Energy Demand Study

Longridge

Client: Barratt Manchester

Author: Michael Woodbridge

www.environmental-economics.co.uk

Revision History

Version	***Date***	***Reason for Issue***	*Issued by*	*QA check*
1	09/02/2016	Report provided in support of planning application	*Michael Woodbridge*	*Zach Sifakis*

Contents

1 Project Overview 1
1.1 Introduction 1
1.2 Description of Site 1
1.3 Local Planning Requirements 1
2 Improvement Measures 2
2.1 Assessment Methodology 2
2.2 Design Philosophy 3
2.3 Specification Improvements 4
3 Evaluation 7
3.1 Conclusion 7
Appendix A ....
Appendix B ....
Appendix C ....
Appendix D ....
Appendix E ....

1. Project Overview

1.1. Introduction

This sustainability study was prepared by Environmental Economics Ltd on behalf of Barratt Homes Manchester (BHM) to support a planning application for a proposed development. The report assesses measures to reduce the energy demand for the domestic housing on site through an improvement in materials and products used.

1.2. Description of Site

The Longridge site consists of 118 dwellings. These units comprise a range of detached, semi-detached and terraced dwellings, as well as some apartment blocks.

The current site use is shown in Appendix A. The proposed site location/boundary for the whole site is shown in Appendix B.

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

1.3. Client Brief

BHM intent to reduce the energy consumption on the development by a fabric first approach and as such various upgrades to the fabric specification have been made in order to reduce energy demand.

This report quantifies these improvements to the building fabric and products in context of resultant reduction in energy demand against Part L 2013.

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 CO_2/m^2/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 regulated energy usage per year for each of the properties on site. The total regulated energy demand for each property is based upon:

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

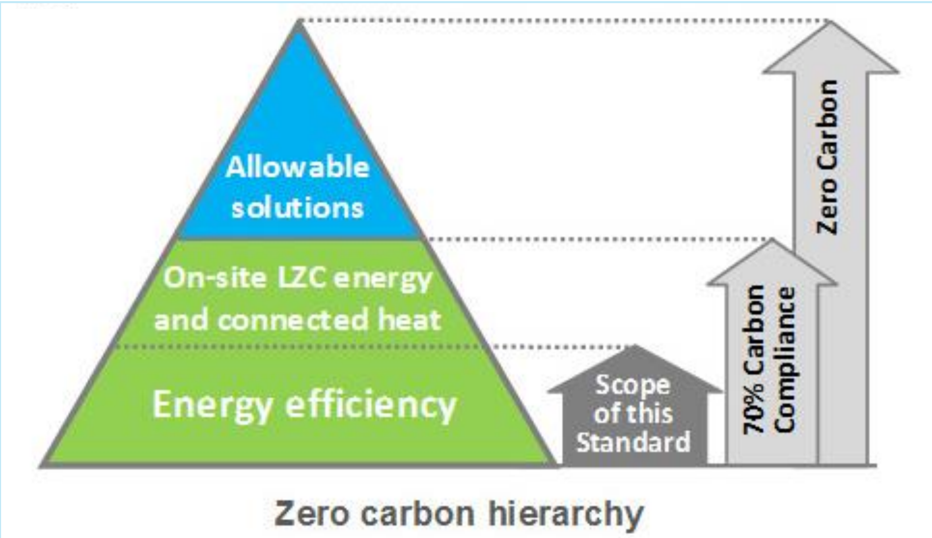
Two models were created in order to calculate the difference in energy demand from the specification improvements. The total energy demand for the site is calculated for each of the models, and then the difference used to establish the level of improvement.

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 (SAP 2013) through version 6 of the NHER Plan Assessor software. An example of a SAP worksheet is shown in Appendix E.

2.2. Design Philosophy

BHM have upgraded a number of elements from their standard build specification in order to improve energy efficiency across the development. The site adopts 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



In order to reduce the residual carbon emissions a number of improvements were made to the standard material and product specification. These improvements include:

- Upgraded heating and hot water controls
- Delayed start controls
- Design air permeability of 5.01m^3/hr/m^2
- Bespoke thermal bridging details

2.3. Specification Improvements

In order to improve energy efficiency the products and the fabric of the dwellings was improved to an enhanced specification.

2.3.1. Product Improvements

The systems used in a property to supply hot water and heating, as well as control it, are important to the overall energy demand of a property. The 2013 Building Regulations state that all systems and their controls must adhere to the minimum standards shown in Domestic Heating Compliance Guide.

For a mains gas fired system the minimum boiler efficiency required is 86%. BHM intend to use Ideal Logic condensing boilers throughout the site for both combination and cylinder based systems. These boilers achieve an efficiency of at least 91% and are recommended by the Energy Saving Trust.

Where installed, hot water cylinders can lose a significant amount of energy. In order to minimise this energy loss and corresponding carbon emissions BHM will utilise Kingspan Tribune Cylinders which have higher levels of insulation in comparison to typical hot water cylinders.

Finally 100% Low-E lighting fixtures shall be fitted to all properties.

2.3.2. Fabric Improvements

The building fabric for all dwellings was improved from basic compliance with Part L1A 2013 to an enhanced specification. These fabric improvements reduce the space heating requirement upon a property. The improvements have been made through a combination of upgraded materials and increased insulation thicknesses. Enhanced glazing with a larger transmittance factor allowing for increased solar gains will also be used. A summary of typical compliant specifications are given in table 1, with the proposed specifications and performance shown in table 2 below.

Table 1

Element	*Typical Specification*	*Performance W/m²K*
Roof	300mm Mineral Wool Insulation	0.15
Floors	100mm Polystyrene Insulation	0.20 - 0.25
Doors	Standard u-PVC Doors	2.20
Glazing	Standard Double Glazed	2.20
Walls	Cavity Wall with 50mm Polystyrene Board Insulation	0.32 - 0.35

Table 2

Element	*Proposed Specification*	*Performance W/m²K*
Roof	400mm Mineral Wool Insulation	0.11
Floors	150mm Platinum Insulation	0.12 – 0.16
Doors	Insulated composite doors	1.00 – 1.70
Glazing	High performance double glazed, low-e coated with Argon fill	1.41
Walls	Cavity wall with 50mm Alreflex Platinum Board Insulation	0.27

As improvements are made to the thermal conductivity of main elements, thermal bridging and air permeability becomes increasingly significant in the overall fabric performance. BHM utilise bespoke thermal bridging designs assessed by H&H Celcon, which achieve much lower heat loss levels in comparison with standard practice.

As a result of following these junction details and focusing on build quality air permeability will also decrease. A target air pressure rating of 5.01m^3/hr.m^2 has been set for all houses on site which is a 50% improvement on the maximum allowable rating in the 2013 Building Regulations.

2.3.3. Hi-Therm Lintels

As the latest set of building regulations have incorporated a Target Fabric Energy Efficiency (TFEE) standard for all new houses, some of the bespoke thermal bridging details would not be sufficient to achieve the latter.

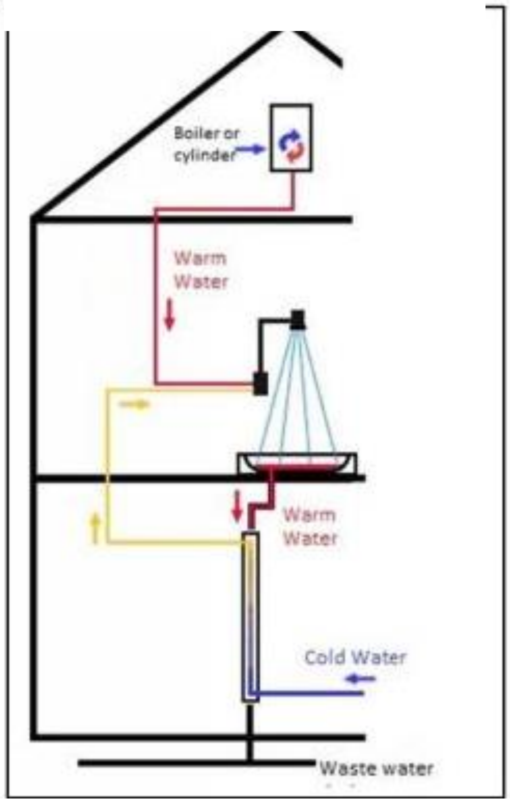
Since a significant amount of heating energy is lost through the dwelling's lintels, BHM intend to use IG Hi-Therm lintels on some house types. IG Hi-Therm lintels achieve a lower linear thermal transmittance (Psi value) of 0.05W/mK, in comparison to the normal IG lintels which achieve a Psi value of 0.23W/mK. More details are shown in Appendix D.

2.3.4. Waste Water Heat Recovery Systems (WWHRS)

WWHRS recovers heat from the warm waste water as it passes through a double walled heat exchanger, before going in the drainage system. The heat is transferred to the mains cold water supply, which is then supplied to the mains cold feed to the shower and/or a combination boiler or a hot water storage cylinder.

This process makes a significant reduction to the energy demand for providing hot water. The energy recovered depends on the temperature of the cold water feed to the dwelling, which varies by month, and the number of systems that are installed. The WWHRS is installed vertically below the point of demand, i.e. within the waste ducting below the shower or bath. A simple schematic of a WWHRS is shown in figure 2. The WWHRS will be installed in some of the house types.

Fig. 2



3. Evaluation

3.1. Conclusion

The table presented in Appendix C shows the energy saving that the improved spec will achieve in comparison to base compliance with Part L 2013 building regulations.

The total energy demand of the Part L 2013 base compliance model is 703.6MWh/Annum. The total energy demand for the actual model with the improved specification is 683.8MWh/Annum. This results in an average energy reduction of 2.8% across the site.

Approved for Release

Date: 09/02/2016

Appendix A


Approximate Site
Boundary
Longridge Rd
Chipping Ln
Longridge Town
Football Club
The Alston Arms
Inglewhite Rd
Sainsbury's
Halfpenny Ln

Appendix B


Existing cricket ground
Track
CHIPPING LANE
Pedestrian link
LEAP
Pedestrian link
LB
Guide Post
INGLEWHITE ROAD
N
BARRATT
HOMES
MANCHESTER

Appendix C

Client:	**Barratt Manchester**	
Project:	**Longridge**	environmental economics
Report:	**Energy Reduction**	

House Type/ Plot Number	Space Heating Requirement	Hot Water Requirement	Lighting Requirement	Pumps and Fans Requirement	SAP Floor Area	Number of Plots	Total Energy Demand #1
-	*kWh/Annum*	*kWh/Annum*	*kWh/Annum*	*kWh/Annum*	m^2	-	*kWh/Annum*
Data Set 1: Base Case Design (Part L 2013 Compliant)							
Ashford End Base	2334	1773	276	75	59	16	71,343
Ashford Mid Base	1957	1775	276	75	59	2	8,166
Bampton Mid Base	2389	1886	305	75	69	2	9,309
Bampton End Base	2849	1884	305	75	69	10	51,133
Barwick End Base	3076	1969	357	75	77	12	65,719
Beadle End Base	2350	1726	266	75	55	10	44,174
Cheadle Det Base	4636	1790	369	75	88	6	41,225
Faringdon Det Base	4533	2168	411	75	103	2	14,377
Helmsley Mid Base	2967	2187	443	75	110	1	5,673
Helmsley End Base	3872	2171	438	75	110	8	52,449
Kennington Det Base	5457	2494	447	75	116	6	50,838
Lincoln Det Base	4822	2172	442	75	113	9	67,594
Morpeth Det Base	4307	2055	373	75	89	6	40,863
Morpeth End Base	3946	2056	373	75	89	10	64,508
Somerton Det Base	4899	2479	424	75	108	8	63,019
Thronbury Det Base	4751	2170	440	75	112	2	14,873
Foxton FF Base	2513	1807	292	75	62	4	18,746
Foxton GF Base	2756	1790	276	75	60	4	19,587
						Data Set 1 Total Energy Demand *(kWh/Annum)*	**703,595**
Data Set 2: Actual Case							
Ashford End	2312	1773	276	75	59	16	70,991
Ashford Mid	1813	1776	276	75	59	2	7,880
Bampton End	2798	1884	305	75	69	2	10,125
Bampton Mid	2158	1887	305	75	69	10	44,248
Barwick End	2944	1970	357	75	77	12	64,141
Beadle End	2243	1727	266	75	55	10	43,101
Cheadle Det	4501	1791	369	75	88	6	40,413
Farringdon Det	4383	2170	411	75	103	2	14,079
Helmsley End	3659	2174	438	75	110	1	6,345
Helmsley Mid	2808	2190	443	75	110	8	44,129
Kennington Det	5186	2496	447	75	116	6	49,227
Lincoln Det	4822	2172	442	75	113	9	67,594
Morpeth End	3888	2056	373	75	89	6	38,355
Morpeth Det	4213	2055	373	75	89	10	67,166
Somerton Det	4899	2479	424	75	108	8	63,019
Thornbury Det	4656	2171	440	75	112	2	14,684
Foxton FF	2513	1807	292	75	62	4	18,746
Foxton GF	2756	1790	276	75	60	4	19,587
						Data Set 2 Total Energy Demand *(kWh/Annum)*	**683,830**
						Reduction in Energy Demand	
						2.8%	

Notes

#1: Calculated by SAP2012 to include total energy demand for space heating, hot water, lighting, pumps and fans.

Appendix D

IG LINTEL GUIDE

Cavity Wall

Cavity widths from **90mm to 165mm**

OUTER LEAF	INNER LEAF
102mm	100mm

If lintels are required to carry loads not indicated on the load tables, please contact IG's Technical Department.

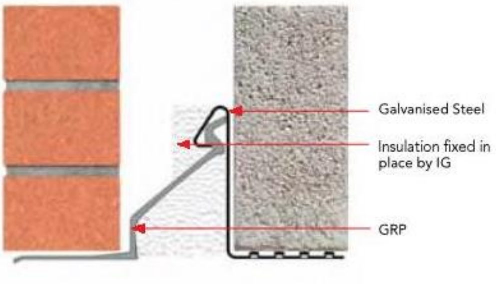
LINTEL HOTLINE
01633 486486

Fax Back Enquiry Forms are also available for download.
www.iglintels.com/technical

IG Fastrack CAD Database is accessible from iglintels.com

Hi-Therm Lintel

IG leads the way with the development of a completely unique lintel range to address the thermal requirements of new building regulations.



Psi 0.05 W/m·K

Building regulations require that lintels should be assessed for their effect on the thermal performance of a building. The thermal performance of a lintel is expressed in terms of Psi Values (Ψ) i.e. linear thermal transmittance.

Psi COMPARISON CHART

To help understand the immense thermal benefits of the Hi-Therm Lintel it must be compared to other lintel types.

Lintel type comparison	Values
IG Hi-Therm Lintel	0.05 W/m·K
Typical IG Lintel	0.23 W/m·K
Non-plated Steel Lintel (default)	0.3 W/m·K
Plated Steel Lintel (default)	0.5 W/m· K

bre THERMAL PERFORMANCE TESTING

Testing of IG's Hi-Therm Lintel was carried out by the BRE (Building Research Establishment) using Physibel's thermal analysis software TRISCO which complies with BS EN ISO 10211-1. The modeling follows the requirements of the BRE conventions document BR497.

KEY BENEFITS

- Up to 5 times more thermally efficient than a steel cavity wall lintel, Hi-Therm outperforms other lintels.
- The significant reductions in thermal bridging due to the GRP component will assist in the building design process to achieve compliance with Part L and The Code for Sustainable Homes.
- The use of Hi-Therm will make a significant contribution to a buildings performance in respect of the Fabric Energy Efficiency Standards (FEES).
- Outperforms Stainless Steel on price and corrosion resistance.
- Hi-Therm has achieved the 1 hour fire resistance test as carried out by Exova Warringtonfire utilising the heating conditions of BS EN 1363-1 1999.

DESIGN FEATURES

- Patented GRP and Galvanised Steel hybrid design.
- Galvanised steel is used to support the heavier load on the inner leaf of the cavity wall.
- Profiled CFC free insulation ensures the continuity of insulation.

DAMP PROOFING

Not required on Hi-Therm lintels.
*Check severe exposure.

Appendix E

SAP 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 Michael Woodbridge	Assessor number	9636
Client		Last modified	15/05/2014
Address	Faringdon 1 House Type Detached Barratt Developments PLC, 2010 Classic Range		

1. Overall dwelling dimensions

		Area (m²)			Average storey height (m)			Volume (m³)	
Lowest occupied		52.29	(1a)	x	2.33	(2a)	=	121.84	(3a)
+1		50.72	(1b)	x	2.55	(2b)	=	129.34	(3b)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =	103.01	(4)						
Dwelling volume					(3a) + (3b) + (3c) + (3d)...(3n) =			251.17	(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	3	x 10 =	30	(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) =	30	÷ (5) =	0.12	(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		5.01	(17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)		0.37	(18)
Number of sides on which the dwelling is sheltered		2	(19)
Shelter factor	1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =	0.31	(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 U2	5.10	5.00	4.90	4.40	4.30	3.80	3.80	3.70	4.00	4.30	4.50	4.70	(22)
Wind factor (22)m ÷ 4	1.28	1.25	1.23	1.10	1.08	0.95	0.95	0.93	1.00	1.08	1.13	1.18	(22a)
Adjusted infiltration rate (allowing for shelter and wind factor) (21) x (22a)m	0.40	0.39	0.39	0.35	0.34	0.30	0.30	0.29	0.31	0.34	0.35	0.37	(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system	N/A	(23a)
If balanced with heat recovery: efficiency in % allowing for in-use factor from Table 4h	N/A	(23c)

d) natural ventilation or whole house positive input ventilation from loft

0.58	0.58	0.57	0.56	0.56	0.54	0.54	0.54	0.55	0.56	0.56	0.57	(24d)

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

0.58	0.58	0.57	0.56	0.56	0.54	0.54	0.54	0.55	0.56	0.56	0.57	(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	κ-value, kJ/m².K	A x κ, kJ/K	
Window			22.43	x	1.33	=	29.94			(27)
Door			2.17	x	1.00	=	2.17			(26)
Door			1.95	x	1.70	=	3.32			(26)
Ground floor			52.29	x	0.16	=	8.37			(28a)
External wall			121.77	x	0.27	=	32.88			(29a)
Roof			50.72	x	0.11	=	5.58			(30)
Roof			1.57	x	0.17	=	0.27			(30)
Total area of external elements ∑A, m²			252.90							(31)

Fabric heat loss, W/K = ∑(A × U)	(26)...(30) + (32) =	82.51	(33)
Heat capacity Cm = ∑(A x κ)	(28)...(30) + (32) + (32a)...(32e) =	N/A	(34)
Thermal mass parameter (TMP) in kJ/m²K		201.00	(35)
Thermal bridges: ∑(L x Ψ) calculated using Appendix K		9.08	(36)
Total fabric heat loss	(33) + (36) =	91.59	(37)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)	48.10	47.85	47.59	46.40	46.18	45.14	45.14	44.95	45.54	46.18	46.63	47.10	(38)
Heat transfer coefficient, W/K (37)m + (38)m	139.69	139.44	139.18	137.99	137.77	136.73	136.73	136.54	137.13	137.77	138.22	138.69	
Average = ∑(39)1...12/12 =												137.99	(39)
Heat loss parameter (HLP), W/m²K (39)m ÷ (4)	1.36	1.35	1.35	1.34	1.34	1.33	1.33	1.33	1.33	1.34	1.34	1.35	
Average = ∑(40)1...12/12 =												1.34	(40)
Number of days in month (Table 1a)	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	(40)

4. Water heating energy requirement

Assumed occupancy, N	2.77	(42)
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	99.89	(43)

	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)	109.87	105.88	101.88	97.89	93.89	89.90	89.90	93.89	97.89	101.88	105.88	109.87	
∑(44)1...12 =												1198.62	(44)
Energy content of hot water used = 4.18 x Vd,m x nm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)	162.94	142.51	147.06	128.21	123.02	106.15	98.37	112.88	114.23	133.12	145.31	157.80	
∑(45)1...12 =												1571.58	(45)
Distribution loss 0.15 x (45)m	24.44	21.38	22.06	19.23	18.45	15.92	14.76	16.93	17.13	19.97	21.80	23.67	(46)

Storage volume (litres) including any solar or WWHRS storage within same vessel	150.00	(47)
Water storage loss:		
a) If manufacturer's declared loss factor is known (kWh/day)	1.31	(48)
Temperature factor from Table 2b	0.54	(49)
Energy lost from water storage (kWh/day) (48) x (49)	0.71	(50)
Enter (50) or (54) in (55)	0.71	(55)

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

21.93	19.81	21.93	21.22	21.93	21.22	21.93	21.93	21.22	21.93	21.22	21.93	(56)

If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] ÷ (47), else (56)

21.93	19.81	21.93	21.22	21.93	21.22	21.93	21.93	21.22	21.93	21.22	21.93	(57)

Primary circuit loss for each month from Table 3

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 for each month from Table 3a, 3b or 3c

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 x (45)m + (46)m + (57)m + (59)m + (61)m

208.13	183.33	192.25	171.94	168.21	149.89	143.56	158.07	157.96	178.31	189.05	202.99	(62)

Solar DHW input calculated using Appendix G or Appendix H

-29.51	-25.96	-26.50	-21.80	-20.24	-16.70	-14.13	-17.11	-17.61	-21.77	-25.22	-28.52	(63)

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

178.63	157.36	165.75	150.14	147.97	133.19	129.43	140.96	140.35	156.55	163.83	174.47	
									∑(64)1...12 =		1838.64	(64)

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

90.33	80.04	85.05	77.62	77.06	70.28	68.86	73.69	72.97	80.42	83.30	88.62	(65)

5. Internal gains

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Metabolic gains (Table 5)													
	165.94	165.94	165.94	165.94	165.94	165.94	165.94	165.94	165.94	165.94	165.94	165.94	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	58.24	51.72	42.07	31.85	23.81	20.10	21.72	28.23	37.89	48.11	56.15	59.85	(67)
Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	389.71	393.75	383.56	361.87	334.48	308.74	291.55	287.50	297.69	319.39	346.77	372.51	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	54.36	54.36	54.36	54.36	54.36	54.36	54.36	54.36	54.36	54.36	54.36	54.36	(69)
Pump and fan gains (Table 5a)													
	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	(70)
Losses e.g. evaporation (Table 5)													
	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	-110.63	(71)
Water heating gains (Table 5)													
	121.41	119.11	114.31	107.80	103.57	97.62	92.55	99.04	101.34	108.09	115.70	119.11	(72)
Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m													
	682.03	677.26	652.61	614.19	574.53	539.13	518.49	527.44	549.60	588.25	631.29	664.16	(73)

6. Solar gains

	Access factor Table 6d		Area m²		Solar flux W/m²		g specific data or Table 6b		FF specific data or Table 6c		Gains W	
SouthWest	0.77	x	1.38	x	36.79	x 0.9 x	0.71	x	0.70	=	17.49	(79)
NorthEast	0.77	x	1.38	x	11.28	x 0.9 x	0.71	x	0.70	=	5.36	(75)
NorthWest	0.77	x	6.22	x	11.28	x 0.9 x	0.71	x	0.70	=	24.17	(81)
West	0.77	x	5.90	x	19.64	x 0.9 x	0.71	x	0.70	=	39.91	(80)
SouthEast	0.77	x	3.30	x	36.79	x 0.9 x	0.71	x	0.70	=	41.82	(77)
East	0.77	x	4.25	x	19.64	x 0.9 x	0.71	x	0.70	=	28.75	(76)

Solar gains in watts ∑(74)m...(82)m

157.50	295.45	467.73	671.75	826.30	850.08	807.38	689.35	538.91	344.49	193.81	131.34	(83)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	839.53	972.71	1120.35	1285.93	1400.83	1389.21	1325.88	1216.79	1088.51	932.75	825.10	795.49	(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)	0.99	0.97	0.95	0.88	0.75	0.58	0.44	0.50	0.73	0.92	0.98	0.99	(86)
Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)	19.45	19.66	20.01	20.44	20.77	20.93	20.98	20.97	20.85	20.41	19.84	19.40	(87)
Temperature during heating periods in the rest of dwelling from Table 9, Th2(˚C)	19.80	19.80	19.80	19.81	19.81	19.82	19.82	19.82	19.82	19.81	19.81	19.80	(88)
Utilisation factor for gains for rest of dwelling n2,m	0.98	0.97	0.93	0.85	0.69	0.49	0.33	0.38	0.65	0.89	0.97	0.99	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)	17.77	18.08	18.58	19.18	19.59	19.78	19.81	19.81	19.70	19.15	18.36	17.71	(90)

Living area fraction — Living area ÷ (4) = 0.18 (91)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Mean internal temperature for the whole dwelling fLA x T1 +(1 - fLA) x T2	18.07	18.36	18.84	19.41	19.80	19.98	20.02	20.02	19.90	19.38	18.62	18.02	(92)
Apply adjustment to the mean internal temperature from Table 4e where appropriate	17.92	18.21	18.69	19.26	19.65	19.83	19.87	19.87	19.75	19.23	18.47	17.87	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, ηm	0.97	0.96	0.92	0.83	0.68	0.49	0.33	0.38	0.64	0.87	0.96	0.98	(94)
Useful gains, ηmGm, W (94)m x (84)m	817.16	929.69	1027.30	1067.75	959.32	686.69	442.78	465.61	698.63	815.74	789.02	777.64	(95)
Monthly average external temperature from Table U1	4.30	4.90	6.50	8.90	11.70	14.60	16.60	16.40	14.10	10.60	7.10	4.20	(96)
Heat loss rate for mean internal temperature, Lm, W [(39)m x [(93)m - (96)m]	1902.79	1856.51	1696.56	1429.22	1095.60	715.72	447.57	473.65	775.14	1188.26	1572.03	1895.38	(97)
Space heating requirement, kWh/month 0.024 x [(97)m - (95)m] x (41)m	807.70	622.82	497.92	260.26	101.39	0.00	0.00	0.00	0.00	277.15	563.76	831.60	

∑(98)1...5, 10...12 = 3962.62 (98)

Space heating requirement kWh/m²/year — (98) ÷ (4) 38.47 (99)

9a. Energy requirements - individual heating systems including micro-CHP

Space heating

Fraction of space heat from secondary/supplementary system (table 11)		0.00	(201)
Fraction of space heat from main system(s)	1 - (201) =	1.00	(202)
Fraction of space heat from main system 2		0.00	(202)
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 system 1 (%)		90.40	(206)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Space heating fuel (main system 1), kWh/month	893.48	688.96	550.80	287.90	112.15	0.00	0.00	0.00	0.00	306.59	623.63	919.91

∑(211)1...5, 10...12 = 4383.43 (211)

Water heating

Efficiency of water heater

88.25	88.02	87.47	86.17	83.73	79.70	79.70	79.70	79.70	86.22	87.75	88.34	(217)

Water heating fuel, kWh/month

202.40	178.79	189.50	174.24	176.72	167.12	162.40	176.87	176.10	181.56	186.70	197.49	

∑(219a)1...12 = 2169.90 (219)

Annual totals

Space heating fuel - main system 1		4383.43	
Water heating fuel		2169.90	
Electricity for pumps, fans and electric keep-hot (Table 4f)			
central heating pump or water pump within warm air heating unit	30.00		(230c)
boiler flue fan	45.00		(230e)
Total electricity for the above, kWh/year		75.00	(231)
Electricity for lighting (Appendix L)		411.39	(232)
Total delivered energy for all uses	(211)...(221) + (231) + (232)...(237b) =	7039.72	(238)

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

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	4383.43	x	3.48	x 0.01 =	152.54	(240)
Water heating	2169.90	x	3.48	x 0.01 =	75.51	(247)
Pumps and fans	75.00	x	13.19	x 0.01 =	9.89	(249)
Electricity for lighting	411.39	x	13.19	x 0.01 =	54.26	(250)
Additional standing charges					120.00	(251)
Total energy cost				(240)...(242) + (245)...(254) =	412.21	(255)

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

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	1.17	(257)
SAP value	83.68	
SAP rating (section 13)	84	(258)
SAP band	B	

12a. CO_2 emissions - individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO_2/kWh		Emissions kg CO_2/year	
Space heating - main system 1	4383.43	x	0.22	=	946.82	(261)
Water heating	2169.90	x	0.22	=	468.70	(264)
Space and water heating				(261) + (262) + (263) + (264) =	1415.52	(265)
Pumps and fans	75.00	x	0.52	=	38.93	(267)
Electricity for lighting	411.39	x	0.52	=	213.51	(268)
Total CO_2, kg/year				(265)...(271) =	1667.95	(272)
Dwelling CO_2 emission rate				(272) ÷ (4) =	16.19	(273)
EI value					84.90	
EI rating (section 14)					85	(274)
EI band					B	

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

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	4383.43	x	1.22	=	5347.78	(261)

Water heating	2169.90	x	1.22	=	2647.28	(264)
Space and water heating			(261) + (262) + (263) + (264) =		7995.06	(265)
Pumps and fans	75.00	x	3.07	=	230.25	(267)
Electricity for lighting	411.39	x	3.07	=	1262.95	(268)
Primary energy kWh/year					9488.27	(272)
Dwelling primary energy rate kWh/m2/year					92.11	(273)