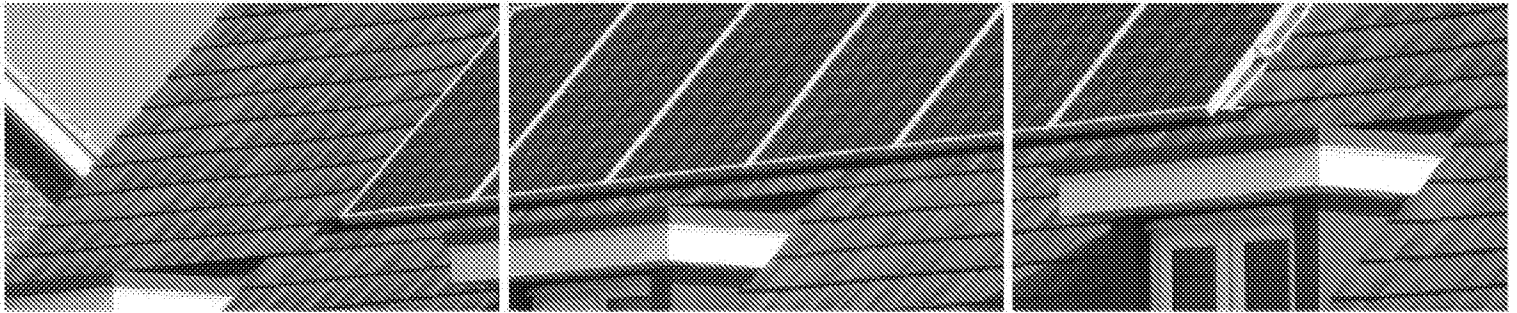
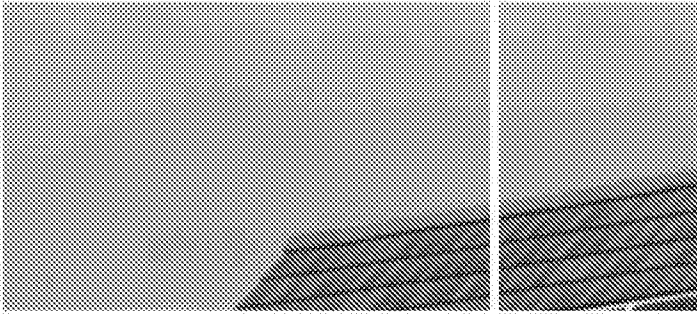
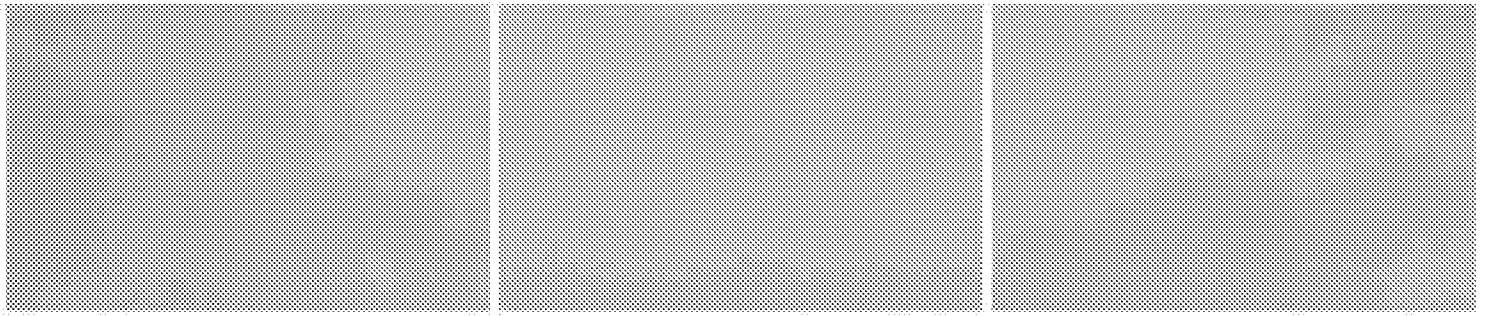


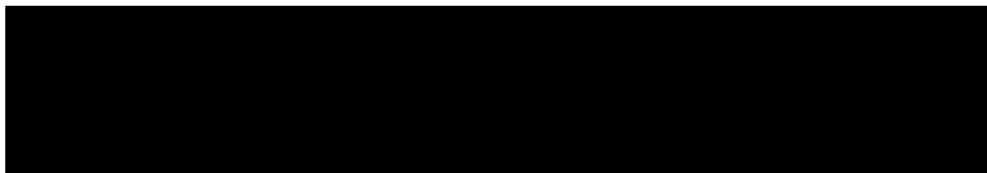
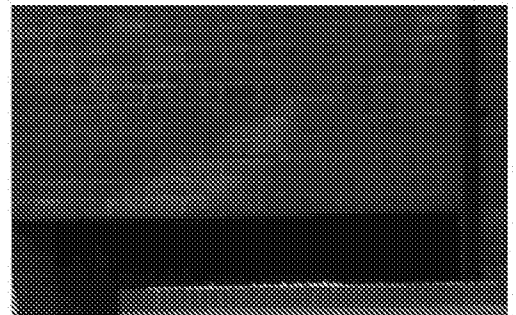


Energy Report

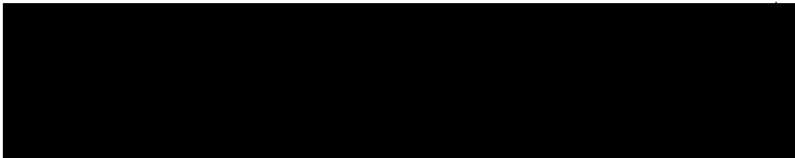
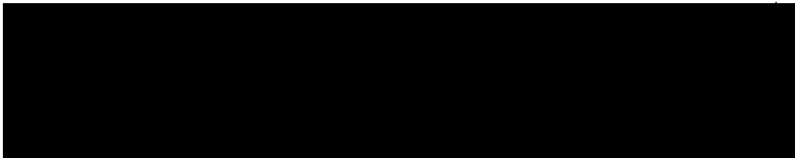
Water Lane, Angmering

Client: BDW Southern Counties

Author: Michael Woodbridge



Revision History

<i>Version</i>	<i>Date Issued</i>	<i>Issued by</i>	<i>QA Check</i>
1	10/02/2021	 Michael Woodbridge	 Andrew Maughan

About Environmental Economics

Our team of experienced consultants specialise in construction and building energy. We have qualifications in sustainability, energy, engineering, building physics and construction as well as environmental, quality management and auditing.

Over the last decade, we have provided assessments and consultancy for some of the largest UK house builders, including Barratt Developments, David Wilson Homes, Bellway Homes, Abbey New Homes and Davidsons. We develop flexible, practical, cost-effective specifications for our clients through identifying solutions and delivering design advice. This includes the following disciplines:

- *Overheating Analysis (dynamic thermal modelling)*
- *Daylighting / Sunlight Simulations*
- *Energy Reports*
- *Compliance assessments and advice covering*
 - *Part L (SAP)*
 - *Part F (ventilation)*
 - *Part G (water)*
- *BREEAM*
- *SBEM (existing and new build)*
- *Minimum Energy Efficiency Standards (MEES)*
- *Thermal Bridging (Psi value calculations)*

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1. Project Overview

1.1. Introduction

- 1.1.1. This energy report was prepared by Environmental Economics Ltd on behalf of BDW Southern Counties. The report assesses measures to reduce the energy demand of the domestic housing on site through the use of fabric efficiency and renewables.

1.2. Description of Site

- 1.2.1. The site consists of 175 plots. These units comprise a range of detached, semi-detached and terraced houses, as well as a number of apartments.
- 1.2.2. The proposed site location/boundary for the whole site is shown in Appendix A.
- 1.2.3. This report addresses a domestic development being undertaken by BDW Southern Counties, and does not include any further proposals for subsequent developments or non-residential parcels.

1.3. Client Brief

- 1.3.1. The development has been designed to achieve a 10% reduction energy demand, achieved through a combined of fabric efficiency and renewable energy.

1.4. Building regulations

- 1.4.1. The SAP assessments have been undertaken using the appropriate legislative guidance; Approved Document Part L1A 2013. It should be noted that future policies and building regulations will reflect changes to the carbon content of fuels. In particular grid electricity is expected to become significantly decarbonized due to the ongoing investment in wind, solar and nuclear energy.
- 1.4.2. It is therefore possible that the solutions outlined in this report will require significant revision if the project is delivered against future building regulations. Currently, it is expected that Approved Document L will be updated in April 2021, and to be enforced in late 2021.

2. Improvement Measures

2.1. Assessment Methodology

2.1.1. 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*

2.1.2. Each of these outputs can be used in different ways to analyse the performance of the dwelling. The total regulated carbon emissions for each property is based upon:

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

2.1.3. Two models were created in order to calculate the energy demand. The required data for the site is calculated for each of the models, and then the difference used to establish the level of improvement. In order to achieve this representative house types have been utilised.

2.1.4. The emissions 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 2012) through version 6 of the NHER Plan Assessor software. An example SAP worksheet can be found in Appendix D.

2.2. Design Philosophy

2.2.1. Upgrades have been made to a number of elements from a 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.

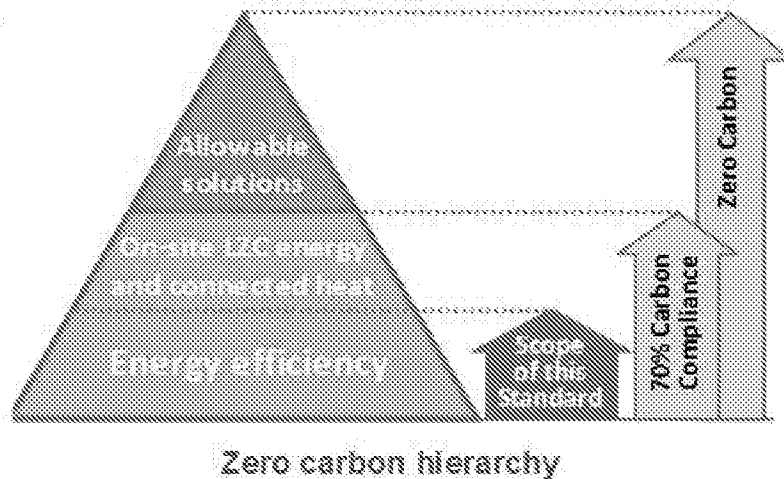


Figure 1

2.2.2. 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 thermostat*
- *Design air permeability of 5.01m³/hr/m²*
- *Bespoke thermal bridging details*

2.3. Product Improvements

- 2.3.1. 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.
- 2.3.2. For a mains gas fired system the minimum boiler efficiency required is 86%. High efficiency condensing boilers have been specified throughout the site for both combination and cylinder based systems. These boilers achieve a SAP 2009 rated efficiency of at least 89% and are recommended by the Energy Saving Trust.
- 2.3.3. Where installed, hot water cylinders can lose a significant amount of energy. In order to minimise this energy loss and corresponding carbon emissions, cylinders which have higher levels of insulation in comparison to typical hot water cylinders will be used.
- 2.3.4. Finally 100% Low-E lighting fixtures shall be fitted to all properties.

2.4. Fabric Improvements

2.4.1. 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. Changes to the U-Value of external elements are shown in table 1 below.

<i>Element</i>	<i>Minimum Standard</i>	<i>Improved Specification</i>	
-	<i>W/m²k</i>	<i>Description</i>	<i>W/m²k</i>
Walls	0.30	50mm Alreflex Platinum Cavity	0.27
Roof	0.20	400mm Mineral Wool Horizontal Ceiling, Loft Space	0.11
		Flat Roof	0.17
Floors	0.25	Spantherm 300mm	0.13 - 0.16
Doors	2.00	Double glazed Low-E, u-PVC frame	1.00 – 1.70
Glazing	2.00	Double glazed Low-E, u-PVC frame	1.30

Table 1.

2.4.2. As improvements are made to the thermal conductivity of main elements, thermal bridging and air permeability becomes increasingly significant in the overall fabric performance. Bespoke thermal bridging designs have been utilised, which achieve much lower heat loss levels in comparison with standard practice.

2.4.3. As a result of following these junction details and focusing on build quality air permeability will also decrease. A target air pressure rating of 5.01m³/hr.m² has been set for all houses on site which is a 50% improvement on the maximum allowable rating in the 2013 Building Regulations.

3. Low and Zero Carbon Technologies

3.1. Photovoltaic (PV) Cells

- 3.1.1. 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.
- 3.1.2. 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 exported to the national grid, as can be seen in figure 2.

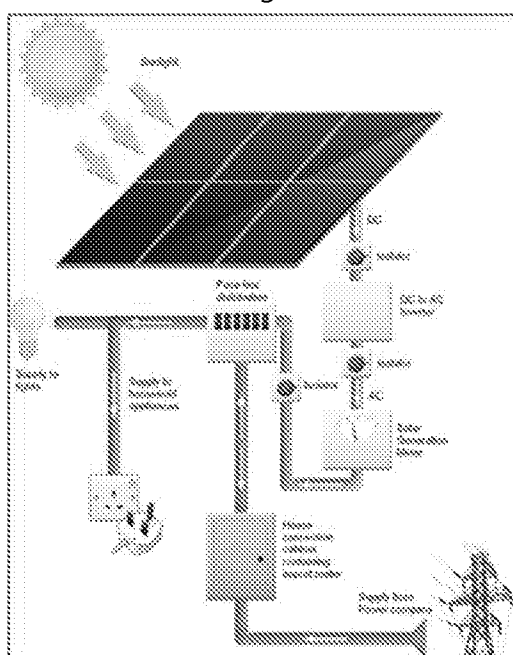


Figure 2

- 3.1.3. 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.

3.2. Solar Hot Water (SHW)

- 3.2.1. 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.
- 3.2.2. 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. An example of the latter can be seen in figure 3.



Figure 3

- 3.2.3. 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*
- 3.2.4. 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.

3.3. Air Source Heat Pumps (ASHP)

- 3.3.1. 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.

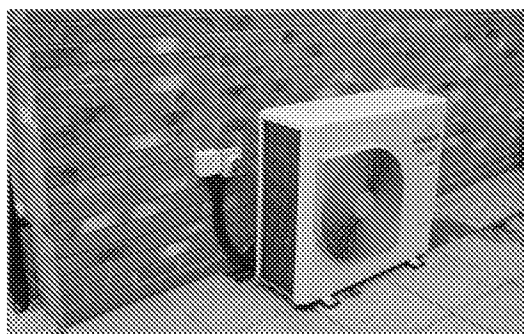


Figure 4

- 3.3.2. 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.
- 3.3.3. ASHP are assessed by their power output and the size of unit chosen depends on the demand from the household. An example external unit can be seen above in figure 4. The units with a larger power output can provide a larger amount of hotter water even in colder climates.

3.4. Ground Source Heat Pumps (GSHP)

- 3.4.1. 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.

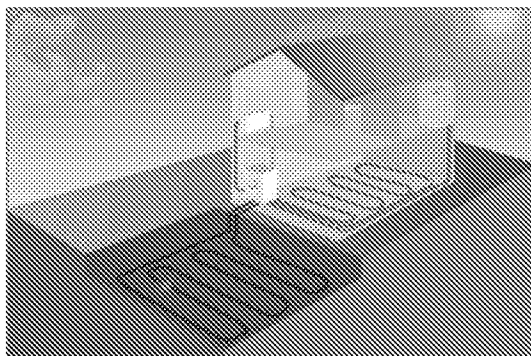


Figure 5

- 3.4.2. 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. A typical system can be seen above in figure 5.

3.5. Biomass Heating Systems

- 3.5.1. 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.
- 3.5.2. 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. An example system can be seen in figure 6.

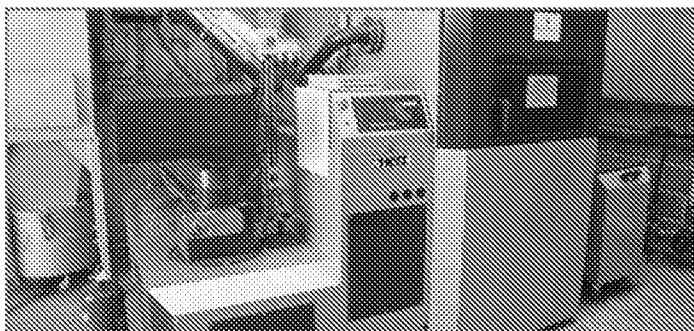


Figure 6

- 3.5.3. 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.

3.6. Wind Turbines

- 3.6.1. 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, as can be seen in figure 7.



Figure 7

- 3.6.2. 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.

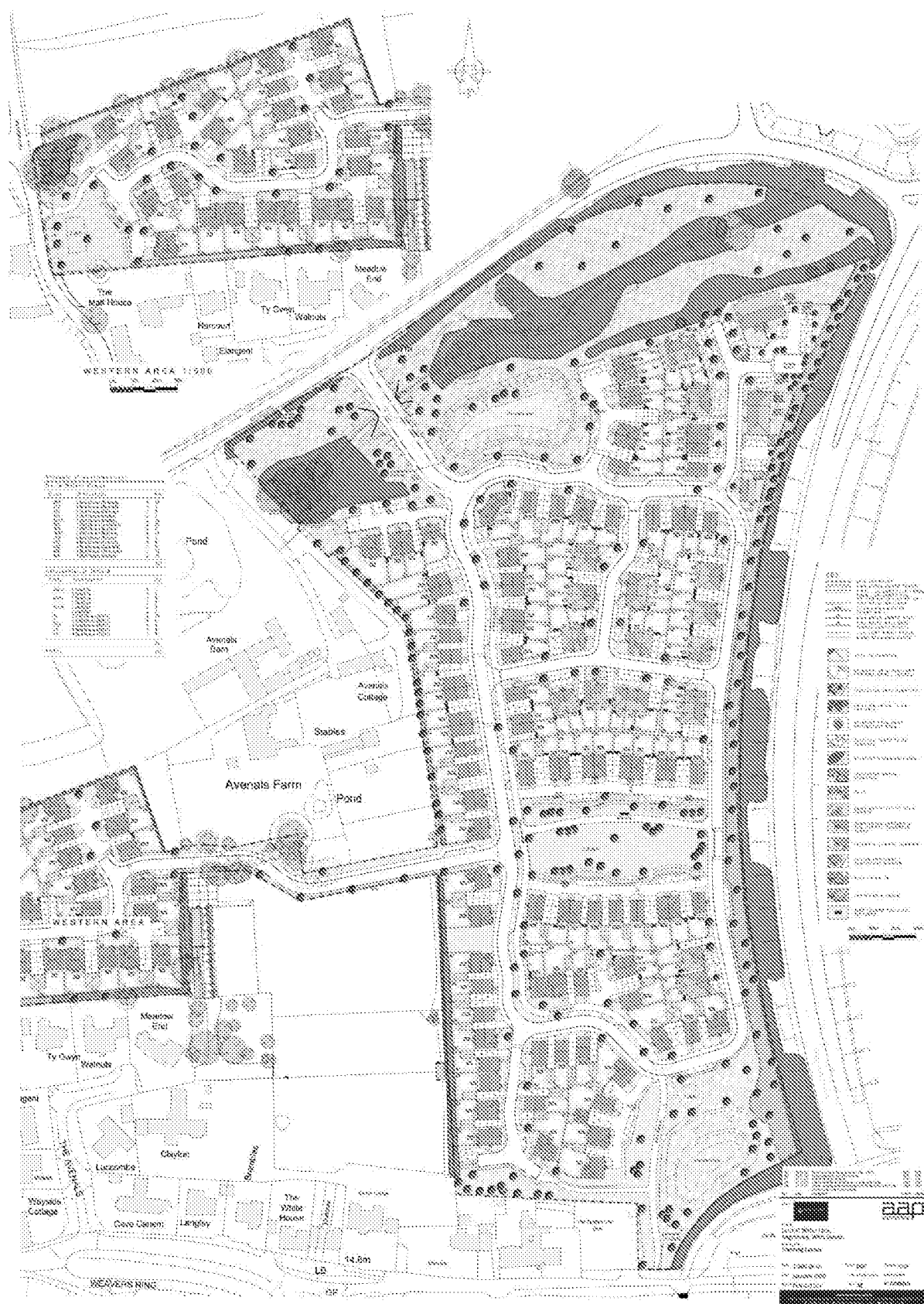
3.7. Comparison

- 3.7.1. SHW can be easily incorporated into new build house designs and has the potential to reduce the energy demand from hot water considerably.
- 3.7.2. The product and installation cost make ASHP 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 same can be said of GSHP, as well as the fact that additional extensive ground work is required in order to make use of the system.
- 3.7.3. 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
- 3.7.4. The density of the site is a major restriction on the potential energy that could be generated from wind turbines. Surrounding houses and the urban location would restrict wind speeds.
- 3.7.5. The solution of PV panel systems will be used. 77.10kWp would be sufficient to aid in achieving the 10% energy reduction target.
- 3.7.6. For the purpose of the report this amount of PV has been distributed as per the schedule in Appendix C.
- 3.7.7. However, the PV may be distributed differently, as long as the energy production of the PV remains the same.

4. Conclusion

- 4.1.1. The table presented in Appendix B shows reduction in energy demand achieved via fabric efficiency measures and renewables.
- 4.1.2. The baseline energy demand, when measured from current building regs minimum performance, is 1,106,491kWh/Annum. After taking into account fabric efficiencies and renewable energy, this demand is reduced to 995,719kWh/Annum.
- 4.1.3. This constitutes a reduction of 10% in energy demand, achieving the target.

Appendix A



Appendix B

Client:	Barratt Southern Counties							
Project:	Water Lane, 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 Floor Area	Number of Plots	Total Energy Demand #1
-	kWh/Annum	kWh/Annum	kWh/Annum	kWh/Annum	kWh/Annum	m ²	-	kWh/Annum
Data Set 1: Base Case Design (Part L 2013 Compliant)								
51	3434	1814	354	75	-	78	19	107,855
52	3590	1870	395	75	-	86	9	53,375
54	4138	1952	452	75	-	103	3	19,851
55	3563	1889	401	75	-	89	4	23,713
Archford	3212	1794	343	75	-	76	27	146,456
Avondale	5403	2221	483	75	-	137	11	89,997
Cornell	5321	2121	463	75	-	127	8	63,840
Exeter	6172	2501	495	75	-	136	3	27,729
Fairway/Blyford	4206	1914	399	75	-	94	3	19,783
Flat GF	2720	1726	356	75	-	69	9	43,895
Flat TF	2351	1728	356	75	-	69	9	40,591
Hadley	4190	1910	398	75	-	93	15	98,605
Holden	5667	2198	497	75	-	141	15	126,549
Ingleby	4501	1935	429	75	-	99	20	138,790
Kirkdale	4855	2143	492	75	-	124	5	37,823
Wilford	2572	1598	265	75	-	58	15	67,639
Data Set 1 Total Energy Demand (kWh/Annum)								1,106,491
Data Set 2: Actual Case (With Renewables)								
51	3039	1815	354	75	-	78	19	100,368
52	3163	1872	395	75	-	86	9	49,541
54	3550	1953	452	75	-	103	3	18,091
55	3152	1891	401	75	-	89	4	22,075
Archford	2894	1795	343	75	-	76	27	137,888
Avondale	5162	2223	483	75	-	137	8	63,543
Cornell	5143	2122	463	75	-	127	8	62,425
Exeter	6021	2502	495	75	-	136	2	18,186
Fairway/Blyford	3864	1915	399	75	-	94	2	12,505
Flat GF PV South	2577	1727	356	75	349	69	9	39,473
Flat TF PV South	2110	1729	356	75	349	69	9	35,293
Hadley	3937	1911	398	75	-	93	14	88,502
Holden	5364	2200	497	75	-	141	5	40,679
Ingleby	4210	1936	429	75	-	99	11	73,144
Kirkdale	4680	2145	492	75	-	124	1	7,392
Wilford	2358	1599	265	75	-	58	15	64,452
Avondale PV West	5162	2223	483	75	1638	137	3	18,915
Blyford PV West	3864	1915	399	75	1638	94	1	4,615
Exeter PV South	6021	2502	495	75	2051	136	1	7,042
Hadley PV South	3937	1911	398	75	2051	93	1	4,271
Holden PV South	5364	2200	497	75	2051	141	4	24,340
Holden PV West	5364	2200	497	75	1638	141	6	38,987
Ingleby PV South	4210	1936	429	75	2051	99	7	32,192
Ingleby PV West	4210	1936	429	75	1638	99	2	10,023
Kirkdale PV South	4680	2145	492	75	2051	124	3	16,023
Kirkdale PV West	4680	2145	492	75	1638	124	1	5,754
Data Set 2 Total Energy Demand (kWh/Annum)								995,719
Reduction In Energy Demand								10.0%
Notes								
#1: Calculated by SAP2012 to include total energy demand for space heating, hot water, lighting, pumps and fans.								

Appendix C

Plot	PV(kWp)	Orientation
150-157	7.5	South
1	2.4	South
4	2.4	South
7	2.4	West
8	2.4	West
9	2.4	West
14	2.4	West
15	2.4	West
16	2.4	West
17	2.4	West
36	2.4	South
37	2.4	South
38	2.4	South
39	2.4	South
40	2.4	South
41	2.4	South
42	2.4	South
45	2.4	West
46	2.4	West
48	2.4	West
49	2.4	West
50	2.4	West
51	2.4	West
52	2.4	West
53	2.4	West
54	2.4	West
58	2.4	South
59	2.4	South
62	2.4	West
63	2.4	West

Appendix D

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	21/01/2021
Address	H403--F7 0500 Ingleby (Front Gable) Detached Part L2013 Masonry, David Wilson Homes		

1. Overall dwelling dimensions			
	Area (m ²)	Average storey height (m)	Volume (m ³)
Lowest occupied	49.50 (1a) x	2.31 (2a) =	114.35 (3a)
+1	49.50 (1b) x	2.56 (2b) =	126.72 (3b)
Total floor area	(1a) + (1b) + (1c) + (1d)...(1n) =		99.00 (4)
Dwelling volume	(3a) + (3b) + (3c) + (3d)...(3n) =		241.07 (5)

2. Ventilation rate				
				m ³ per hour
Number of chimneys	0	x 40 =	0	(6a)
Number of open flues	0	x 20 =	0	(6b)
Number of intermittent fans	4	x 10 =	40	(7a)
Number of passive vents	0	x 10 =	0	(7b)
Number of fuelless gas fires	0	x 40 =	0	(7c)
Air changes per hour				
Infiltration due to chimneys, flues, fans, PSVs	(6a) + (6b) + (7a) + (7b) + (7c) =		40	÷ (5) = 0.17 (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)				0.42 (18)
Number of sides on which the dwelling is sheltered				0 (19)
Shelter factor	1 - {0.075 x (19)} =		1.00	(20)
Infiltration rate incorporating shelter factor	(18) x (20) =		0.42	(21)
Infiltration rate modified for monthly wind speed:				



	0.64	0.64	0.63	0.60	0.60	0.58	0.58	0.57	0.59	0.60	0.61	0.62	(25)
2. Fabric losses and heat loss parameter													
Element	Gross area, m ²	Openings m ²	Net area A, m ²	U-value W/m ² K	A x U W/K	κ-value, kJ/m ² K	A x κ, kJ/K						
Door			2.38	1.10	2.62								(26)
Window			14.06	1.24	17.37								(27)
Ground floor			49.50	0.15	7.43								(28a)
External wall			124.00	0.27	33.48								(29a)
Roof			49.50	0.11	5.45								(30)
Total area of external elements ΣA, m ²			239.44										(31)
Fabric heat loss, W/K = Σ(A × U)													(26)...(30) + (32) =
Heat capacity Cm = Σ(A × κ)													(28)...(30) + (32) + (32a)...(32a) =
Thermal mass parameter (TMP) in kJ/m ² K													(33) + (36) =
Thermal bridges: Σ(L × W) calculated using Appendix K													(33) + (36) =
Total fabric heat loss													(33) + (36) =
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ventilation heat loss calculated monthly 0.33 x (25)m x (5)													
	50.99	50.55	50.13	48.12	47.75	48.00	48.00	45.68	46.67	47.75	48.51	49.30	(38)
Heat transfer coefficient, W/K (37)m + (38)m													
	126.39	125.96	125.53	123.53	123.15	123.41	123.41	121.08	122.08	123.15	123.91	124.70	
													Average = Σ(39)1...12/12 =
Heat loss parameter (HLP), W/m ² K (39)m + (4)													(39)
	1.28	1.27	1.27	1.25	1.24	1.23	1.23	1.22	1.23	1.24	1.25	1.26	
													Average = Σ(40)1...12/12 =
Number of days in month (Table 1a)													(40)
	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00	
3. Water heating energy requirements													
Assumed occupancy, N													2.73 (42)
Annual average hot water usage in litres per day Vd, average = (25 × N) + 36													99.04 (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)													
	108.94	104.98	101.02	97.06	93.10	89.14	89.14	93.10	97.06	101.02	104.98	108.94	
													Σ(44)1...12 =
Energy content of hot water used = 4.18 x Vd,m x cm x Tm/3600 kWh/month (see Tables 1b, 1c 1d)													(44)
	161.56	141.30	145.81	127.12	121.98	105.26	97.53	111.92	113.26	131.99	144.08	156.46	
													Σ(45)1...12 =
Distribution loss 0.15 x (45)m													(45)
	24.23	21.20	21.87	19.07	18.30	15.79	14.63	16.79	16.99	19.80	21.61	23.47	
Water storage loss calculated for each month (58) x (41)m													(46)
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
If the vessel contains dedicated solar storage or dedicated WWHRS (56)m x [(47) - Vs] + (47), else (56)													(56)
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Primary circuit loss for each month from Table 3													(57)
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Combi loss for each month from Table 3a, 3b or 3c													(58)
	14.14	12.76	14.11	13.61	14.03	13.54	13.97	14.01	13.58	14.07	13.66	14.13	
Total heat required for water heating calculated for each month 0.85 x (45)m + (46)m + (57)m + (59)m + (61)m													(61)

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175.70	154.07	159.92	140.73	136.00	118.79	111.50	125.93	126.84	146.07	157.74	170.59	(62)
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Solar DHW input calculated using Appendix G or Appendix H

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(63)
------	------	------	------	------	------	------	------	------	------	------	------	------

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

175.70	154.07	159.92	140.73	136.00	118.79	111.50	125.93	126.84	146.07	157.74	170.59	(64)
											$\sum(64)1 \dots 12 =$	1723.88

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

57.25	50.17	52.01	45.67	44.06	38.38	35.92	40.72	41.05	47.41	51.32	55.56	(65)
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6. Internal gains

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
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Metabolic gains (Table 5)

163.80	163.80	163.80	163.80	163.80	163.80	163.80	163.80	163.80	163.80	163.80	163.80	(66)
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Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

60.71	53.92	43.85	33.20	24.82	20.95	22.64	29.43	39.50	50.15	58.53	62.40	(67)
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Appliance gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

380.15	384.10	374.15	352.99	326.28	301.17	284.40	280.45	290.39	311.56	338.27	363.38	(68)
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Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

54.11	54.11	54.11	54.11	54.11	54.11	54.11	54.11	54.11	54.11	54.11	54.11	(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)

-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	-109.20	(71)
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Water heating gains (Table 5)

76.96	74.66	69.90	63.43	59.23	53.31	48.28	54.73	57.02	63.72	71.28	74.67	(72)
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Total internal gains (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

629.53	624.39	599.62	561.33	522.03	487.14	467.03	476.32	498.62	537.14	579.79	612.16	(73)
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7. Solar gains

	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	
South-East	0.77	4.29	36.79	$\times 0.9 \times$	0.71	$\times 0.70 =$	54.37 (77)
North-West	0.77	7.13	11.28	$\times 0.9 \times$	0.71	$\times 0.70 =$	27.71 (81)
North-East	0.77	1.98	11.28	$\times 0.9 \times$	0.71	$\times 0.70 =$	7.59 (75)
South-West	0.77	6.66	36.79	$\times 0.9 \times$	0.71	$\times 0.70 =$	8.36 (79)

Solar gains in watts: $\sum(74)m \dots (82)m$

98.33	178.91	276.03	394.37	489.51	506.99	480.05	405.85	316.51	206.16	119.68	82.59	(83)
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Total gains - internal and solar (73)m + (83)m

727.66	803.31	875.66	955.70	1011.55	994.14	947.08	882.17	815.13	743.30	699.48	694.76	(84)
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7. Mean internal temperature & heating area (m²)

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

												21.00	(85)
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Utilisation factor for gains for living area m², m (see Table 9a)

0.98	0.97	0.95	0.91	0.82	0.67	0.53	0.58	0.79	0.93	0.97	0.98	(86)
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Mean internal temp of living area T1 (steps 3 to 7 in Table 9c)

19.21	19.40	19.73	20.19	20.59	20.86	20.95	20.94	20.74	20.23	19.65	19.18	(87)
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Temperature during heating periods in the rest of dwelling from Table 9, Th2(°C)

	19.86	19.86	19.87	19.88	19.88	19.90	19.90	19.90	19.89	19.88	19.88	19.87	(88)
Utilisation factor for gains for rest of dwelling n2,m													
	0.98	0.97	0.94	0.88	0.77	0.59	0.41	0.46	0.72	0.90	0.96	0.98	(89)
Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)													
	17.50	17.78	18.26	18.92	19.45	19.78	19.88	19.87	19.66	18.99	18.18	17.47	(90)
Living area fraction													
												0.15	(91)
Mean internal temperature for the whole dwelling fLA x T1 + (1 - fLA) x T2													
	17.76	18.03	18.49	19.11	19.63	19.95	20.04	20.03	19.82	19.18	18.39	17.73	(92)
Apply adjustment to the mean internal temperature from Table 4e where appropriate													
	17.61	17.88	18.34	18.96	19.48	19.80	19.89	19.88	19.67	19.03	18.24	17.58	(93)

9. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, n1m													
	0.96	0.95	0.92	0.86	0.75	0.58	0.41	0.46	0.70	0.88	0.95	0.97	(94)
Useful gains, n1mGm, W (94)m x (84)m													
	701.57	763.24	807.40	822.83	759.27	575.09	387.31	403.35	569.85	654.90	662.77	672.91	(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)]													
	1682.79	1634.67	1486.05	1242.92	957.86	631.37	399.64	421.54	680.57	1038.69	1380.44	1669.08	(97)
Space heating requirement, kWh/month $0.024 \times [(97)m - (95)m] \times (41)m$													
	730.03	589.60	504.92	362.46	147.75	0.00	0.00	0.00	0.00	285.54	516.73	741.15	
	$\sum(98)1...5, 10...12 =$												3814.18 (98)
Space heating requirement kWh/m ² /year													
	$(98) \div (4) =$												95.35 (99)

10. Energy requirements - Domestic Heating Systems including minor SAP

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	(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 system 1 (%)													90.60	(206)	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Space heating fuel (main system 1), kWh/month															
	805.77	646.36	557.30	333.84	163.08	0.00	0.00	0.00	0.00	315.16	578.34	818.05			
													$\sum(211)1...5, 10...12 =$	4209.91	(211)
Water heating															
Efficiency of water heater															
	89.86	89.91	89.81	89.56	89.04	87.40	87.40	87.40	87.40	89.49	89.83	89.98		(217)	
Water heating fuel, kWh/month															
	195.31	171.35	178.06	157.14	152.75	135.92	127.57	144.08	145.12	163.22	175.60	189.58			
													$\sum(219a)1...12 =$	1935.70	(219)
Annual totals															
Space heating fuel - main system 1													4209.91		
Water heating fuel													1935.70		
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 1)	428.87	(232)
Total delivered energy for all uses	(211) ... (221) + (231) + (232) ... (237b) =	6649.48 (238)

12. Fuel costs - individual heating systems including mains CHP

	Fuel kWh/year		Fuel price		Fuel cost £/year	
Space heating - main system 1	4209.91	x	3.48	x 0.01 =	146.50	(240)
Water heating	1935.70	x	3.48	x 0.01 =	67.36	(247)
Pumps and fans	75.00	x	13.19	x 0.01 =	9.89	(248)
Electricity for lighting	428.87	x	13.19	x 0.01 =	56.57	(250)
Additional standing charges					120.00	(251)
Total energy cost			(240) ... (242) + (245) ... (254) =		400.33	(255)

13. SAP rating - individual heating systems including mains CHP

Energy cost deflator (Table 12)	0.42	(256)
Energy cost factor (ECF)	1.17	(257)
SAP value	83.71	
SAP rating (section 13)	84	(258)
SAP band	B	

14. CO₂ emissions - individual heating systems including mains CHP

	Energy kWh/year		Emission factor kg CO ₂ /kWh		Emissions kg CO ₂ /year	
Space heating - main system 1	4209.91	x	0.216	=	909.34	(261)
Water heating	1935.70	x	0.216	=	418.11	(264)
Space and water heating			(261) + (262) + (263) + (264) =		1327.45	(265)
Pumps and fans	75.00	x	0.519	=	38.93	(267)
Electricity for lighting	428.87	x	0.519	=	222.59	(268)
Total CO ₂ , kg/year			(265) ... (271) =		1588.96	(272)
Dwelling CO ₂ emission rate			(272) ÷ (4) =		16.05	(273)
EI value					85.21	
EI rating (section 14)					55	(274)
EI band					B	

15. Primary energy - individual heating systems including mains CHP

	Energy kWh/year		Primary factor		Primary Energy kWh/year	
Space heating - main system 1	4209.91	x	1.22	=	5136.09	(261)
Water heating	1935.70	x	1.22	=	2361.56	(264)
Space and water heating			(261) + (262) + (263) + (264) =		7497.64	(265)
Pumps and fans	75.00	x	3.07	=	230.25	(267)
Electricity for lighting	428.87	x	3.07	=	1316.64	(268)
Primary energy kWh/year					9044.53	(272)
Dwelling primary energy rate kWh/m ² /year					91.36	(273)