

Josh Street

From: Kennett, Darren [REDACTED]
Sent: 11 September 2014 14:23
To: Peter Cleveland
Subject: FW: Ref: A/82/12/ Land to East Roundstone lane Angmering - Condition 23
Attachments: Swanbourne Park Energy Demand Reduction Study PV.pdf

Dear Peter,

Condition 23 – 10% Renewable or Low-carbon energy sources
See the report from Environmental Economics dated June 2014

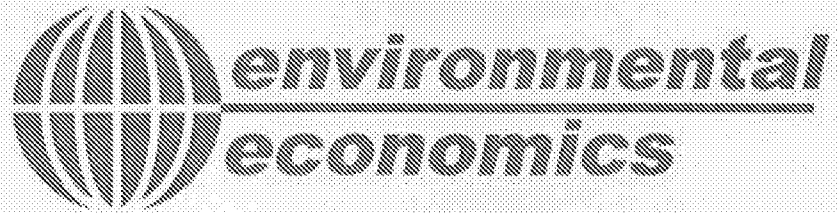
Regards

Darren

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Energy Demand Reduction Study

Swanbourne Park, Angmering

Client: Barratt Homes Southampton

Author: Sean O'Callaghan

June 2014

Thermal House

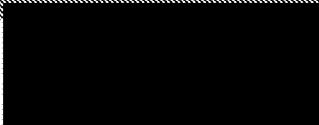
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Revision History

<i>Version</i>	<i>Date</i>	<i>Reason for Issue</i>	<i>Issued by</i>	<i>QA check</i>
1	27/06/2014	Report provided in response to the planning requirement	 Sean O'Callaghan	 Tim James

Contents

1 Project Overview	1
1.1 Introduction	1
1.2 Description of Site	1
1.3 Client Brief	1
2 Improvement Measures	2
2.1 Assessment Methodology	2
2.2 Design Philosophy	3
2.3 Renewables Technology	4
3 Evaluation	8
3.1 Recommended Solution	8
3.2 Conclusion	8
Appendix A	
Appendix B	
Appendix C	
Appendix D	

1. Project Overview

1.1. Introduction

This energy demand reduction study was prepared by Environmental Economics Ltd on behalf of Barratt Homes Southampton (BHS) to support a planning application for a proposed development in Angmering. The report assesses measures to reduce the energy demand from the domestic housing on site through the use of Low and Zero Carbon (LZC) technologies.

1.2. Description of Site

The Swanbourne Park site consists of 138 detached, semi-detached, and terraced dwellings.

The site location is shown in Appendix A. The proposed site layout/design is shown in Appendix B.

This energy demand reduction study addresses a domestic development being undertaken by BHS, and does not include any further proposals for subsequent developments or non-residential parcels.

1.3. Local Planning Requirements

The development has been designed to achieve a 10% reduction in energy demand through the use of Low and Zero Carbon (LZC) technologies.

The development is set to comply with the targets set by the Arun District Council. Policy ECC SP2 states:

'All major developments must produce 10% of the total predicted energy requirements from renewables or low carbon energy generation on site unless it can be demonstrated that this is unviable.'

2. Improvement Measures

2.1. Assessment Methodology

Environmental Economics have modelled the proposed dwellings using NHER Plan Assessor software. The software provides a number of outputs which can be used to assess and compare the improvements from any number of build specifications in terms of:

- *Building regulations compliance*
- *Energy usage per year (kWh/annum)*
- *Carbon emissions as a measure of building regulations compliance (kg CO₂/m²/year)*
- *Energy costs per year (£/annum)*
- *More detailed breakdowns by end use (space heating, water heating, cooking, lighting, appliances)*
- *Code for Sustainable Homes compliance*
- *Effective air change rate*

Each of these outputs can be used in different ways to analyse the performance of the dwelling. For this project the requirement as set out in the previous section relates to a reduction in energy demand.

The analysis, therefore, evaluated the energy usage per year for each of the properties on site. The total energy demand for each property is based upon:

- *Space heating*
- *Water heating*
- *Electricity for pumps and fans*
- *Electricity for lighting*

Two models were created in order to calculate the difference in energy demand from the fabric improvements and addition of renewables. The total energy demand for the site is calculated for each of the models, and then the difference used to establish the improvement from LZC technology.

The first model without renewable technologies which achieves base compliance with current Building Regulations is based upon standard BHEC heating and hot water designs. Depending on total floor area, this will take the form of a mains gas combi or regular condensing boiler.

The energy calculation for the space and water heating, as well as the electricity for pumps, fans and lighting were all assessed using the Standard Assessment Procedure 2009 (SAP) through the Plan Assessor software.

2.2. Design Philosophy

In addition to LZC technology, BHS have improved numerous elements of the build specification in order to improve energy efficiency across the site. The improved site specification is shown on table 1.

BHEC have adopted the good design principles endorsed and promoted by The Zero Carbon Hub, the construction industries' key advisors and partners with the Governments Communities and Local Government Department. This guidance follows the general good principles of energy efficiency as the industry moves towards zero carbon. The principles are illustrated in figure 1 below.

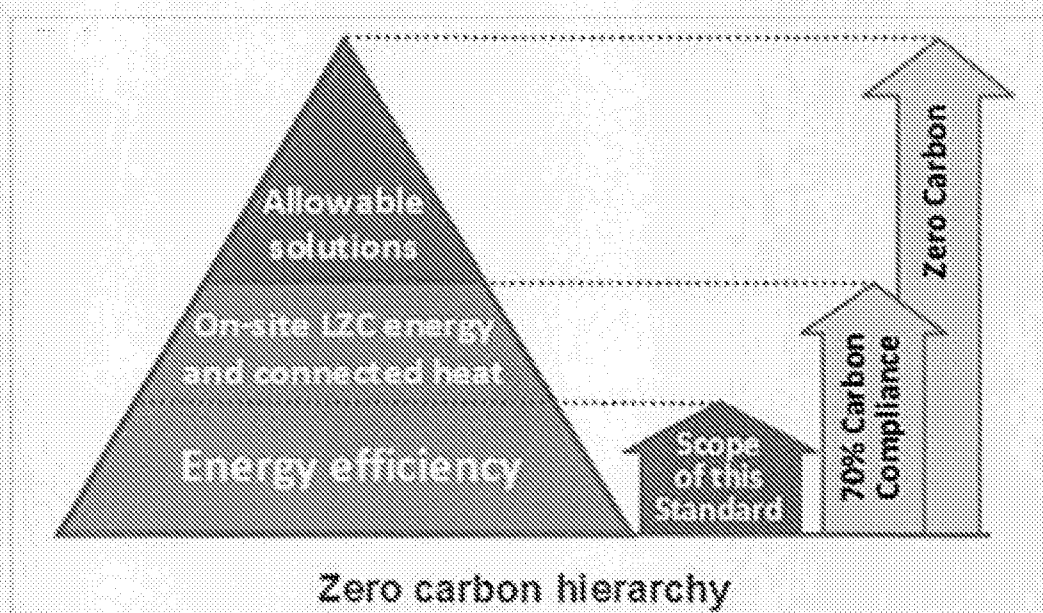


Fig. 1

Element	Proposed Specification	Performance W/m^2k
Roof	400mm Mineral Wool Insulation	0.11
Ground Floors	130mm Areflex Platinum	0.14 – 0.18
Doors	Insulated Composite Doors	1.00 - 1.70
Glazing	High Performance Double Glazed, Low-E Coated and Argon Filled	1.41
Walls	Cavity Wall with 50mm Areflex Platinum	0.27
Air Permeability	Air Pressure rate	$5.01m^3/hm^2$ (@50Pa)

Table 1

2.3. LZC Technologies

2.3.1. Photovoltaic (PV) Cells

The efficiency of PV cells has improved rapidly over the last 15 years. This has made a previously uneconomical technology an increasingly viable solution to rising energy costs and demand. The cells can be produced in a variety of formats but are typically manufactured as a panel or a roof tile for domestic housing applications.

The PV system typically produces direct current (DC) which is then sent through an inverter to supply the house with electricity. If a greater amount of electricity is produced than used by the household, this extra can be sold back to the national grid.

A PV cell is assessed on its peak power rating. This is tested by exposing the cell to the equivalent of full solar radiation and measuring the power output. The peak power is input into the NHER software as well as the physical attributes of the installation such as pitch, orientation and over-shading. A total energy saving per year can then be calculated through SAP for the PV installation. This is then offset against the electricity energy demand for the house.

2.3.2. Solar Hot Water (SHW) Systems

SHW systems provide hot water to a household usually in conjunction with a conventional boiler and cylinder system. Because of this they are best suited to houses with a need for a cylinder hot water system rather than a combi boiler.

There are two main SHW systems: evacuated tubes and flat plate collectors. Evacuated tubes are more efficient at transferring solar irradiation to the fluid although flat plate collectors are considered to be better aesthetically and to install.

The final energy contribution to the household, calculated through SAP, is based on a number of factors:

- *Pitch, orientation and over-shading*
- *Heat absorption efficiency for the collector*
- *Average hot water usage of the dwelling*

The majority of the energy savings will be made in the hot water demand for the dwelling however, adding a SHW system will impact upon other energy demands.

2.3.3. Air Source Heat Pumps (ASHP)

ASHP provide heating and hot water to a home through thermal energy gathered from air outside the dwelling. Systems can be designed to work in conjunction with a boiler system but in the case of energy efficient new builds it is possible for an ASHP unit to provide 100% of the heating and hot water demand.

The thermal performance of the unit depends on the outside temperature as well as the unit's Coefficient of Performance. This is the ratio of thermal energy produced to energy used. A typical value for this would be around 3.5, meaning that for every 1kW of electricity consumed the unit would provide 3.5kW of thermal energy to the household. This efficiency leads to large carbon and energy savings for both space and water heating.

ASHP are assessed by their power output and the size of unit chosen depends on the demand from the household. The units with a larger power output can provide a larger amount of hotter water even in colder climates.

2.3.4. Wind Turbines

Wind turbines provide electricity directly to a dwelling. They can be added to a property in two ways: pole mounted or building mounted. The pole mounted systems are free standing and therefore require enough space around them to allow for the construction and maintenance of the structure, as well as to allow for efficient operation. The building mounted systems have a lower power output but do not require additional structures.

The energy produced from a wind turbine is heavily dependent upon the surrounding landscape. The energy saved will be offset against the electricity usage of the dwelling.

2.3.5. Biomass Heating Systems

Biomass heating systems burn fuels, considered carbon neutral, to heat the water required for a dwelling. There are a large variety of systems available and choice depends on the type of fuel to be burned and the level of automation.

The system would offset the energy demand from the hot water and main space heating. However, biomass systems typically require a large amount of maintenance and monitoring.

The savings from such a system, in terms of CO₂ and money, depends upon what it is replacing. The savings are greatest when replacing an electrical hot water system but are considerably less for replacing mains gas.

2.3.6. Ground Source Heat Pumps (GSHP)

GSHP provide heating and hot water to a dwelling through geothermal effects. A GSHP system would offset the energy demand from the main space heating. There is, however, an additional electricity demand for the pump and control system. This would reduce energy savings from the installation.

GSHP are expensive to install and rely on having appropriate ground conditions and suitable space around the dwelling for the pipe looping. Energy savings are dependent upon the type of system being replaced and the way the system is operated by the homeowner.

2.3.7. Comparison

SHW can be easily incorporated into new build house designs and has the potential to reduce the energy demand from hot water considerably. The site layout has taken into account passive solar gains and therefore is suitable to benefit fully from solar technology.

The density of the site is a major restriction on the potential energy that could be generated from wind turbines. Surrounding houses and the inner city location would restrict wind speeds. In order to obtain the energy savings required, larger, more expensive pole mounted systems would be required.

Biomass hot water systems are more suited to the replacement of inefficient, carbon heavy systems such as electrical immersion heaters. The requirement of maintenance and monitoring makes it unsuitable for large scale new build developments

The installation cost and groundwork requirement make GSHP an expensive option. There is also a degree of uncertainty about the energy saving that can be obtained from the system as it requires diligent operation.

The solution of PV panel systems will be used to meet the 10% energy generation requirement.

SAP2009 provides solar yield for the various combinations of roof pitch, orientation and over shading. The potential annual energy savings per kWp installed, depending on roof pitch and orientation, are shown in the table below.

Energy (kWh)

<i>Pitch</i>	<i>N</i>	<i>NE</i>	<i>E</i>	<i>SE</i>	<i>S</i>	<i>SW</i>	<i>W</i>	<i>NW</i>
0	769	769	769	769	769	769	769	769
30	584	628	730	822	858	822	730	628
45	512	549	683	798	843	798	683	549
60	400	478	621	742	791	742	621	478
90	297	352	466	564	597	564	466	352

Table 1

3. Evaluation

3.1. Potential Solution

The table presented in Appendix C shows the possible schedule of the PV arrays for each house type on the site, based on their proposed orientation. The proposed plots to be installed with a system in order to reach the 10% mark are listed along with their orientation. The tables presented in Appendix D shows the results of the energy consumption of the site without and with the use of renewables and fabric improvements.

The total energy demand of the housing without any LZC technology is 1026MWh/Annum. Therefore in order to meet the demand a saving of at least 102.6MWh/Annum needs to be achieved through the addition of renewables.

The installation of the PV schedule as shown in Appendix C would be sufficient for the site. The total energy reduction from the PV systems on the site is 102.6MWh/annum, representing a 10.0% saving across the site.

3.2. Conclusion

Adoption of the illustrated schedule of photovoltaic panel arrays would result in a reduction in energy demand of at least 10% for the development.

Approved for Release



Date: 27/06/2014

Appendix A



Appendix B



Appendix C

Proposed PV Allocation

House type	Plots	PV (kWp)	Orientation
H404 DET	48	4.5	South
H433 DET	74, 133	6.25	South
H451 DET	92, 95, 135	5.5	South
H469 DET	93, 94, 134	2.5	South
P382 END	87, 88, 105, 106, 128, 129, 136, 137	2.5	South
SH28 EOT	123, 113, 127	2.5	South
SH28 MID	124, 126, 114, 115	2.5	South
SH35 EOT	117	1	South
SH39 EOT	58, 61, 69, 71, 77, 79, 80, 82, 83, 84, 85, 86	2.5	South
SH39 MID	59, 60, 70, 76, 81	2.5	South
SH48 EOT	118	2.5	South

Appendix D

Client: Barratt Homes Southampton

Project: Swanbourne Park, Angmering

Report: Energy Reduction from On-Site Renewable Energy Generation

House Type/ Plot Number	Space Heating Requirement	Hot Water Requirement	Lighting Requirement	Pumps and Fans Requirement	PV Contribution	SAP ⁸ Floor Area	Number of Plots	Total Energy Demand ⁹
-	kWh/Annum	kWh/Annum	kWh/Annum	kWh/Annum	kWh/Annum	m ²	-	kWh/Annum
Data Set 1: Base Case Design (Part L 2010 Compliant)								
H404—5	4383	2691	445	175	-	108	3	22,783
H421—5	6703	2778	530	175	-	165	13	132,415
H433—5	5238	2620	463	175	-	127	8	67,965
H435—5	5887	2721	503	175	-	148	21	195,006
H451—5	5060	2621	506	175	-	127	4	33,455
H469—5	5229	2719	513	175	-	139	7	60,438
H500—5	6762	2719	554	175	-	171	6	61,264
H535—5	6404	2801	621	175	-	220	3	36,003
P206-E-5	2350	1826	294	175	-	63	5	23,126
P206-I-5	1845	1828	297	175	-	63	2	8,290
P230—5	3083	1862	309	175	-	66	1	5,429
P230—5 FOG EOT	3253	1862	309	175	-	66	1	5,579
P331—L5	3625	2540	391	175	-	94	2	13,462
P341—D5	3803	2635	393	175	-	93	12	82,926
P382-EB5	2717	2440	349	175	-	78	23	130,670
P382-IB5	2205	2451	355	175	-	78	1	5,186
SH28 MID	2304	1984	383	175	-	78	4	19,336
SH28 EOT	2970	1982	372	175	-	78	3	16,495
SH35 EOT	3577	2558	425	175	-	98	1	6,735
SH39 MID	2453	2044	415	175	-	86	5	25,436
SH39 EOT	3047	2042	403	175	-	86	12	68,007
SH43	3200	2585	450	175	-	103	1	6,409

Data Set 1 Total Energy Demand (kWh/Annum) 1,026,463

*Energy Demand Reduction Study,
Swanbourne Park, Angmering*

Data Set 2: Actual Case (With Renewables)

H404 PV S	4383	2591	445	175	3794	100	1	7,594
H404—5	4383	2591	445	175	-	100	2	15,189
H421—5	6703	2778	530	175	-	165	13	132,415
H433 PV S	5238	2620	463	175	5270	127	2	6,451
H433—5	5238	2620	463	175	-	127	6	50,973
H436—5	5887	2721	503	175	-	148	21	195,006
H451 PV S	5060	2621	508	175	4636	127	3	11,178
H451—5	5060	2621	508	175	-	127	1	8,364
H469 PV S Front	5228	2719	513	175	2108	139	3	19,576
H469—5	5228	2719	513	175	-	139	4	34,536
H500—5	6762	2719	554	175	-	171	6	61,264
H536—5	8404	2801	621	175	-	230	3	36,003
P206-E-5	2330	1826	234	175	-	63	5	23,125
P206-I-5	1845	1828	237	175	-	63	2	8,290
P230—5	3083	1862	309	175	-	66	1	5,429
P230—5 FOG EOT	3233	1862	309	175	-	66	1	5,579
P331-L5	3625	2540	331	175	-	94	2	13,462
P341-D5	3803	2535	338	175	-	93	12	82,926
P382 EOT PV S	2717	2440	349	175	2108	78	9	28,587
P382-EB5	2717	2440	349	175	-	78	15	85,220
P382-IB5	2205	2451	355	175	2108	78	1	3,078
SH29 MID PV S	2304	1984	393	175	2108	78	4	10,954
SH29 EOT PV S	2970	1982	372	175	2108	78	3	10,171
SH35 EOT PV S	3577	2558	425	175	791	98	1	5,944
SH39 MID PV SE-SW	2453	2044	415	175	1994	86	5	15,466
SH39 PV S	3047	2042	403	175	2108	86	12	42,711
SH40 PV E-W	3200	2585	450	175	1708	103	1	4,701

Data Set 2 Total Energy Demand (kWh/Annum) 924,193

**Reduction in Energy Demand
10.0%**

Notes

#1: Calculated by SAP2009 to include total energy demand for space heating, hot water, lighting, pumps and fans.

Appendix E

Example SAP Worksheet – Part L 2010 Compliant

SAP 2009 Worksheet

Design - Draft



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	Mr Tim James	Assessor number	3539
Client	David Wilson Homes	Last modified	24/06/2014
Address	H433—5 Detached, David Wilson Homes		

1. Overall dwelling dimensions

	Area (m ²)	Average storey height (m)	Volume (m ³)
Lowest occupied	65.04 (1a) x	2.32 (2a) =	150.89 (3a)
+1	61.63 (1b) x	2.56 (2b) =	157.77 (3b)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =		
Dwelling volume		(3a) + (3b) + (3c) + (3d)...(3n) =	308.67 (5)

2. Ventilation rate

		m ³ per hour
Number of chimneys	0 x 40 =	0 (5a)
Number of open flues	0 x 20 =	0 (5b)
Number of intermittent fans	5 x 10 =	50 (7a)
Number of passive vents	0 x 10 =	0 (7b)
Number of fuelless gas fires	0 x 40 =	0 (7c)

Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =	50 (5)	0.16 (8)
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If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Air permeability value, q ₅₀ , expressed in cubic metres per hour per square metre of envelope area	5.01 (17)
--	-----------

If based on air permeability value, then (18) = [(17) + 20] ÷ (8), otherwise (18) = (16)	0.41 (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	2 (19)
--	--------

Shelter factor	1 - [0.075 x (19)] =	0.89 (20)
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Adjusted infiltration rate	(18) x (20) =	0.35 (21)
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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
Σ(22)1...12 =	54.30 (22)											

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
Σ(22a)1...12 =	13.52 (22a)											

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

(22b)m	0.47	0.45	0.45	0.39	0.36	0.34	0.32	0.32	0.37	0.39	0.42	0.45
Σ(22b)1...12 =	4.74 (22b)											

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	N/A (23a)
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if exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)), otherwise (23b) = (23a)

N/A (23b)

if balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) ×

N/A (23c)

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)m × 0.5]

(24d)m 0.61 0.60 0.60 0.58 0.56 0.56 0.55 0.55 0.57 0.58 0.59 0.60 (24d)

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

(25)m 0.61 0.60 0.60 0.58 0.56 0.56 0.55 0.55 0.57 0.58 0.59 0.60 (25)

3. Heat losses and heat capacity parameters

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

Element	Gross Area, m ²	Openings, m ²	Net area A, m ²	U-value, W/m ² K	A × U, W/K	k-value, kJ/m ² .K	A × k, kJ/K
Window*			26.89	1.33	35.89	N/A	N/A (27)
Doors			4.33	1.60	6.92	N/A	N/A (28)
Ground floor			65.04	0.16	10.41	N/A	N/A (28a)
External wall			131.01	0.27	35.37	N/A	N/A (28a)
Roof			61.63	0.11	6.78	N/A	N/A (30)
Roof			3.41	0.17	0.58	N/A	N/A (30)
Total area of external elements ΣA, m ²			292.30				(31)

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

Fabric heat loss, W/K = Σ[A × U] (26) ... (30) + (32) = 95.95 (32)

Heat capacity Cm = Σ[A × k] (28) ... (30) + (32) + (32a) ... (32e) = N/A (34)

Thermal mass parameter (TMP) in kJ/m²K Calculated separately = 100.00 (35)

Thermal bridges: Σ[l × Ψ] calculated using Appendix K 12.15 (36)

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

Total fabric heat loss (33) + (36) = 108.11 (37)

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

(38)m 62.34 61.11 61.11 58.85 57.51 56.88 56.29 55.29 57.83 58.85 59.95 61.11 (38)

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

(39)m 170.45 169.21 169.21 166.96 165.61 164.99 164.39 164.39 165.94 166.96 168.05 169.21
Average = Σ{(39)1...12/12} = 167.12 (39)

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

(40)m 1.35 1.34 1.34 1.32 1.31 1.30 1.30 1.30 1.31 1.32 1.33 1.34
Average = Σ{(40)1...12/12} = 1.32 (40)

4. Water heating energy requirement

kWh/year

Assumed occupancy, N

2.85 (42)

if TFA > 13.9, N = 1 + 1.76 × [1 - exp(-0.009349 × (TFA - 13.9)²)] + 0.0013 × (TFA - 13.9)

if TFA ≤ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 × N) + 36

102.74 (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 × (43)

(44)m 113.01 108.90 104.79 100.68 96.57 92.46 92.46 96.57 100.68 104.79 108.90 113.01
Σ{(44)1...12} = 1232.85 (44)

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

(45)m 167.99 146.93 151.62 132.18 126.83 109.45 101.42 116.38 117.77 137.25 149.82 162.69
Σ{(45)1...12} = 1620.33 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (51)

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

Distribution loss $0.15 \times (45)m$

(45)m

25.20	22.04	22.74	19.83	19.02	16.42	15.21	17.46	17.67	20.59	22.47	24.40
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 (46)

Water storage loss:

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

1.23

 (47)

Temperature factor from Table 2b

0.54

 (48)

Energy lost from water storage, kWh/day (47) $\times$ (48)

0.66

 (49)

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

0.66

 (55)

Water storage loss calculated for each month = (55) $\times$ (41)m

(56)m

20.59	18.60	20.59	19.93	20.59	19.93	20.59	20.59	19.93	20.59	19.93	20.59
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 (56)

If cylinder contains dedicated solar storage, = (56)m $\times$ [(50) - (M11)] $\div$ (50), else = (56)m where (M11) is from Appendix H

(57)m

20.59	18.60	20.59	19.93	20.59	19.93	20.59	20.59	19.93	20.59	19.93	20.59
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (57)

Primary circuit loss (annual) from Table 3

360.00

 (58)

Primary circuit loss for each month (58) $\div$ 365 = (41)m

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

(59)m

30.58	27.82	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 $0.85 \times (45)m + (46)m + (57)m + (59)m + (61)m$

(62)m

719.16	193.14	202.78	181.70	178.00	158.96	152.58	167.55	167.28	188.41	199.33	213.86
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (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
------	------	------	------	------	------	------	------	------	------	------	------

2(63)1...12 =

0.00

 (63)

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

(64)m

219.16	193.14	202.78	181.70	178.00	158.96	152.58	167.55	167.28	188.41	199.33	213.86
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

2(64)1...12 =

2222.77

 (64)

If (64)m $<$ 0 then set to 0

Heat gains from water heating, kWh/month $0.25 \times (0.85 \times (45)m + (61)m) + 0.8 \times ((46)m + (57)m + (59)m)$

(65)m

96.79	85.82	91.35	83.56	83.10	76.00	74.65	79.63	78.77	88.57	89.43	95.03
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (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 6a)

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

Metabolic gains (Table 5), Watts

(66)m

173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (66)

Lighting gains (calculated in Appendix L, equation 19 or (9a), also see Table 5)

(67)m

65.58	58.25	47.37	35.86	26.81	22.63	24.46	31.79	42.67	54.18	63.23	67.41
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (67)

Appliances gains (calculated in Appendix L, equation 113 or (13a), also see Table 5)

(68)m

438.30	482.85	431.39	406.99	376.19	347.28	327.90	323.35	334.81	359.21	390.01	418.96
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (68)

Cooking gains (calculated in Appendix L, equation 115 or (15a), also see Table 5)

(69)m

55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (69)

Pumps and fans gains (Table 5a)

(70)m

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (70)

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

(71)m

-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43
---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------

 (71)

Water heating gains (Table 5)

(72)m

139.09	127.72	122.78	116.06	111.70	105.58	100.34	107.03	109.40	116.39	124.20	127.73
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (72)

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

(73)m

756.89	751.73	724.45	681.83	637.61	598.35	575.61	585.08	609.80	652.66	709.36	737.01
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 (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 m ²		Solar flux W/m ²		g Specific data or Table 6b		FF Specific data or Table 6c		Gains (W)
Northeast	0.77	x	10.50	x	11.51	x 0.9 x	0.71	x	0.70	=	43.21 (75)
North	0.77	x	0.74	x	10.73	x 0.9 x	0.71	x	0.70	=	1.72 (74)
East	0.77	x	0.74	x	19.57	x 0.9 x	0.71	x	0.70	=	5.05 (76)
Northwest	0.77	x	9.04	x	11.51	x 0.9 x	0.71	x	0.70	=	35.84 (81)
Southeast	0.77	x	1.38	x	37.39	x 0.9 x	0.71	x	0.70	=	17.73 (77)
Southwest	0.77	x	4.10	x	37.39	x 0.9 x	0.71	x	0.70	=	52.77 (79)

Solar gains in watts, calculated for each month (74)m... (82)m

(83)m	157.30	286.86	465.28	697.76	877.44	937.25	899.83	757.92	556.16	357.90	193.89	130.95	(83)
-------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	------

Total gains - internal and solar (73)m + (83)m

(84)m	914.39	1048.60	1189.74	1379.59	1515.05	1535.60	1475.44	1342.30	1165.96	1010.56	894.25	867.96	(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, n1,m (see Table 9a)	0.95	0.93	0.90	0.83	0.71	0.57	0.42	0.45	0.69	0.86	0.94	0.95	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

(87)m	18.43	18.71	19.23	19.79	20.38	20.75	20.92	20.91	20.59	19.89	18.99	18.49	(87)
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

Temperature during heating periods in the living area from Table 9, Th2 (°C)

(88)m	19.61	19.82	19.82	19.83	19.84	19.84	19.85	19.85	19.84	19.83	19.82	19.82	(88)
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

Utilisation factor for gains for rest of dwelling n2,m (see Table 9a)

(89)m	0.94	0.92	0.88	0.80	0.66	0.49	0.31	0.34	0.62	0.83	0.93	0.95	(89)
-------	------	------	------	------	------	------	------	------	------	------	------	------	------

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

(90)m	16.43	16.83	17.57	18.36	19.17	19.63	19.80	19.79	19.45	18.53	17.24	16.51	(90)
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

Living area fraction $f_{LA} = \frac{23.77}{100} = 0.2377$ (91)

Mean internal temperature for the whole dwelling $f_{LA} \times T1 + (1 - f_{LA}) \times T2$

(92)m	16.81	17.18	17.88	18.63	19.40	19.84	20.01	20.00	19.65	18.78	17.57	16.89	(92)
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	------

Apply adjustment to the mean internal temperature from Table 6e, where appropriate

(93)m	16.66	17.03	17.73	18.48	19.25	19.69	19.86	19.85	19.51	18.63	17.42	16.73	(93)
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8. Space heating requirement

Set T1 to the mean internal temperature obtained at step 11 of Table 9b, so that tim = (92)m and recalculate the utilisation factor for gains using Table 9a

Utilisation factor for gains, n1,m	0.91	0.89	0.84	0.76	0.64	0.48	0.31	0.34	0.60	0.79	0.89	0.92	(94)
------------------------------------	------	------	------	------	------	------	------	------	------	------	------	------	------

Useful gains, n1Gm, W = (94)m x (84)m

(95)m	836.18	931.86	998.83	1052.91	964.77	738.56	464.25	438.16	695.26	799.07	798.79	796.87	(95)
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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)
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Heat loss rate for mean internal temperature, lm, W

(97)m	2072.14	2036.00	1849.92	1633.04	1250.19	839.52	486.89	485.22	863.26	1307.53	1750.51	2062.40	(97)
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Space heating requirement for each month, kWh/month = 0.024 x ((97)m - (95)m) x (41)m

(98)m	919.55	741.98	633.21	417.69	212.35	0.00	0.00	0.00	0.00	378.27	586.68	896.91	(98)
-------	--------	--------	--------	--------	--------	------	------	------	------	--------	--------	--------	------

Total per year (kWh/year) = $\sum (98)1..5, 10..12 = 4886.65$ (99)

Space heating requirement in kWh/m²/year $(98) \div (4) = 38.58$ (99)

Table 4a: Space heating requirements - Individual heating system (main system - 2HP)

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	0.00	(203)
Fraction of total space heat from main system 1 (202) x [1 - (203)]	1.00	(204)
Fraction of total space heat from main system 2 (202) x (203)	0.00	(205)
Efficiency of main space heating system 1 (%)	93.30	(206)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating requirement, kWh/month (as calculated above)													
(98)in	919.55	741.58	633.31	417.69	212.35	0.00	0.00	0.00	0.00	378.27	686.68	896.91	
Space heating fuel (main heating system 1), kWh/month = (98)in x (204) x 100 ÷ (206)													
(211)in	985.59	795.27	678.68	447.69	227.60	0.00	0.00	0.00	0.00	405.43	735.59	961.32	
Total per year (kWh/year) = Σ(211)1...5, 10...12 =	5237.57												(211)

Water heating:

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

(64)in	219.16	193.14	202.78	181.70	178.00	158.98	152.58	167.95	167.28	188.41	199.33	213.86	
Σ(64)1...12 =	2222.77												(64)

Efficiency of water heater per month

(217)in	88.02	87.26	87.48	86.78	85.08	79.60	79.60	79.60	79.60	86.48	87.65	88.02	
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Fuel for water heating, kWh/month = (64)in x 100 ÷ (217)in

(219)in	248.96	219.83	231.89	209.42	209.20	199.70	191.69	210.48	210.16	217.98	227.42	242.96	
Total per year (kWh/year) = Σ(219)1...12 =	2619.71												(219)

Annual Totals Summary:

	kWh/year	kWh/year
Space heating fuel used, main system 1	5237.57	(211)
Water heating fuel used	2619.71	(219)

Electricity for pumps, fans and electric keep-hot (Table 4f):

mechanical ventilation fans - balanced, extract or positive input from outside	0.00	(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	Σ(230a)...(230g) =	175.00 (231)

Electricity for lighting (calculated in Appendix I):

463.25 (232)

Table 4b: Space heating requirements - Individual heating system (main system - 2HP)

	Fuel kWh/year		Fuel price (Table 12)		Fuel cost £/year	
Space heating - main system 1	5237.57	x	3.10	x 0.01 =	162.36	(240)
Water heating cost (other fuel)	2619.71	x	3.10	x 0.01 =	81.21	(241)
Pumps, fans and electric keep-hot	175.00	x	11.46	x 0.01 =	20.06	(242)
Energy for lighting	463.25	x	11.46	x 0.01 =	53.09	(243)
Additional standing charges (Table 12)					106.00	(244)
Total energy cost				(240)...(242) + (244) ÷ (254) =	422.72	(245)

11. SAP rating - individual heating systems including micro-CHP

Energy cost deflator (Table 12)				0.47	(256)
Energy cost factor (ECF)			$[(255) \times (256)] \div [(4) + 45.0] =$	1.16	(257)
SAP value				83.86	
SAP rating				B4	(258)
SAP band				B	

12. Carbon dioxide emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emissions Factor		Emissions (kgCO ₂ /year)	
Space heating - main system 1	5237.57	x	0.198	=	1037.04	(261)
Water heating	2619.71	x	0.198	=	518.79	(264)
Space and water heating				$(261) + (262) + (263) + (264) =$	1555.74	(266)
Pumps, fans and electric keep-hot	175.00	x	0.517	=	90.48	(267)
Lighting	463.29	x	0.517	=	239.52	(268)
Total carbon dioxide emissions				$\Sigma(261) \dots (271) =$	1685.74	(272)
Dwelling carbon dioxide emissions rate				$(272) \div (4) =$	14.89	(273)
EI value					85.28	
EI rating (see section 14)					B5	(274)
EI band					B	

13. Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary Energy Factor		Primary Energy	
Space heating - main system 1	5237.57	x	1.02	=	5342.32	(261*)
Water heating	2619.71	x	1.02	=	2672.10	(264*)
Space and water heating				$(261*) + (262*) + (263*) + (264*) =$	8014.42	(266*)
Pumps, fans and electric keep-hot	175.00	x	2.92	=	511.00	(267*)
Lighting	463.29	x	2.92	=	1352.81	(268*)
Total primary energy kWh/year				$\Sigma(261*) \dots (271*) =$	9878.23	(272*)
Primary energy kWh/m ² /year				$(272*) \div (4) =$	77.98	(273*)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (63)

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

Distribution loss $0.15 \times (45)m$

(46)m

25.20	22.64	22.74	19.83	19.02	16.42	15.21	17.46	17.67	20.59	22.47	24.40
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (46)

Water storage loss:

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

1.23

 (47)

Temperature factor from Table 2b

0.54

 (48)

Energy lost from water storage, kWh/day (47) $\times$ (48)

0.66

 (49)

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

0.66

 (55)

Water storage loss calculated for each month = (55) $\times$ (41)m

(56)m

20.59	18.60	20.59	19.93	20.59	19.93	20.59	20.59	19.93	20.59	19.93	20.59
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (56)

If cylinder contains dedicated solar storage, = (56)m $\times$ [(50) $\div$ (H11)] $\div$ (50), else = (56)m where (H11) is from Appendix H

(57)m

20.59	18.60	20.59	19.93	20.59	19.93	20.59	20.59	19.93	20.59	19.93	20.59
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (57)

Primary circuit loss (annual) from Table 3

360.00

 (58)

Primary circuit loss for each month (58) $\div$ 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 $0.85 \times (45)m + (46)m + (57)m + (59)m + (61)m$

(62)m

219.16	193.14	202.78	181.70	178.00	158.96	152.58	167.55	167.28	188.41	199.33	213.86
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (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
------	------	------	------	------	------	------	------	------	------	------	------

$\Sigma(63)1..12 = 0.00$ (63)

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

(64)m

219.16	193.14	202.78	181.70	178.00	158.96	152.58	167.55	167.28	188.41	199.33	213.86
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

$\Sigma(64)1..12 = 2322.77$ (64)

If (64)m < 0 then set to 0

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

(65)m

96.79	85.82	91.35	83.56	83.10	76.00	74.65	79.63	78.77	86.57	89.43	95.63
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 (65)

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

Internal gains (see Table 5 and 6)

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

Metabolic gains (Table 5), Watts

(66)m

173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15	173.15
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 (66)

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

(67)m

65.58	58.25	47.37	35.86	26.81	22.63	26.46	31.79	42.67	54.18	63.23	67.41	67.41
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (67)

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

(68)m

438.30	442.85	431.39	406.99	378.19	347.24	327.90	323.35	334.81	359.21	390.01	418.96	418.96
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (68)

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

(69)m

55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20	55.20
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (69)

Pumps and fans gains (Table 5a)

(70)m

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

 (70)

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

(71)m

-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43	-115.43
---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------	---------

 (71)

Water heating gains (Table 5)

(72)m

130.09	127.72	122.78	118.06	111.70	105.56	100.34	107.03	109.40	116.39	124.20	127.73	127.73
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

 (72)

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

(73)m

756.89	751.73	724.45	681.83	637.61	598.35	575.61	585.08	609.80	652.66	700.36	737.01	737.01
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 (73)

7. 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 m ²		Solar flux W/m ²		g Specific data or Table 6b		FF Specific data or Table 6c		Gains (W)	
Northeast	0.77	x	10.90	x	11.51	x 0.9 x	0.71	x	0.70	=	43.21	(75)
North	0.77	x	0.74	x	10.79	x 0.9 x	0.71	x	0.70	=	2.72	(76)
East	0.77	x	0.74	x	19.87	x 0.9 x	0.71	x	0.70	=	5.03	(76)
Northwest	0.77	x	9.04	x	11.51	x 0.9 x	0.71	x	0.70	=	35.84	(81)
Southeast	0.77	x	1.38	x	37.39	x 0.9 x	0.71	x	0.70	=	17.73	(77)
Southwest	0.77	x	4.10	x	37.39	x 0.9 x	0.71	x	0.70	=	52.77	(79)

Solar gains in watts, calculated for each month (74)m - (82)m

(83)m	157.30	255.86	465.29	697.16	677.44	937.25	899.83	757.02	556.16	357.90	193.89	130.95	(83)
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Total gains - internal and solar (73)m + (83)m

(84)m	914.19	1048.60	1189.74	1379.59	1515.05	1535.60	1475.44	1342.10	1165.96	1010.56	894.75	867.96	(84)
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7.1 Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 8, Th1 (°C)

21.00	(85)
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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains for living area, n1,m (see Table 9a)													
(86)m	0.95	0.93	0.90	0.83	0.71	0.57	0.41	0.45	0.69	0.86	0.94	0.95	(86)

Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

(87)m	18.43	18.71	19.23	19.79	20.38	20.75	20.92	20.91	20.59	19.89	18.99	18.49	(87)
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Temperature during heating periods in the living area from Table 8, Th2 (°C)

(88)m	19.81	19.82	19.62	19.89	19.84	19.84	19.85	19.85	19.84	19.83	19.82	19.82	(88)
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Utilisation factor for gains for rest of dwelling n2,m (see Table 9a)

(89)m	0.94	0.92	0.88	0.80	0.66	0.49	0.31	0.34	0.62	0.83	0.93	0.95	(89)
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Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m	16.43	16.83	17.57	18.36	19.17	19.63	19.80	19.73	19.45	18.93	17.24	16.51	(90)
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Living area fraction								fLA	23.77	x (4) =	0.19	(91)
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Mean internal temperature for the whole dwelling fLA x T1 + (1 - fLA) x T2

(92)m	16.81	17.18	17.88	18.63	19.40	19.84	20.01	20.00	19.66	18.78	17.57	16.88	(92)
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Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m	16.66	17.03	17.73	18.48	19.25	19.69	19.86	19.85	19.51	18.63	17.42	16.73	(93)
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8. Space heating requirements

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, nm													
(94)m	0.91	0.89	0.84	0.76	0.64	0.48	0.31	0.34	0.60	0.79	0.89	0.92	(94)

Useful gains, nmGm, W = (84)m x (84)m

(95)m	836.18	931.85	998.83	1052.91	964.77	734.56	464.75	458.15	699.20	799.07	756.79	796.87	(95)
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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)
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Heat loss rate for mean internal temperature, Lm, W

(97)m	2072.14	2035.00	1849.52	1633.04	1250.19	839.52	486.89	425.22	865.26	1307.50	1750.51	2002.40	(97)
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Space heating requirement for each month, kWh/month = 0.024 x [(97)m - (95)m] x (41)m

(98)m	919.55	741.98	633.21	417.89	212.35	0.00	0.00	0.00	0.00	378.27	686.68	895.91	(98)
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Total per year (kWh/year) = Σ(98)1..12 = 4886.65 (99)

Space heating requirement in kWh/m²/year (99) ÷ (4) = 38.58 (100)

Table 4c: Fuel costs – mechanical 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	0.00	(203)
Fraction of total space heat from main system 1 (202) x (1 - (203))	1.00	(204)
Fraction of total space heat from main system 2 (202) x (203)	0.00	(205)
Efficiency of main space heating system 1 (%)	93.33	(206)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating requirement, kWh/month (as calculated above)													
(98)m	919.55	741.98	533.31	417.69	212.35	0.00	0.00	0.00	0.00	378.27	686.68	836.81	
Space heating fuel (main heating system 1), kWh/month = (98)m x (204) x 100 ÷ (206)													
(211)m	989.59	795.37	578.68	447.69	227.60	0.00	0.00	0.00	0.00	405.43	735.99	901.32	
Total per year (kWh/year) = Σ(211)1...12 =	5237.57												(211)

Water heating:

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

(64)m	219.16	193.14	292.78	181.70	178.00	158.96	152.58	167.55	167.28	188.41	199.33	213.86	
Σ(64)1...12 =	2132.77												(64)

Efficiency of water heater per month

(217)m	88.02	87.86	87.42	86.75	85.08	79.60	79.60	79.60	79.60	86.44	87.65	88.02	
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Fuel for water heating, kWh/month = (64)m x 100 ÷ (217)m

(219)m	248.98	219.83	331.89	209.42	209.20	199.70	191.69	210.48	210.16	217.58	227.41	241.96	
Total per year (kWh/year) = Σ(219)1...12 =	2619.71												(219)

Annual Totals Summary:

	kWh/year	kWh/year
Space heating fuel used, main system 1	5237.57	(211)
Water heating fuel used	2619.71	(219)

Electricity for pumps, fans and electric keep-hot (Table 4f):

mechanical ventilation fans - balanced, extract or positive input from outside	0.00	(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	Σ(230a)...(230g)	175.00 (231)

Electricity for lighting (calculated in Appendix L):

463.29 (232)

Energy saving/generation technologies (Appendices M, N and O):

Electricity generated by PVs (Appendix M) (negative quantity)	5270.00	(233)
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Table 4d: Fuel costs – mechanical heating systems including micro-CHP

	Fuel kWh/year		Fuel price (Table 12)		Fuel cost £/year	
Space heating - main system 1	5237.57	x	3.10	x 0.01 =	162.36	(240)
Water heating cost (other fuel)	2619.71	x	3.10	x 0.01 =	81.21	(247)
Pumps, fans and electric keep-hot	175.00	x	11.46	x 0.01 =	20.06	(248)
Energy for lighting	463.29	x	11.46	x 0.01 =	53.09	(250)
Additional standing charges (Table 12)					106.00	(251)

Energy saving/generation technologies (Appendices M, N and Q):

PV savings (negative quantity)	-5270.00	x	11.46	x 0.01 =	-603.94	(252)
Total energy cost				(248) + (242) + (245) + (254) =	-181.22	(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] =	-0.50	(257)
SAP value					106.92	
SAP rating					107	(258)
SAP band					A	

12a Carbon dioxide emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emissions Factor		Emissions (kgCO ₂ /year)	
Space heating - main system 1	5237.57	x	0.198	=	1037.04	(261)
Water heating	2619.71	x	0.198	=	518.70	(264)
Space and water heating				(261) + (262) + (263) + (264) =	1555.74	(265)
Pumps, fans and electric keep-hot	175.00	x	0.517	=	90.48	(267)
Lighting	463.29	x	0.517	=	239.52	(268)
Energy saving/generation technologies:						
PV emission savings (negative quantity)	-5270.00	x	0.529	=	-2787.83	(269)
Total carbon dioxide emissions				Σ(261)...(271) =	-902.09	(272)
Dwelling carbon dioxide emissions rate				(272) ÷ (4) =	-7.12	(273)
Ei value					107.04	
Ei rating (see section 14)					107	(274)
Ei band					A	

12b Primary energy - individual heating systems including micro-CHP

	Energy kWh/year		Primary Energy Factor		Primary Energy	
Space heating - main system 1	5237.57	x	1.02	=	5342.32	(281*)
Water heating	2619.71	x	1.02	=	2672.10	(284*)
Space and water heating				(281*) + (282*) + (283*) + (284*) =	8014.42	(285*)
Pumps, fans and electric keep-hot	175.00	x	2.92	=	511.00	(287*)
Lighting	463.29	x	2.92	=	1352.81	(288*)
Energy saving/generation technologies:						
PV primary energy savings (negative quantity)	-5270.00	x	2.92	=	-15388.40	(289*)
Total primary energy kWh/year				Σ(281*)...(291*) =	-5510.17	(292*)
Primary energy kWh/m ² /year				(292*) ÷ (4) =	-43.50	(293*)

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

N/A (23b)

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

N/A (23c)

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)m × 0.5]

(24d)m 0.61 0.60 0.60 0.58 0.58 0.56 0.55 0.55 0.57 0.58 0.59 0.60 (24d)

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

(25)m 0.61 0.60 0.60 0.58 0.58 0.56 0.55 0.55 0.57 0.58 0.59 0.60 (25)

3.1 Heat losses and heat loss parameter

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

Element	Gross Area, m ²	Openings, m ²	Net area A, m ²	U-value, W/m ² K	A × U, W/K	κ -value, kJ/m ² .K	A × κ , kJ/K
Window*			26.89	1.33	35.89	N/A	N/A (27)
Doors			4.33	1.60	6.92	N/A	N/A (28)
Ground floor			65.04	0.18	10.41	N/A	N/A (28a)
External wall			131.01	0.27	35.37	N/A	N/A (28a)
Roof			61.53	0.11	6.78	N/A	N/A (30)
Roof			3.41	0.17	0.58	N/A	N/A (30)
Total area of external elements ΣA, m ²			292.20				

* for windows and roof windows, effective window U-value is calculated using formula $1/(1/U_{value}) + 0.04$ paragraph 3.2

Fabric heat loss, W/K = Σ[A × U] (26) ... (30) + (32) = 95.65 (33)

Heat capacity Cm = Σ[A × κ] (28) ... (30) + (32) + (32a) ... (32e) = N/A (34)

Thermal mass parameter (TMP) in kJ/m².K Calculated separately = 100.00 (35)

Thermal bridges: Σ[L × W] calculated using Appendix X 12.16 (36)

If details of thermal bridging are not known then (36) = 0.15 × (31)

Total fabric heat loss (33) + (36) = 108.11 (37)

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

(38)m 62.34 61.11 61.11 58.85 57.51 56.88 56.29 56.29 57.83 58.85 59.95 61.11 (38)

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

(39)m 170.45 169.21 169.21 166.96 165.61 164.99 164.39 164.39 165.98 166.96 168.05 169.21
Average = Σ(39)1...12/12 = 167.12 (39)

Heat loss parameter (HLP), W/m².K (39)m + (4)

(40)m 1.35 1.34 1.34 1.32 1.31 1.30 1.30 1.30 1.31 1.32 1.33 1.34
Average = Σ(40)1...12/12 = 1.32 (40)

3.2 Water heating energy requirement

kWh/year

Assumed occupancy, N

2.89 (41)

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

If TFA ≤ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 × N) × 36

102.74 (42)

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 × (43)

(44)m 113.01 108.90 104.79 100.68 96.57 92.46 92.46 96.57 100.68 104.79 108.90 113.01
Σ(44)1...12 = 1232.85 (44)

Energy content of hot water used - calculated monthly = 4.190 × Vd,m × cm × Tm/3500 kWh/month (see Tables 1b, 1c 1d)

(45)m 167.99 146.93 151.62 132.18 126.83 109.49 101.42 116.38 117.77 137.25 149.82 162.69
Σ(45)1...12 = 1620.33 (45)

Appendix E

Example SAP Worksheet – Part L 2010 Compliant