Lighting and Appliances

All general lighting within the building will consist of high efficiency luminaires, with some decorative and specialist lighting in the reception area. If LED lighting is considered in later stages of design, the lighting energy demand could be further reduced.

The proposed programmable lighting controls will utilise movement detectors and daylight sensors to decrease energy demands.

Target lighting levels are given in the CIBSE Interior Code for Lighting, as below:

- General Office space – 400lux
- Entrance/Reception – 300lux
- Corridors – 150lux
- Plant Rooms – 200lux
- Lift Lobbies – 150lux
- Toilets – 200lux

4.7 Energy Management

Load logging of electrical power, supplementary cooling, heating and gas requirements will be captured on the BMS, to assist the building manager in monitoring and tuning the performance of the M&E systems to operate at better efficiencies. All major plant items can be monitored. This will be formatted to capture and present information on an hourly/daily/weekly/monthly or annual basis, such that any unreasonably high energy consumption trends can be readily identified, investigated and remedied.

5. Energy Supplied Efficiently(Be Clean)

5.1 Introduction

This section outlines how the energy supplied to 262 High Holborn could be reduced by the use of a CHP in line with policy 5.6 of The London Plan 2011 – Decentralised Energy in Development Proposals.

> ***A. Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites.***
>
> ***B. Major development proposals should select energy systems in accordance with the following hierarchy:***
>
> ***1 Connection to existing heating or cooling networks***
>
> ***2 Site wide CHP network***
>
> ***3 Communal heating and cooling.***
>
> ***C. Potential opportunities to meet the first priority in this hierarchy are outlined in the London Heat Map tool. Where future network opportunities are identified, proposals should be designed to connect to these networks.***

The following options are considered:

- CHP
- Tri-Generation CHP or CCHP (Combined heating, cooling and Power).
- District Heating system

Appendix A shows background information regarding CHP and CCHP.

5.2 CHP

Overview

A Combined Heat and Power (CHP) plant consists of an electrical generator powered by a gas turbine or a gas - or oil-fired combustion engine. The excess thermal energy, which in a conventional plant would be wasted, is used in a subsidiary system, providing low or medium temperature hot water (or, in some cases, steam) for heating. This makes the overall energy efficiency greater than that of a conventional generator, and the total energy use and carbon dioxide emissions for which a building is responsible can be reduced. However, the CHP plant cannot be run efficiently at small fractions of their maximum output and its' efficiency is also limited by the heat demand of the building.

A CHP study was undertaken based on the following plant efficiencies:

CHP electricity	29%
CHP heat	44%
Conventional gas boiler	87%

A CHP with thermal output of 90kW, electrical output of 60kW, and a 2000 litre thermal store were considered.

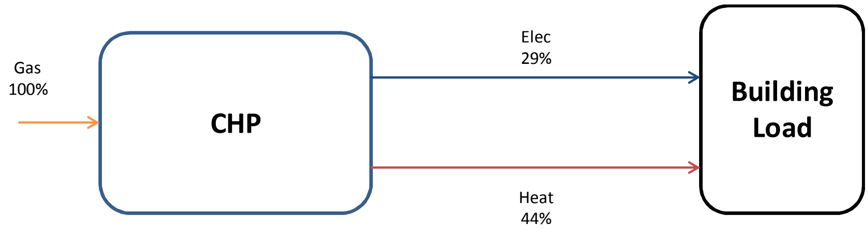


Figure 5 - Summary of building energy flows with CHP

The proposed CHP was shown to provide carbon savings of 1.045 tonnesCO_2/year, which is equivalent to 0.4% CO_2 emissions reduction.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
CHP	90 kWth, 60 kWe	0.4	1.045

Table 8 - Summary of CO_2 savings of CHP

5.3 CCHP

Overview

Heat from a CHP plant could also be used for cooling via an absorption chiller. This system is known as tri generation as it is capable of generating heat, power and cooling.

As previously noted, the heating demand for the site is small, whereas the cooling and electricity demands are high. A combined heat and power system was considered based on the following plant efficiencies.

CHP electricity	29%
CHP heat	44%
Conventional chiller	360%
Absorption chiller	70%

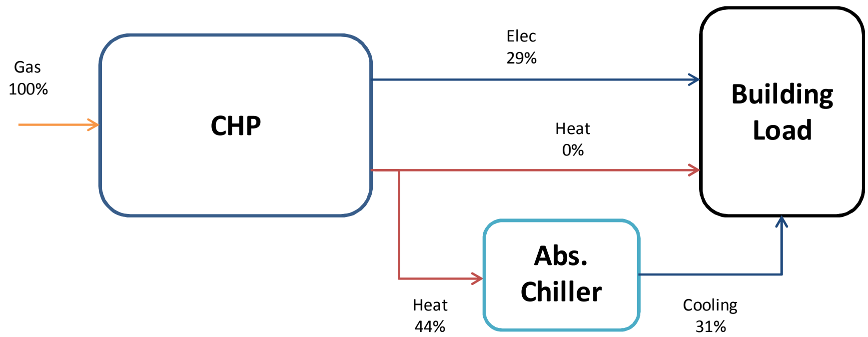


Figure 6 - Summary of building energy flows with CCHP

With a 56kW output absorption chiller, the proposed CCHP was shown to provide carbon saving of 2.201 tonnesCO_2/year, which is equivalent to 0.9% CO_2 emissions reduction.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
CCHP	90 kWth, 60 kWe & 56 kW absorption cooling	0.9	2.201

Table 9 - Summary of CO_2 savings of CCHP

5.4 District Heating system

The possibility of connecting 262 High Holborn to a district heating system was investigated. There is an existing District Heating network in the Farringdon area, however connection to this network it is not feasible because of its distance away from the development.

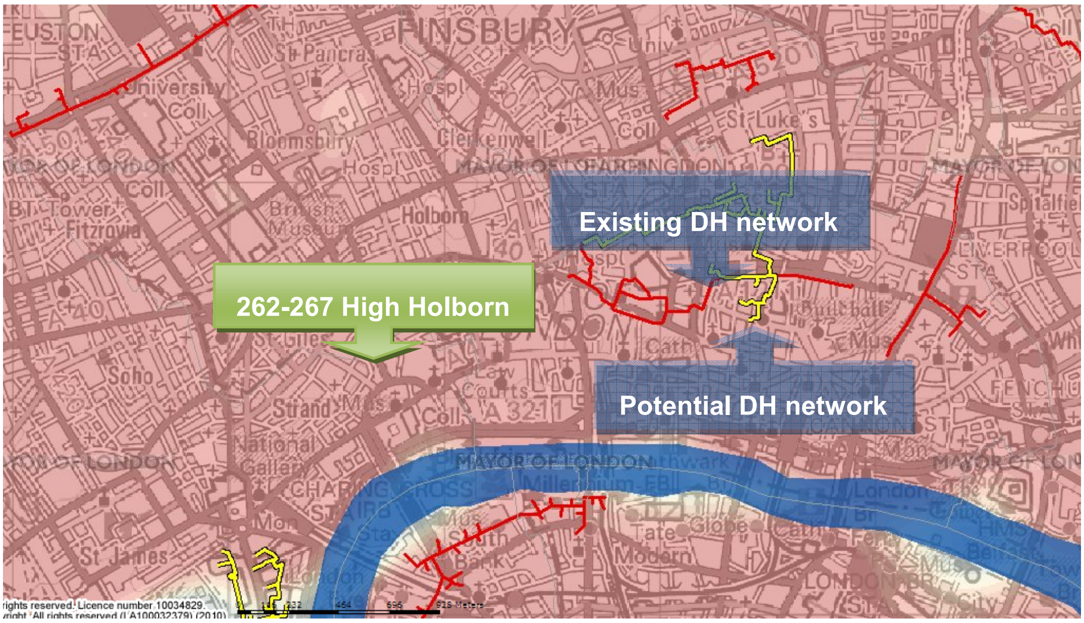


Figure 7 London Heat Map

6. Renewable Energy Technologies (Be Green)

6.1 Introduction

This section outlines the renewable energy technologies (Be Green) which have been considered. Each renewable energy technology has been assessed separately in the first instance, and then scenarios explored for using more than one technology in combination.

Appendix A shows the background information of renewable technologies.

6.2 Solar Thermal Water Heating

Solar thermal systems are conceptually simple; they use solar collectors to supplement a boiler in heating water, reducing the work done by the boiler. They can meet up to 70% of a residential building's requirements. Commercial systems are typically sized to meet 45-50% of the annual DHW demand.

Solar water heating systems use the energy from the sun to heat water, most commonly in the UK for hot water needs.

There are two standard types of collectors used - flat plate collectors and evacuated tube collectors. The flat plate collector is most commonly used in solar domestic hot water systems, as they tend to have a lower cost for each unit of energy saved. Evacuated tube collectors are generally slightly more expensive due to a more complex manufacturing process (to achieve the vacuum) but manufacturers claim better energy performance, particularly in winter to capture the low level sunlight.

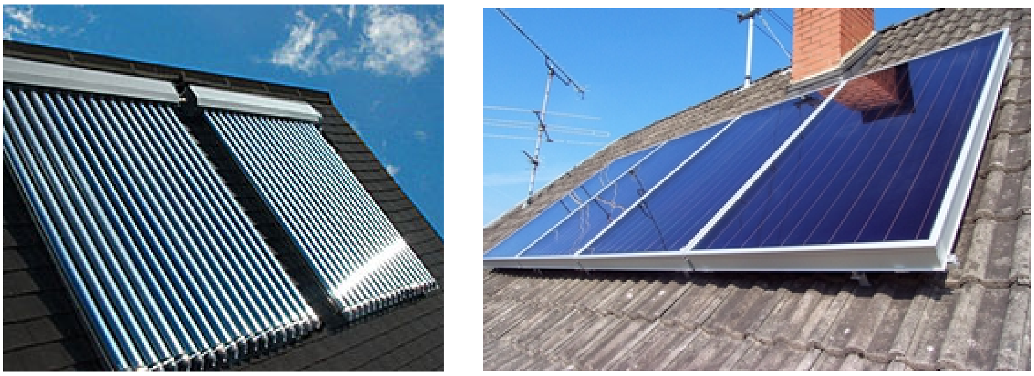


Figure 8 - Solar Thermal Panels

In 262 High Holborn, the areas highlighted in red (in Figure 9) have been identified as possible locations for solar panels in the roof top area.

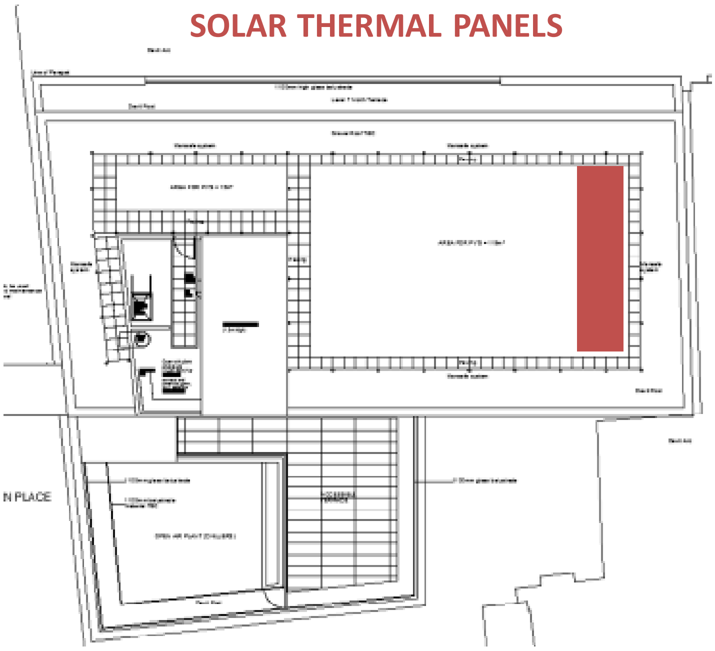


Figure 9 - Proposed Mounting Position for Solar Panels (in red) at roof level

This represents 7m² of solar thermal panel area (active panel area). The panels would be positioned at an angle to optimise the output with minimum roof area required. The solar heating system is sized to meet the hot water demand of the building.

The proposed solar thermal panels were shown to provide a carbon saving of 2.172 tonnesCO_2/year, which is equivalent to 0.9% CO_2 emissions reduction.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO2/year)
Solar Thermal Panels	7 m² (active panel area)	0.9	2.172

Table 10 - Summary of CO_2 savings of solar thermal panels

6.3 Photovoltaic

Photovoltaic (PV) cells produce a direct electrical current from the energy in solar radiation. A film of silicone containing deliberate specific impurities (e.g. Boron) is exposed to sunlight. The impurities create gaps in the electron array. This means that when electrons are excited by electromagnetic radiation of the correct frequency they are able to move, producing an electric current.

The energy output of the cell is dependant on how much sunlight is available, and on the efficiency of the cell. Maximum efficiencies are around 28%, but this is only attainable at 0°C and drops off as the temperature rises.

As they use energy from the Sun, solar PV cells are environmentally friendly and cheap to run. This makes PV cells worth considering even though at the moment they are an expensive way of supplying energy to a building.

Figure 10 - Photovoltaic Panels.

In 262 High Holborn, the areas highlighted in red (in Figure 11) have been identified as possible locations for PV panels in the roof top area.

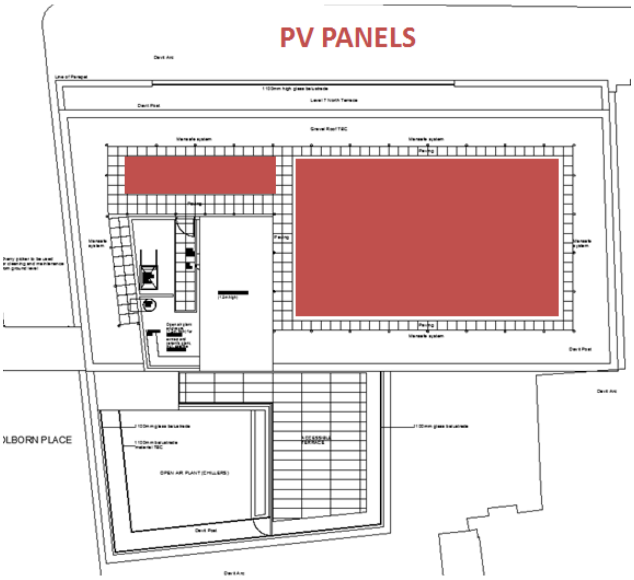


Figure 11 - Proposed Mounting Positions for Photovoltaic Panels (in red) at roof level

This represents 72m² of PV panel area (active panel area). The panels will be positioned at an angle to optimise their output with minimum roof area required.

The proposed PV panels were shown to provide carbon savings of 4.678 tonnesCO_2/year, which is equivalent to 1.9% CO_2 emission reduction.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
PV Panels	72 m² (active panel area)	1.9	4.678

Table 11 - Summary of CO_2 savings of PV panels

Refer to Appendix D for details of the system proposed. This information has been provided by a Photovoltaic specialist.

6.4 Wind Power

Wind turbines produce electricity by using the natural power of the wind to drive a generator. The UK has the largest potential wind energy resource in Europe with 33% of total European offshore potential yet currently generates less than 1% of its electricity from wind. Wind energy applications in the UK range from small battery charging applications producing a few hundred Watts of useful electricity remote from the electricity distribution network, 6kW turbines powering part of a building, to large wind farms producing megawatts of electricity at a comparable price to conventional power stations. Single turbines are available which can generate up to 2MW.

Figure 12 - Wind Turbines

At 262 High Holborn, the areas highlighted in red (in Figure 13) have been identified as possible locations for wind turbines at the roof top area. Small wind turbines would be used to minimise visual impacts.

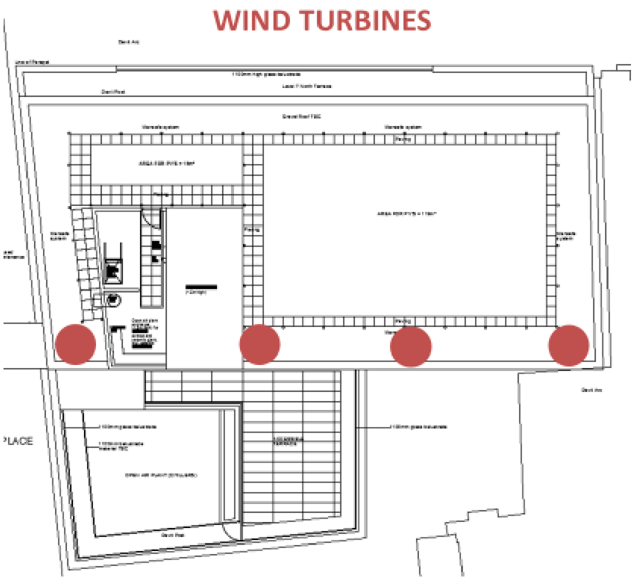


Figure 13 - Possible Mounting Positions for wind turbines (in red) at roof level

4 no. wind turbines rated at 1.5kW could be located on the South side of the roof, to reduce the visual impact from High Holborn. The proposed wind turbines would provide carbon saving of 1.264 tonnesCO_2/year, which is equivalent to 0.4% CO_2 emissions reduction.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
Wind Turbines	4 x 1.5kW	0.4	1.264

Table 12 - Summary of CO_2 savings of wind turbines

Issues for Consideration

- Potential wind loading and vibration issues.
- Wind turbines will have a visual impact, which will need to be considered
- Wind turbines will typically increase total building height

6.5 Bio Mass Boiler

Biomass burners apply modern, high-efficiency boiler technology to burning wood for heat.

Figure 14 - Bio-mass Boiler

Biomass boilers work best at full load, however they are difficult to run at lower capacities. Thus there may be times when there is a low heating demand that they are unable to match, hence a thermal store is required to maximise efficiency.

A 49 kW biomass boiler was used for the study; this was shown to provide a carbon saving of 4.274 tonnesCO_2/year, which is equivalent to 1.7% CO_2 emissions reduction.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
Bio Mass Boiler	49 kW	1.7	4.274

Table 13 - Summary of CO_2 savings of Bio-mass heating

Issues for Consideration:

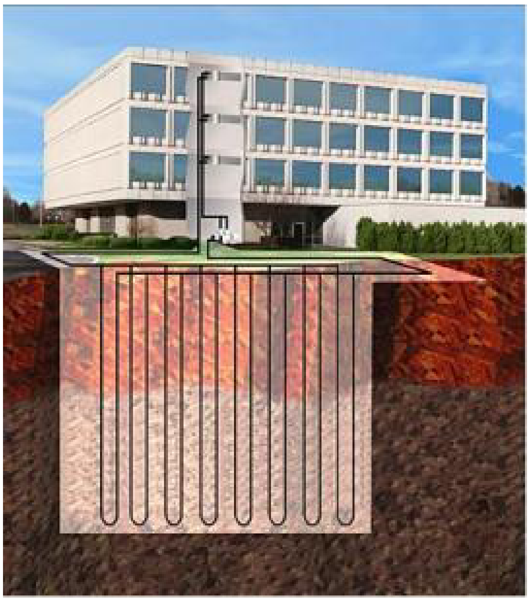
- Would require a large plant room area (space for buffer tank and fuel storage)
- Would require access for fuel delivery lorries
- Would require a flue to the full height of the building
- Would require contracts to be set up for the delivery of fuel
- Would require a management function to maintain the boiler and bill tenants for the energy used
- Maintenance costs will be higher than for gas boilers
- Fuel store must be dry and fire protection would be required.

6.6 Ground Source Heat Pumps

Ground Source Heat Pumps (GSHPs) are electrically powered systems which use the earth's relatively constant temperature to provide heating, cooling, and DHW. The environmental gain is due to the higher performance of the cooling equipment when coupled to the ground. Ground Source Heat Pumps can be categorised as closed or open loop.

For closed loop systems, water or antifreeze solution is circulated through plastic pipes buried beneath the earth's surface. During the winter, the fluid collects heat from the earth and carries it through the system and into the building. During the summer, the system reverses itself to cool the building by pulling heat from the building, carrying it through the system and placing it in the ground. This process creates free cooling in the summer and delivers substantial hot water savings in the winter.

Open loop systems depend more strongly on the ground conditions, as it may be impossible to draw the required volume of water. The only way to test this is by construction of a test borehole. Due to the limited area of the site there is insufficient space to accommodate both an abstraction borehole and recharge borehole on the development. For this reason, a closed loop system has been examined in this section.



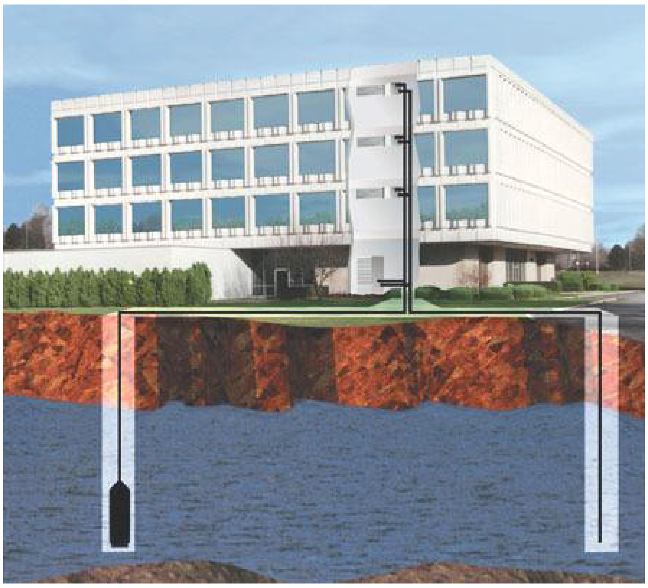


Figure 15 – Closed Loop Ground Source Heat Pump *Open Loop Ground Source Heat Pump*

A Ground Source Heat Pump study was carried out for 262 High Holborn, based on the following system parameters:

Heating Requirement - 168kW
Cooling Requirement - 137kW
Heat Pump Number - 1
Main Header Trench Length - 30m
Bore Hole Number - 14

The proposed Ground Source Heat Pump was shown to provide carbon saving of 10.962 tonnesCO_2/year, which is equivalent to 4.4% CO_2 emissions reduction. Refer to Appendix C for details of the system proposed. This was produced by a Ground Source Heat Pump specialist.

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
GSHP – Heating	178 kW	1.5	3.767
GSHP – Cooling	192 kW	2.9	7.195
Total		4.4	10.962

Table 15 - Summary of CO_2 savings of GSHP

Issues for Consideration

- It will be necessary to accurately establish the ground thermal parameters using a Geothermal Response Test. This test will measure the ground thermal conductivity, heat capacity, temperature gradient and borehole resistance. Possible effects of natural ground water movement will be measured as well. Both the total size of the ground source heat exchanger as well as the optimal spacing between adjacent boreholes depends to a large extent on these parameters.
- Requires a detailed assessment by a geotechnical engineer and detailed design input from the structural engineers.
- Requires additional space within the plant room for the heat pumps and heat exchangers which is currently allowed.
- Will require additional calculation to ensure ground overheating and loss of COP does not occur. (geotechnical study).
- Further economical and thermal optimisation of the system will be required (to optimise selection of component capacities and ground source heat exchanger size).

6.7 Summary of Renewable and Low Carbon Energy Options

Technology	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)	Recommended
Low Carbon Options				
CHP	90 kWth, 60 kWe	0.4	1.045	No
CCHP	90 kWth, 60 kWe & 56 kW absorption cooling	0.9	2.201	No
Renewable Options				
GSHP – Heating	178 kW	1.5	3.767	Yes
GSHP – Cooling	192 kW	2.9	7.195	Yes
Solar Thermal Panels	7 m² (active panel area)	0.9	2.172	No
PV Panels	72 m² (active panel area)	1.9	4.678	Yes
Wind Turbines	4 x 1.5kW	0.4	1.264	No
Bio Mass Boiler	49 kW	1.7	4.274	No

Table 16 - Summarises the low and zero carbon technology options

6.8 Proposal for Planning Submission

Figure 16 below shows the matrix of low carbon and renewable technologies considered and how they can or cannot be integrated together. Those identified in the red and blue blocks are not compatible to be used together.

Based on the assessments undertaken, the following low carbon technologies were considered but are incompatible with one or more of the proposed technologies:

- Bio-mass heating - this is incompatible with the application of GSHP as the GSHP system meets part of the space heating demands. And GSHP is a preferable option because it serves both the cooling and heating loads in the building.

Bio-mass heating delivers 1.7% carbon saving with a potential for 3.6% when used in conjunction of PV panels. This 3.6% saving is lower than the recommended strategy using GSHPs with PV panels (6.3%).

- CHP and trigeneration - these are incompatible with the application of GSHP as the GSHP system meets part of the space heating demands and cooling demands.

  CHP or Trigeneration delivers a 0.9% carbon saving with a potential for 2.8% when used in conjunction with PV panels which is lower than the recommended strategy using GSHPs with PV panels (6.3%).

  There are also practical constraints of the use of CHP or Trigeneration, 1) Acoustic issues, 2) Additional heat rejection plant on the roof, which will reduce the area available for PV panels.

The following renewable technologies were also considered but not recommended:

- Wind turbines. 1) In this urban, the average wind speed may be below the threshold for them to operate, 2) the planning constraints such as sight lines and height restriction 3) vibration and noise issue.

	CHP	CCHP	GSHP	Solar Thermal	PV	Wind	Biomass
CHP	x						
CCHP		x	C				
GSHP		C	x				C
Solar Thermal				X			
PV					x	E	
Wind					E	x	
Biomass			C				x

	Competes for Roof Space
E	Competes for electricity
	Competes for Heating
C	Competes for Heating And Cooling

Figure 16 - Low carbon and renewable technologies integration matrix

To optimise the potential carbon savings, GSHPs to meet a proportion of the buildings heating and cooling demand are recommended and to be used in conjunction with PV panels. This solution can be integrated within the confines of the development. Table 17 indicates the potential CO_2 savings from the proposed low and zero carbon technologies.

This has been estimated to provide a maximum of up to 6.3% CO_2 reduction. This will be subject to further detailed geotechnical studies and design development during the detailed design stages.

	System Size	CO_2 Saving (%)	CO_2 Saving (tonnesCO_2/year)
Solar PV	72 m²	1.9	4.678
GSHP - Heating	178 kW	1.5	3.767
GSHP - Cooling	192 kW	2.9	7.195
Total		6.3	15.640

Table 5 - Summarises the proposed renewable technologies

The renewable energy study has indicated that the development can achieve 6.3% CO_2 saving via the application of onsite renewable energy technologies. There are technical and practical constraints that provide limitations on increasing the renewable CO_2 savings as details below:

Technical Constraints

1. Most of the Low or zero carbon emission technologies, such as GSHP, CHP, Tri-gen CHP, Bio-mass and solar thermal are targeting the heating demand of the building, and they can't be used together. The heating demand is relatively low for the development, and the building heating demand has been significantly reduced through a number of energy efficiency measures such as heat recovery system of ventilation system and high performance facade. Therefore, the carbon saving from heat targeting Low and Zero Carbon technologies are limited.

Practical Constraints

1. The proposed GSHP cooling system enhances the carbon saving of the building, however because of the site constraints; the size of the GSHP cooling system is limited. The limited site area in turn limits the number of boreholes, and hence the size of the GSHP. The number and positions of structural piles also influence the size of the GSHP as the boreholes need to be spaced apart from the structural piles.
2. Insufficient roof space limits the use of PV panels and wind turbines. The building has a small footprint, and the roof level also has a further reduced area due to the mansafe system, roof access panel, boiler flue termination and smoke vent opening. These further reduce the useable area for PV panels.
3. On the roof, the lift overrun is approximately 1.5m above the main roof level. This would result in the shading on the PV panels, and hence the output of the PV panels has been reduced. The PV panels can't be raised to 1.5m above roof level to overcome the shading issue, because of planning concerns.
4. The uncertainty of wind conditions in an urban environment, height restriction and sight lines make wind turbines an impractical renewable option for this building.

7. Summary

This section summarises how 262 High Holborn has been designed to address the Energy Hierarchy:

- Use less energy (be lean)
- Supply energy efficiently (be clean)
- Use renewable energy (be green)

Use Less Energy (be lean)
The building has been designed to be energy efficient. It benefits from good day lighting and has high efficiency lighting equipment and controls. High performance facades will be used, which will reduce the demands for cooling in the summer.

Proposed heating, cooling and ventilation system included a number of features which serve to reduce the heating energy requirements, these include:

Proposed Heating System

- Thermal wheel heat recovery with high operating efficiencies is proposed within all main AHUs. This significantly reduces the heating required to warm up incoming fresh air in winter.
- LTHW circuits have variable volume flow rates, which require less pump energy.
- TRV control to achieve more precise control and reduce wastage.
- Heating will be provided by high efficiency, low NOx, condensing boilers. All selected plant will exceed the minimum Building Regulation Part L2A efficiency requirement.
- Heating coils in the Air Handling Units will be operated at a lower water temperature, allowing the proposed Ground Source Heat Pump system to work at higher efficiency.

Proposed Cooling System

- Active chilled beams operate at a higher chilled water temperatures hence improving the efficiencies of the chillers
- Cooling will be provided by high efficiency air cooled chillers.
- Active chilled beams operate without the need of in built fan, with less energy consumption compared to the more standard Fan Coil Unit designs.
- All selected plant will outperform the minimum Building Regulation Part L2A efficiency requirement.

Proposed Ventilation System

- All fans operated with inverter control, the air volume would be modulated to suit demand. All fans will be driven by high efficiency EC/DC motors.
- All selected plant will outperform the minimum Building Regulation Part L2A efficiency requirement.

Proposed Lighting System

- All general lighting within the building will consist of high efficiency luminaires, with some decorative and specialist lighting in the reception area. If LED lighting is considered in later stages of design, the lighting energy could be further reduced.
- The proposed programmable lighting controls will utilise movement detectors and daylight linking to decrease energy demands.

Supply Energy Efficiently (be clean)
CHP and CCHP have been included as part of this study, and have been discounted as the site is small compared to those where a CHP or CCHP plant would be considered practical.

Use Renewable Energy (be green)
Potential CO_2 savings and capital costs from the following technologies have been reviewed for incorporation into 262 High Holborn

- Building Mounted Wind Turbines
- Photovoltaic
- Solar Water Heating
- Biomass Heating

- Ground Source Heating
- Ground Source Cooling

The proposed solution is to use a combination of Photovoltaic panels and Ground Source Heating and Cooling, which combined produce CO_2 emissions savings of 6.3%.

Summary

The energy demand of this building has been significantly reduced through a number of energy efficiency measures. In addition to the energy efficiency measures, the building will include renewable technologies in the form of ground source heating/cooling, PV panels to provide 6.3% of the predicted building CO_2 emissions

8. Appendix A - Background Information, Low and Zero Carbon Technologies

CHP

A CHP plant is an installation where there is simultaneous generation of usable heat and power in a single process. The basic elements of a CHP plant comprise one or more prime movers usually driving electrical generators, where the heat generated in the process is utilised via suitable heat recovery equipment for a variety of purposes including: industrial processes, community heating and space heating. More recently the heat generated has been used to drive absorption cooling as a way of utilising the heat throughout the year. This type of installation is often referred to as trigeneration or CCHP (Combined Cooling, Heating & Power).

The main factor in the economic viability of CHP is the difference between the cost of electricity and gas, referred to as the “spark gap”. CHP is more likely to be viable, the greater the cost difference between the two fuels.

Wind Turbines

Wind energy can be one of the most cost effective methods of renewable power generation. Wind turbines can produce electricity without carbon dioxide emissions ranging from Watts to Megawatt outputs.

Small turbines of 1 to 2.5 kW can be mounted on buildings and whilst there are currently few practical implementations of building mounted wind turbines in the UK, there is potential for this technology to become fairly common, as several manufacturers are gearing up for mass production. These products achieve relatively good carbon savings compared to their cost, they typically range in price from around £2,000 to £30,000 and are rated between 1 and 6kW.

The small scale or micro turbines have a diameter of around two metres and require mounting on a pole which increases the turbine overall height to at least 4m. Typically these turbines are mounted above roof level, as the increased height usually means greater wind speeds.

Wind turbines on buildings are usually very visible and can have implications on planning especially in conservation areas.

In an urban environment, the wind speeds experienced even at roof level are often insufficient for the turbines to operate for much of the time.

Solar Water Heating

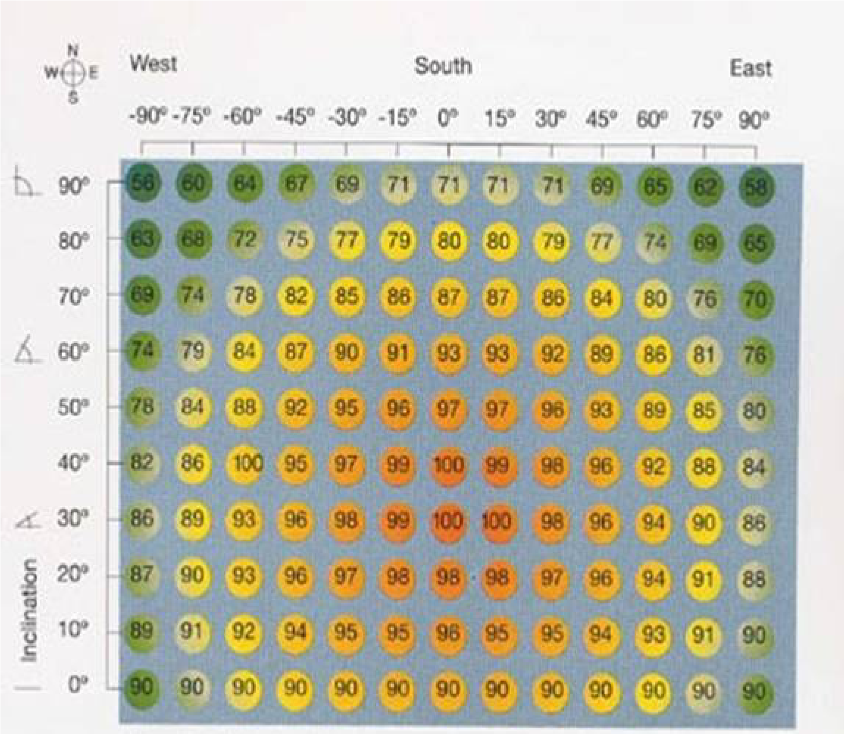
There are two standard types of collectors used - flat plate collectors and evacuated tube collectors. The flat plate collector is the predominant type used in solar domestic hot water systems, as they tend to have a lower cost for each unit of energy saved. Evacuated tube collectors are generally more expensive due to a more complex manufacturing process (to achieve the vacuum) but manufacturers generally claim better winter performance.

	
Filsol flat plate system on Wedgewood Visitor Centre (photo courtesy of John Blower), serving washrooms	*Viessmann evacuated tube system, London Borough Of Camden (photo courtesy of LB Camden), serving washrooms for office accommodation, library and health centre.*

Photovoltaic

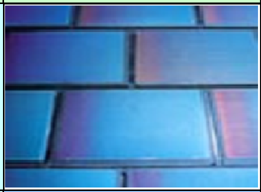
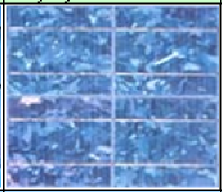
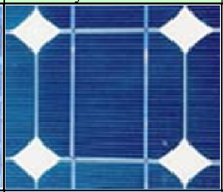
Photovoltaic (PV) systems convert energy from the sun into electricity through semi conductor cells. Systems consist of semi-conductor cells connected together and mounted into modules. Modules are connected to an inverter to turn their direct current (DC) in to alternating current (AC), which is usable in buildings. PV can supply electricity either to the buildings they are attached to, or when the building demand is insufficient electricity can be exported to the electricity grid.

For PV to work effectively it should ideally face south and at an incline of 30º to the horizontal, although orientations within 45º of south are acceptable. It is essential that the system is non-shaded, as even a small shadow may significantly reduce output. The figure below shows how PV efficiency varies depending on panel orientation and pitch.



Solar Sundial showing energy yield relative to the inclination and orientation of your roof

PVs are available in a number of forms including monocrystalline, polycrystalline, amorphous silicon (thin film) or hybrid panels that are mounted on or integrated into the roof or facades of buildings. The table below from PV supplier Solar Century shows carbon savings per metre squared or output of panel for all the various forms, which is useful for comparing the various PV technologies currently available.

	'Thin Film'	Polycrystalline	Monocrystalline	'Hybrid'*
Appearance				
Description	The most efficient in poor light conditions. An extremely sturdy, vandal-proof PV.	Also highly efficient in good light conditions. Less embodied energy than monocrystalline.	The most efficient of the PV technologies in good light conditions	A combination of monocrystalline and thin-film technologies, this has high peak output coupled with excellent performance in poor light conditions
Efficiency at STC**	Good 7 - 8%	Very good 11 - 13%	Very good 14 - 16%	Excellent 17 - 19%
Efficiency in overcast conditions	Excellent	Good	Good	Excellent
Area needed per kWp***	Kaneka module: 15.5m2 Unisolar modules: 16m2	Sharp modules: 8m2	Sharp modules: 7m2	Sanyo modules: 6.5m2
Area needed per kWp	Solar metal roofing: 23.5m2 Glass-glass laminate: 25m^2	C21 tile: 10m2 Glass-glass laminates: 10m^2 - 30m^2	Sunslate: 10m2 Glass-glass laminates: 8m^2 - 30m^2	n/a
Annual energy generated per kWp	900 kWh/kWp	750 kWh/kWp	750 kWh/kWp	900 kWh/kWp
Annual energy generated per m^2	55 - 60 kWh/m^2	90 - 95 kWh/m^2	105 - 110 kWh/m^2	125 - 135 kWh/m^2
Annual CO_2 savings per kWp	390 kg/kWp	325 kg/kWp	325 kg/kWp	390 kg/kWp
Annual CO_2 savings per m^2	25 kg/m^2	40 kg/m^2	45 kg/m^2	55 - 60 kg/m^2
Annual Carbon savings per m^2	6.8 kgC/m^2	10.90 kgC/m^2	12.27 kgC/m^2	15 - 16.36 kgC/m^2

* 'Hybrid' PV combines both monocrystalline and thin-film silicon to produce cells with the best features of both technologies
** Standard Test Conditions are: 25 °C, light intensity of 1000W/m2, air mass = 1.5
*** kWp = kilowatt 'peak'. Solar PV products and arrays are rated by the power they generate at STC

PV system size is measured in kWp. This is the peak possible kW output. A 1kWp polycrystalline system will cost around £5,500 and will generate around 750kWh of electricity a year. The size of the PV systems can be varied to match the carbon saving required.

A relatively new PV mounting system called Solion Sunmount, provides a neat solution for flat roofs, using an interlocking mounting system where integral PV panel system are inclined at 10 degrees. Solion Sunmount panels can be placed on flat roofs without requiring any roof penetrations, so will not interfere with the integrity of the roof.

Another option for flat roofs is the Kalzip AluPlusSolar system, which involves a flexible PV laminate (PVL) adhered to the surface of a specific Kalzip profiled standing seam roof, constructed in the normal manner and still retaining the full choice of structural decking, liner deck or tray. The system can be installed on roofs inclined from 3.5º to 60º.

PV panels angled at 10º on flat roofs

Kalzip AluplusSolar standing seam roof

Biomass Heating

Biomass is normally considered a carbon neutral fuel, as the carbon dioxide emitted during burning has been (relatively) recently absorbed from the atmosphere by photosynthesis and no fossil fuel is involved. The wood is normally seen as a by-product of other industries and the small quantity of energy for drying, sawing, pelleting and delivery are discounted. Biomass from coppicing is likely to have some external energy inputs, for fertiliser, cutting, drying etc. and these may need to be considered in the future. Currently the London Mayors' Energy policy considers biomass fuels to have zero net carbon emissions.

Wood from forests, urban tree pruning, farmed coppices or farm and factory waste can be burnt directly to provide heat in buildings, although nowadays most of these wood sources are commercially available in the form of wood chips or pellets, which makes transport and handling on site easier.

Modern systems can be fed automatically by screw drives from fuel hoppers. This typically involves daily addition of bagged fuel to the hopper, although this process can also be automated with use of augers, conveyors or walking floors. Electric firing and automatic de-ashing are also available and systems are designed to burn smokelessly to comply with the Clean Air Act.

The most common application of biomass heating is as one or more boilers in a sequenced (multi-boiler) installation where there is a communal or district heating system.

Issues which can prevent uptake up biomass boiler technology are:

- On site access problems for large lorries delivering wood chip, especially for urban locations
- Lack of space for a large fuel storage area in the basement plant area of the building (and therefore a need for more frequent loads of fuel to be delivered by a lorry to the site).
- Lack of an adequate supply chain in place *currently* to provide a regular and cheap biomass supply.

Ground Source Heat Pumps

Ground source heat pumps use the refrigeration cycle to take low grade heat from the ground (a renewable resource) and deliver it as higher grade heat to a building. Heat pumps take in heat at a certain temperature and release it at a higher temperature, using the same thermodynamic process as a chiller. As the ground stays at a fairly constant temperature throughout the year (ground source temperature in London is typically 12°C) heat pumps can use the ground as the source of heat. The ground temperature is not necessarily higher than ambient air temperature throughout the entire winter but it is more stable whereas air has a greater temperature range.

The technology is very efficient, typically delivering 3-5 units of heat for every 1 unit of electrical power consumed. Limiting factors are the rate at which energy can be drawn out of the ground and the maximum temperatures at which heat can be delivered to the building (typically 50-55°C). The measure of efficiency of a heat pump is given by the Coefficient of Performance (CoP), which is defined as the ratio of the output, divided by quantity of energy put in. Annual seasonal CoPs of 3 or more are achievable with ground sourced heat pump systems, giving good energy and running cost savings.

Whilst a ground sourced heat pump is clearly not a wholly renewable energy source as it uses electricity, the renewable component is considered as the heat extracted from the ground, measured as the difference between the heat outputs, less the primary electrical energy input.

Typical ground sourced heating systems will use vertical boreholes for installing the piping system. When considering buildings with piled foundations, the pipes can be integrated in the design using several piling systems.

View down a ground source energy pile

Ground level view – ground source energy pile

For heating systems, the thermal energy extracted from the ground via the foundation structures is then raised to a higher temperature, suitable for heating purposes by the heat pump. While the average temperature to be found in the concrete foundations is in the region of 12°C, the heat pump increases the temperature between 25°C and 40°C in the heat transfer medium (water or mixture of water and anti-freeze), which is suitable for radiant heating systems such as floor slab or concrete core heating.

These systems can be used for both heating and cooling purposes. The heat transfer medium, which circulates through the integrated piping system is cooled by the ground in the summer and heated in the winter. For cooling systems, water can be introduced directly in the building or if the capacity of the soil is inadequate, a refrigerator unit or a reversible heat pump can be integrated into the system. When the system is used both for heating and cooling the building, the investment and running costs are particularly economical as the cool ground temperatures can be used at virtually no cost. The energy obtained can be used in conventional air-conditioning systems, low-temperature heating systems, wall, floor and ceiling heating systems and also chilled ceilings.

In the case of piles or other foundation structures, closed circuits of piping are incorporated in the concrete. The piping units are either attached to the reinforcing cages at the factory or on site. The rigged cages are then placed in the locations determined by the structural engineer and cast in the concrete. The individual circuits are subsequently joined up via connecting lines. Pipes are laid primarily in the ground slab and along the exterior face of the outer wall of the building, which is in contact with the soil.

Energy piles can be used in several different structures, depending on the structural engineering requirements of the building and the soil conditions.

A ground water system can be either a closed or open loop system. In a closed loop system, water (or another fluid) is circulated through pipes buried in the ground and passes through a heat exchanger in the heat pump that extracts heat from the fluid. In an open system, water is pumped out of the ground, through the heat exchanger and into a waste water system or discharged directly back to the aquifer.

Detailed geological/geotechnical assessment is required on a site by site basis to ensure that sufficient energy can be extracted from the ground on each site. The ease of which energy piles or open injection, abstraction bore holes can be drilled is dependant of the site specific geology. The yield of the open boreholes or limitations on the number of piles can limit energy which can be extracted from the ground.

9. Appendix B - Energy Modelling / Part L Input Summary

IES Model Input Summary				
	TER (Notional Building)	BER (Actual Building)		
	Base Line	Energy Efficiency	GSHP	GSHP and PV
FABRIC U values	W/m2K			
Roof	0.18	0.18	0.18	0.18
Wall	0.26	0.22	0.22	0.22
Ground Floor	0.22	0.2	0.2	0.2
Windows	1.8 (G 0.40)	1.1 (G value 0.27)	1.1 (G value 0.27)	1.1 (G value 0.27)
Internal Wall	1.8	1.8	1.8	1.8
Internal floor/ceiling	1	1	1	1
Air Permeability (m3/h.m2 @50Pa)	5	5	5	5

IES Model Input Summary				
	TER (Notional Building)	BER (Actual Building)		
	Base Line	Energy Efficiency	GSHP	GSHP and PV
OFFICE TEMPLATE				
Heating (°C / profile)	22 / NCM	22 / NCM	22 / NCM	22 / NCM
Cooling (°C / profile)	24 / NCM	24 / NCM	24 / NCM	24 / NCM
DHW l/(h.p)	0.2002	0.2002	0.2002	0.2002
Plant Aux Energy	NCM	NCM	NCM	NCM
System	NB side/no-lit HH Base Case system	HH Base Case system	HH Base Case system	HH Base Case system
Occupancy Density (m2/p)	9.01	9.01	9.01	9.01
Lighting (gain / power)(w/m2)	8.6	8/ 1div,Photo&Dimm	8/ 1div,Photo&Dimm	8/ 1div,Photo&Dimm
Equipment	11.68 / 11.76	11.68 / 11.77	11.68 / 11.77	11.68 / 11.77
Aux vent (l/s/p)	10	10	10	10
TOILET TEMPLATE				
Heating (°C / profile)	20 / NCM	20 / NCM	20 / NCM	20 / NCM
Cooling (°C / profile)	25 / NCM	25 / NCM	25 / NCM	25 / NCM
DHW l/(h.p)	0	0	0	0
Plant Aux Energy	NCM	NCM	NCM	NCM
System	NB side/no-lit HH Base Case system toilet	HH Base Case system toilet	HH Base Case system toilet	HH Base Case system toilet

Occupancy Density (m2/p)	8.89	8.89	8.89	8.89
Lighting (gain / power)(w/m2)	10	8/ 1div,Photo&Dimm	8/ 1div,Photo&Dimm	8/ 1div,Photo&Dimm
Equipment	5.48	5.48	5.48	5.48
Aux vent (l/s/m2)	1.35	1.35	1.35	1.35
CORRIDOR/STAIR TEMPLATE				
Heating (°C / profile)	20 / NCM	20 / NCM	20 / NCM	20 / NCM
Cooling (°C / profile)	23 / NCM	23 / NCM	23 / NCM	23 / NCM
DHW l/(h.p)	0	0	0	0
Plant Aux Energy	NCM	NCM	NCM	NCM
System	NB side/no-lit HH Base Case system	HH Base Case system	HH Base Case system	HH Base Case system
Occupancy Density (m2/p)	8.52	8.52	8.52	8.52
Lighting (gain / power)(w/m2)	3.54	10 / 2.2 (stair)	10 / 2.2 (stair)	10 / 2.2 (stair)
Equipment	1.85	1.85	1.85	1.85
Aux vent (l/s/m2)	1.17	1.17	1.17	1.17
ENTRANCE TEMPLATE				
Heating (°C / profile)	20 / NCM	20 / NCM	20 / NCM	20 / NCM
Cooling (°C / profile)	23/ NCM	23 / NCM	23 / NCM	23 / NCM
DHW l/(h.p)	0.0331	0.0331	0.0331	0.0331
Plant Aux Energy	NCM	NCM	NCM	NCM
System	NB side/no-lit HH Base Case system	HH Base Case system	HH Base Case system	HH Base Case system
Occupancy Density (m2/p)	8.52	9.92	9.92	9.92
Lighting (w/m2)	4.7 Lit - 6.13 LitD	16 Lit,9 LitD,Photo&Dimm	16 Lit,9 LitD,Photo&Dimm	16 Lit,9 LitD,Photo&Dimm
Equipment	6.19	6.19	6.19	6.19
Aux vent (l/s/m2)	1.0083	1.0083	1.0083	1.0083
PLANT TEMPLATE				
Heating (°C / profile)	OFF	OFF	OFF	OFF
Cooling (°C / profile)	NCM OFF	NCM OFF	NCM OFF	NCM OFF
DHW l/(h.p)	0	0	0	0
Plant Aux Energy	NCM	NCM	NCM	NCM
System	NB side/no-lit HH Base Case system PLANT/STORE	NB side/no-litHH Base Case system PLANT/STORE	NB side/no-litHH Base Case system PLANT/STORE	NB side/no-litHH Base Case system PLANT/STORE
Occupancy Density (m2/p)	9.09	9.09	9.09	9.09

Lighting (gain / power)(w/m2)	4.803	10 / 0.3 diversity	10 / 0.3 diversity	10 / 0.3 diversity
Equipment	52.5	52.5	52.5	52.5
Aux vent (l/s/m2)	1.1	1.1	1.1	1.1
STORE TEMPLATE				
Heating (°C / profile)	OFF	OFF	OFF	OFF
Cooling (°C / profile)	23 / NCM OFF	23 / NCM OFF	23 / NCM OFF	23 / NCM OFF
DHW l/(h.p)	0	0	0	0
Plant Aux Energy	NCM	NCM	NCM	NCM
System	NB side/no-lit HH Base Case system PLANT/STORE	HH Base Case system PLANT/STORE	HH Base Case system PLANT/STORE	HH Base Case system PLANT/STORE
Occupancy Density (m2/p)	9.09	9.09	9.09	9.09
Lighting (gain / power)(w/m2)	4.803	8 / 0.3 diversity	8 / 0.3 diversity	8 / 0.3 diversity
Equipment	52.5	52.5	52.5	52.5
Aux vent (l/s/m2)	1.1	1.1	1.1	1.1

IES Model Input Summary				
	TER (Notional Building)	**BER (Actual Building)**		
	Base Line	**Energy Efficiency**	**GSHP**	**GSHP and PV**
MAIN SYSTEM OFFICES	**ASHP, ASChiller, MVHR**	**LTHW boiler, ASChiller, MVHR**	**GSHP, ASChiller, Boiler MVHR**	**GSHP, ASChiller, Boiler MVHR**
NCM Type	Active chilled Beams	Active chilled Beams	Active chilled Beams	Active chilled Beams
Heating Seas. Ef. / SCoP	2.43 / 2.19	0.8765 / 0.7987	4.48/ 4.08	4.48/ 4.08
HW SCoP	2.43 / 2.20	0.8765 / 0.7987	4.4 8/ 4.08	4.4 8/ 4.08
Cooling SEER / SSEER	3.15 / 2.84	3.93 / 3.61	5.21 / 6.34 / 5.21	5.21 / 6.34 / 5.21
Heat Recovery	70	75	75	75
SFP (W/l/s)	1.8	2.1	2.1	2.1
Pumps W/m2	0.9	1.5	1.5	1.5
MAIN SYSTEM TOILETS	**ASHP, Extract only**	**LTHW boiler (Radiators), Extract only**	**GSHP, Boilers, Extract only**	**GSHP, Boilers, Extract only**
NCM Type	Central heating using water: radiators	Central heating using water: radiators	Central heating using water: radiators	Central heating using water: radiators
Heating Seas. Ef. / SCoP	2.43 / 2.19	0.8765 / 0.8233	4.35 / 4.08	4.35 / 4.08
HW SCoP	2.43 / 2.20	0.8765 / 0.8233	4.35 / 4.08	4.35 / 4.08
Cooling SEER / SSEER	-	-	-	-

Heat Recovery	-	-	-	-
SFP (W/l/s)	0.6	0.6	0.6	0.6
Pumps W/m2	0.3	0.6	0.6	0.6
MAIN SYSTEM PLANT/STORE	**ASHP, MVHR**	**LTHW boiler (Radiators), MVHR**	**GSHP, Boilers, MVHR**	**GSHP, Boilers, MVHR**
NCM Type	Central heating using water: radiators	Central heating using water: radiators	Central heating using water: radiators	Central heating using water: radiators
Heating Seas. Ef. / SCoP	2.43 / 2.19	0.8765 / 0.7987	4.35 / 4.08	4.35 / 4.08
HW SCoP	2.43 / 2.20	0.8765 / 0.7987	4.35 / 4.08	4.35 / 4.08
Cooling SEER / SSEER	-	-	-	-
Heat Recovery	70	45	45	45
SFP (W/l/s)	1.8	1.8	1.8	1.8
Pumps W/m2	0.3	0.5	0.5	0.5
Renewables				
PV panels area (m2)	-	-	-	72
PV Array type	-	-	-	Monocristaline silicon
PV module nominal efficiency	-	-	-	0.201

Unregulated energy assumptions:

Small power calculation based on NCM template.

Lifts annual consumption based on 15.9 kWh/day/lift for 3 lifts.

Over door heater annual consumption based on 3kW heater working when temperature outside is below12°C and Building occupied (weekdays 7am to 7pm)

10. Appendix C - Ground Source Heat Pump proposal

Ground Source System Proposal

Prepared for

Meinhardt (UK) Ltd

New Penderel House

283-288 High Holborn

London

WC1V 7HP

Edward Chan & Joan Senent

Prepared by

ENER-G Sustainable Technologies

Trevor Day

Quote reference	Date
Q13/0212	*March 2013*

ENER-G Ground Source Solutions Limited
4a Hamilton Way, Oakham Business Park
Mansfield, Nottinghamshire
NG18 5BU
T: +44 (0)1623 666 340 F: +44 (0)1623 666 341
E: heatpumps@energ.co.uk
W: www.energ.co.uk/heatpumps

PROJECT TITLE

QUOTE REF Q13/0212

Total Price £ 153,534.00*

Valid for 30 days from date of issue.

Our price is fixed to 21/06/2013

Contents Amendment Record

This proposal has been issued and amended as follows:

Revision	**Date of issue**	**Amended by**
A	21/02/2013	Trevor Day
B	19/03/2013	Trevor Day

Record of Acceptance

We confirm acceptance of this proposal and confirm ENER-G Ground Source Solution Ltd are to commence works in accordance with this Proposal and our terms and conditions which are enclosed.

Signed for and on behalf of:	
Signed:	
Name:	
Title:	
Date:	

ENER-G Sustainable Technologies is a trading name of ENER-G Ground Source Solutions Ltd and any acceptance is Subject to ENER·G Ground Source Solution Ltd's terms and conditions enclosed.

Table of Contents

Contents

Introduction

The following document outlines ENER-G Sustainable Technologies proposal to develop the design, supply, install, test and commission the ground source heat pump system for the following project : -

Project Title:	1674 High Holborn
Project Address	London WC1V

To allow us to compile our proposal for the above project we have been issued with the documentation and information listed within the schedule in section eight of this proposal.

In addition to the above information provided, we have reviewed the local geology of the site using our in-house British Geology Survey maps and our own Bore Hole Log/Drilling Records.

Given the information provided we offer a solution as outlined below and described in section 4.

Heating Requirement	-	168kW
Cooling Requirement	-	137kW
Heat Pump Number	-	1
Main Header Trench Length	-	30m
Bore Hole Number	-	14

In addition to the above we reserve the right to undertake any tests to ratify the information provided.

In summary our price includes for a closed loop ground source system comprising a ground loop pipe work arrangement, trenching and backfilling in association with, ground source heat pumps, variable speed ground loop circulation pump set and associated equipment (subsequently noted) to allow for a hydraulically arranged installation of the ground loop and plant room.

Our installation also includes for a low loss header arrangement comprising a building side pipe work arrangement, circulation pumps and associated equipment also subsequently noted to allow for a hydraulically arranged installation from the building side of the heat pumps to the buffer vessel arrangement all as per our scope of works.

Our ground loop model is based on the annual load profile or peak heating and cooling loads/information provided but to summarise, we have based our design on 56,445kWh of Cooling and 33,078kWh of heating.

The ground loop model is extended over a 50 year period to indicate the long term effect of the annual load profile on the ground loop.

We provide a solution that includes design, and as such, systems based on our design are offered with design liabilities (PI Cover). We also offer initial heat pump manufacturer's warranty of 12 months.

Proposal Cost Summary

Item	Deliverable	Cost (£)
1.0	Conductivity Test	**£4,332.00**
2.0	Design	**£3,221.00**
3.0	Ground Loop Installation	**£78,968.00**
4.0	Plant Room Installation (including heat pumps)	**£61,872.00**
5.0	Power Distribution and Electrical	**Excluded**
5.1	Controls, Energy Metering & Monitoring	**Excluded**
6.0	Final Testing & Commissioning	**£4,647.00**
7.0	Operation & Maintenance Manuals	**£495.00**
	Total Cost Excluding VAT	**£153,534.00**

Please note that extended warranty periods may be available on request. Maintenance contracts can also be provided.

The performance of Microgeneration heat pump systems is impossible to predict with certainty due to the variability of the climate and its subsequent effect on both heat supply and demand. This estimate is based upon the best available information but is given as guidance only and should not be considered as a guarantee.

Our proposal is based upon the following working hours:-

Monday to Friday 07:30 to 18:00 inclusive (excluding Bank Holidays)

System Outline

3.1 Schedule of Heat Pumps

Item	Heat Pump Manufacturer	HP Model	Qty	Heating Capacity (kW)	Heating flow/return (DegC)	Cooling Capacity (kW)	Cooling flow/return (DegC)
01	CLIVET	WSHN-XEE 602	1	178kW	50/45^{o}C	192kW	7/12^{o}C

Note: Exact GSHP to be used will be dependent on status of possible RHI funding specifications if applicable, EST are an MCS accredited company.

3.2 Schedule of Auxiliary Equipment

Item	Equipment	Model	Qty	Capacity	Notes
01	Loop Circulation Pump	TBC	1	TBC	Twin head close coupled variable speed
02	System Circulation Pump	TBC	1	TBC	Twin head close coupled variable speed
03	Buffer Vessel	TBC	2	TBC	Insulated BSP connections

3.3 Test Bore Holes

The total number of boreholes stated does not include any test borehole installed under a separate contract.

System Description

4.1 Design

The following items are included within our design and will form our final Technical Submission for the scheme

Ground Loop Design

Mechanical Design of Ground Loop

Mechanical Design of our Plant Room installation

Equipment Selection and Approvals

Please note that all drawings will be submitted for, and follow the approvals process prior to our works commencing. In completing our designs, we will work closely with all relevant parties so that our designs are reasonably co-ordinated with existing/ proposed below ground services. We are not however, responsible for the final co-ordination of below ground services.

4.2 Ground Loop Heat Exchanger Arrangement – Vertical Bore Holes

Working from our approved design drawings our installation works for this element will generally be as follows.

4.2.1 Set-up & Drilling

Prior to commencing of any drilling works, a drilling programme will be discussed and agreed with the relevant parties. With the assistance/attendance of the site engineer, our boreholes will be set out as per our approved design drawings. It is essential that we work in close co-ordination with the ground worker and main contractor whilst we set up our drilling equipment and undertake our drilling works.

On agreement to the above we will set up and drill the boreholes. A twin 32mm or 40mm U tube will be installed. Boreholes will be grouted/backfilled with an appropriate material to suit ground conditions and where possible enhance thermal conductivity.

In the event that drilling design depths cannot be achieved during our works ENER-G Ground Source Solutions Ltd reserve the right to alter our design in accordance with the specific site conditions.

4.2.2 Trenching

As per our approved design drawings, we will excavate trenches to accommodate our ground loop pipe work, manifold chambers and flow and return pipe work to the building. We will work in close co-ordination with all relevant parties to plan and execute these works.

Trenching will be up to 1200mm deep by up to 900mm wide and, subject to site conditions may decrease in width and depth. Trenches will be backfilled with an initial bedding layer of up to 50mm, on which our ground loop pipe work will be placed. The ground loop pipe work will be provided with a covering layer of up to 300mm of sand or similarly graded material. marker tape will be placed directly onto the upper layer of sand.

Trenches will then be backfilled and compacted in layers to 100mm below finished ground level. If excavated material is deem unsuitable then suitable backfill material will be provided free issue to ENER-G Ground Source Solutions Ltd by others. Finished levels to be provided by others.

4.2.3 Ground Loop Pipe Work Installation

We will install and pipe up as per our design drawings our HDPE/MDPE ground loop pipe work. Our ground loop will be arranged with resilience in mind with header pipes returning to a series of manifolds. Manifold chambers are supplied and installed by ENER-G Ground Source Solutions Ltd .

The pipe work will then route to and rise into the plant room.

4.3 Not Applicable

4.4 Plant Room Installation

Working from our approved design drawings our installation works for this element will generally be as follows.

4.4.1 Plant Room Arrangement

As per our approved design drawings we will supply and undertake the final position of the heat pumps and ground loop circulation pump. ENER-G Ground Source Solutions Ltd will supervise the offloading and initial positioning of the heat pumps.

From the riser location we will route suitably sized pipe work to/from the ground side of heat pumps and ground loop circulation pump. This pipe work installation will include all relevant valving so that the heat pumps and circulations pumps can be operated and maintained.

This hydraulic installation will include any relevant mechanical plant to allow for the operation of the ground loop circulation pump and the removal of dirt and air from the system.

From the building side of the heat pumps we will also supply and install the buffer vessel as per our design including associated valves, pipe work, circulation pump and equipment between the heat pumps and buffer vessel only.

4.5 Power Distribution and Electrical Installation

Our scope with regard to design, supply and installation of power distribution, electrical systems and controls is detailed below.

4.5.1 Power Distribution

We have not included within our solution to undertake any power distribution works in association with our installation.

4.5.2 Electrical Installation

We have not included within our solution to undertake any electrical works in association with our installation.

We will work closely with your electrical contractor and provide all relevant electrical information for our equipment in a timely fashion, all as part of our technical submission to assist you with these works.

4.6 Controls, Energy Metering & Monitoring

4.6.1 Controls

We have not included within our solution to undertake any controls works in association with our installation.

We will work closely with your controls specialist and provide all relevant controls information for our equipment in a timely fashion, all as part of our technical submission to assist you with these works.

4.6.2 Energy Metering & Monitoring

We have not included at this stage within our solution, to supply or install any heat or electrical energy monitoring equipment.

We can (on request) supply and install heat meters within our solution. The final scope can be agreed.

We can also (on request), provide electrical meters for our equipment. The installation of electrical meters is by others.

4.6.3 Refrigerant Leak Detection

We have not included at this stage within our solution, to supply or install any refrigerant leak detection or monitoring equipment.

We can (on request) supply and install refrigerant leak detection within our solution. The final scope can be agreed.

4.7 Testing & Commissioning

The below outlines our testing and commissioning for both our ground loop installation and our plant room installation.

4.7.1 System Pressure Testing, Cleaning & Treatment

a. Pressure Testing

Prior to pressure testing the ground loop will be filled and flushed with mains water provided by others. Air will be removed during this process. The ground loop will be pressure tested (generally) in a number of stages. The U tubes or loops will be individually tested. Zones or circuits will also be individually tested. The ground loop will be tested and remain under pressure on completion of the complete system.

b. Cleaning & Treatment

On successful completion of the ground loop pressure test, allow for system flushing and cleaning with a cleaning agent. Allow for biocide-al and antifreeze treatment of the system. Include test results in system operation and maintenance manuals.

Our works within the plant room will also be filled, flushed, pressure tested, cleaned and treated.

Water supplies and discharge licenses in association with the loop filling, flushing, cleaning and treatment of the system are by others.

4.7.2 Plant & System Testing & Commissioning

a. Ground Loop Commissioning

Allow for hydraulic commissioning of the ground loop.

b. Heat Pumps

Allow for commissioning and testing of the heat pumps. Electrical supplies, and connections to the heat pumps by others.

c. Variable Speed Circulation Pumps

Allow for hydraulic commissioning of the ground loop circulation pump. Electrical and controls testing/commissioning by others.

d. Pressurisation Unit

Allow for hydraulic commissioning of the pressurisation unit. Mains water supply to and connections to drain by others. Electrical and controls testing/commissioning by others.

We will work closely with your electrical contractor and controls specialist and provide all relevant information for equipment in a timely fashion.

4.7.3 Operation & Maintenance Submittals and Handover

Provide as installed drawings, system instruction, O&M submittal for inclusion in your O&M manual.

Attendances

Item	Attendance	Description	Comment
01	Parking	Works vehicle parking	On or adjacent to site.
02	Access	Unrestricted safe access to our works is required at all times.	No allowances have been made for restricted access to our works.
03	Site Storage	For ENER-G Sustainable Technologies Parts and equipment	Shared container is required as a minimum
04	Site Desk	“Hot” desk allocation for ENER-G Sustainable Technologies Project Manager / Site Supervisor	On Site
05	Welfare Facilities	Shared welfare facilities provided by others.	-
06	Power Supply	110 Volt	To a point adjacent to our works.
07	General Lighting	To assist with the plant room installation. Task lighting by EST.	May be required during the ground loop installation.
08	Setting Out	Borefield and trenching setting out by others.	As per ENER-G Sustainable Technologies design drawings, as minimum we require each corner of the bore field or either end of each row of bores.
09	Site Fencing	To protect our works from other site operatives	“Zonal” protection of our works by others. Local protection by ENER-G Sustainable Technologies
10	Signage	Health and Safety signage in association with “zonal”protection	
11	Spoil Removal	During both drilling and trenching works	EST will pile spoil within 30m of borefield final removal from site by others.
12	Telescopic fork truck or similar	For off-loading materials and deliveries during ground loop and plant room installations.	Materials to placed on or near the works by others. Final positioning by ENER-G Sustainable Technologies
13	Water Supply	To fill, flush, test, clean & treat the installation	50mm (2”) **mains pressure** water supply is required adjacent to the works.
14	Piling Mat	Design, provision and maintenance of a suitable working platform by others.	Plant loads provided by EST on request.
15	Logging	Daily logging of ground loop pressure gauges	To monitor ground loop pressure whilst between phases of work.

The above attendances are to be provided without charge.

Builders Work by Others

Item	Builders Work	Description	Comment
01	Building Penetrations	To allow the ground loop pipe work to enter the building	Sleeve’s, de-bonding and water proofing by others
01a		To allow the ground loop pipe work to pass through walls and floors.	Sleeve’s, de-bonding and water proofing by others
01b		To allow the ground loop pipe work to pass through fire partitions	Sleeves, intumescent strips/dampers/valving/fire protection by others
02	Plinths	Concrete “plant room” plinths to support heat pumps and associated equipment.	By others.
03	Inertia Bases	Inertia base by others.	
04	Concrete Bases	Concrete pads to support manifold chambers	By others.
05	Chambers Lids	Setting to finish level(s) of chamber access lids including brick courses and concrete haunches in association with.	By others
06	Pipe supports	Supply and construction of primary or secondary frame work to support pipework brackets	By others.

Exclusions

Item	Exclusion	Description	Comment
01	Site Surveys	To determine existing below ground services. Including unexploded bombs	Location, identification and final co-ordination of our works with existing below ground services by others. ENER-G Sustainable Technologies will assist only during the co-ordination works.
02	Below Ground Conditions	ENER-G will not be responsible for any costs in association with the any below ground conditions not accordance with the BGS records.	
03	Licenses	Water supply and discharge licenses/consents	By others.
04	Insulation and cladding	All insulation and cladding	By others
05	Anti-vibration	Anti-vibration mounts to heat pumps and circulation pumps to prevent structural borne noise	If required. By others.
06	CRB Checks	Criminal Record Bureau checks.	Costs in association with applications or delays incurred.
07	Approvals	Local authority, planning or building control approvals – London Underground	By others
08	Steel Plates	To bridge excavations during excavations works if required.	By others.
09	Contaminated land	Ground loop installations in contaminated land	Costs to comply with the specification of our ground loop installation within contaminated land have been excluded.
10	Breaking out of rock	Costs associated with the breaking out of rock within all horizontal trenched excavations.	By others.

Schedule of reference information and documentation.

Our Quotation ref Q120212 is based upon the following information issued to us as detailed below.

DRAWINGS

INFORMATION	DOCUMENT REF	DOCUMENT TYPE	REVISION / DATE	ISSUED BY	ISSUED DATE
Site Plan					
Plant Room Layout					
Site Location Plan					
Building Layout	4728-20-200	DWG/PDF	16/11/2012	Joan Senent	07/02/2013
System Schematic					

SPECIFICATION

INFORMATION	DOCUMENT REF	DOCUMENT TYPE	REVISION / DATE	ISSUED BY	ISSUED DATE
Load profiles	1674-262-267 High Holborn Energy Calcs.	Excel	19/02/2013	Joan Senent	19/02/2013
Mech Serv Specification					

SITE / GEOLOGY INFORMATION

INFORMATION	DOCUMENT REF	DOCUMENT TYPE	REVISION / DATE	ISSUED BY	ISSUED DATE
Thermal Response Test					
Site Investigation					
Contamination reports					

ADDITIONAL INFORMATION

INFORMATION	DOCUMENT REF	DOCUMENT TYPE	REVISION / DATE	ISSUED BY	ISSUED DATE

11. Appendix D - Photovoltaic proposal

27 Eldon Business Park
Nottingham
Nottinghamshire
NG9 6DZ

Mr Joan Senent
Meinhardt
(0)20 7831 7969
Joan.Senent@meinhardt.co.uk

Date: 02/04/2013
Ref: 11-01045

PV proposal to be updated, to suit the reduction of PV panels by 4 modules.

For details of PV CO_2 strategy, refer to the main report.

Dear Mr Senent,

Re: Solar Photovoltaic (PV) system at High Holborn, WC1V

Thank you for your enquiry into solar PV with EvoEnergy. The system shown in the proposal meets the specification as set out in the tender documents we've received.

This proposal is based on the installation of high quality modules and a balance of system with a long design life and excellent warranties.

Our price is based on information provided at time of quoting. A breakdown of what is included can be found within this proposal.

As an MCS installer the solar PV system shown in this proposal are eligible for the governments Feed-in-Tariff scheme. The rate of FiT you will receive will depend on the system size and date of final commissioning. This proposal talks you through the expected FiT rates and financial benefits.

Summary

Option	Size	kWh	kgCO2/yr	Cost/kWp	Total Cost ex VAT	ROI	Assumed install date
1	15.70 kWp	10,029	5,305	£2,042	£32,044	7.91%	Jun-13

If you have any questions or require additional information regarding this quotation please do not hesitate to contact me.

James Clifford

Commercial sales

James Clifford 0115 957 5467 07773 972 122 james.clifford@evoenergy.co.uk

Site

High Holborn, WC1V

TBC

Fixing Method

Commercial sales

James Clifford 0115 957 5467 07773 972 122 james.clifford@evoenergy.co.uk

Financial Savings & the Feed-in Tariff

1. Electricity generation

In 2009, the UK government introduced the Feed-in Tariff to incentivise the installation of solar PV. Your FiT supplier is obliged to pay you the following rates for every unit of electricity you generate from your solar PV system, regardless of whether you use this or not. These rates are linked to RPI and are guaranteed for 20 years. We will submit your application for you to ensure you receive your FiT payments.

Size of PV System	FiT (p/kWh)*
<4kW	15.44
>4-10kW	13.99
>10-50kW	13.03
>50-150kW	11.10
>150-250kW	10.62
>250kW- 5MW	6.85
Off Grid System	6.85

* assumed 3.5% degression on previous FiT rates

2. Exporting to the grid

If you do not use all of the energy your system generates, you will export the remainder back to the grid. Your FiT provider will pay you an extra 4.5p for every unit you sell back. For systems under 30kWp, 50% of the electricity generated is deemed to have been exported and will qualify for an extra 4.5p payment, even if the electricity is used in the building.

3. Saving on your electricity bill

While your panels are generating electricity, you will save around 10p for every unit you use. If you need more electricity, you will buy it from the grid at your normal rate.

PV Returns

PV Summary	System 1
Peak Output (kWp)	15.70
Estimated Energy Production (kWh/year)	10,029
Capital Cost excl VAT (£)	£32,044
FiT Generation Rate Applicable (p/kWh)	13.03p
Electricity Saving Rate (p/kWh)	10p
Percentage of Electricity Exported	0%
FiT Money Earned (£/year)	£1,532
Electricity Money Saved (£/year)	£1,003
Total (£/year)	**£2,535**
Year 1 Return	**7.91%**

James Clifford 0115 957 5467 07773 972 122 james.clifford@evoenergy.co.uk

EVOENERGY

Design 1 — 11-01045 Meinhardt, High Holborn - 15.696kWp

System Summary

PV Angle	10 degrees
PV Orientation	south
Annual energy Generation, kWh/year (SAP 2009)	10,029
Carbon Savings (based on 0.529kgCO2/kWh)	5,305
PV Active Area (sqm)	78
Year 1 Return on investment	7.91%

Project Breakdown

Stage	Description	Details	Responsibility
Design	Planning permission submission	Planning Approved	Client
	Wind load calculations	Not included	N/A
	Structural calculations to identify roof strength	Not Included	N/A
	Building EPC survey	Quote available on request	Client
	Roof asbestos survey	Not included	N/A
	Health and safety information	Method and risk assessments	EvoEnergy
	Electrical design and schematics	Included	EvoEnergy
	Mechanical fixing design	Included	EvoEnergy
	DNO application for PV connection - G59	Application form and submission	EvoEnergy
Equipment	Modules	48 x SUNPOWER SPR-327NE-WHT-D	EvoEnergy
	Mounting frame	All PV panels flat roof fixings and rail	EvoEnergy
	Mounting structure	Low load ballast (south facing)	EvoEnergy
	DC switchgear, cables and connectors	Tier 1 DC equipment and connection points	EvoEnergy
	Inverter(s)	Selected to match modules & system size	EvoEnergy
	Inverter(s) housing	Not applicable	N/A
	AC switchgear, cables and connectors	Tier 1 AC equipment and connection points	EvoEnergy
	AC G59 protection	No G59	N/A
	All relevant labelling	All stickers and live cable labels	EvoEnergy
	Ofgem approved generation meter	Ofgem approved	EvoEnergy
	Ofgem approved export meter	No import/export meter required	N/A
	Display and monitoring equipment	No Display	N/A
Installation	Project Manager and installation team	3 days on site required	EvoEnergy
	Provision of site welfare facilities		Client
	Delivery to site		EvoEnergy
	Secure site storage	Lockable	Client
	Access equipment	Scaffold	Client
	Lifting equipment	Hoists	Client
	Mechanical installation	Included	EvoEnergy
	Electrical connection - DC	Included	EvoEnergy
	Electrical connection - AC	Included	EvoEnergy
	Waterproofing of cable entry points	Not included	N/A
	Lightning protection system	Not included	N/A
	Man-safe or edge protection system	Not included	N/A
	Site waste disposal	Onsite waste facility available	EvoEnergy
	Testing and commissioning	Included	EvoEnergy
Payment	Deposit		Both
	Delivery to site		Both
	Testing and commissioning		Both
Aftercare	Warranty*	Included	EvoEnergy
	MCS certificate		EvoEnergy
	operation & maintenance manual		EvoEnergy
	PV system explainaton and client training		EvoEnergy
	FiT application and submission		Client
	Support		EvoEnergy
	Data monitoring and maintenance	Not included	N/A
Total Cost (excluding VAT)			**£32,044**

*see CS001.1 - EvoEnergy Commercial Terms and conditions

Design agreed ______________________________

Name (please print): Signed: Date signed: Install month requested:

Commercial sales

James Clifford 0115 957 5467 07773 972 122 james.clifford@evoenergy.co.uk

Reasons to work with EvoEnergy

We pride ourselves on our ability to work alongside our clients to deliver projects on-time, within budget and to the highest quality whilst maintaining our 100% health and safety record. Here are a few reasons why you can have complete confidence in us.

Our reputation

We consistently receive good feedback from our clients; over 30% of our business comes through existing relationships or recommendations. We are specialists in every aspect of solar development from design and planning to our efficient procurement and installation capability. Work with us and you can expect a hassle-free project from start to finish. Our strong in-house design competence ensures every system we install is tailored to meet our clients' exact needs. At the same time, dedicated project management keeps projects moving smoothly and swiftly.

We've installed systems all over the UK and have a large network of commercial clients who are willing to act as references to tell you what it was like to work with us. If you require a reference please don't hesitate to ask.

Our people

EvoEnergy has been built around a team of highly skilled, like-minded technical professionals. We've continued to attract the brightest talent in the industry and invest heavily in training our teams. With so many factors affecting the performance of solar PV, no two projects are the same. Our technical and design expertise means we create bespoke solutions every time, selecting the components and panel layout that best suit the project and it's energy requirements.

Our accreditations

We are Renewable Energy Assurance Listed and have a long list of nationally recognised accreditations. These include the Microgeneration Certification Scheme (MCS), the Construction Skills Certification Scheme (CSCS), the Contractors Health and Safety Assessment Scheme, NICEIC approved Contractor

Our Awards

In the past year we've been named the Renewable Energy Association's Installer of the Year, Solar Installer of the Year at the Renewables Award, and the Solar Energy Provider of the Year at the Renewable Energy Infrastructure awards. We're also recommended by Which? magazine and the consumer website moneysavingexpert.com. Independent judges have been impressed by our combination of technical expertise and first-rate customer service - so you can be confident you're working with the best in the industry.

Commercial sales

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Reasons to work with EvoEnergy - Our clients

Further Reading

Some extra information and handy resources. Just click to download each document as a pdf.

Panel Comparison
An at-a-glance look at the panels we stock

Panel specifications
Some more detailed information on the panels we've recommended for you

Industry reviews
Read more about our awards and recommendations

Terms and conditions
This quotation is valid for 30 days
Prices quoted assume no significant fluctuation in the Euro exchange rate and no changes to Government taxes, duties or levies.
CS001.1 - EvoEnergy Commercial Terms and Conditions

Commercial sales

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SUNPOWER

E20/327 SOLAR PANEL

20% EFFICIENCY

SunPower E20 panels are the highest efficiency panels on the market today, providing more power in the same amount of space

MAXIMUM SYSTEM OUTPUT

Comprehensive inverter compatibility ensures that customers can pair the highest efficiency panels with the highest-efficiency inverters, maximizing system output

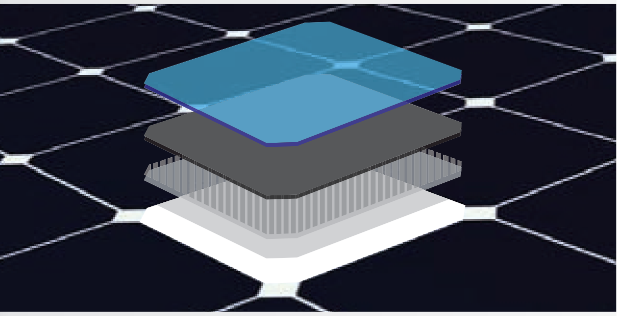
REDUCED INSTALLATION COST

More power per panel means fewer panels per install. This saves both time and money.

RELIABLE AND ROBUST DESIGN

SunPower's unique Maxeon™ cell technology and advanced module design ensure industry-leading reliability

E20 SERIES



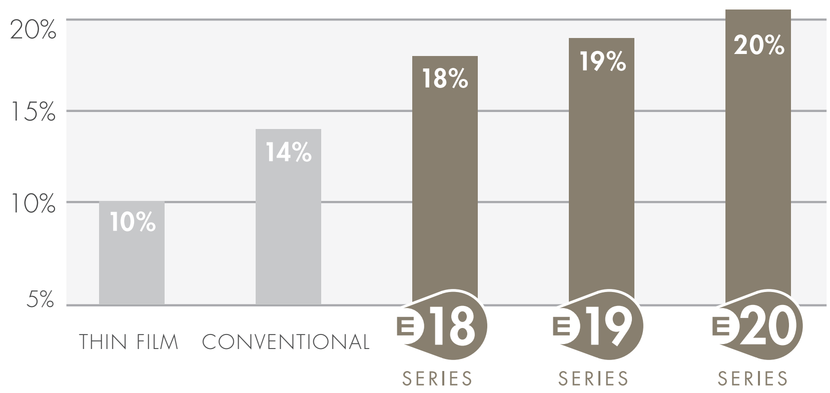
MAXEON™ CELL TECHNOLOGY

Patented all-back-contact solar cell, providing the industry's highest efficiency and reliability.

THE WORLD'S STANDARD FOR SOLAR™

SunPower™ E20 Solar Panels provide today's highest efficiency and performance. Powered by SunPower Maxeon™ cell technology, the E20 series provides panel conversion efficiencies of up to 20.1%. The E20's low voltage temperature coefficient, anti-reflective glass and exceptional low-light performance attributes provide outstanding energy delivery per peak power watt.

SUNPOWER'S HIGH EFFICIENCY ADVANTAGE



sunpowercorp.com

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SUNPOWER

E20/327 SOLAR PANEL

MODEL: SPR-327NE-WHT-D

ELECTRICAL DATA

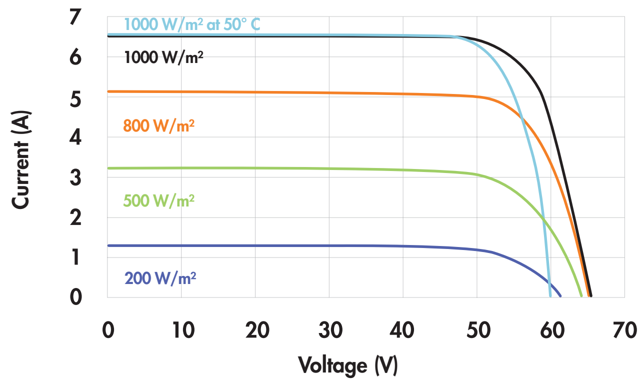
Measured at Standard Test Conditions (STC): irradiance of 1000W/m², AM 1.5, and cell temperature 25° C

Peak Power (+5/-3%)	P_{max}	327 W
Cell Efficiency	η	22.5 %
Panel Efficiency	η	20.1 %
Rated Voltage	V_{mpp}	54.7 V
Rated Current	I_{mpp}	5.98 A
Open-Circuit Voltage	V_{oc}	64.9 V
Short-Circuit Current	I_{sc}	6.46 A
Maximum System Voltage	UL	600 V
Temperature Coefficients	Power (P)	-0.38% / K
	Voltage (V_{oc})	-176.6mV / K
	Current (I_{sc})	3.5mA / K
NOCT		45° C +/-2° C
Series Fuse Rating		20 A
Grounding	Positive grounding not required	

MECHANICAL DATA

Solar Cells	96 SunPower Maxeon™ cells
Front Glass	High transmission tempered glass with anti-reflective (AR) coating
Junction Box	IP-65 rated with 3 bypass diodes Dimensions: 32 x 155 x 128 mm
Output Cables	1000mm length cables / MultiContact (MC4) connectors
Frame	Anodized aluminum alloy type 6063 (black)
Weight	41.0 lbs (18.6 kg)

I-V CURVE



Current/voltage characteristics with dependence on irradiance and module temperature.

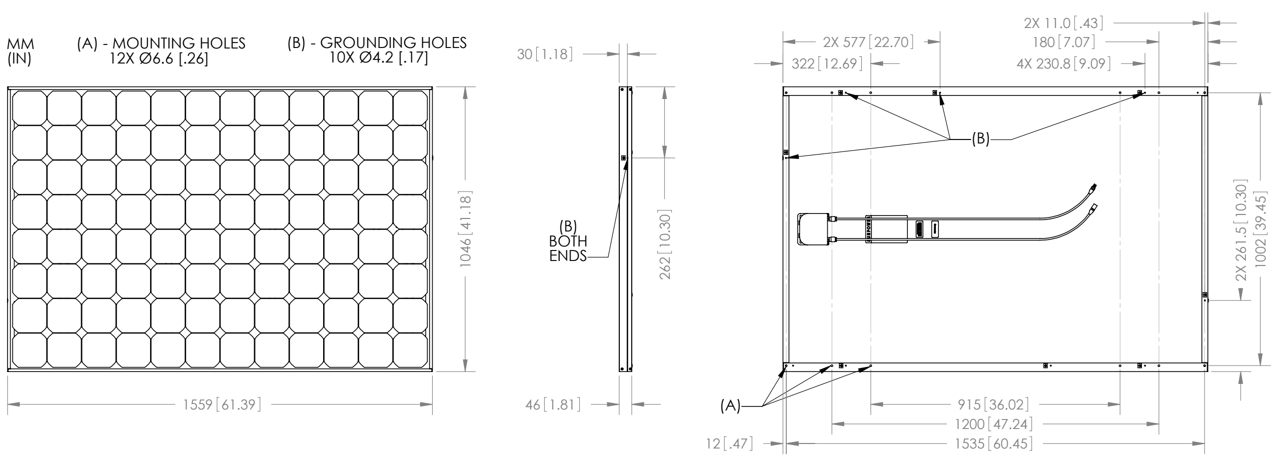
TESTED OPERATING CONDITIONS

Temperature	-40° F to +185° F (-40° C to + 85° C)
Max load	113psf 550 kg/m² (5400 Pa), front (e.g. snow) w / specified mounting configurations 50 psf 245 kg/m² (2400 Pa) front and back – e.g. wind
Impact Resistance	Hail: (25 mm) at 51mph (23 m/s)

WARRANTIES AND CERTIFICATIONS

Warranties	25-year limited power warranty
	10-year limited product warranty
Certifications	Tested to UL 1703. Class C Fire Rating

DIMENSIONS



Please read safety and installation instructions before using this product, visit sunpowercorp.com for more details.

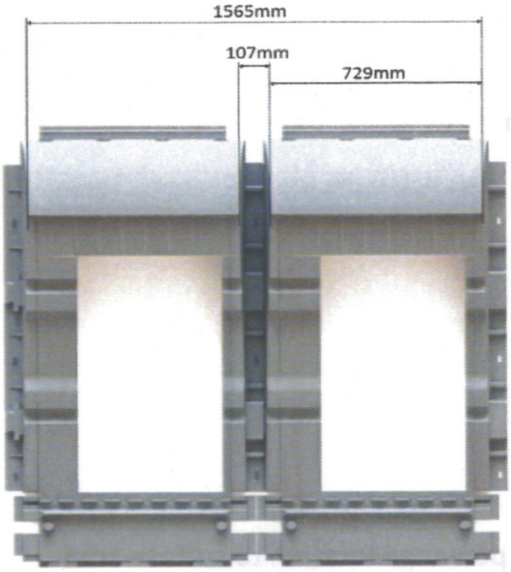
sunpowercorp.com
Document #001-65484 Rev*B / LTR_EN
CS 11_242

SOLION

INNOVATION • QUALITY • SERVICE

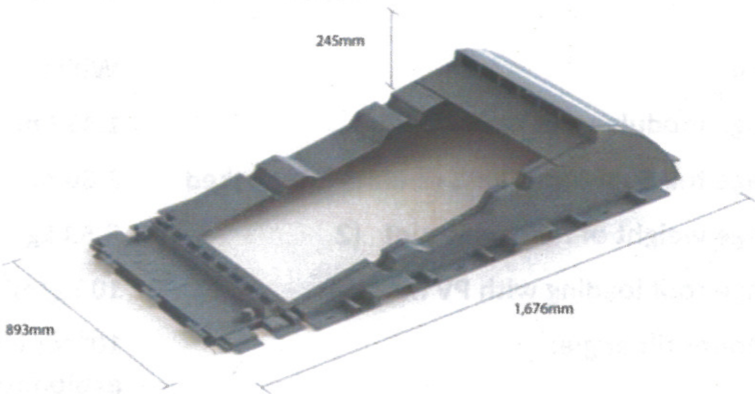
The Universal SunMount^{TM}

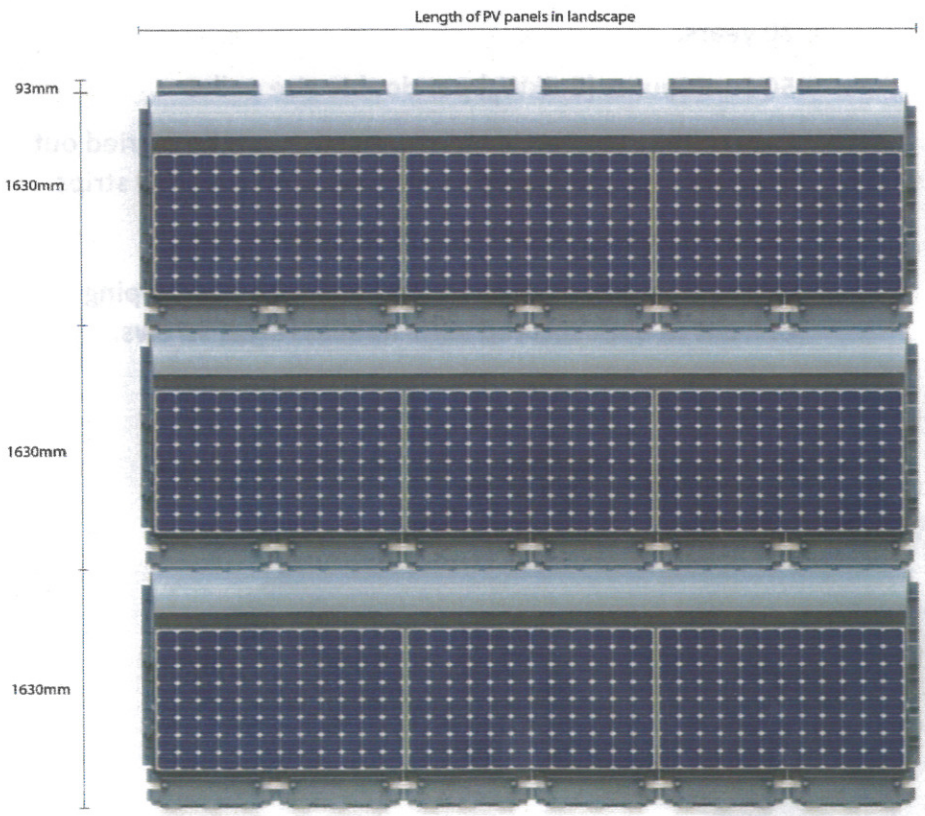
Fits PV panel widths between 960-1060mm and any length.



Two SunMounts

Modular unit size





- **Withstands winds of 120 mph**
- **No roof Penetration**
- **Fast installation**
- **1 modular unit**
- **Interlocking units**
- **Low Loading (10 kg/m^2)**
- **10^{o} tilt angle**
- **20 years guarantee**
- **Easy to transport (5-6kW$_p$/pallet)**

Solion Ltd, South Bank Technopark, 90 London Road, London SE1 6LN, United Kingdom
Tel: 020 78157678, Fax: 020 79283957, Email: query@solion.co.uk, www.solion.co.uk

SOLION
INNOVATION • QUALITY • SERVICE

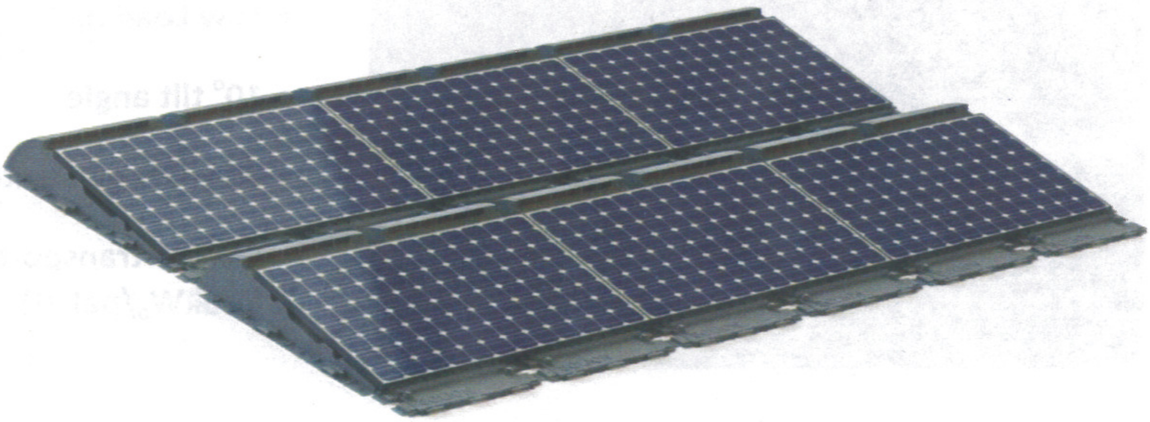
Universal SunMount™

Specification Sheet

Compatible PV panel dimensions:

X-direction:	Any PV panel length
Y-direction:	960 – 1060 mm
Depth :	35 – 50mm

Colour	White
Average modular unit area:	1.497 m^2
Average full SunMount area (2 units interlocked	2.80 m^2
Average weight of full SunMount (2	9.53 kg
Average roof loading with PV module:	10 kg/m^2
SunMount tilt angle:	10^0 for best ratio of power generation to surface area exploitation for European climate.
Maximum wind speed uplift resistance:	112 mph
SunMount Material:	Polypropylene UV stabilised.
Product life guarantee:	20 years.
Transport:	50 SunMounts (5-6kW_p) per double size pallet
PV cable connection:	Easy cabling connection/disconnection can be carried out from the top and placed in recesses with covering strips.
Aesthetics:	Flush modules give an integrated appearance.
Interlocking method:	Left to right interlock by latches and with overlapping of front to back secured with stainless steel screws.



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