LINTON HOUSE

ENERGY ASSESSMENT

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Issue History:

Issue No.	Date	Description
1	28/01/2013	Draft
2	26/04/2013	Planning Submission
3	13/03/2015	Planning Submission

CONTENTS

1.0 Executive Summary

This energy statement relates to a FULL planning submission.

The project involves the construction of a new residential extension on the roof of an existing office building on the Highgate Road, Camden. The proposed extension is single storey, approximately 700m2 and has 7No. Apartments.

The energy strategy is based on very high insulation levels, Air Souce Heat Pumps and roof-mounted Photovoltaic panels. The resulting regulated and unregulated emissions are sumarised below.

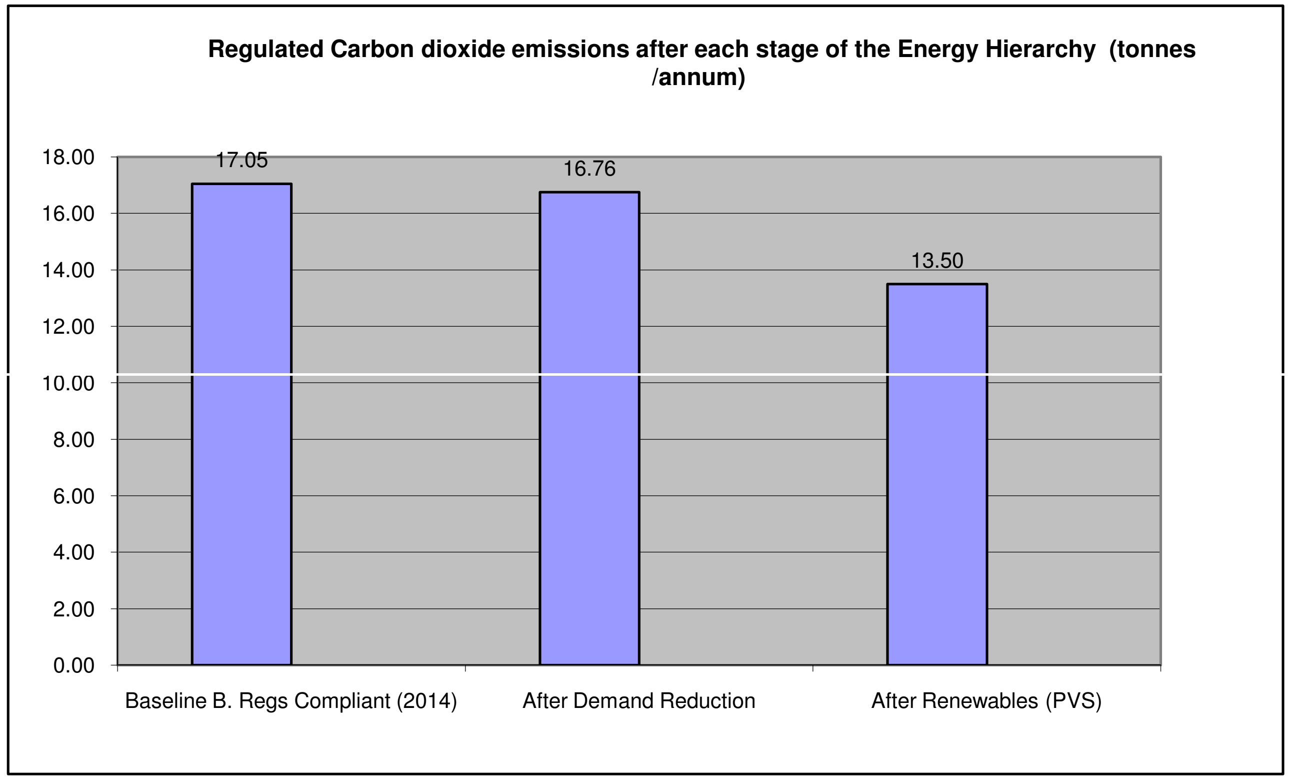


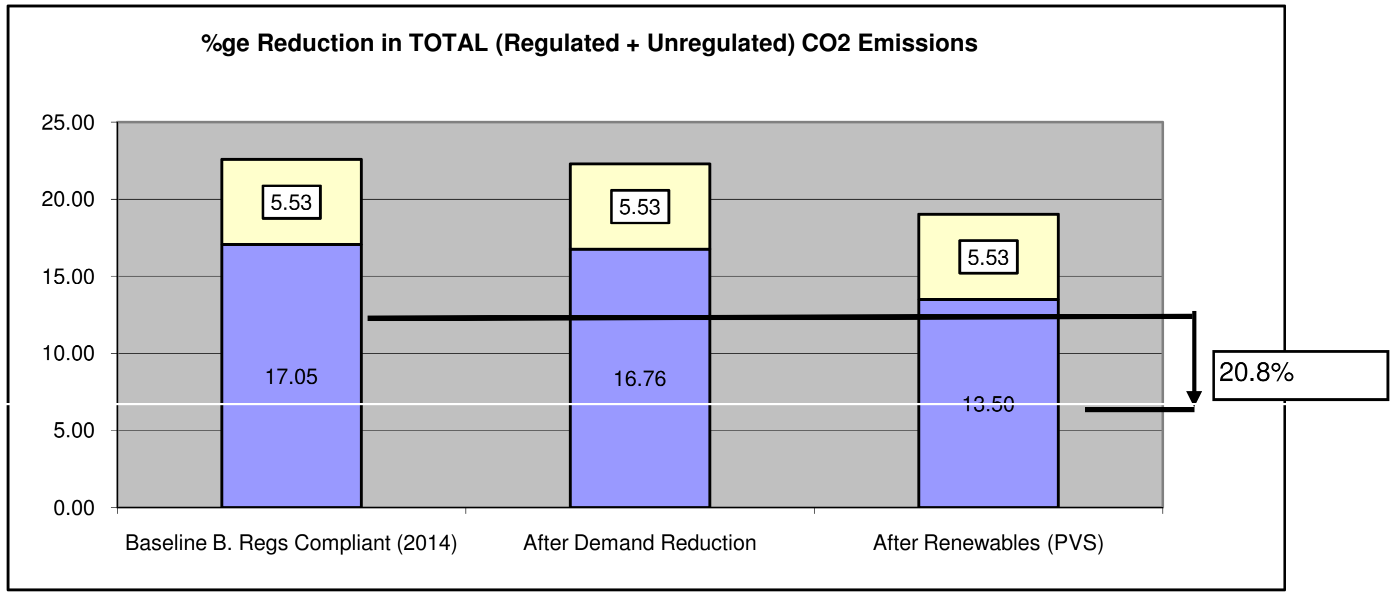
Table1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy

	Carbon dioxide emissions (Tonnes per annum)	
	Regulated	**Unregulated**
Baseline B. Regs Compliant (2014)	17.05	5.53
After Demand Reduction	16.76	5.53
After Renewables (PVS)	13.50	5.53

The resulting percentage reductions in regulated carbon dioxide emissions are given in the table below

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

	Regulated Carbon dioxide savings	
	Tonnes CO^2 / annum	**%**
Baseline Building Regs TER	17.05	
Savings from demand reduction	0.30	1.7%
Savings from renewable energy	3.26	19.1%
Total Cumulative Savings	3.55	20.8%



Lastly; the percentage reductions in total (unregulated + regulated) carbon dioxide emissions are given in the table below.

2.0 Energy Hierarchy

2.1 Demand Reduction

The "regulated" CO_2 Emissions were calculated using recognised SAP software, Stroma FSAP2012 for all the flats.

The calculations take into account a number of "energy demand reduction" measures, which are summarised in the table opposite.

2.2 Efficient Infrastructure

2.2.1 District Heating (not available)

Having established the CO_2 emissions after applying demand reduction measures, the next step was to investigate the use of efficient heating and cooling networks. The London heat map (see below) indicates there are no existing, or proposed district heating mains nearby. The closest, at the Royal Free Hospital is more than 1000m away.

2.2.2 Sitewide Heating

Although there is currently no district heating locally available it would be prudent to design the heating systems such that future connection is not precluded. For this reason a wet heating system (eg radiators, or fan convectors, or underfloor heating) would be preferable to electric heatersor air-to-air heat pumps. With a wet heating system the heat source can be swapped for a district heating plate heat exchanger - should district heating ever become available - without requiring the rest of the heating system to be replaced.

2.2.3 CHP (not proposed)

CHP is really only economically viable for much larger developments.

2.3 On-site Renewables (proposed)

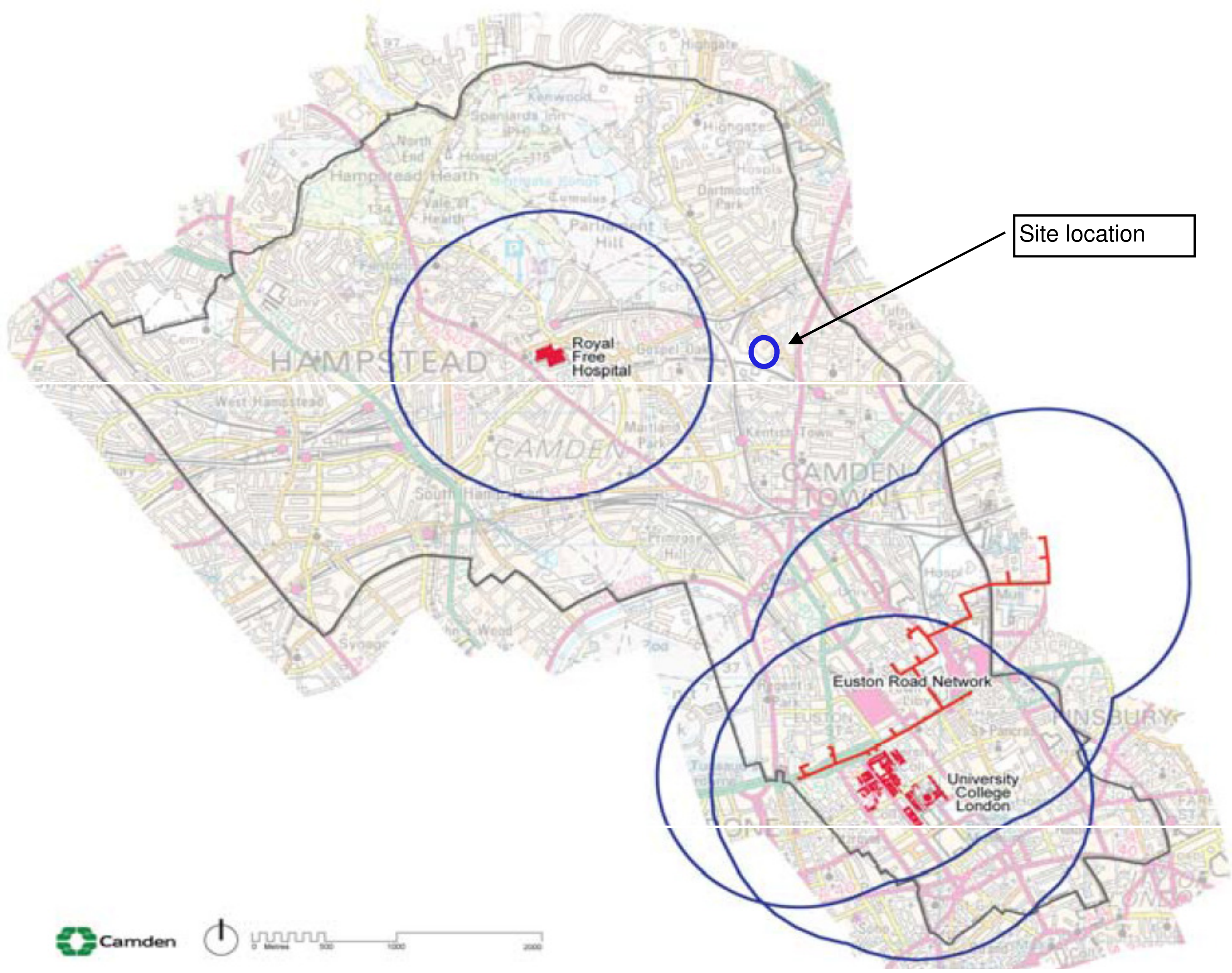
A number of renewable energy sources were looked at; Solar (PV and thermal), Wind, Biomass and Heat Pumps.

Our proposed strategy is wet heating Heating using centralised heat pumps "topped-up" with roof-mounted photovoltaics.This is described in more detail in section 3.

Table 4: Energy Efficiency Measures - "Be Lean"

Element or System	Reference value	Demand Reduction Proposal	Comment
Wall U-Values	0.35	0.15	Requires extra 100 mm P.U. insulation
Floor U-Values	0 (Intermediate Floor)	0	
Roof U-Values	0.16	0.1	Requires extra 100 mm P.U. insulation
Opaque Door	2	0.55	Requires extra 10 mm P.U. insulation
Thermal Bridging	0.11	0.05	Requires robust details
Windows	All East or West Facing		
Areas	25% of floor area =		Requires low-e triple glazing with argon fill
U- Values	1.8	1.3	
Frame Factor	0.7	0.7	
Solar Energy Trans.	0.51	0.51	
Light Trans.	0.67	0.67	
Ventilation system	Natural Ventilation with Intermittent extract fans	Continuous Mechanical Extract with SFP= 0.17 W/l/s	
Extract Fans	3 Fans per apt	Centralised extract system	
Hot Water Cylinder	150l Cylinders with 35mm factory foam	150l Cylinders with 80mm factory foam	
Primary Losses	Primary pipework not insulated, cylinder temp controlled by thermostat	Primary and secondary pipework insulated. Time and temperature control of cylinder.	
Secondary Space Htg	10% Elec	10% Elec	
Low-e light fittings	70% of fixed outlets	100% of fixed outlets	
Heating Fuel	Natural Gas	Natural Gas	
Heating System	Boiler – SEDBUK 78% efficient room-sealed fanned flue appliance	Boiler – SEDBUK 80% efficient room-sealed fanned flue appliance	
Heating Controls	Programmer + room thermostat + TRVs + boiler interlock		
Hot Water System	Stored water, heated by boiler, separate timers for HTG and DHW	Stored water, heated by boiler, separate timers for HTG and DHW	

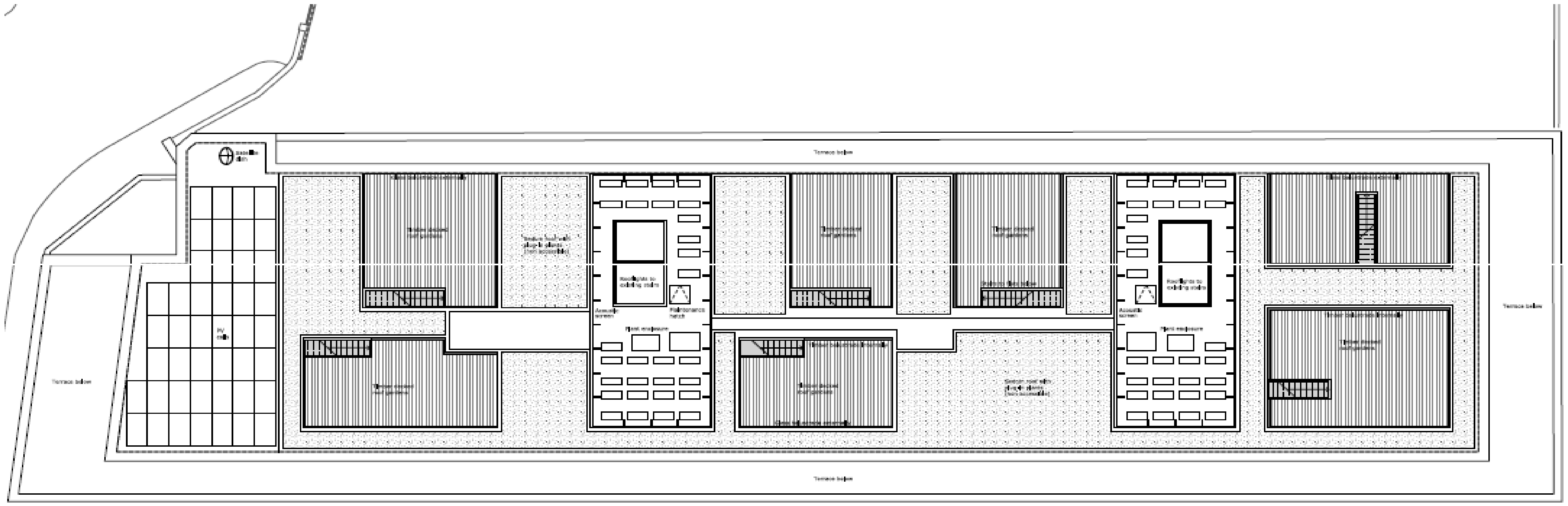
Figure 4. Developments within 1km radius of an existing or emerging network.



3.0 Detailed Proposal

The propsals involve installing 40 No. 250Wpeak PV panels to give a total output of 10KW peak.

The panels will be located at the Southern end of the building, above the existing stair well as shown.



Appendix I

Establishing the targets -

Energy Calculations

Establishing the targets - SAP calculations

Core Strategy 13 , para 13.11 states that developments will be expected to demonstrate a 20% reduction in CO2 emmissions from on-site renewable energy generation.

SAP software (Stroma fSAP) was used as follows:

1. The target for Regulated CO2 emissions for building regulations compliance (TER) was calculated for three representative flat types (NW corner, SE corner and W mid-facade). The resulting Target emmissions were averaged and extrapolated across the total floor area to give an overall "Baseline" figure for the development.

2. The *Regulated* CO2 emissions (DER) after energy reduction measures were calculated and extrapolated across the whole development

3. *Unregulated* were calculated using the NHER Plan Assessor software and extrapolated across the whole development

A SAP worksheet for one of the apartments is given on the following pages, for information.

Full calculations are available on request.

Baseline: Building Regs TER from SAP calculations								Total CO2 Emissions (kg/year)	
	Flat 501 147.5 m2	Flat 502 127.9 m2	Flat 503 83.0 m2	Flat 504 112.5 m2	Flat 505 55.2 m2	Flat 506 91.5 m2	Flat 507 87.6 m2	Sum of Samples 705.3 m2	Extrapolate to overall area 705.3 m2
	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg	T/yr
1. TER from SAP	26.08	24.62	27.77	29.77	31.10	28.75	32.62	17052.90	17.05
2. Unregulated CO2 emissions	14.06	15.16	18.28	16.16	20.22	17.67	17.95	5530.65	5.53
								Regulated + Unregulated	22.58

Be Lean: Emissions after Energy Efficiency Improvements								Total CO2 Emissions (kg/year)	
Representative flats for SAP:	Flat 501 147.5 m2	Flat 502 127.9 m2	Flat 503 83.0 m2	Flat 504 112.5 m2	Flat 505 55.2 m2	Flat 506 91.5 m2	Flat 507 87.6 m2	Sum of Samples 705.3 m2	Extrapolate to overall area 705.3 m2
	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg	T/yr
1. Regulated CO2, DER	21.88	23.20	30.30	27.75	39.24	29.56	33.38	16756.69	16.76
2. Unregulated CO2 emissions	14.06	15.16	18.28	16.16	20.22	17.67	17.95	5530.65	5.53
								Regulated + Unregulated	22.28

Be Green: Emissions after PV Added								Total CO2 Emissions (kg/year)	
Representative flats for SAP:	Flat 501 147.5 m2	Flat 502 127.9 m2	Flat 503 83.0 m2	Flat 504 112.5 m2	Flat 505 55.2 m2	Flat 506 91.5 m2	Flat 507 87.6 m2	Sum of Samples 705.3 m2	Extrapolate to overall area 705.3 m2
	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg/m2	kg	T/yr
1. Regulated CO2, DER	20.54	19.34	21.98	23.36	24.94	23.09	25.50	13500.45	13.50
2. Unregulated CO2 emissions	14.06	15.16	18.28	16.16	20.22	17.67	17.95	5530.65	5.53
								Regulated + Unregulated	19.03

User Details:

Assessor Name:	Mike Ovenden	**Stroma Number:**	STRO006697
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.1.14

Property Address: Flat 501

Address : 501, Linton House

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	147.54	(1a) x	2.7	(2a) =	398.36	(3a)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	147.54	(4)				
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =	398.36	(5)

2. Ventilation rate:

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

Air changes per hour

Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	0 ÷ (5) =	0	(8)
If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)			
Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction		0	(11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35			
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		5	(17)
If based on air permeability value, then (18) = [(17) ÷ 20]+(8), otherwise (18) = (16)		0.25	(18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used			
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.21	(21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7 (22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7
Wind Factor (22a)m = (22)m ÷ 4 (22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

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

0.27	0.27	0.26	0.23	0.23	0.2	0.2	0.2	0.21	0.23	0.24	0.25

Calculate effective air change rate for the applicable case

If mechanical ventilation:	0.5	(23a)
If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a)	0.5	(23b)
If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) =	0	(23c)

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

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

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)

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]

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

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)
(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)
(24c)m=	0.52	0.52	0.51	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	(24c)
(24d)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24d)
(25)m=	0.52	0.52	0.51	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	(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	
Windows Type 1			7.78	x1/[1/(1.2)+ 0.04]	=	8.91			(27)
Windows Type 2			7.67	x1/[1/(1.2)+ 0.04]	=	8.78			(27)
Windows Type 3			7.59	x1/[1/(1.2)+ 0.04]	=	8.69			(27)
Windows Type 4			13.8	x1/[1/(1.2)+ 0.04]	=	15.8			(27)
Windows Type 5			14.09	x1/[1/(1.2)+ 0.04]	=	16.13			(27)
Floor			147.54	x 0.16	=	23.6064			(28)
Walls	71.28	50.93	20.35	x 0.2	=	4.07			(29)
Roof	147.54	0	147.54	x 0.16	=	23.61			(30)
Total area of elements, m²			366.36						(31)
Party wall			87.31	x 0	=	0			(32)

** 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) =	109.6	(33)
Heat capacity Cm = S(A x k)	((28)…(30) + (32) + (32a)…(32e) =	8772.11	(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		13.59	(36)
if details of thermal bridging are not known (36) = 0.15 x (31)			
Total fabric heat loss	(33) + (36) =	123.19	(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

SAP WorkSheet: New dwelling design stage

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	68.48	67.78	67.08	65.73	65.73	65.73	65.73	65.73	65.73	65.73	65.73	65.73	(38)

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

(39)m=	191.67	190.97	190.28	188.92	188.92	188.92	188.92	188.92	188.92	188.92	188.92	188.92	

Average = Sum(39)$_{1...12}$ /12= 189.43 (39)

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

(40)m=	1.3	1.29	1.29	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	

Average = Sum(40)$_{1...12}$ /12= 1.28 (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 2.93 (42)

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

if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 103.79 (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=	114.17	110.02	105.87	101.72	97.57	93.41	93.41	97.57	101.72	105.87	110.02	114.17	

Total = Sum(44)$_{1...12}$ = 1245.53 (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=	169.32	148.08	152.81	133.22	127.83	110.31	102.22	117.3	118.7	138.33	151	163.97	

Total = Sum(45)$_{1...12}$ = 1633.08 (45)

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

(46)m=	25.4	22.21	22.92	19.98	19.17	16.55	15.33	17.59	17.8	20.75	22.65	24.6	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 180 (47)

If community heating and no tank in dwelling, enter 110 litres in (47)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in (47)

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day): 1.38 (48)

Temperature factor from Table 2b 0.54 (49)

Energy lost from water storage, kWh/year (48) x (49) = 0.75 (50)

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

Hot water storage loss factor from Table 2 (kWh/litre/day) 0 (51)

If community heating see section 4.3

Volume factor from Table 2a 0 (52)

Temperature factor from Table 2b 0 (53)

Energy lost from water storage, kWh/year (47) x (51) x (52) x (53) = 0 (54)

Enter (50) or (54) in (55) 0.75 (55)

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

(56)m=	23.1	20.87	23.1	22.36	23.1	22.36	23.1	23.1	22.36	23.1	22.36	23.1	(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=	23.1	20.87	23.1	22.36	23.1	22.36	23.1	23.1	22.36	23.1	22.36	23.1	(57)

SAP WorkSheet: New dwelling design stage

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

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

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

(59)m=	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(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=	215.68	189.96	199.17	178.09	174.19	155.18	148.58	163.66	163.56	184.69	195.87	210.34	(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=	215.68	189.96	199.17	178.09	174.19	155.18	148.58	163.66	163.56	184.69	195.87	210.34	

Output from water heater (annual)$_{1...12}$ 2178.98 (64)

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

(65)m=	93.39	82.74	87.9	80.19	79.59	72.57	71.08	76.09	75.36	83.09	86.1	91.61	(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=	175.82	175.82	175.82	175.82	175.82	175.82	175.82	175.82	175.82	175.82	175.82	175.82	(66)

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

(67)m=	70.84	62.92	51.17	38.74	28.96	24.45	26.42	34.34	46.09	58.52	68.3	72.81	(67)

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

(68)m=	474.38	479.3	466.9	440.49	407.15	375.82	354.89	349.97	362.37	388.78	422.12	453.45	(68)

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

(69)m=	55.51	55.51	55.51	55.51	55.51	55.51	55.51	55.51	55.51	55.51	55.51	55.51	(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=	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	-117.21	(71)

Water heating gains (Table 5)

(72)m=	125.52	123.12	118.15	111.38	106.98	100.79	95.54	102.27	104.67	111.67	119.58	123.13	(72)

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

(73)m=	784.86	779.46	750.33	704.72	657.21	615.18	590.96	600.7	627.24	673.09	724.12	763.51	(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)	
Northeast 0.9x	0.77	x	7.78	x	11.28	x	0.4	x	0.8	=	19.47	(75)
Northeast 0.9x	0.77	x	7.67	x	11.28	x	0.4	x	0.8	=	19.19	(75)

Northeast	0.9x	0.77	x	7.59	x	11.28	x	0.4	x	0.8	=	18.99	(75)
Northeast	0.9x	0.77	x	13.8	x	11.28	x	0.4	x	0.8	=	34.53	(75)
Northeast	0.9x	0.77	x	7.78	x	22.97	x	0.4	x	0.8	=	39.62	(75)
Northeast	0.9x	0.77	x	7.67	x	22.97	x	0.4	x	0.8	=	39.06	(75)
Northeast	0.9x	0.77	x	7.59	x	22.97	x	0.4	x	0.8	=	38.66	(75)
Northeast	0.9x	0.77	x	13.8	x	22.97	x	0.4	x	0.8	=	70.28	(75)
Northeast	0.9x	0.77	x	7.78	x	41.38	x	0.4	x	0.8	=	71.39	(75)
Northeast	0.9x	0.77	x	7.67	x	41.38	x	0.4	x	0.8	=	70.38	(75)
Northeast	0.9x	0.77	x	7.59	x	41.38	x	0.4	x	0.8	=	69.65	(75)
Northeast	0.9x	0.77	x	13.8	x	41.38	x	0.4	x	0.8	=	126.63	(75)
Northeast	0.9x	0.77	x	7.78	x	67.96	x	0.4	x	0.8	=	117.24	(75)
Northeast	0.9x	0.77	x	7.67	x	67.96	x	0.4	x	0.8	=	115.59	(75)
Northeast	0.9x	0.77	x	7.59	x	67.96	x	0.4	x	0.8	=	114.38	(75)
Northeast	0.9x	0.77	x	13.8	x	67.96	x	0.4	x	0.8	=	207.96	(75)
Northeast	0.9x	0.77	x	7.78	x	91.35	x	0.4	x	0.8	=	157.6	(75)
Northeast	0.9x	0.77	x	7.67	x	91.35	x	0.4	x	0.8	=	155.37	(75)
Northeast	0.9x	0.77	x	7.59	x	91.35	x	0.4	x	0.8	=	153.75	(75)
Northeast	0.9x	0.77	x	13.8	x	91.35	x	0.4	x	0.8	=	279.54	(75)
Northeast	0.9x	0.77	x	7.78	x	97.38	x	0.4	x	0.8	=	168.02	(75)
Northeast	0.9x	0.77	x	7.67	x	97.38	x	0.4	x	0.8	=	165.64	(75)
Northeast	0.9x	0.77	x	7.59	x	97.38	x	0.4	x	0.8	=	163.91	(75)
Northeast	0.9x	0.77	x	13.8	x	97.38	x	0.4	x	0.8	=	298.02	(75)
Northeast	0.9x	0.77	x	7.78	x	91.1	x	0.4	x	0.8	=	157.18	(75)
Northeast	0.9x	0.77	x	7.67	x	91.1	x	0.4	x	0.8	=	154.95	(75)
Northeast	0.9x	0.77	x	7.59	x	91.1	x	0.4	x	0.8	=	153.34	(75)
Northeast	0.9x	0.77	x	13.8	x	91.1	x	0.4	x	0.8	=	278.8	(75)
Northeast	0.9x	0.77	x	7.78	x	72.63	x	0.4	x	0.8	=	125.3	(75)
Northeast	0.9x	0.77	x	7.67	x	72.63	x	0.4	x	0.8	=	123.53	(75)
Northeast	0.9x	0.77	x	7.59	x	72.63	x	0.4	x	0.8	=	122.24	(75)
Northeast	0.9x	0.77	x	13.8	x	72.63	x	0.4	x	0.8	=	222.26	(75)
Northeast	0.9x	0.77	x	7.78	x	50.42	x	0.4	x	0.8	=	86.99	(75)
Northeast	0.9x	0.77	x	7.67	x	50.42	x	0.4	x	0.8	=	85.76	(75)
Northeast	0.9x	0.77	x	7.59	x	50.42	x	0.4	x	0.8	=	84.87	(75)
Northeast	0.9x	0.77	x	13.8	x	50.42	x	0.4	x	0.8	=	154.3	(75)
Northeast	0.9x	0.77	x	7.78	x	28.07	x	0.4	x	0.8	=	48.42	(75)
Northeast	0.9x	0.77	x	7.67	x	28.07	x	0.4	x	0.8	=	47.74	(75)
Northeast	0.9x	0.77	x	7.59	x	28.07	x	0.4	x	0.8	=	47.24	(75)
Northeast	0.9x	0.77	x	13.8	x	28.07	x	0.4	x	0.8	=	85.89	(75)
Northeast	0.9x	0.77	x	7.78	x	14.2	x	0.4	x	0.8	=	24.49	(75)
Northeast	0.9x	0.77	x	7.67	x	14.2	x	0.4	x	0.8	=	24.15	(75)
Northeast	0.9x	0.77	x	7.59	x	14.2	x	0.4	x	0.8	=	23.9	(75)

Northeast	0.9x	0.77	x	13.8	x	14.2	x	0.4	x	0.8	=	43.45	(75)
Northeast	0.9x	0.77	x	7.78	x	9.21	x	0.4	x	0.8	=	15.9	(75)
Northeast	0.9x	0.77	x	7.67	x	9.21	x	0.4	x	0.8	=	15.67	(75)
Northeast	0.9x	0.77	x	7.59	x	9.21	x	0.4	x	0.8	=	15.51	(75)
Northeast	0.9x	0.77	x	13.8	x	9.21	x	0.4	x	0.8	=	28.2	(75)
Southeast	0.9x	0.77	x	14.09	x	36.79	x	0.4	x	0.8	=	114.97	(77)
Southeast	0.9x	0.77	x	14.09	x	62.67	x	0.4	x	0.8	=	195.83	(77)
Southeast	0.9x	0.77	x	14.09	x	85.75	x	0.4	x	0.8	=	267.94	(77)
Southeast	0.9x	0.77	x	14.09	x	106.25	x	0.4	x	0.8	=	331.99	(77)
Southeast	0.9x	0.77	x	14.09	x	119.01	x	0.4	x	0.8	=	371.86	(77)
Southeast	0.9x	0.77	x	14.09	x	118.15	x	0.4	x	0.8	=	369.17	(77)
Southeast	0.9x	0.77	x	14.09	x	113.91	x	0.4	x	0.8	=	355.92	(77)
Southeast	0.9x	0.77	x	14.09	x	104.39	x	0.4	x	0.8	=	326.18	(77)
Southeast	0.9x	0.77	x	14.09	x	92.85	x	0.4	x	0.8	=	290.12	(77)
Southeast	0.9x	0.77	x	14.09	x	69.27	x	0.4	x	0.8	=	216.43	(77)
Southeast	0.9x	0.77	x	14.09	x	44.07	x	0.4	x	0.8	=	137.7	(77)
Southeast	0.9x	0.77	x	14.09	x	31.49	x	0.4	x	0.8	=	98.39	(77)

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

(83)m=	207.14	383.46	605.99	887.17	1118.12	1164.77	1100.18	919.51	702.04	445.73	253.69	173.66	(83)

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

(84)m=	992	1162.92	1356.32	1591.89	1775.33	1779.95	1691.14	1520.21	1329.29	1118.82	977.8	937.17	(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	
(86)m=	1	0.99	0.98	0.93	0.82	0.64	0.48	0.55	0.81	0.97	0.99	1	(86)

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

(87)m=	21	21	21	21	21	21	21	21	21	21	21	21	(87)

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

(88)m=	19.84	19.85	19.85	19.86	19.86	19.86	19.86	19.86	19.86	19.86	19.86	19.86	(88)

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

(89)m=	1	0.99	0.97	0.91	0.76	0.54	0.36	0.42	0.73	0.95	0.99	1	(89)

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

(90)m=	19.84	19.85	19.85	19.86	19.86	19.86	19.86	19.86	19.86	19.86	19.86	19.86	(90)

fLA = Living area ÷ (4) = 0.33 (91)

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

(92)m=	20.23	20.23	20.23	20.24	20.24	20.24	20.24	20.24	20.24	20.24	20.24	20.24	(92)

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

(93)m=	20.23	20.23	20.23	20.24	20.24	20.24	20.24	20.24	20.24	20.24	20.24	20.24	(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

SAP WorkSheet: New dwelling design stage

Utilisation factor for gains, hm:

(94)m=	1	0.99	0.98	0.92	0.78	0.57	0.4	0.47	0.76	0.96	0.99	1	(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	988.03	1152.61	1323.31	1463.79	1385.41	1022.7	680.77	712.35	1012.39	1070.09	969.71	934.29	(95)

Monthly average external temperature from Table 8

(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2	(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	3052.91	2927.67	2613	2141.88	1612.91	1065.04	687.2	724.98	1159.5	1820.72	2481.94	3029.81	(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	1536.27	1192.84	959.53	488.22	169.26	0	0	0	0	558.47	1088.8	1559.07

Total per year (kWh/year) = Sum(98)$_{1...5,10...12}$ = 7552.46 (98)

Space heating requirement in kWh/m²/year 51.19 (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		276.67	(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)	1536.27	1192.84	959.53	488.22	169.26	0	0	0	0	558.47	1088.8	1559.07		
(211)m = {[(98)m x (204)] + (210)m } x 100 ÷ (206)	555.28	431.15	346.82	176.47	61.18	0	0	0	0	201.86	393.54	563.52		(211)
Total (kWh/year) =Sum(211)$_{1...5,10...12}$=													2729.79	(211)
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)	215.68	189.96	199.17	178.09	174.19	155.18	148.58	163.66	163.56	184.69	195.87	210.34		
Efficiency of water heater													103.68	(216)
(217)m=	103.68	103.68	103.68	103.68	103.68	103.68	103.68	103.68	103.68	103.68	103.68	103.68		(217)
Fuel for water heating, kWh/month (219)m = (64)m x 100 ÷ (217)m (219)m=	208.02	183.22	192.1	171.77	168.01	149.67	143.31	157.85	157.76	178.14	188.91	202.87		
Total = Sum(219a)$_{1...12}$ =													2101.64	(219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		2729.79
Water heating fuel used		2101.64
Electricity for pumps, fans and electric keep-hot		

SAP WorkSheet: New dwelling design stage

mechanical ventilation - balanced, extract or positive input from outside		476.28		(230a)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =		476.28	(231)
Electricity for lighting			500.41	(232)
Electricity generated by PVs			-380.25	(233)

10a. Fuel costs - individual heating systems:

	Fuel kWh/year	**Fuel Price** (Table 12)		**Fuel Cost** £/year	
Space heating - main system 1	(211) x	13.19	x 0.01 =	360.05988902912	(240)
Space heating - main system 2	(213) x	0	x 0.01 =	0	(241)
Space heating - secondary	(215) x	13.19	x 0.01 =	0	(242)
Water heating cost (other fuel)	(219)	13.19	x 0.01 =	277.21	(247)
Pumps, fans and electric keep-hot	(231)	13.19	x 0.01 =	62.82	(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)	13.19	x 0.01 =	66	(250)
Additional standing charges (Table 12)				0	(251)
	one of (233) to (235) x)	13.19	x 0.01 =	-50.15	(252)
Appendix Q items: repeat lines (253) and (254) as needed					
Total energy cost	(245)…(247) + (250)…(254) =			715.94	(255)

11a. SAP rating - individual heating systems

Energy cost deflator (Table 12)		0.42	(256)
Energy cost factor (ECF)	[(255) x (256)] ÷ [(4) + 45.0] =	1.56	(257)
SAP rating (Section 12)		78.21	(258)

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

	Energy kWh/year	**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x	0.519	=	1416.76	(261)
Space heating (secondary)	(215) x	0.519	=	0	(263)
Water heating	(219) x	0.519	=	1090.75	(264)
Space and water heating	(261) + (262) + (263) + (264) =			2507.51	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.519	=	247.19	(267)
Electricity for lighting	(232) x	0.519	=	259.71	(268)
Energy saving/generation technologies Item 1		0.519	=	-197.35	(269)
Total CO2, kg/year	sum of (265)…(271) =			2817.06	(272)
CO2 emissions per m²	(272) ÷ (4) =			19.09	(273)
EI rating (section 14)				80	(274)

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13a. Primary Energy

	Energy kWh/year		Primary factor		P. Energy kWh/year	
Space heating (main system 1)	(211)	x	3.07	=	8380.47	(261)
Space heating (secondary)	(215)	x	3.07	=	0	(263)
Energy for water heating	(219)	x	3.07	=	6452.03	(264)
Space and water heating	(261) + (262) + (263) + (264) =				14832.5	(265)
Electricity for pumps, fans and electric keep-hot	(231)	x	3.07	=	1462.17	(267)
Electricity for lighting	(232)	x	0	=	1536.25	(268)
Energy saving/generation technologies						
Item 1			3.07	=	-1167.36	(269)
'Total Primary Energy			sum of (265)...(271) =		16663.56	(272)
Primary energy kWh/m²/year			(272) ÷ (4) =		112.94	(273)

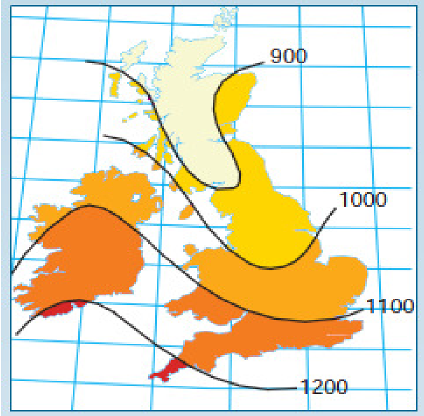
Appendix II

Feasibility Study for Proposed Strategy

Renewable: Photovoltaics

1. SITE ANALYSIS

Incoming annual radiation	1,100 kWh/m2
Tilt	30 deg
Direction (S=0, W=90, E=-90)	0 deg
Correction Factor	100%
Shading	None
Shading Correction Factor	1.00
Inverter loss Correction Factor	91%
Dist'n loss Correction Factor	97%
Balance Of System C.F.	85%
Total Combined Correction Factor	75.0%
Corrected annual radiation	**825 kWh/m2**



Annual radiation kWh/m2
For South-facing @30 deg tilt

Tilt	Annual output as percentage of maximum for stated orientation (with respect to due south) and tilt / %												
	–90° West	–75°	–60°	–45° SW	–30°	–15°	0° South	15°	30°	45° SE	60°	75°	90° East
Vertical	56	60	64	67	69	71	71	71	71	69	65	62	58
80°	63	68	72	75	77	79	80	80	79	77	74	69	65
70°	69	74	78	82	85	86	87	87	86	84	80	76	70
60°	74	79	84	87	90	91	93	93	92	89	86	81	76
50°	78	84	88	92	95	96	97	97	96	93	89	85	80
40°	82	86	90	95	97	99	100	99	98	96	92	88	84
30°	86	89	93	96	97	99	100	100	98	96	94	90	86
20°	87	90	93	96	97	98	98	98	97	96	94	91	88
10°	89	91	92	94	97	95	96	95	95	94	93	91	90
Horizontal	90	90	90	90	90	90	90	90	90	90	90	90	90

Correction for tilt and direction

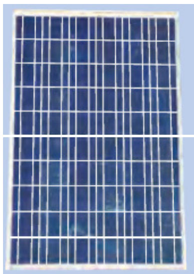
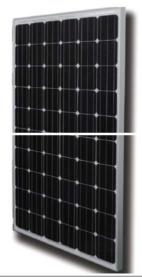
	%ge of sky blocked by obstacles	Correction Factor
None	<20%	1.00
Modest	20-60%	0.80
Significant	60-80%	0.65
Heavy	80-100%	0.50

Correction for sky obstructions

2. PANEL SELECTION

Chosen Panel	HIT 250
Manufacturer	Sanyo
Dims	1610 x 861 x 35
Output at 1000 W/m2 radiation	250 W
Annual corrected output	206 kWh
Annual output per m2	149 kWh/m2
Installed Cost per m2	£300

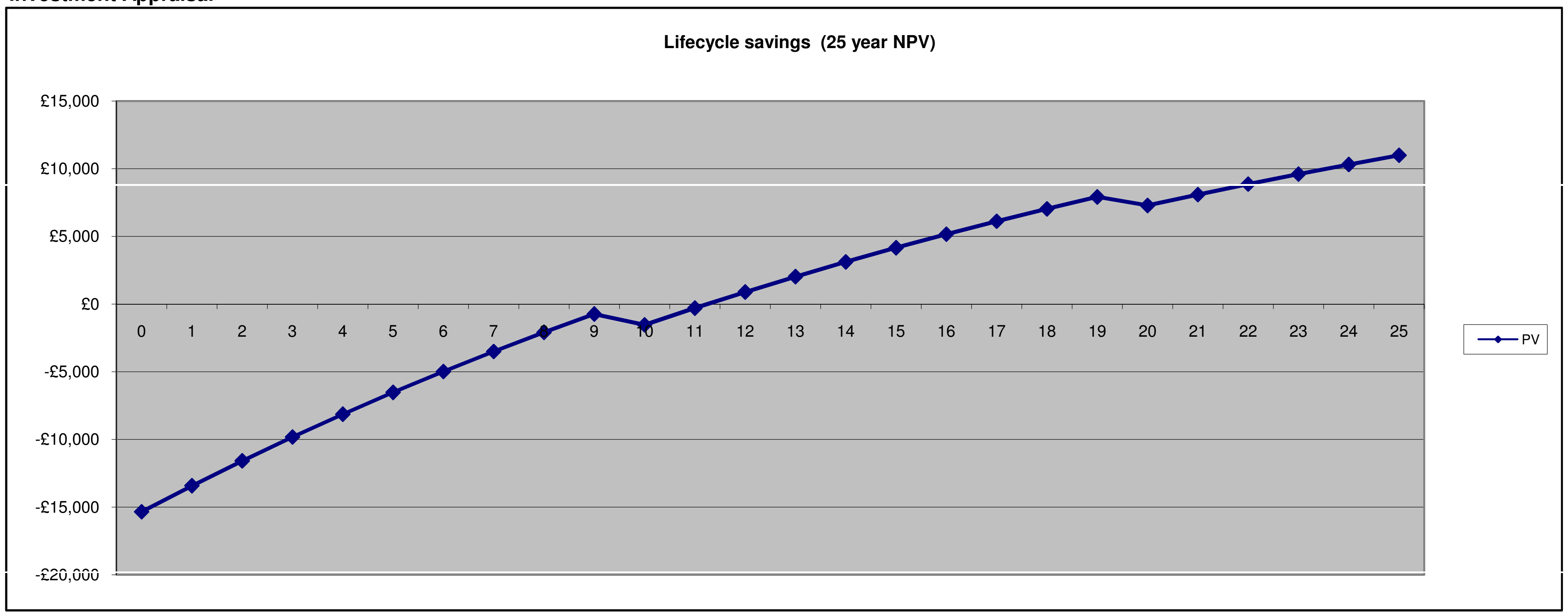
Manufacturer's information

MBPV240	HIT 250	STP 250		
MoserBaer	Sanyo	Suntech		
1661 x991 x 40	1610 x 861 x 35	1665 x991 x 50		
240 W	250 W	250 W		
120 kWh/m2	149 kWh/m2	125 kWh/m2		
£350	£300	£250		
				

3. TARGET CO2 REDUCTION

Target (from Appendix I)	**4,456 kg CO2**
CO2 saved per kWh	0.517
KWh to achieve target	8,619kWh
Peak Output Required	10 kW
Panel Area Required	**58 m2**
Installed Cost	**£17,372**
Annual maintenance (@1.5%)	£261
Replace inverters (10 yearly)	£3,000
Output drop (per year)	1.5%
Feed-in Tariff	13.0 p/kWh
Duration	25 years
Year 1 FIT	£1,123
Output used on site	100%
Elec price from grid	13.5 p/kWh
Year 1 Elec Saving	£1,164
Output sold to Grid	0%
Elec price to grid	3.5 p/kWh
Year 1 Elec Sales	£0
SIMPLE PAYBACK	7.7 years
25 year NPV	£92,502
CO2 saved	4,456 kg CO2
%ge renewable	20.0%

Investment Appraisal



4. OTHER CONSIDERATIONS

4.1 Space - approximately 120m2 available on roof.
4.2 Maintenance - annual inspection and occasional repair , but otherwise, fairly minimal
4.3 Noise - not an issue.
4.4 Energy mix - would work well with heat pumps, should not affect future district heating, but would be a bad match for future private-wire electricity from, say, a community CHP system.