50 AVENUE ROAD
Rev 0

ENERGY STATEMENT
DRAFT ISSUE FOR COMMENT

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Audit Sheet

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0	Planning draft for team comment	EB / RC	RE	05.09.2013

CONTENTS

1. EXECUTIVE SUMMARY

This report has been produced by Hoare Lea Consulting Engineers to outline the energy strategy for the proposed 50 Avenue Road development. The assessment was carried out to show compliance with the requirements of the London Borough of Camden and the London Plan Policy.

This energy strategy has been developed in line with the Energy Hierarchy of "Be Lean"' "Be Clean" and "Be Green" stages to reduce the energy consumption of the development.

The baseline energy benchmarks for the energy strategy are based on the Target Emissions Rating (TER) from the Building Regulations Part L 2010 assessment. This has been derived for the building using compliance software; NHER Plan Assessor v5.4.2. Emissions associated with non-Building Regulation elements (i.e. cooking and appliances) have been calculated in accordance with the methodology in SAP 2009.

"Be Lean" measures are proposed within the report. The overall development reduction in CO_2 emissions over a Part L 2010 compliant scheme due to the energy efficiency proposals is approximately 21%.

The passive and active energy efficiency measures proposed for the scheme include:

- High-performance, engineered façade with optimised U-Values and G-Values;
- Windows carefully designed to balance daylight, heat loss and heat gain;
- Low air permeability;
- Low energy lighting;
- Variable speed pumping;
- Efficient ventilation systems with heat recovery.

Consideration has been given to connecting to off-site networks. Currently there are no district heating schemes in the area and none are currently planned. An assessment as to the feasibility of CHP has been carried out. It was found that a micro-CHP unit was suitable for the site. The incorporation of the micro-CHP unit resulted in a further 2% decrease in carbon emissions over the "Be Lean" scheme.

Various renewable technologies have been appraised. The technology that has been considered appropriate for the scheme is solar photovoltaic. The other technologies that were appraised but considered inappropriate for the scheme include ground source heat pumps, solar water heating panels, biomass boilers, wind turbines and bio-diesel CHP.

The incorporation of renewable technologies results in a further 4% reduction in carbon dioxide emissions over the "Be Clean" scheme.

The overall predicted reduction in CO_2 emissions from the baseline development (which is Part L 2010 compliant) is approximately 25%, which represents an annual saving of approximately 6 tonnes of CO_2.

Figure 1 below sets out how the proposed energy efficiency measures and renewable systems reduce CO_2 emissions in line with the London Plan Energy Hierarchy.

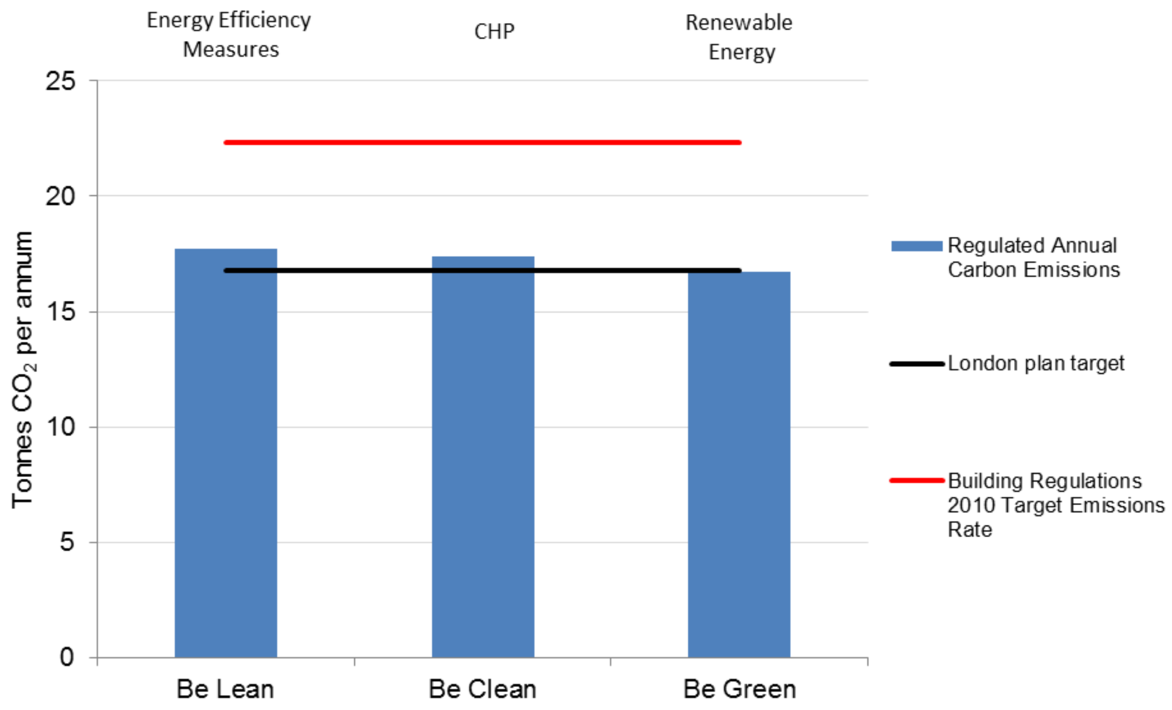


Figure 1: The Energy Heirarchy

Table 1 and Table 2, below show CO_2 emissions breakdown and percentage savings at each stage of the hierarchy.

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Carbon Dioxide Emissions (tonnes CO_2 per annum)	
	Regulated	Unregulated
Building Regulations 2010 Part L Compliant Development	22	5
After energy demand reduction	18	5
After CHP	17	5
After renewable energy	17	5

Table 2: Regulated carbon dioxide savings from each stage of the Energy Hierarchy

	Regulated Carbon Dioxide Savings	
	(Tonnes of CO_2 per annum)	(%)
Savings from energy demand reduction	4.6	21%
Savings from CHP	0.3	2%
Savings from renewable energy	0.7	4%
Total cumulative savings	**5.6**	**25%**

Regulated Carbon Dioxide emissions reductions are shown to be approximately 25% lower on average than a Part L 2010 compliant development.

2. INTRODUCTION

The energy assessment for 50 Avenue Road has taken a three-stage approach to reducing the building's carbon emissions:

"Be Lean"	Reduce the building's energy requirements by incorporating passive design measures and reduce the building's energy consumption through the use of energy efficient mechanical and electrical engineering systems.
"Be Clean"	Reduce the building's carbon dioxide emissions through the supply of heat and electricity delivered by Combined Heat and Power (CHP).
"Be Green"	Reduce the building's carbon dioxide emissions through the use of renewable technologies.

The energy assessment comprised the following stages:

1. Estimating a target for total regulated and unregulated annual energy consumption and CO_2 emissions of the proposed development. The estimates are based on Part L Approved Software modelling results.
2. Estimating savings in regulated and unregulated annual energy consumption and CO_2 emissions of the proposed development (broken down into heating, hot water, cooling and other electricity loads) through passive and active measures. The estimates are based on Part L Approved Software modelling results.
3. Assessing if CHP would be appropriate for the development and assessing the potential reduction of CO_2 emissions.
4. Estimating the potential contribution to Carbon Dioxide reductions that could be achieved by the use of renewable technologies.

3. ASSESSMENT OF ENERGY CONSUMPTION AND CARBON DIOXIDE EMISSIONS (BASELINE SCHEME - TARGET)

The first step in showing the required improvement on 2010 Building Regulations, is to calculate a baseline, on which to compare subsequent improvements.

For the purpose of this study the baseline will be the carbon dioxide emissions for a 2010 compliant building.

In order to work out this figure the building has been modelled using NHER Plan Assessor v5.4.2.

One of the outputs of the model is the TER, which is the target CO_2 emission rate expressed as $kgCO_2/(m^2.year)$. To turn this figure into total emissions, the TER was multiplied by the area of the dwelling.

The figure worked out above covers the regulated emissions of the dwelling. The unregulated emissions, that is, emissions associated with cooking and appliances have been calculated using the methodology suggested in SAP 2009.

The baseline carbon dioxide emissions are summarised in Table 3.

Table 3 – Baseline Carbon Dioxide Emissions

	Carbon Dioxide Emissions (tonnes CO_2 per annum)	
	Regulated	Unregulated
Building Regulations 2010 Part L Compliant Development	22	5

4. PASSIVE & ACTIVE ENERGY EFFICIENCY MEASURES *"BE LEAN"*

4.1 Passive Measures

The following typical envelope performance characteristics and passive design measures will be incorporated into the scheme design to limit the building's energy consumption:

- High-performance, engineered facade with optimised U-values and g-values
  - Walls – 0.15 W/m^2.K
  - Glazing – 1.0 W/m^2.K
  - Pedestrian Doors – 2 W/m^2.K
  - Heat Loss Floors – 0.12 W/m^2.K
  - Heat Loss Roofs – 0.12 W/m^2.K
  - Glazing Shading coefficient – 0.76
- Low air permeability – targeting 3.5 m^3/hr per m^2 envelope @ 50Pa
- The design of energy efficient facades with appropriate proportions of glazing has also been incorporated (this complies with Part L 2010 Criterion 3 limit on solar gains)

4.2 Active Measures

The energy consumption of the development will be further reduced by the incorporation of active energy efficiency measures in the design of the mechanical and electrical engineering systems. The following energy efficiency measures will be incorporated into the scheme design:

- Low Energy Lighting
- Variable speed pumping
- Efficient ventilation systems with heat recovery
- High Efficiency Boilers – Targeting >89% efficient (SAP efficiency)

Figure 2 below shows that the Regulated Carbon Dioxide Emissions of the Energy Efficient Scheme are approximately 21% below that of the Baseline scheme.

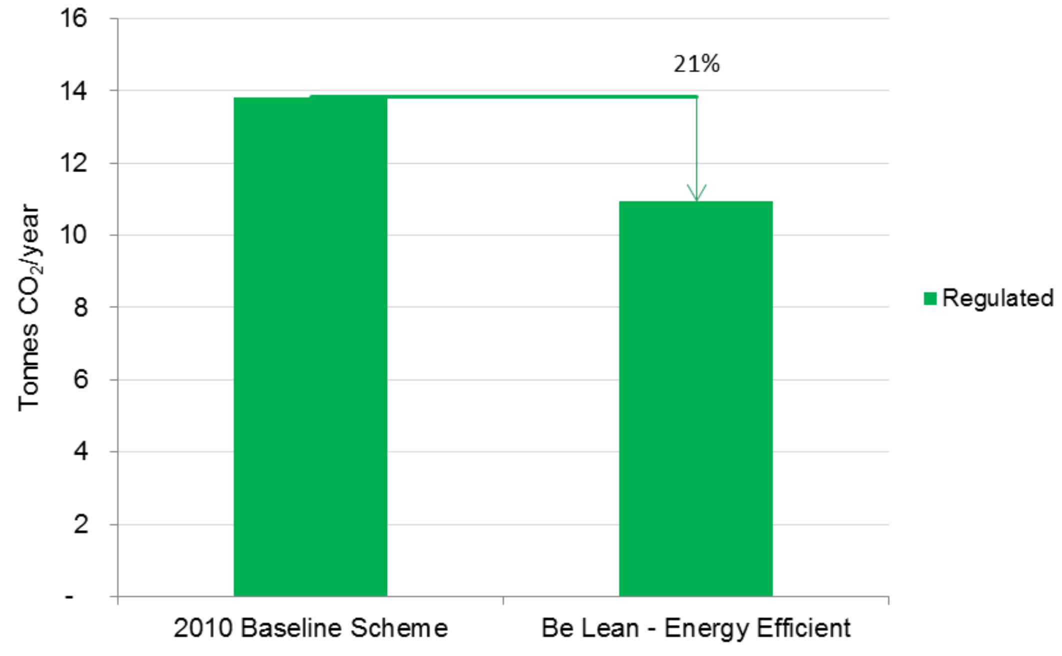


Figure 2: Regulated Carbon Dioxide Emissions

5. ENERGY NETWORKS AND COMBINED HEAT & POWER "BE CLEAN"

5.1 Decentralized Energy Networks

Currently there are no district heating schemes in the area and none are currently planned.

5.2 Gas-fired combined heat and power (CHP)

CHP uses a gas-fired reciprocating engine, connected to a generator to simultaneously generate both heat and power (electricity). Useable heat is generated by recovering the heat from the engine that, in a conventional generator, is rejected to atmosphere. In order to optimise the performance of the CHP engine it is important to provide consistent heating and electrical loads. For this reason, such a system would be supplemented by a gas fired boiler system and public electrical supply.

To ensure that CHP is financially viable it is essential that the unit is selected to meet the base heat load and that this load is maintained over a large proportion of the day (a figure of 14 – 17 hours per day is often quoted subject to the load profiles and gas and electricity prices) to ensure that the additional costs (maintenance) associated with running a CHP unit can be recovered.

The need to run the CHP plant, as much as possible makes the building load profile of prime importance when reviewing the viability of such solutions and in particular the summer time heat load profile. CHP systems only make financial sense to operate when the waste heat associated with generating the electricity is usefully used. To enable the CHP plant to run continuously when it is operating, a thermal store is often used so that excess CHP capacity can be used to generate hot water for use at a later time.

To analyse the appropriateness of using CHP, the regulated carbon dioxide emissions have been broken down into emissions by each end use, see Figure 3.

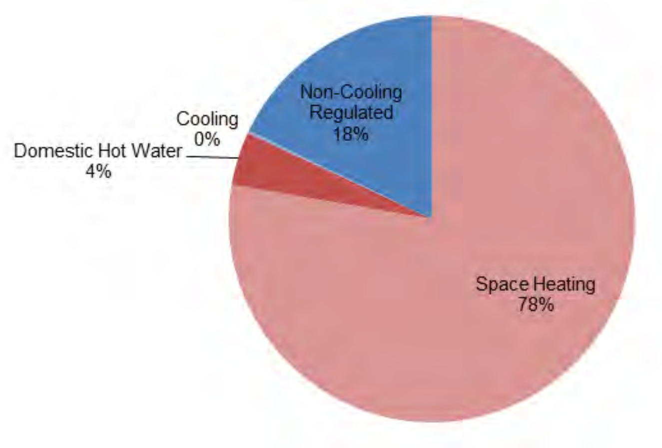


Figure 3 – Regulated Carbon Emissions by End Use

Figure 3 shows that the carbon emissions due to hot water production only account for 4% of the total regulated emissions of the development. As this is a relatively low load, A micro-CHP unit has been deemed suitable for this development.

Figure 4 below shows the estimated reduction in regulated carbon dioxide emissions after the "Be Clean" stage. Emissions are compared against the energy efficient and baseline schemes.

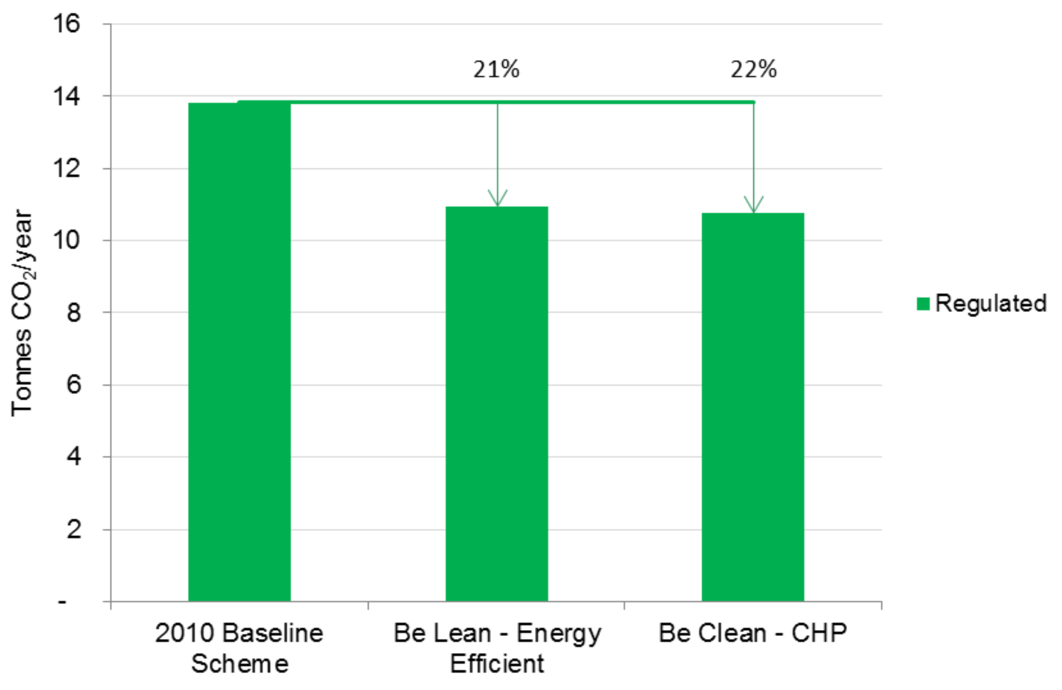


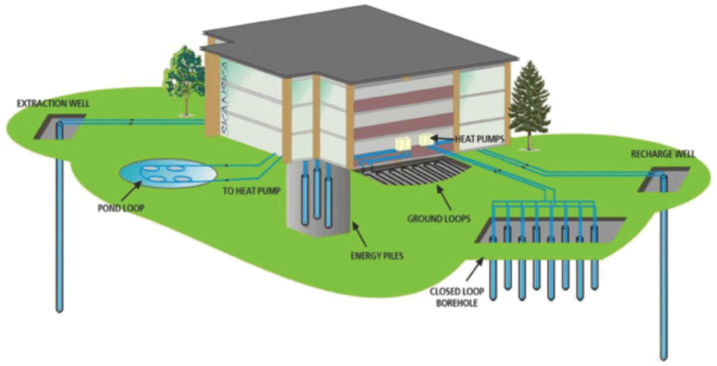
Figure 4: Regulated Carbon Dioxide Emissions

6. RENEWABLE ENERGY "BE GREEN"

6.1 Ground Source Heat Pumps

Ground source heat pumps utilise either water extracted from an aquifer (open loop) or water circulated within underground pipework (closed loop) as the heat source in a refrigeration process enabling them to produce hot water, typically at around 45°C, that can be used as a heating medium in buildings. Due to the relatively constant temperature of the ground at depth (typically 10-14°C in the UK) this produces heat more efficiently in winter than an air source heat pump, and usually with lower carbon emissions than a gas-fired boiler.

Open loop systems require the water extracted to be re-injected into the aquifer at another borehole on another part of the site. A licence from the Environment Agency (EA) is required for both abstraction and discharge although these licences cannot be obtained until a test borehole has been constructed and the appropriate EA tests undertaken.

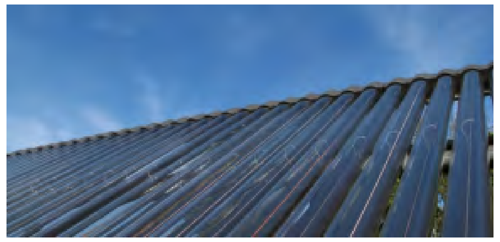


The high density nature of the site makes the use of GSHPs unsuitable due to the small area available for ground coupling in comparison to the heating and cooling demand.

Ground Source Heat Pumps are therefore not proposed for the development.

6.2 Solar Water Heating Panels

Solar water heating systems use heat from the sun to heat domestic hot water. The system requires solar panels on the roof, ideally south facing, linked to hot water storage cylinders.



As the panels produce hot water they will reduce the load on the proposed CHP unit. They will also have a negative impact on the visual appearance of the building, which is located in a conservation area. Solar water heating panels are therefore not proposed for the development.

6.3 Biomass Boilers

A biomass boiler uses a natural fuel such as wood chips or wood pellets for combustion. Since it uses a natural resource that can be replanted it is considered as a renewable energy source subject to the distance the fuel is transported. The carbon dioxide emitted from burning biomass is balanced by that absorbed during the fuel's production. Biomass heating therefore approaches a carbon neutral process.

The primary disadvantage of a biomass boiler is that it would reduce the heat load on the proposed CHP unit. In addition, large storage volumes are required for fuel, regular deliveries are required and biomass exhaust gases would require significant treatment to avoid degrading local air quality.

Biomass boilers are therefore not proposed for the development

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6.4 Wind Turbines

Wind turbines use the wind's lift forces to turn aerodynamic blades that turn a rotor thus generating electricity. There are three basic types to consider: horizontal axis (propeller type), vertical access (helical type) and building integrated (where the building design is adapted to suit the wind turbine). Building integrated systems are still at the development stage.

Wind turbines have a significant visual impact and the roof space will be sensitive in townscape terms, which is likely to preclude wind turbines. They can create noise and vibration problems. Additionally, there is limited roof area across the site where clean air flows and good wind speeds can be realised and which are vital to delivering a useful electrical output. Even if a suitable location could be found, the output of a wind turbine and the consequential Carbon Dioxide emissions will be very limited when compared to the emissions of the whole development. They will also have a negative impact on the visual appearance of the building which is located in a conservation area.

Wind turbines are therefore not proposed for the development.

6.5 Solar Photovoltaic (PV)

Solar photovoltaic (PV) solar cells generate electricity from the sun's energy. Solid PV panels can be either roof or façade mounted (although solar modules fitted on a south facing façade have only 75% the output of roof mounted modules). The solar PV array will be located at roof level of the tallest part of the building to prevent shadowing. The proposed solar PV will reduce regulated emissions by approximately 1%.



Table 4 shows the photovoltaic selections.

Table 4: Photovoltaic Details

Orientation	South
Inclination (degree)	30°
Area (m^2)	$10m^2$ (approx.)

6.6 Bio-diesel CHP

Bio-diesel CHP is essentially the same as gas-fired CHP apart from the different fuel source and different engine type; a compression ignition engine rather than spark ignition engine. Bio-diesel fuel comes from many sources and in varying blends from just 5% biodiesel to 100% biodiesel.

Although additional CO_2 savings over gas-fired CHP could be realised by use of bio-diesel there are disadvantages. Bio-diesel is approximately 2.5 – 3 times the cost of gas. Competing demand for fuel in the transport industry may drive up prices and may exacerbate the problem. Diesel fired engine exhaust gases also contain significantly higher NO_x emissions than an equivalent gas fired engine and therefore have more of an impact on air quality. The lack of a constant base heat load, as explained before for gas-fired CHP, also means that bio-diesel CHP will have a limited impact on CO_2 emissions.

Bio-diesel CHP is therefore not proposed for the development.

6.7 Renewables Summary

Figure 5 shows the revised estimated development regulated carbon dioxide emissions taking into account the contribution of the PV array. Emissions are compared against the clean, energy efficient and baseline schemes.

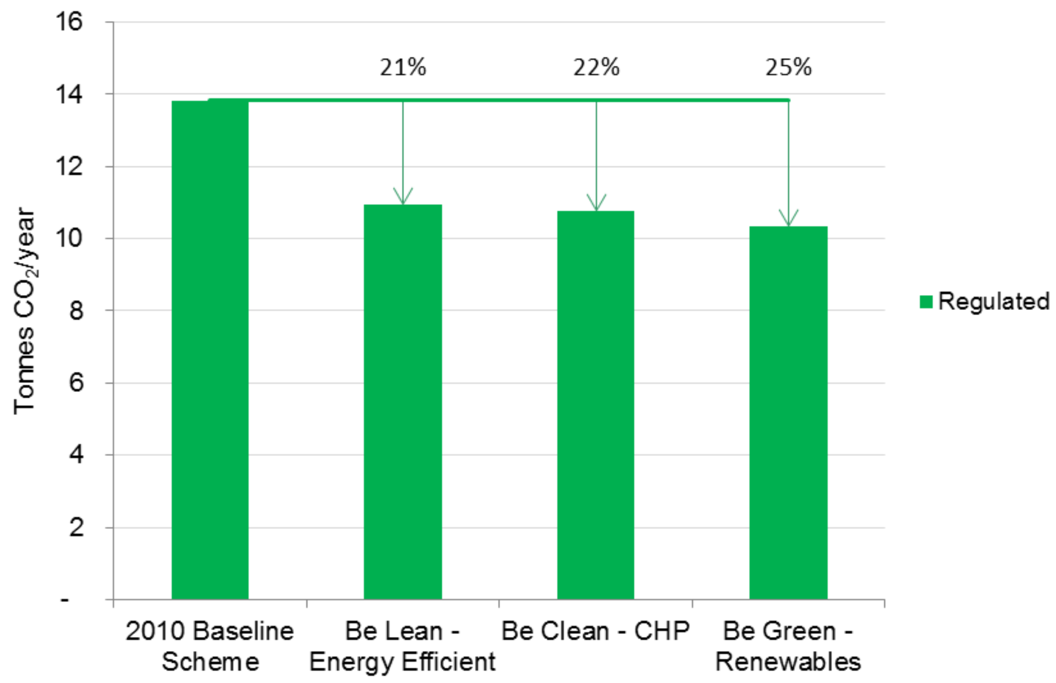

Figure 5: Carbon Dioxide Emissions

7. CONCLUSIONS

An energy assessment has been undertaken in line with GLA guidance to address the Borough of Camden and GLA policies.

A range of passive and active energy efficiency measures will be employed on the development. A PV array is also proposed for the development.

Regulated Carbon Dioxide emissions reductions are shown to be approximately 25% lower than a Part L 2010 compliant development.

Table 5 and Table 6 below show CO_2 emissions breakdown and percentage savings at each stage of the hierarchy.

Table 5: CO_2 Emissions Breakdown

	Carbon Dioxide Emissions (tonnes CO_2 per annum)	
	Regulated	Unregulated
Building Regulations 2010 Part L Compliant Development	22	5
After energy demand reduction	18	5
After CHP	17	5
After renewable energy	17	5

Table 6: Regulated CO2 Emissions Savings

	Regulated Carbon Dioxide Savings	
	(Tonnes of CO_2 per annum)	(%)
Savings from energy demand reduction	4.6	21%
Savings from CHP	0.3	2%
Savings from renewable energy	0.7	4%
Total cumulative savings	**5.6**	**25%**

Figure 6 below sets out how the proposed energy efficiency measures and LZC systems reduce regulated CO2 emissions in line with the London Plan Energy Hierarchy.

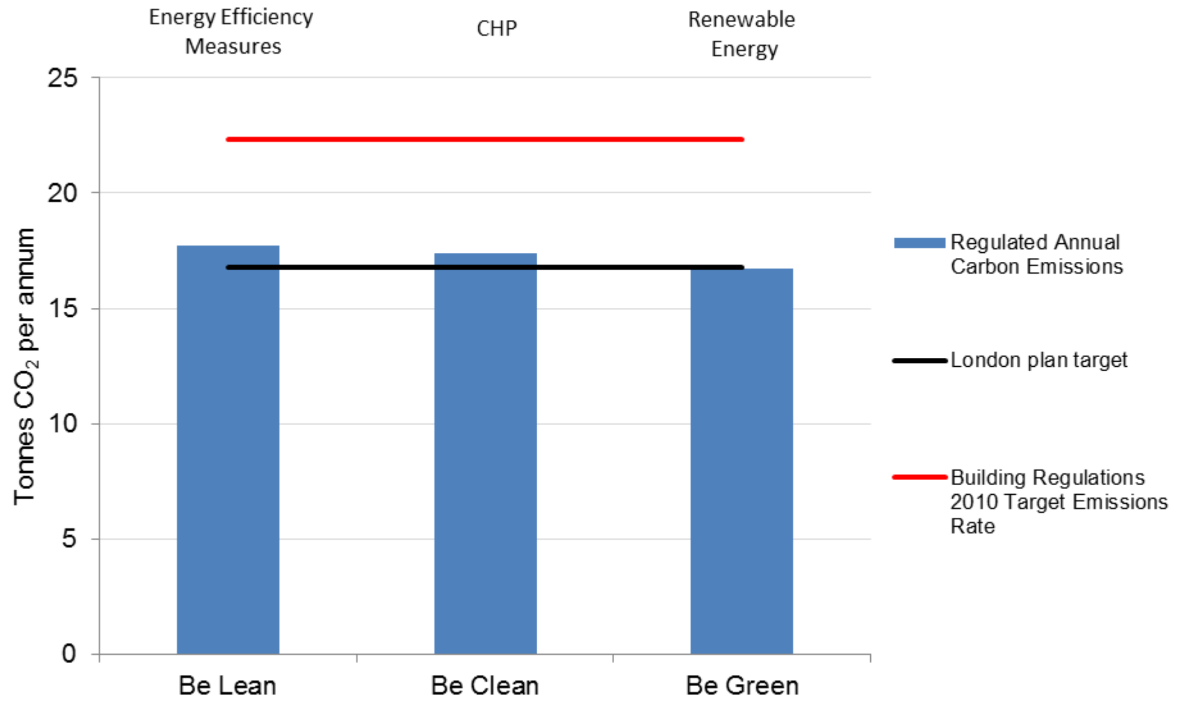

Figure 6: The Energy Heirarchy

APPENDIX A – PART L MODELLING RESULTS – SAP WORKSHEET

SAP 2009 Worksheet

Design - Draft

NHER

This design submission has been carried out using Approved SAP software. It has been prepared from plans and specifications and may not reflect the property as constructed.

Assessor name	Mrs Vicki Limbrick	Assessor number	5907
Client		Last modified	04/09/2013
Address	50 Avenue Road 50, London, NW8 6HS		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		533.59	(1a)	x	3.40	(2a)	=	1814.21	(3a)
+1		516.08	(1b)	x	3.70	(2b)	=	1909.50	(3b)
+2		236.52	(1c)	x	3.70	(2c)	=	875.12	(3c)
+3		190.46	(1d)	x	3.60	(2d)	=	685.66	(3d)
+4		139.61	(1e)	x	3.00	(2e)	=	418.83	(3e)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	1616.26	(4)						
Dwelling volume							(3a) + (3b) + (3c) + (3d)...(3n) =	5703.31	(5)

2. Ventilation rate

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

				Air changes per hour	
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =	0	÷ (5) =	0.00	(8)

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

Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		3.50	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.18	(18)

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

Number of sides on which dwelling is sheltered		0	(19)
Shelter factor	1 - [0.075 x (19)] =	1.00	(20)
Adjusted infiltration rate	(18) x (20) =	0.18	(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	5.40	5.10	5.10	4.50	4.10	3.90	3.70	3.70	4.20	4.50	4.80	5.10
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	1.20	1.27
Adjusted infiltration rate (allowing for shelter and wind speed) = (21) × (22a)m												
(22b)m	0.24	0.22	0.22	0.20	0.18	0.17	0.16	0.16	0.18	0.20	0.21	0.22

∑(22)1...12 = 54.10 (22)

∑(22a)1...12 = 13.52 (22a)

∑(22b)1...12 = 2.37 (22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	0.50	(23a)
If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)), otherwise (23b) = (23a)	0.50	(23b)
If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) =	79.90	(23c)

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

(24a)m	0.34	0.32	0.32	0.30	0.28	0.27	0.26	0.26	0.28	0.30	0.31	0.32	(24a)

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

(25)m	0.34	0.32	0.32	0.30	0.28	0.27	0.26	0.26	0.28	0.30	0.31	0.32	(25)

3. Heat losses and heat loss parameter

The κ-value is the heat capacity per unit area, see Table 1e.

Element	Gross Area, m²	Openings, m²	Net area A, m²		U-value, W/m²K		A x U, W/K	κ-value, kJ/m².K	A x κ, kJ/K	
Doors			22.28	x	2.00	=	44.56	N/A	N/A	(26)
Window*			76.66	x	0.96	=	73.71	N/A	N/A	(27)
Roof window*			20.91	x	0.96	=	20.11	N/A	N/A	(27a)
Basement floor			533.59	x	0.12	=	64.03	N/A	N/A	(28)
Basement wall			835.85	x	0.15	=	125.38	N/A	N/A	(29)
External wall			537.77	x	0.15	=	80.67	N/A	N/A	(29a)
Roof			512.67	x	0.12	=	61.52	N/A	N/A	(30)
Total area of external elements ∑A, m²			2539.73	(31)						

** for windows and roof windows, effective window U-value is calculated using formula 1/[(1/UValue)+0.04] paragraph 3.2*

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	469.97	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K	Calculated separately =	250.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		203.18	(36)

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

Total fabric heat loss	(33) + (36) =	673.15	(37)

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

(38)m	633.79	609.09	609.09	559.69	526.75	510.28	493.81	493.81	534.98	559.69	584.39	609.09	(38)

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

(39)m	1306.94	1282.24	1282.24	1232.84	1199.90	1183.43	1166.96	1166.96	1208.13	1232.84	1257.54	1282.24	

Average = ∑(39)1...12/12 = 1233.52 (39)

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

(40)m	0.81	0.79	0.79	0.76	0.74	0.73	0.72	0.72	0.75	0.76	0.78	0.79

Average = ∑(40)1...12/12 = 0.76 (40)

4. Water heating energy requirement

kWh/year

Assumed occupancy, N 4.84 (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) + 36 149.22 (43)

Annual average hot water usage has been reduced by 5% if the dwelling is designed to achieve a water use target of not more than 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)												
(44)m	164.15	158.18	152.21	146.24	140.27	134.30	134.30	140.27	146.24	152.21	158.18	164.15

∑(44)1…12 =	1790.67 (44)

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

(45)m	244.00	213.41	220.22	191.99	184.22	158.97	147.31	169.04	171.06	199.35	217.61	236.31	
										∑(45)1…12 =		2353.47	(45)

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

For community heating include distribution loss whether or not hot water tank is present

Distribution loss 0.15 x (45)m

(46)m	36.60	32.01	33.03	28.80	27.63	23.85	22.10	25.36	25.66	29.90	32.64	35.45	(46)

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day):	2.97	(47)
Temperature factor from Table 2b	0.54	(48)
Energy lost from water storage, kWh/day (47) x (48)	1.60	(49)
Enter (49) or (54) in (55)	1.60	(55)

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

(56)m	49.72	44.91	49.72	48.11	49.72	48.11	49.72	49.72	48.11	49.72	48.11	49.72	(56)

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

(57)m	49.72	44.91	49.72	48.11	49.72	48.11	49.72	49.72	48.11	49.72	48.11	49.72	(57)

Primary circuit loss (annual) from Table 3	360.00	(58)

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

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

(59)m	30.58	27.62	30.58	29.59	30.58	29.59	30.58	30.58	29.59	30.58	29.59	30.58	(59)

Combi loss for each month from Table 3a, 3b or 3c (enter '0' if not a combi boiler)

(61)m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(61)

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

(62)m	324.30	285.93	300.51	269.69	264.51	236.67	227.60	249.33	248.76	279.64	295.31	316.60	(62)

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

(63)m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
										∑(63)1…12 =		0.00	(63)

Output from water heater for each month, kWh/month (62)m + (63)m

(64)m	324.30	285.93	300.51	269.69	264.51	236.67	227.60	249.33	248.76	279.64	295.31	316.60	
										∑(64)1…12 =		3298.86	(64)

if (64)m < 0 then set to 0

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

(65)m	145.37	128.98	137.46	126.00	125.49	115.02	113.21	120.44	119.04	130.52	134.52	142.81	(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)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5), Watts													
(66)m	290.58	290.58	290.58	290.58	290.58	290.58	290.58	290.58	290.58	290.58	290.58	290.58	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m	348.92	309.90	252.03	190.80	142.63	120.41	130.11	169.12	227.00	288.22	336.40	358.61	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m	1858.06	1877.34	1828.75	1725.31	1594.74	1472.03	1390.04	1370.76	1419.35	1522.79	1653.36	1776.07	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m	68.90	68.90	68.90	68.90	68.90	68.90	68.90	68.90	68.90	68.90	68.90	68.90	(69)
Pumps and fans gains (Table 5a)													
(70)m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(70)
Losses e.g. evaporation (negative values) (Table 5)													
(71)m	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	-193.72	(71)
Water heating gains (Table 5)													
(72)m	195.38	191.93	184.75	175.00	168.67	159.75	152.17	161.88	165.33	175.43	186.83	191.94	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m													
(73)m	2568.12	2544.93	2431.30	2256.88	2071.80	1917.95	1838.09	1867.53	1977.44	2152.20	2342.35	2492.39	(73)

6. Solar gains

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

Rows (74) to (82) are used 12 times, one for each month, repeating as needed if there is more than one window type.

Details for month of January and annual totals are shown below:

	Access factor Table 6d		Area m²		Solar flux W/m²		g Specific data or Table 6b		FF Specific data or Table 6c		Gains (W)	
Northeast	0.77	x	30.52	x	11.51	x 0.9 x	0.76	x	0.70	=	129.51	(75)
Southeast	0.77	x	8.82	x	37.39	x 0.9 x	0.76	x	0.70	=	121.57	(77)
Northwest	0.77	x	8.18	x	11.51	x 0.9 x	0.76	x	0.70	=	34.71	(81)
Southwest	0.77	x	29.14	x	37.39	x 0.9 x	0.76	x	0.70	=	401.66	(79)
Rooflights	1.00	x	20.91	x	26.00	x 0.9 x	0.76	x	0.70	=	260.30	(82)

Solar gains in watts, calculated for each month ∑(74)m…(82)m													
(83)m	947.76	1768.67	2706.48	3917.40	4769.12	5013.52	4847.38	4192.20	3192.60	2115.82	1164.95	790.94	(83)
Total gains - internal and solar (73)m + (83)m													
(84)m	3515.88	4313.61	5137.78	6174.28	6840.93	6931.47	6685.47	6059.73	5170.04	4268.02	3507.30	3283.33	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1(˚C)	21.00 (85)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area, η1,m (see Table 9a)													
(86)m	1.00	1.00	1.00	1.00	0.99	0.92	0.70	0.76	0.99	1.00	1.00	1.00	(86)
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)													
(87)m	20.12	20.20	20.35	20.54	20.76	20.90	20.96	20.95	20.82	20.57	20.30	20.15	(87)
Temperature during heating periods in the living area from Table 9, Th2(˚C)													
(88)m	20.25	20.26	20.26	20.29	20.30	20.31	20.32	20.32	20.30	20.29	20.27	20.26	(88)
Utilisation factor for gains for rest of dwelling η2,m (see Table 9a)													
(89)m	1.00	1.00	1.00	1.00	0.98	0.87	0.59	0.65	0.97	1.00	1.00	1.00	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)													
(90)m	19.03	19.16	19.37	19.67	20.00	20.21	20.27	20.26	20.09	19.72	19.31	19.08	(90)

Living area fraction	fLA	60.47	÷ (4) =	0.04	(91)

Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2													
(92)m	19.07	19.20	19.41	19.70	20.03	20.23	20.29	20.29	20.12	19.75	19.35	19.12	(92)
Apply adjustment to the mean internal temperature from Table 4e, where appropriate													
(93)m	18.92	19.05	19.26	19.55	19.88	20.08	20.14	20.14	19.97	19.60	19.20	18.97	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that tim = (93)m and recalculate the utilisation factor for gains using Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm													
(94)m	1.00	1.00	1.00	1.00	0.98	0.85	0.56	0.62	0.96	1.00	1.00	1.00	(94)
Useful gains, ηmGm, W = (94)m x (84)m													
(95)m	3515.84	4313.42	5136.29	6160.23	6680.53	5884.51	3758.78	3736.85	4983.81	4264.48	3507.21	3283.31	(95)
Monthly average external temperature from Table 8													
(96)m	4.50	5.00	6.80	8.70	11.70	14.60	16.90	16.90	14.30	10.80	7.00	4.90	(96)
Heat loss rate for mean internal temperature, Lm, W													
(97)m	18842.54	18014.99	15977.87	13382.35	9813.97	6489.69	3783.11	3780.76	6848.89	10851.35	15342.00	18043.11	(97)
Space heating requirement for each month, kWh/month = 0.024 x [(97)m - (95)m] x (41)m													
(98)m	11403.06	9207.45	8066.13	5199.93	2331.28	0.00	0.00	0.00	0.00	4900.63	8521.05	10981.30	

	Total per year (kWh/year) = ∑(98)1...5, 10...12 =	60610.83	(98)
Space heating requirement in kWh/m²/year	(98) ÷ (4)	37.50	(99)

8c. Space cooling requirement

Calculated for June, July and August. See Table 10b.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat loss rate Lm (calculated using 24˚C internal temperature and external temperature from Table 10)													
(100)m	0.00	0.00	0.00	0.00	0.00	10177.52	7235.18	7235.18	0.00	0.00	0.00	0.00	(100)
Utilisation factor for loss, ηm													
(101)m	0.00	0.00	0.00	0.00	0.00	0.74	0.89	0.85	0.00	0.00	0.00	0.00	(101)
Useful loss, ηmLm (Watts) = (100)m x (101)m													
(102)m	0.00	0.00	0.00	0.00	0.00	7504.31	6461.65	6172.13	0.00	0.00	0.00	0.00	(102)
Gains (internal gains as for heating except that column (A) of Table 5 is always used; solar gains calculated for applicable weather region based on Table 10, not Table 6a)													
(103)m	0.00	0.00	0.00	0.00	0.00	7794.61	7440.69	6813.96	0.00	0.00	0.00	0.00	(103)
Space cooling requirement for the month, whole dwelling, continuous (kWh) = 0.024 x [(103)m - (102)m] x (41)m set (104)m to zero if (104)m < 3 x (98)m with (98)m with (98)m calculated using weather data from Table 10													
(104)m	0.00	0.00	0.00	0.00	0.00	0.00	728.40	477.52	0.00	0.00	0.00	0.00	

	Total = ∑(104)6...8 =	1205.93	(104)
Cooled fraction	fc = cooled area ÷ (4) =	0.80	(105)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Intermittency factor (Table 10b)												
(106)m	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.00	0.00	0.00	0.00

Total = ∑(106)6...8 = 0.75 (106)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Space cooling requirement for month = (104)m x (105) x (106)m												
(107)m	0.00	0.00	0.00	0.00	0.00	0.00	145.68	95.51	0.00	0.00	0.00	0.00

	Total = ∑(107)6...8 =	241.19	(107)
Space cooling requirement in kWh/m²/year	(107) ÷ (4) =	0.15	(108)

9a. Energy Requirements - Individual heating systems including micro-CHP

Space heating:

Fraction of space heating from secondary/supplementary system (Table 11)	0.00	(201)
Fraction of space heating from main system(s) 1 - (201)	1.00	(202)
Fraction of main heating from main system 2	0.60	(203)
Fraction of total space heat from main system 1 (202) x [1 - (203)]	0.40	(204)
Fraction of total space heat from main system 2 (202) x (203)	0.60	(205)
Efficiency of main space heating system 1 (%)	84.04	(206)

(from database or Table 4a/4b, adjusted where appropriate by the amount shown in the 'space efficiency adjustment' column of Table 4c)

Efficiency of main space heating system 2 (%)	93.40	(207)

(from database or Table 4a/4b, adjusted where appropriate by the amount shown in the 'space efficiency adjustment' column of Table 4c

Cooling System Energy Efficiency Ratio (see Table 10c)	4.32	(209)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Space heating requirement, kWh/month (as calculated above)												
(98)m	11403.06	9207.45	8066.13	5199.93	2331.28	0.00	0.00	0.00	0.00	4900.63	8521.05	10981.30
Space heating fuel (main heating system 1), kWh/month = (98)m x (204) x 100 ÷ (206)												
(211)m	5427.13	4382.16	3838.97	2474.84	1109.54	0.00	0.00	0.00	0.00	2332.39	4055.48	5226.40

Total per year (kWh/year) = ∑(211)1...5, 10...12 = 28846.89 (211)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Space heating fuel (main heating system 2), kWh/month = (98)m x (203) x 100 ÷ (206)												
(213)m	7325.31	5914.85	5181.67	3340.43	1497.61	0.00	0.00	0.00	0.00	3148.15	5473.91	7054.37

Total per year (kWh/year) = ∑(213)1...5, 10...12 = 38936.29 (213)

Water heating:

Output from water heater, kWh/month (calculated above)

(64)m	324.30	285.93	300.51	269.69	264.51	236.67	227.60	249.33	248.76	279.64	295.31	316.60

∑(64)1...12 = 3298.86 (64)

Efficiency of water heater per month												
(217)m	80.11	79.79	79.06	77.46	72.23	48.30	48.30	48.30	48.30	76.94	79.36	80.06
Fuel for water heating, kWh/month = (64)m x 100 ÷ (217)m												
(219)m	404.82	358.35	380.11	348.15	366.20	490.00	471.22	516.21	515.03	363.47	372.10	395.44

Total per year (kWh/year) = ∑(219)1...12 = 4981.11 (219)

Space cooling

Space cooling fuel, kWh/month (107)m ÷ (209)												
(221)m	0.00	0.00	0.00	0.00	0.00	0.00	33.72	22.11	0.00	0.00	0.00	0.00

Total per year (kWh/year) = ∑(221)6...8 = 55.83 (221)

Annual Totals Summary:		kWh/year	kWh/year	
Space heating fuel used, main system 1			28846.89	(211)
Space heating fuel used, main system 2			38936.29	(213)
Water heating fuel used			4981.11	(219)
Space cooling fuel used			55.83	(221)
Electricity for pumps, fans and electric keep-hot (Table 4f):				
mechanical ventilation fans - balanced, extract or positive input from outside		3479.02		(230a)
warm air heating system fans		0.00		(230b)
central heating pump		130.00		(230c)
oil boiler pump		0.00		(230d)
boiler flue fan		45.00		(230e)
maintaining electric keep-hot facility for gas combi boiler		0.00		(230f)
pump for solar water heating		0.00		(230g)
Total electricity for the above	∑(230a)...(230g)		3654.02	(231)
Electricity for lighting (calculated in Appendix L):			2464.79	(232)
Energy saving/generation technologies (Appendices M, N and Q):				
Electricity generated by PVs (Appendix M) (negative quantity)			-1287.60	(233)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)			-2028.60	(235)

10a. Fuel costs - Individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price (Table 12)		Fuel cost £/year	
Space heating - main system 1	28846.89	x	3.10	x 0.01 =	894.25	(240)
Space heating - main system 2	38936.29	x	3.10	x 0.01 =	1207.03	(241)
Water heating cost (other fuel)	4981.11	x	3.10	x 0.01 =	154.41	(247)
Space cooling	55.83	x	11.46	x 0.01 =	6.40	(248)
Pumps, fans and electric keep-hot	3654.02	x	11.46	x 0.01 =	418.75	(249)
Energy for lighting	2464.79	x	11.46	x 0.01 =	282.46	(250)
Additional standing charges (Table 12)					106.00	(251)
Energy saving/generation technologies (Appendices M, N and Q):						
PV savings (negative quantity)	-1287.60	x	11.46	x 0.01 =	-147.56	(252)
Micro-CHP cost (negative if net generation)	-2028.60	x	11.46	x 0.01 =	-232.48	(252)
Total energy cost				(240)...(242) + (245)...(254)	2689.27	(255)

11a. SAP rating - Individual heating systems including micro-CHP

Energy cost deflator (Table 12)		0.47	(256)
Energy cost factor (ECF)	[(255) x (256)] ÷ [(4) + 45.0] =	0.76	(257)

SAP value	89.39
SAP rating	89 (258)
SAP band	B

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

	Energy kWh/year		Emissions Factor		Emissions (kgCO2/year)	
Space heating - main system 1	28846.89	x	0.198	=	5711.68	(261)
Space heating - main system 2	38936.29	x	0.198	=	7709.39	(262)
Water heating	4981.11	x	0.198	=	986.26	(264)
Space and water heating			(261) + (262) + (263) + (264) =		14407.33	(265)
Space cooling	55.83	x	0.517	=	28.86	(266)
Pumps, fans and electric keep-hot	3654.02	x	0.517	=	1889.13	(267)
Lighting	2464.79	x	0.517	=	1274.30	(268)
Energy saving/generation technologies:						
PV emission savings (negative quantity)	-1287.60	x	0.529	=	-681.14	(269)
Micro-CHP (negative if net generation)	-2028.60	x	0.529	x 0.01 =	-1073.13	(269)
Total carbon dioxide emissions			∑(261)...(271) =		15845.35	(272)
Dwelling carbon dioxide emissions rate			(272) ÷ (4) =		9.80	(273)
EI value					87.22	
EI rating (see section 14)					87	(274)
EI band					B	

13a. Primary energy - Individual heating systems including micro-CHP

	Energy kWh/year		Primary Energy Factor		Primary Energy	
Space heating - main system 1	28846.89	x	1.02	=	29423.83	(261*)
Space heating - main system 2	38936.29	x	1.02	=	39715.02	(262*)
Water heating	4981.11	x	1.02	=	5080.74	(264*)
Space and water heating			(261*) + (262*) + (263*) + (264*) =		74219.59	(265*)
Space cooling	55.83	x	2.92	=	163.02	(266*)
Pumps, fans and electric keep-hot	3654.02	x	2.92	=	10669.74	(267*)
Lighting	2464.79	x	2.92	=	7197.19	(268*)
Energy saving/generation technologies:						
PV primary energy savings (negative quantity)	-1287.60	x	2.92	=	-3759.79	(269*)
Micro-CHP (negative if net generation)	-2028.60	x	2.92	x 0.01 =	-5923.51	(269*)
Total primary energy kWh/year			∑(261*)...(271*) =		82566.24	(272*)
Primary energy kWh/m2/year			(272*) ÷ (4) =		51.08	(273*)