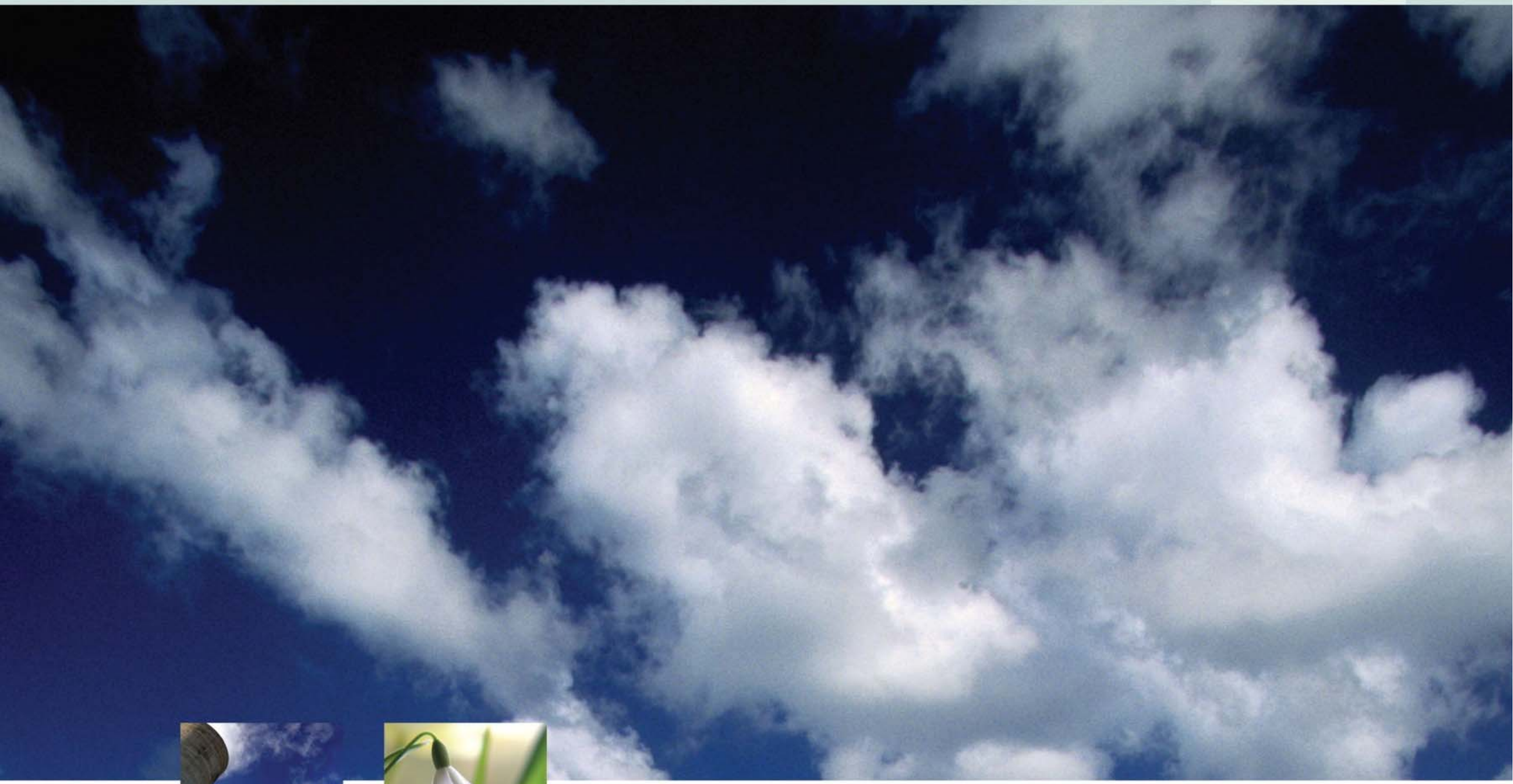

ENERGY ASSESSMENT

Mixed Use development of

141 Dollis Road, Mill Hill East LONDON

Prepared for:
PGMI (Finchley) Ltd

Date:
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Project Issue Number:
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Contents

EXECUTIVE SUMMARY

This report has been compiled in order to provide an Energy Demand and Carbon Dioxide (CO_2) Emissions Assessment to accompany the Sustainability Statement (ref. SOL1512ENT02-Dollis Road_Sustainability Statement) prepared for the planning application for the proposed mixed use development at 141 Dollis Road, Mill Hill East.

This document has been compiled by Sol Environment Ltd on behalf of PGMI (Finchley) Ltd (‘*the applicant’*). The Energy Demand Assessment has been formulated in order to provide a sustainable energy solution for the proposed site in accordance with *National Planning Policy Framework, Barnet’s Local Plan (Development Management Policies and SPD)* and the *London Plan* with particular reference to Barnet’s *Policy DM4 – Environmental Considerations for Development* and *London Plan Policy 5.2: Minimising Carbon Dioxide Emissions*.

The assessment and subsequent strategy has been prepared such that it is aligned with the Energy Hierarchy (see Section 2.1), with particular focus on sustainable building design (reduction of energy consumption at source), provision of energy efficiency measures and installation of building-integrated LZC technologies.

The strategy has been derived in order to ensure compliance with current energy planning policy, in particular, London Plan Policy 5.2. Policy 5.2 states that all new build residential developments involving 10 or more residential units will require the total estimated carbon emissions of the development to achieve a ***40% carbon reduction improvement against Building Regulations Part L 2010.***

The proposed strategy is based on utilising **passive design measures**, **super insulated and air tight building fabric** and **high efficient gas fuelled heating system** with the installation of **Photovoltaic Panels** for the provision of supplementary renewable energy generation such that a significant reduction in CO_2 emissions is achieved through LZC/renewable technology.

To achieve a >40% reduction in CO_2 emissions compared to Building Regulations 2010 TER (as required by the Local Authority) the following measures are proposed:

- High performance super insulated building fabric u-values
  - External Walls – 0.13 W/m^{2}K
  - Floors – 0.11 W/m^{2}K
  - Roof – 0.11 W/m^{2}K
  - Door & Windows – 1.3 W/m^{2}K
  - Party Walls – 0.0 W/m^{2}K

- Air Tightness – 5.0 $m^3/(h.m^2)$
- Thermal Bridging y value – 0.08 W/m^2K (Accredited Construction Details assumed)
- Space and Water heating – gas fuelled boiler with >91% efficiency
- Renewable / LZC technologies – a **~22kWp building integrated flush mounted solar PV array** distributed across the south-west facing roof of Apartment Block A. This is the equivalent of a total roof area of approximately **154m^2 of panels**.

Specific detail relating to the predicted reductions in annual CO_2 emissions is detailed within the table below.

Dollis Road Site: Energy Strategy Summary (based on revised Planning Application documentation dated 24.05.17)			
Scenario	**Regulated CO_2 Emissions ($kgCO_2$ / year)**	**Emissions saving on previous scenario achieved (%)**	**Ave DER ($kgCO_2$ / m^2 / year)**
Baseline Building (BRUKL compliant TER)	29,203	-	20.02
After Energy Demand Reduction ('Residual' Scenario)	26,318	10%	18.04
After On-Site Renewables (savings compared to 'Residual Scenario)	16,838	36%	11.53
Total Saving Compared to Building Regulations Compliant TER	**12,365**	**42%**	**-**

The strategy illustrates that the development exceeds the required minimum 40% reduction in carbon dioxide emissions compared to Building Regulations 2010 TER through energy efficiency measures and the installation of renewable or low carbon technologies in accordance with London Plan and Barnet Local Plan

A graphical representation of the cumulative reduction in CO_2 emissions through implementation of various stages of the Energy Hierarchy is provided below.

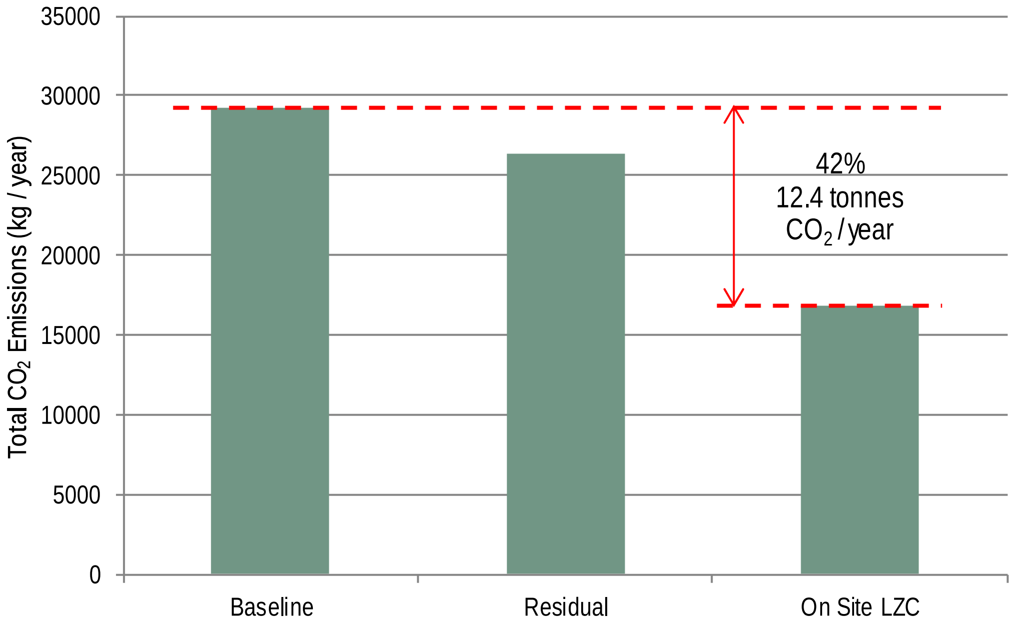

Figure E1: Implementation of the Energy Hierarchy at the Dollis Road Site.

1. INTRODUCTION

1.1 Background

Sol Environment Ltd ('Sol' hereafter) were engaged by Entran Ltd on behalf of PGMI (Finchley) Ltd *('the applicant'* hereafter) to undertake an assessment of energy use and CO_2 emissions and produce an energy demand assessment for the proposed mixed use development at 141 Dollis Road, Mill Hill East.

This report has been prepared by Sol Environment Ltd in cooperation with the applicant and in accordance with the following policies and guidance published by the Mayor of London and Barnet Borough Council;

- London Plan Policy 5.2: Minimising Carbon Dioxide Emissions

This Energy Demand Assessment has been prepared in association with a new planning application for the development.

1.2 Proposed Development

A new planning application will be made for the proposed mixed use development at 141 Dollis Road, Mill Hill East. The overall site will also include 4 no. new 'conversion' residential dwellings and 2 no. new 'conversion' commercial / retail units all within the existing buildings on the larger site. The new 'conversion' residential units and new commercial / retail units are not included within the Energy Assessment because they are not considered new build.

A schedule of the overall site information use and associated gross internal areas is provided in Table 1.1 below.

Table 1.1: Proposed Gross Internal Areas (based on revised Planning Application documentation dated 24.05.17)

Dwelling / Unit Type	No. of Beds	Average Dwelling / Unit Area (m^2)	No. of Dwellings / Units	Total Area (m^2)
1 Bed Flat – New Build	1	48.4	10	484
2 Bed Flat – New Build	2	66.0	4	264
2 Bed Mews House – New Build	2	88.375	8	707
TOTAL – New Build			**22**	**1577**
Conversion dwellings *(not included in assessment)*		53.50	4	209
Conversion commercial / retail units *(not included in assessment)*		76.5	2	163

Fig 1.1: Proposed Site Plan prepared by Collado Collins Architects (updated 24.05.17)

In accordance with the London Plan Policy 5.2: Minimising Carbon Dioxide Emissions this report will assess the development against the energy hierarchy to show reduced energy use and target at least 40% reduction in carbon dioxide emissions compared to Building Regulations 2010 compliant TER through energy efficiency measures and the installation of renewable or low carbon technologies.

2. ENERGY ASSESSMENT

This section comprises the Energy Assessment for the proposed development, in accordance with the London Plan and Barnet's Local Development Framework.

2.1 The Energy Hierarchy

The Energy Hierarchy adopts a set of principles to guide design development and decisions regarding energy, balanced with the need to optimise environmental and economic benefits. The Hierarchy, which is a widely accepted approach amongst many Councils, seeks to ensure that developments meet the Council's objectives of incorporating energy efficiency through the approach detailed in Figure 2.1.

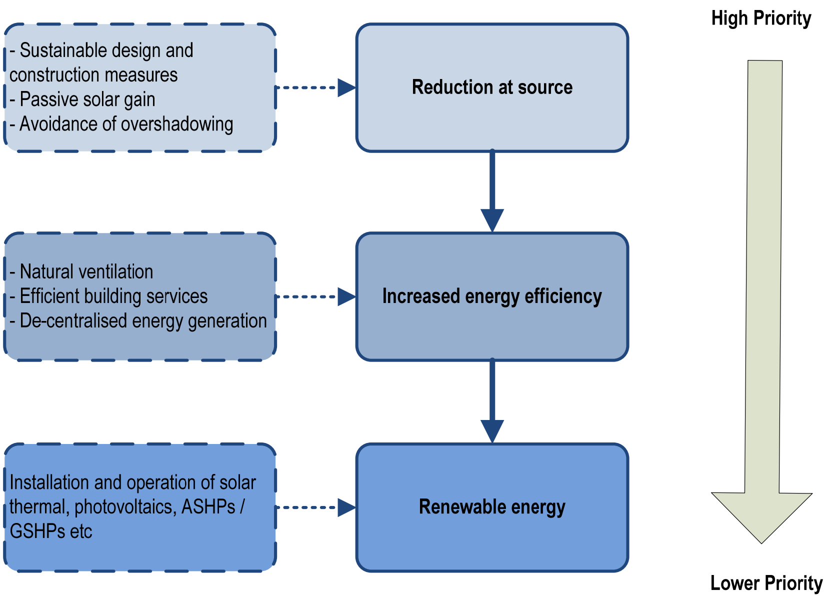

Figure 2.1: The Energy Hierarchy

It is considered that the above principles for carbon reduction form the most appropriate approach from both a practical and financial perspective. The industry is broadly in agreement that energy efficiency and low carbon technologies have the greatest impact in offsetting CO_2 emissions. Therefore, it is logical to encourage enhanced mitigation through energy efficiency and low carbon technologies in the first instance, with the application of renewable energy technologies as a secondary measure to reduce the primary energy requirements of a building.

Consequently, as a result of the above principles, the first stage in the energy strategy for the proposed development is the consideration of energy efficiency measures to ensure that the baseline energy demand is minimised.

2.2 Site Layout and Building Design

2.2.1 Overview

It is stated within the Part L of the 2010 Building Regulations that *'measures to make the building energy efficient must be incorporated within the scheme design.'*

Typically, passive energy efficient design measures can bring about a significant improvement upon the Dwelling Emission Rate ('DER') in new built projects, as a result of energy efficiency measures alone.

2.2.2 Passive Solar Design

Passive design measures manage internal heating through solar gain and as such reduce the need for cooling. Buildings that are aligned in a north-south orientation are observed to maximise daylight and sunlight (i.e. solar gain), subsequently reducing energy consumption associated with excessive heating and lighting requirements.

A benefit of the design of the buildings is the high levels of natural light and solar gain afforded by the large windows on all building aspects. In order to optimise this design feature, the design team have attempted to further optimise solar gain through the consideration of the solar orientation of internal facilities. Accordingly a majority of the unoccupied building service areas and stairwells have been incorporated wherever possible, into the areas which are not served by high levels of natural light.

The site has been designed in consideration of the parameters detailed within Table 3.1 and performance has been maximised in the absence of any constraints. Specific objectives related to overshadowing are referenced in Box 2.1 below.

Box 2.1: ***Minimising Overshadowing***
1 – *Where no restrictions apply due to internal site layout, service and auxiliary areas (ie those that do not require heating) shall be located to the north of the building, therefore maximising the utilisation of solar gain for living spaces and subsequently lower residual energy consumption.*
2 – *All dwellings on-site have been designed such that potential overshadowing issues are alleviated, through low building heights and the separating distance between them.*
3 – *Where possible dwellings have been orientated and internal layouts arranged to ensure the maximum amount of southern aspect (and passive solar heating) for the main living space.*

The internal aspects of the development shall be designed (wherever possible) to further maximise the benefits provided by solar orientation. Subsequently, the building shall be constructed to specified design briefs and the principles detailed in Box 2.2 below.

Box 2.2: ***Building Design Principles***

1 *– Where orientation provides favourable conditions and no physical restrictions are provided by surrounding buildings, the glazing ratios within the development shall be designed such that potential for solar gain is maximised.*

2 *– Consideration will be given to the design of the internal envelopes of the proposed development, which will seek to utilise materials that not only provide high insulation values, but also have a high thermal mass.*

3 *- Accredited Construction Details will be used to ensure thermal bridging is limited to achieve a* ***maximum Y-value of 0.08 W/m²K.***

4 *– Consideration will be given to the selection of insulation materials for the building, ensuring the following heat loss parameters (U-Values) as a minimum:*

Component	*U Value*
External Walls	*0.13*
Roof	*0.11*
Floor	*0.11*
Doors	*1.3*
Windows	*1.3*

5 *– The dwellings shall not exceed a* ***maximum air permeability of 5m³ / (hr.m²).*** *This shall be achieved through the following measures;*

- *Adequate sealing between openings / windows and panels;*
- *Adequate sealing of ceiling-to-wall joints;*
- *Provision of a continuous air barrier over ceiling areas and adequate sealing of service ducts (where appropriate);*
- *High specification openings (see Objective B4);*
- *Brick / block construction will be mitigated against through application of wet plastering / parging / dry lining.*

6 *– The internal layout of the dwellings shall be constructed in consideration of building orientation and achieving maximum solar gain. Where no restrictions apply due to internal site layout (i.e. orientation of road infrastructure), the internal design of dwellings shall typically comprise the following:*

- *The most heated and frequently used rooms (i.e. master bedrooms and living rooms) shall be placed on the south side of the dwelling (where appropriate).*
- *Rooms that benefit little from sunlight (i.e. hallways, utility rooms, bathrooms and storage areas) are placed on the north side of the dwelling.*
- *Wherever relevant and possible, the dining-room will be linked with the living-room in each proposed dwelling (in preference to the kitchen in order to maximise solar gain).*

Consideration has also been given to minimising excessive solar gain and subsequent building overheating, thus avoiding excessive use of mechanical cooling systems in the summer months. Mechanical (forced draught) ventilation systems can account for a significant percentage of building energy use due mainly to the forced draught and fan plant required to maintain sufficient through-flow of internal air.

Given the high end nature of the building and the constricted site it is assumed mechanical ventilation will be provided in a number of the areas of the building to ensure sufficiently ventilated conditions.

Box 2.3: ***Limiting Excessive Solar Gain***

1 *– In order to limit the requirement for excessive mechanical cooling., cross or stack-ventilation shall be provided where possible and practicable, in the form of operable (secure) windows and trickle vents, such that night cooling can be encouraged without compromising building security.*

2 *– Natural ventilation shall be utilised within all buildings on-site (unless specific conditions require the use of mechanical ventilation such as wet rooms / trickle vents etc).*

3 *– Where the external envelope has large glazed areas, the windows shall be inset from the main external building facade (wherever possible) or fitted with low emissivity coatings such that potential overheating is minimised.*

2.2.3 Energy Efficiency Measures

In addition to regulated emissions (heating, cooling and ventilation), energy consumed by ancillary activities (primarily electricity consumption derived from the use of lighting and electrical appliances) is anticipated to account for approximately 30-40% of the overall CO_2 emissions from the development.

Significant energy efficiency measures shall be installed such that unnecessary energy consumption is reduced at source (in accordance with the Energy Hierarchy).

Box 2.4: *Energy Efficiency Measures*
1 *– All fixed lighting will comprise dedicated low energy fittings (i.e. those which are only capable of accepting low energy lamps with a luminous efficacy of ≤ 40 lumens per circuit Watt).*   ***2*** *– The building shall be fitted with AMR energy display devices for the provision of half hourly energy consumption data.*   ***3*** *– All occupants shall be provided with a 'Home User Guide', which shall provide information on energy systems within the building and details on best practice and energy saving techniques.*

2.3 Energy Modelling

2.3.1 Overview

In accordance with the London Plan and Barnet's Local Development Framework an assessment of the energy demand and carbon dioxide emissions is require for all major developments, this should demonstrate the expected energy and carbon dioxide emission savings from energy efficiency and renewable energy measures incorporated in the development.

The inclusion of energy efficiency measures and on-site renewable / low carbon technologies is to be provided to contribute a >40% reduction in carbon dioxide emissions when compared to 2010 Building Regulations compliant Target Emissions Rate. The following appraisal reviews the carbon reduction opportunities with a particular focus on a comparison of appropriate LZC technologies.

In order to assess opportunities and show required percentage reduction in CO_2 emissions, the applicant has commissioned a high level feasibility study to ascertain the predicted energy consumption (and associated carbon dioxide emissions) for the site and select appropriate LZC technologies.

2.3.2 Baseline Energy Assessment

In order to determine the type and size of LZC technology suitable for the site, a detailed baseline modelling and assessment exercise was undertaken.

Proprietary energy demand calculations for the proposed development have been undertaken using SAP modelling software. In accordance with L1A of the current Building Regulations (2010) a notional building will be used as the minimum benchmark for the dwellings housed within the extension. The total emissions combined will form the baseline standard for the assessment for regulated emissions (heating, lighting and ventilation). Pursuant to this, initial energy demand calculations for the building have been undertaken to provide a '*baseline*' building from which further calculations based on energy measures, efficient supply and renewable energy systems can be progressed. SAP modelling was undertaken for each dwelling.

2.3.3 Scenarios Energy Assessment

Upon calculation of a baseline SAP output, the dwellings were then remodelled in order to account for the various stages of the Energy Hierarchy and subsequently demonstrate the reduction in regulated CO_2 emissions.

Table 2.1 below provides a summary of the various modelled scenarios.

Table 2.1: Summary of SAP Modelled Scenarios				
Parameter		**Scenario**		
		Baseline (TER)	**Residual**	**After LZC Energy**
Dwelling Emission Rate ($kgCO_2/m^2/year$)		***18.09 – 21.29 Ave. – 20.02***	***17.61 – 19.14 Ave. – 18.04***	***9.30 – 12.77 Ave. – 11.54***
U-Values ($W/m^2.K$)	Walls	0.30	0.13	0.13
	Roofs	0.20	0.11	0.11
	Floors	0.25	0.11	0.11
	Doors	2.0	1.3	1.3
	Windows	2.0	1.3	1.3
Y-Values		0.15	0.08	0.08
Air permeability ($m^3/(hr.m^2)$ @ 50 Pa)		10.0	5.0	5.0
Heating / Domestic Hot Water (DHW)	Type	Notional Gas Boiler	High efficiency gas boiler	High efficiency gas boiler
	Efficiency	85%	>91%	>91%
	Fuel	Gas	Gas	Gas
	Controls	Room thermostats; programmer	Room thermostats; programmer; TRVs	Room thermostats; programmer; TRVs
	DHW	From Main Heating System	From Main Heating System	From Main Heating System
Cooling		-	-	-
Internal Lighting		50% non-dedicated low energy	100% non-dedicated low energy	100% non-dedicated low energy
Electricity		Grid Supplied	Grid Supplied	Grid Supplied
Renewable Technologies		-	-	22 kWp Solar PV array (~154m2 roof integrated flush mount PV panels)

The baseline emissions for the dwellings, captured within the Target Emission Rate (TER) are based on notional building fabric, services and performance in accordance with Approved Documents L1A.

Table 2.2 below details the 'baseline case' scenarios for the development regarding CO_2 emissions.

Table 2.2: Baseline CO_2 Emissions

Scenario	Regulated CO_2 Emissions ($kgCO_2$ / year)	Ave DER ($kgCO_2$ / m^2 / year)
'Baseline' scenario	29,203	20.02

The above baseline case assumes an operating scenario based on those parameters detailed within Column 2 of Table 2.1.

The utilisation of Combined Heat and Power was considered (in accordance with the energy hierarchy). The installation of a CHP system was considered but has been discounted on the basis that the inconsistent load requirements of the predominately residential development are not suited to a CHP plant.

Table 2.3 below details the 'residual' scenario for the development regarding energy and CO_2 emissions.

Table 2.3: Residual CO_2 Emissions

Scenario	Regulated CO_2 Emissions ($kgCO_2$ / year)	Saving achieved on baseline CO_2 emissions (%)	Ave DER ($kgCO_2$ / m^2 / year)
'Residual' scenario	26,318	10%	18.04

The above residual case assumes an operating scenario based on those parameters detailed within Column 3 of Table 2.1, excluding the installation of renewable energy measures.

In accordance with London Plan Policy 5.2 – Minimising Carbon Dioxide Emissions, the development is required to reduce carbon emissions by at least 40% through the use of energy efficiency measures and low/zero carbon and renewable technologies compared to building regulations compliant Building Regulations 2010 TER. Therefore, in addition to the energy efficiency measures nominated above renewable technologies have been proposed to achieve the overall 40% reduction in CO_2 emissions.

Table 2.4 below details the 'renewable' scenario for the development regarding CO_2 emissions. The below scenario has been modelled on the technologies proposed in Section 2.3.3 (summarised in Col 4, Table 2.1)

Table 2.4: LZC Technologies CO_2 Emissions

Scenario	Regulated CO_2 Emissions ($kgCO_2$ / year)	Saving achieved on residual CO_2 emissions (%)	Ave DER ($kgCO_2$ / m^2 / year)
'LZC Technologies' scenario	16,838	36%	11.54

Table 2.4 details an approximated overall 36% reduction in CO_2 emissions for the development through installation of low/zero carbon technologies when compared to the residual scenario.

Table 2.5 below provides a tabular summary of the energy assessment conducted for the proposed site, detailing a significant reduction in energy consumption (and subsequent CO_2 emissions) through the installation of photovoltaic panels.

Table 2.5: Energy Strategy Summary

Scenario	Regulated CO_2 Emissions ($kgCO_2$ / year)	Emissions saving on previous scenario achieved (%)	Ave DER ($kgCO_2$ / m^2 / year)
Baseline Building (BRUKL 2010 compliant TER)	29,203	-	20.02
After Energy Demand Reduction ('Residual' Scenario)	26,318	10%	18.04
After On-Site Renewables (savings compared to 'Residual Scenario)	16,838	36%	11.53
Total Saving compared to Building Regulations 2010 Compliant TER	**12,365**	**42%**	**-**

Based on the above, the proposed development will endeavour to achieve a >40% reduction in CO_2 emissions through energy efficiency measures and the installation of supplementary PV and in turn show compliance with London Plan Policy 5.2.

A graphical representation of CO_2 emissions savings provided by the various assessment stages for the development is detailed in Figure 2.2 below.

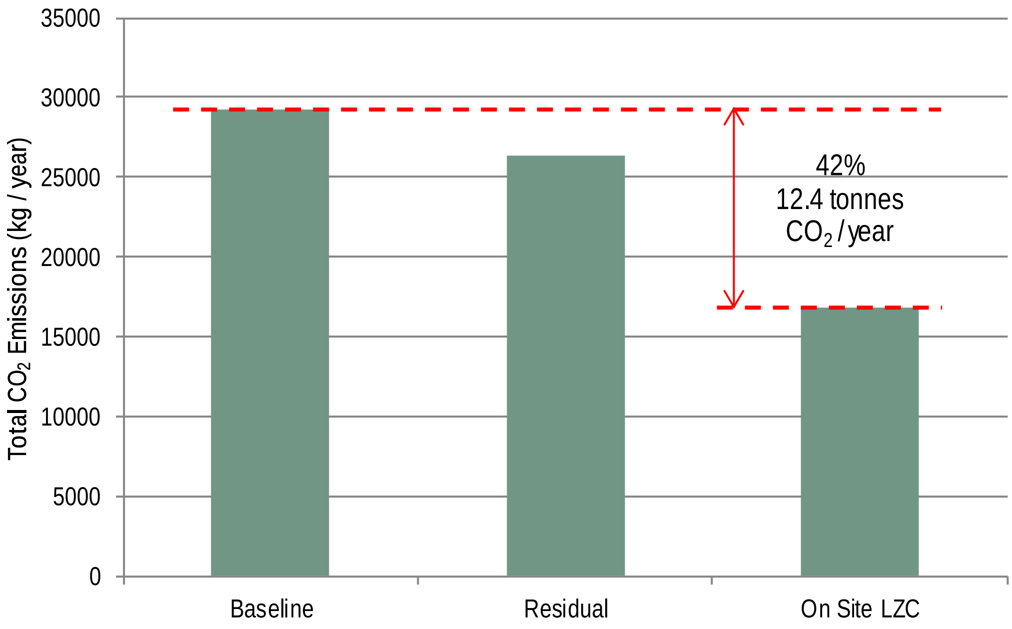

Figure 2.2: Implementation of the Energy Hierarchy at the Dollis Road Site.

2.4 Low-Zero Carbon Technologies Feasibility Review

Combined Heat & Power

CHP comprises combination of the generation of electricity for general consumption, with the recovery of exhausted heat energy (otherwise emitted from power stations / generators as waste heat) which can be used to provide heating for domestic and industrial processes.

Although not considered a renewable source (excepting biofuel-fired plants), CHP plants (typically 75% - 80% efficient) are significantly more efficient than a typical oil / gas fired power station (35% - 45% efficient), even when it is used in combination with fossil fuels such as gas and diesel. Therefore they are viewed as being more efficient than obtaining energy from the National Grid ('the grid').

In addition, transmission losses (typically 5% when consuming electricity from the grid) are minimised by on-site generation and, as such, a gas-fired CHP can be seen as a relatively carbon efficient means of energy supply.

The utilisation of Combined Heat and Power has been considered (in accordance with the heat hierarchy), and proposed as an option but only if there is the opportunity for a full integrated solution incorporating both the residential development and the Health and Racquet Club. The combined varying load requirements of both the residential and health club components will be more suited to the consistent / constant energy generated by a CHP plant.

As such it has been concluded that the proposed development is neither appropriate in nor sufficient in scale to warrant CHP.

Box 2.5: Feasibility Summary – CHP
The installation of a CHP system was considered but has been discounted on the basis that the inconsistent load requirements of the residential development are not suited to a CHP plant.

Solar Thermal Heating / Hot Water

Solar thermal panels are typically used in order to provide supplementary heat for the purposes of space heating or domestic hot water (DHW).

These systems consist of solar collectors, a pump, a control unit, connecting pipes, hot water tank and a conventional heat source (gas / oil fired boiler). The collectors are usually mounted on the roof and provide heat to a fluid circulated between the collectors and a water tank.

The efficiency of solar collector panels depends on a number of factors, including the type of collector, correct installation, location and orientation.

Installing solar thermal heating panels could reduce energy consumption and carbon impacts through significant reductions in electric water heating and typically produce approximately 5-600 kWh/m^2 of hot water.

Although evacuated tube systems are about 30% more efficient, they have a corresponding increased capital outlay. A collector area of 4–5 m^2 will normally save approximately 230kg of CO_2 emissions per year. A well designed system should satisfy 70-80% of the hot water demand in the summer and 20-30% in the winter.

Box 2.6: Feasibility Summary – Solar Thermal
Based on the orientation of the dwellings and the limited roof space DHW heating via installation of solar thermal is not considered to be the most feasible option. Utilising the roof space for PV is considered a more preferable approach.

Ground Source Heat Pumps

Ground Source Heat Pumps (GSHPs) operate by the removal of residual heat from the ground by using various 'loops' containing a water and glycol fluid mix, heat from the ground is absorbed into this fluid and is pumped through a heat exchanger in the heat pump. Low grade heat passes through a compressor and is concentrated into a higher temperature gas capable of heating water for DHW and central heating systems.

There are a number of configurations for GSHP systems. A vertical collector system is considered to be the most appropriate in the context of the proposed development given the large scale of the system and limited area available for horizontal collectors. Vertical collectors can be between 15 – 180m deep and minimum spacing between adjacent boreholes should be maintained at 5 - 15m to prevent thermal interference.

The heat yielded from GSHPs is relatively small (collecting approximately 14 - 20W_{th} per metre of collector loop), therefore the adequacy of the accompanying heat exchanger is vital in ensuring greater heat transfer (although more efficient exchangers have a significantly larger capital cost).

The performance of a GSHP system is entirely dependent on the appropriateness of the ground conditions (i.e. depth of soil cover, the type of soil or rock, ground temperature and thermal conductivity), which would be established subject to a ground survey.

'Reversible' heat pumps systems are also available that give the potential for provision of space cooling, if required. Groundwater can also be used to cool buildings where a suitable source exists, abstraction and discharge permissions can be obtained from the Environment Agency and test bores are favourable.

Box 2.7: Feasibility Summary – Ground Source Heat Pumps
Due to the compact urban nature of the site the installation of GSHPs for the provision of primary space / DHW heating for the development were considered achievable only if vertical heat pump ground loops were used. On review of the cost implications of vertical loops Ground Source Heap Pump system was not considered viable.

Air Source Heat Pumps

Air source heat pumps (ASHPs) absorb heat from ambient air in order to provide heat for the purposes of space heating and domestic hot water. An evaporator coil, mounted outside absorbs the heat; a compressor unit then drives refrigerant through the heat pump and compresses it to the right level to suit the heat distribution system.

Finally, a heat exchanger transfers the heat from the refrigerant for use, depending on which of the two main types of systems (identified below) is installed;

- Air to air system - produces warm air which is circulated by fans to heat a home; and
- Air to water system - uses heat to warm water. Heat pumps heat water to a lower temperature than a standard boiler system; therefore, these systems are more suitable for underfloor heating systems than radiator systems, requiring less space to incorporate, compared with an air to air system.

The efficiency of ASHPs is measured by a coefficient of performance (CoP) i.e. the amount of heat produced compared to the amount of electricity needed for them to operate.

ASHPs are often a more popular (and technically / financially viable) alternative to GSHPs due to lack of requirement for extensive excavation, requiring far less space and easier installation.

Box 2.8: Feasibility Summary – Air Source Heat Pumps
The utilisation of Air Source Heat Pumps as the primary space and water heating source was not considered feasible due to the limited opportunities for external wall units.

Biomass Heating

Biomass boilers replace conventionally powered boilers with an almost carbon neutral fuel (such as wood pellets). In addition, the installation and operation of a biomass boiler in new-build developments could yield significant revenue from the forthcoming Renewable Heat Incentive, a government funded clean energy cashback scheme.

Although many biomass burners will meet Clean Air Act requirements, combustion of woody biomass releases higher quantities of NOx compared to a comparable system fuelled by natural gas. As a consequence, many Local Authorities, particularly in urban areas have concerns about the potential impact on air quality that the widespread uptake of biomass boilers would have. Therefore, a large number of Councils generally approve of the specification of biomass when linked to a large-scale biomass CHP as opposed to being used for individual boilers.

Box 2.9: Feasibility Summary – Biomass Boilers
The use of an energy centre with a biomass boiler was considered a feasible option but due to the limited amount of available space and the relatively small size of the overall development it was discounted as a viable option.

Photovoltaic Cells

Solar Photovoltaics (PVs) are solar panels which generate electricity through photon-to-electron energy transfer, which takes place in the dielectric materials that make up the cells. The cells comprise layers of semi-conducting silicon material which, when illuminated by the sun, produces an electrical field which generates an electrical current. PVs can generate electricity even on overcast days, requiring daylight, rather than direct sunlight. This makes them viable even in the UK, although peak output is obtained at midday on a sunny summer's day. PVs offer a simple, proven solution to generating renewable electricity.

Box 2.10: Feasibility Summary – Photovoltaic Cells
Given the variety of south sloping roofs within the proposed site and the fact that they are mostly not visible from the surrounding streets, a roof mounted solar PV array is considered the **preferred option** for the incorporation of LZC technologies on the site. **A 22kWp roof integrated flush-mounted solar PV array is proposed. This equates to approximately 154m^2 panel area integrated into the south-west facing roof of apartment block A.**

Micro Wind Turbines

Large wind turbines are an established means of capturing wind energy and converting it into usable electricity. Wind turbines come in various sizes depending on the location and electrical load of a particular site. A wind turbine usually consists of a nacelle containing a generator connected, sometimes via a gearbox, to a rotor generally consisting of three blades.

Box 2.11: Feasibility Summary – Micro Wind Turbines
Owing to site-constraints, micro-wind turbines have not been considered as part of this feasibility study. Constraints also include low wind speeds in this area, averaging < 5.1 ms^{-1}. Wind turbines are also likely to have a significant visual impact on local environment, as well as health and safety implications for occupiers or users on-site and on adjacent areas as a result of noise and light flicker associated with the wind turbines. Wind turbines are also not feasible for urban locations.

3. SUMMARY

The installation of a CHP system has been discounted on the basis that the inconsistent load requirements of the residential development are not suited to a CHP plant. Of the remaining options, ground source heating, solar thermal, air-source heat pumps and wind turbines have been excluded with the preference for a roof mounted solar array.

The proposed strategy is based on utilising **passive design measures, super insulated and air tight building fabric, high efficient gas fuelled heating system and the installation of solar photovoltaic panels** for the provision of supplementary renewable energy generation such that a >40% reduction in CO_2 emissions compared to Building Regulations compliant TER (as required by the Local Authority). A **~22kWp roof integrated flush-mounted solar PV array** evenly distributed across the south-west facing roof of apartment building A is required to achieve this reduction. This is the equivalent of a total roof area of approximately **154m^2 of PV panels**.

A summary of the proposed energy efficiency measures and site-integrated renewable technologies, in accordance with the London Plan and Barnet's Local Plan, are provided in Box 2.11 below.

Box 2.12: ***Energy efficiency measures and site-integrated renewable technologies***

Energy Efficiency Measures

The developer will install the following energy efficiency measures are installed

Element	***U-Value***
Walls	0.13
Roofs	0.11
Floors	0.11
Doors	1.1
Windows	1.1
Air Tightness and Thermal Bridging	
Y-Values	0.08 (achieved through Accredited Construction Details)
Air permeability (m^3/(hr.m^2) @ 50 Pa)	5.0
Space Heating	***Efficiency***
Gas-fuelled Boiler	>91%
Water Heating	***Efficiency***
Gas-fuelled Boiler supplemented by Flue Gas Heat Recovery	>91%

Site Integrated Renewable Technologies

The developer will install a roof integrated flush-mounted Photovoltaic array on the south-west facing roof of Apartment Block A.

The Photovoltaic system shall be installed to the following guideline specification or similar;

Parameter	***Value***
Capacity	*~22kWp (c. 154m2 of roof integrated flush-mounted panels)*
Orientation	*South*
Pitch	*c. 45°*
ECA List	*Yes*

Annex A – Sample SAP modelling output

SAP WorkSheet: New dwelling design stage

User Details:

Assessor Name: **Stroma Number:**
Software Name: Stroma FSAP 2009 **Software Version:** Version: 1.5.0.69

Property Address: House Type 2B

Address : -, -, -, -, -

1. Overall dwelling dimensions:

	Area(m²)		Ave Height(m)		Volume(m³)	
Basement	78.9	(1a) x	2.9	(2a) =	228.81	(3a)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	78.9	(4)				
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =	228.81	(5)

2. Ventilation rate:

	main heating		Secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							1	x 10 =	10	(7a)
Number of passive vents							1	x 10 =	10	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

DRAFT

			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	20	÷ (5) =	0.09	(8)

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

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction *if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35*		0	(11)
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		6	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.39	(18)

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

Number of sides on which sheltered		0	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	1	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.39	(21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.4	5.1	5.1	4.5	4.1	3.9	3.7	3.7	4.2	4.5	4.8	5.1
Wind Factor (22a)m = (22)m ÷ 4												
(22a)m=	1.35	1.27	1.27	1.12	1.02	0.98	0.92	0.92	1.05	1.12	1.2	1.27

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

0.52	0.49	0.49	0.44	0.4	0.38	0.36	0.36	0.41	0.44	0.46	0.49

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

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

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

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

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

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

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

c) If whole house extract ventilation or positive input ventilation from outside
if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

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

d) If natural ventilation or whole house positive input ventilation from loft
if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.64	0.62	0.62	0.6	0.58	0.57	0.56	0.56	0.58	0.6	0.61	0.62	(24d)

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

(25)m=	0.64	0.62	0.62	0.6	0.58	0.57	0.56	0.56	0.58	0.6	0.61	0.62	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Doors			2.1	x	1.2	=	2.52			(26)
Windows Type 1			26.2		x1/[1/(1.2)+ 0.04]	=	30			(27)
Windows Type 2			2.7		x1/[1/(1.2)+ 0.04]	=	3.09			(27)
Windows Type 3			1.1		x1/[1/(1.2)+ 0.04]	=	1.26			(27)
Floor			78.9	x	0.15	=	11.84			(28)
Walls Type1	33.2	0	33.2	x	0.19	=	6.31			(29)
Walls Type2	40.5	0	40.5	x	0.19	=	7.69			(29)
Walls Type3	26.2	0	26.2	x	0.19	=	4.98			(29)
Roof	78.9	0	78.9	x	0.14	=	11.05			(30)
Total area of elements, m²			289.8							(31)

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

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 78.73 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 28370.1005 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

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

Thermal bridges : S (L x Y) calculated using Appendix K 23.18 (36)

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

Total fabric heat loss (33) + (36) = 101.92 (37)

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

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
(38)m=	48.08	46.96	46.96	44.92	43.71	43.14	42.6	42.6	44	44.92	45.91	46.96		(38)

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

(39)m=	150	148.88	148.88	146.84	145.62	145.06	144.52	144.52	145.92	146.84	147.83	148.88		

Average = Sum(39)1…12 /12= 146.98 (39)

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

(40)m=	1.9	1.89	1.89	1.86	1.85	1.84	1.83	1.83	1.85	1.86	1.87	1.89		

Average = Sum(40)1…12 /12= 1.86 (40)

Number of days in month (Table 1a)

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

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N — 2.44 (42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)
if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 — 92.19 (43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(44)m=	101.41	97.72	94.03	90.35	86.66	82.97	82.97	86.66	90.35	94.03	97.72	101.41	

Total = Sum(44)1…12 = 1106.27 (44)

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

(45)m=	150.75	131.84	136.05	118.61	113.81	98.21	91.01	104.43	105.68	123.16	134.44	145.99	

Total = Sum(45)1…12 = 1453.97 (45)

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

(46)m=	22.61	19.78	20.41	17.79	17.07	14.73	13.65	15.66	15.85	18.47	20.17	21.9	(46)

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day): 0 (47)

Temperature factor from Table 2b: 0 (48)

Energy lost from water storage, kWh/year — (47) x (48) = 0 (49)

If manufacturer's declared cylinder loss factor is not known:

Cylinder volume (litres) including any solar storage within same: 150 (50)

If community heating and no tank in dwelling, enter 110 litres in box (50)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in box (50)

Hot water storage loss factor from Table 2 (kWh/litre/day): 0.01 (51)

Volume factor from Table 2a: 0.93 (52)

Temperature factor from Table 2b: 0.78 (53)

Energy lost from water storage, kWh/year — ((50) x (51) x (52) x (53) = 1.12 (54)

Enter (49) or (54) in (55): 1.12 (55)

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

(56)m=	34.64	31.29	34.64	33.52	34.64	33.52	34.64	34.64	33.52	34.64	33.52	34.64	(56)

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

(57)m=	34.64	31.29	34.64	33.52	34.64	33.52	34.64	34.64	33.52	34.64	33.52	34.64	(57)

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Primary circuit loss (annual) from Table 3 | 610 | (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m
(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	51.81	46.79	51.81	50.14	51.81	50.14	51.81	51.81	50.14	51.81	50.14	51.81	(59)

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

(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(61)

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

(62)m=	237.19	209.93	222.5	202.27	200.26	181.87	177.46	190.88	189.34	209.61	218.1	232.44	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)
(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

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

Output from water heater

(64)m=	237.19	209.93	222.5	202.27	200.26	181.87	177.46	190.88	189.34	209.61	218.1	232.44	

Output from water heater (annual)1…12 | 2471.84 | (64)

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

(65)m=	91.57	81.27	86.68	79.55	79.29	72.76	71.71	76.17	75.25	82.4	84.81	89.99	(65)

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

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

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	146.5	146.5	146.5	146.5	146.5	146.5	146.5	146.5	146.5	146.5	146.5	146.5	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m=	48.39	42.98	34.96	26.46	19.78	16.7	18.05	23.46	31.48	39.97	46.66	49.74	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m=	324.07	327.43	318.96	300.92	278.14	256.74	242.44	239.08	247.55	265.59	288.37	309.77	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m=	52.09	52.09	52.09	52.09	52.09	52.09	52.09	52.09	52.09	52.09	52.09	52.09	(69)
Pumps and fans gains (Table 5a)													
(70)m=	0	0	0	0	0	0	0	0	0	0	0	0	(70)
Losses e.g. evaporation (negative values) (Table 5)													
(71)m=	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	-97.67	(71)
Water heating gains (Table 5)													
(72)m=	123.08	120.94	116.51	110.48	106.57	101.06	96.38	102.38	104.51	110.75	117.79	120.95	(72)
Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m													
(73)m=	596.46	592.28	571.35	538.79	505.42	475.43	457.79	465.84	484.47	517.24	553.74	581.38	(73)

6. Solar gains:

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

Orientation:		Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
North	0.9x	0.77	x	2.7	x	10.73	x	0.72	x	0.7	=	10.12	(74)
North	0.9x	0.77	x	2.7	x	20.36	x	0.72	x	0.7	=	19.2	(74)

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North	0.9x	0.77	x	2.7	x	33.31	x	0.72	x	0.7	=	31.41	(74)
North	0.9x	0.77	x	2.7	x	54.64	x	0.72	x	0.7	=	51.53	(74)
North	0.9x	0.77	x	2.7	x	75.22	x	0.72	x	0.7	=	70.93	(74)
North	0.9x	0.77	x	2.7	x	84.09	x	0.72	x	0.7	=	79.3	(74)
North	0.9x	0.77	x	2.7	x	79.12	x	0.72	x	0.7	=	74.61	(74)
North	0.9x	0.77	x	2.7	x	61.56	x	0.72	x	0.7	=	58.06	(74)
North	0.9x	0.77	x	2.7	x	41.09	x	0.72	x	0.7	=	38.74	(74)
North	0.9x	0.77	x	2.7	x	24.81	x	0.72	x	0.7	=	23.4	(74)
North	0.9x	0.77	x	2.7	x	13.22	x	0.72	x	0.7	=	12.47	(74)
North	0.9x	0.77	x	2.7	x	8.94	x	0.72	x	0.7	=	8.43	(74)
South	0.9x	0.77	x	26.2	x	47.32	x	0.72	x	0.7	=	433.05	(78)
South	0.9x	0.77	x	26.2	x	77.18	x	0.72	x	0.7	=	706.3	(78)
South	0.9x	0.77	x	26.2	x	94.25	x	0.72	x	0.7	=	862.44	(78)
South	0.9x	0.77	x	26.2	x	105.11	x	0.72	x	0.7	=	961.89	(78)
South	0.9x	0.77	x	26.2	x	108.55	x	0.72	x	0.7	=	993.33	(78)
South	0.9x	0.77	x	26.2	x	108.9	x	0.72	x	0.7	=	996.52	(78)
South	0.9x	0.77	x	26.2	x	107.14	x	0.72	x	0.7	=	980.41	(78)
South	0.9x	0.77	x	26.2	x	103.88	x	0.72	x	0.7	=	950.62	(78)
South	0.9x	0.77	x	26.2	x	99.99	x	0.72	x	0.7	=	915.01	(78)
South	0.9x	0.77	x	26.2	x	85.29	x	0.72	x	0.7	=	780.5	(78)
South	0.9x	0.77	x	26.2	x	56.07	x	0.72	x	0.7	=	513.09	(78)
South	0.9x	0.77	x	26.2	x	40.89	x	0.72	x	0.7	=	374.19	(78)
West	0.9x	0.77	x	1.1	x	19.87	x	0.72	x	0.7	=	7.64	(80)
West	0.9x	0.77	x	1.1	x	38.52	x	0.72	x	0.7	=	14.8	(80)
West	0.9x	0.77	x	1.1	x	61.57	x	0.72	x	0.7	=	23.65	(80)
West	0.9x	0.77	x	1.1	x	91.41	x	0.72	x	0.7	=	35.12	(80)
West	0.9x	0.77	x	1.1	x	111.22	x	0.72	x	0.7	=	42.73	(80)
West	0.9x	0.77	x	1.1	x	116.05	x	0.72	x	0.7	=	44.59	(80)
West	0.9x	0.77	x	1.1	x	112.64	x	0.72	x	0.7	=	43.28	(80)
West	0.9x	0.77	x	1.1	x	98.03	x	0.72	x	0.7	=	37.66	(80)
West	0.9x	0.77	x	1.1	x	73.6	x	0.72	x	0.7	=	28.28	(80)
West	0.9x	0.77	x	1.1	x	46.91	x	0.72	x	0.7	=	18.02	(80)
West	0.9x	0.77	x	1.1	x	24.71	x	0.72	x	0.7	=	9.49	(80)
West	0.9x	0.77	x	1.1	x	16.39	x	0.72	x	0.7	=	6.3	(80)

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

(83)m=	450.8	740.3	917.5	1048.54	1106.99	1120.4	1098.3	1046.35	982.03	821.92	535.04	388.92	(83)

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

(84)m=	1047.27	1332.58	1488.85	1587.33	1612.42	1595.83	1556.09	1512.18	1466.5	1339.16	1088.78	970.3	(84)

7. Mean internal temperature (heating season)

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

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

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

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(86)m=	0.97	0.94	0.89	0.82	0.71	0.54	0.37	0.38	0.6	0.82	0.95	0.97	(86)

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

(87)m=	19.77	20.03	20.3	20.53	20.75	20.87	20.91	20.91	20.85	20.61	20.1	19.78	(87)

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

(88)m=	20.05	20.06	20.06	20.07	20.08	20.08	20.08	20.08	20.08	20.07	20.06	20.06	(88)

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

(89)m=	0.96	0.93	0.87	0.8	0.66	0.48	0.29	0.3	0.54	0.78	0.94	0.97	(89)

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

(90)m=	18.93	19.18	19.44	19.67	19.88	19.98	20	20	19.95	19.75	19.27	18.94	(90)

fLA = Living area ÷ (4) = 0.31 (91)

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

(92)m=	19.2	19.45	19.71	19.94	20.15	20.26	20.29	20.29	20.23	20.01	19.53	19.2	(92)

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

(93)m=	19.2	19.45	19.71	19.94	20.15	20.26	20.29	20.29	20.23	20.01	19.53	19.2	(93)

8. Space heating requirement

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, hm:													
(94)m=	0.96	0.92	0.86	0.79	0.66	0.49	0.31	0.32	0.55	0.78	0.93	0.96	(94)
Useful gains, hmGm , W = (94)m x (84)m													
(95)m=	1003	1222.52	1284.45	1257.29	1070.29	780.14	484.04	483.45	804.13	1046.11	1010.5	934.23	(95)
Monthly average external temperature from Table 8													
(96)m=	4.5	5	6.8	8.7	11.7	14.6	16.9	16.9	14.3	10.8	7	4.9	(96)
Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]													
(97)m=	2204.34	2151.17	1922.39	1650.53	1230.63	820.52	489.76	489.69	865.87	1353.09	1851.93	2129.58	(97)
Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m													
(98)m=	893.8	624.05	474.63	283.13	119.29	0	0	0	0	228.4	605.83	889.34	

Total per year (kWh/year) = Sum(98)1...5,9...12 = 4118.47 (98)

Space heating requirement in kWh/m²/year 52.2 (99)

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

Space heating:

Fraction of space heat from secondary/supplementary system		0	(201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1	(202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1	(204)
Efficiency of main space heating system 1		175	(206)
Efficiency of secondary/supplementary heating system, %		0	(208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)													
	893.8	624.05	474.63	283.13	119.29	0	0	0	0	228.4	605.83	889.34	
(211)m = {[(98)m x (204)] + (210)m } x 100 ÷ (206)													(211)
	510.74	356.6	271.22	161.79	68.17	0	0	0	0	130.51	346.19	508.19	

Total (kWh/year) =Sum(211)1...5,10...12= 2353.41 (211)

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Space heating fuel (secondary), kWh/month
= {[(98)m x (201)] + (214) m } x 100 ÷ (208)

(215)m=	0	0	0	0	0	0	0	0	0	0	0	0

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= 0 (215)

Water heating

Output from water heater (calculated above)

237.19	209.93	222.5	202.27	200.26	181.87	177.46	190.88	189.34	209.61	218.1	232.44

Efficiency of water heater 175 (216)

(217)m=	175	175	175	175	175	175	175	175	175	175	175	175	(217)

Fuel for water heating, kWh/month
(219)m = (64)m x 100 ÷ (217)m

(219)m=	135.54	119.96	127.14	115.58	114.43	103.93	101.4	109.07	108.19	119.78	124.63	132.82

Total = Sum(219a)$_{1...12}$ = 1412.48 (219)

Annual totals	**kWh/year**	**kWh/year**	
Space heating fuel used, main system 1		2353.41	
Water heating fuel used		1412.48	
Electricity for pumps, fans and electric keep-hot			
central heating pump:	130		(230c)
Total electricity for the above, kWh/year sum of (230a)…(230g) =		130	(231)
Electricity for lighting		341.85	(232)

10a. Fuel costs - individual heating systems:

	Fuel kWh/year	Fuel Price (Table 12)		Fuel Cost £/year	
Space heating - main system 1	(211) x	11.46	x 0.01 =	269.7007	(240)
Space heating - main system 2	(213) x	0	x 0.01 =	0	(241)
Space heating - secondary	(215) x	0	x 0.01 =	0	(242)
Water heating cost (other fuel)	(219)	11.46	x 0.01 =	161.87	(247)
Pumps, fans and electric keep-hot	(231)	11.46	x 0.01 =	14.9	(249)

(if off-peak tariff, list each of (230a) to (230g) separately as applicable and apply fuel price according to Table 12a

Energy for lighting	(232)	11.46	x 0.01 =	39.18	(250)
Additional standing charges (Table 12)				0	(251)

Appendix Q items: repeat lines (253) and (254) as needed

Total energy cost (245)...(247) + (250)...(254) = 485.645 (255)

11a. SAP rating - individual heating systems

Energy cost deflator (Table 12)		0.47	(256)
Energy cost factor (ECF)	[(255) x (256)] ÷ [(4) + 45.0] =	1.8422	(257)
SAP rating (Section 12)		74.3008	(258)

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

	Energy kWh/year	Emission factor kg CO2/kWh	Emissions kg CO2/year

SAP WorkSheet: New dwelling design stage

Space heating (main system 1)	(211) x	0.517	=	1216.71	(261)
Space heating (secondary)	(215) x	0	=	0	(263)
Water heating	(219) x	0.517	=	730.25	(264)
Space and water heating	(261) + (262) + (263) + (264) =			1946.97	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.517	=	67.21	(267)
Electricity for lighting	(232) x	0.517	=	176.74	(268)
Total CO2, kg/year		sum of (265)...(271) =		2190.91	(272)
CO2 emissions per m²		(272) ÷ (4) =		27.77	(273)
EI rating (section 14)				76	(274)

13a. Primary Energy

	Energy kWh/year	Primary factor		P. Energy kWh/year	
Space heating (main system 1)	(211) x	2.92	=	6871.95	(261)
Space heating (secondary)	(215) x	0	=	0	(263)
Energy for water heating	(219) x	2.92	=	4124.44	(264)
Space and water heating	(261) + (262) + (263) + (264) =			10996.4	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	2.92	=	379.6	(267)
Electricity for lighting	(232) x	0	=	998.2	(268)
'Total Primary Energy		sum of (265)...(271) =		12374.2	(272)
Primary energy kWh/m²/year		(272) ÷ (4) =		156.83	(273)