Mark Sheehan Building Consultancy

39 The Old Common, Stroud, Gloucestershire, GL6 8HH T: 07779 341875

Building Summary: Dwelling as designed

Applicable document: England & Wales L1 AD 2006 edition provisions

			Orient	Area m^2 Gross	Open	U-value	Total heat loss W/K
Wall	1:	South Elevation	B	50.01	9.85	0.17	24.02
	2:	North Elevation	F	18.56	4.59	0.17	12.64
	3:	East Elevation	L	29.44	3.37	0.17	12.72
	4:	West Elevation	R	31.26	2.03	0.17	8.51
	5:	Basement Walls		50.58	0.00	0.25	12.65
	6:	East Facing Dormer Cheeks	R	2.73	0.00	0.32	0.88
	7:	West Facing Dormer Cheeks	L	2.73	0.00	0.32	0.88
GdFlr	1:	Ground Floor	N/A	85.03	0.00	0.24	20.53
Roof	1:	South Facing	B	47.00	0.00	0.14	6.60
	2:	North Facing	F	37.18	0.00	0.14	5.22
	3:	East Facing	L	24.52	0.00	0.14	3.44
	4:	West Facing	R	24.52	0.00	0.14	3.44
							Total: 111.52

Breakdown by element type:		Area		
Wall	Bag End, External Walls	109.43	0.17	18.60
Wall	User-entered U-value	50.58	0.25	12.65
Wall	Bag End, Dormer Cheek	5.46	0.32	1.75
Gd floor	U-value based on shape factor	85.03	0.24	20.53
Roof	Bag End Roof	133.22	0.14	18.70
Window	DG wood frame 16mm gap low-E (en=0.05)	12.28	1.68	20.64
Door	Solid wood	3.78	3.00	11.34
Door	DG wood frame 16mm gap low-E glass (en=0.05)	3.78	1.80	6.80

Window U-values include curtain factor adjustment (SAP-2005 §3.2)

Average/maximum U-values: Walls: 0.20/0.32 OK; Floors: 0.24/0.24 OK
Roofs: 0.14/0.14 OK; Openings: 2.03/3.00 OK

Floor area: 162.93m^2 Living area fraction: 0.20 Internal volume: 418m^3

Front faces: N

Storeys: 2 Chimneys: 0 Flues: 2 Fans: 4 Flueless gas heaters: 0 Sheltered sides: 2

Pressurisation test q_{50} design value = 15.00

Natural ventilation with intermittent extract fans

Low energy lighting: 30% of fixed lighting points

Primary heating system: Ground-to-air heat pump warm air
Zone control (delayed start stat)
Fuel: Electricity (standard tariff)

Secondary heating system: Closed room heater
Fuel: Wood

Domestic hot water supply: Primary heating system
150 litre cylinder, 50mm factory-insulated
3.00m^2 solar panel

SAP 2005 Rating 76 Band C
EI Rating 85 Band B

Target Carbon Dioxide Emission Rate **TER: 30.79**
Dwelling Carbon Dioxide Emission Rate **DER: 14.58 PASS**

Total CO_2 emissions = 2.38 tonnes/year

Mark Sheehan Building Consultancy
39 The Old Common, Stroud, Gloucestershire, GL6 8HH T: 07779 341875

These calculations should not be accepted without first checking the input data

Important design features *(L1A Appendix B)*
One or more walls has a U-value of less than 0.28
One or more roofs has a U-value of less than 0.15
The design includes a 3.0m² solar panel

Elements of construction used in building

Walls

Bag End, External Walls

1	:	N/A	Exposed wall outside surface	0.04 = 0.040		0.040
2	:	100mm	Limestone (dry)	100/1.50x1000 = 0.067		0.067
3	:	50mm	Rockwool Full Cavity Fill	50/0.037x1000 = 1.351		1.351
4	:	100mm	Celcon Solar blockwork	100/0.11x1000 = 0.909		0.909
5	:	100mm	Cement mortar (protected)	100/0.88x1000 = 0.114		0.114
6	:	13mm	Plaster (lightweight)	13/0.18x1000 = 0.072		0.072
7 A	:	150mm	Studs	150/0.16x1000 = 0.938	0.083)	
7 B	:	150mm	Rockwool Flexi	150/0.037x1000 = 4.054	0.917)-	3.175
8	:	N/A	Exposed wall inside surface	0.13 = 0.130		0.130
				Proportion/Resistance	R_{ower} =	5.858

Heat path A: 0.083/3.620 = 0.023
B: 0.917/6.737 = 0.136

R_{upper} = 1/(0.023+0.136) = 6.286

Total resistance, R_T = (6.286+5.858)/2 = 6.072 U-value = 1/6.072 = 0.16

Add correction(s) to U-value (Table A4)

Timber frame where insulation fills space between studs: 0.010

Adjusted U-value = 0.17

Bag End, Dormer Cheek

1	:	N/A	Exposed wall outside surface	0.04 = 0.040		0.040
2	:	22mm	External rendering	22/0.57x1000 = 0.039		0.039
3	:	12.5mm	Plywood	12.5/0.13x1000 = 0.096		0.096
4 A	:	100mm	Celotex tuff-R GA3000	100/0.023x1000 = 4.348	0.889)	
4 B	:	100mm	Studs	100/0.16x1000 = 0.625	0.111)-	2.616
5	:	12.5mm	Plasterboard 12.5mm	0.070 = 0.070		0.070
6	:	5mm	Plaster (lightweight)	5/0.18x1000 = 0.028		0.028
7	:		Exposed wall inside surface	0.13 = 0.130		0.130
				Proportion/Resistance	R_{ower} =	3.019

Heat path A: 0.889/4.750 = 0.187
B: 0.111/1.028 = 0.108

R_{upper} = 1/(0.187+0.108) = 3.387

Total resistance, R_T = (3.387+3.019)/2 = 3.203 U-value = 1/3.203 = 0.31

Add correction(s) to U-value (Table A4)

Timber frame where insulation fills space between studs: 0.010

Adjusted U-value = 0.32

Ground floor

U-value has been calculated using BS EN 13370:1998

Location: Ground Floor
Solid ground floor: exposed perimeter = 46.10m Area = 85.03m^2
B = 85.03/(0.5 x 46.10) = 3.689
Subsoil type: Clay/unknown λ = 1.5 External wall thickness: 300mm
O/A insulation: 60mm Celotex tuff-R GA3000
Thermal resistance of insulation, R_f = 60x1/0.023x1000 = 2.609
d_t = 4.53m.
U-value of insulated floor = 0.24

Roofs

Bag End Roof

1	:		Roof outside surface	0.04 = 0.040		0.040
2	:		Roof tiles, battens and felt	0.12 = 0.120		0.120
3 A	:	250mm	Celotex tuff-R GA3000	250/0.023x1000 = 10.870	0.889)	
3 B	:	250mm	Rafters	250/0.13x1000 = 1.923	0.111)-	7.166
4	:	12.5mm	Plasterboard 12.5mm	0.070 = 0.070		0.070
5	:	5	Plaster (lightweight)	5/0.18x1000 = 0.028		0.028
6	:		Roof inside surface	0.10 = 0.100		0.100
				Proportion/Resistance		R_{lower} = 7.523

Heat path A: 0.889/11.227 = 0.079
B: 0.111/2.281 = 0.049
R_{upper} = 1/(0.079+0.049) = 7.819

Total resistance, R_T = (7.819+7.523)/2 = 7.671 U-value = 1/7.671 = 0.13

Add correction(s) to U-value (Table A4)

Insulation between joists or rafters: 0.010

Adjusted U-value = 0.14

Doors and windows	*U-value*	*Solar Transmittance*	*Frame Factor*
DG wood frame window 16mm gap low-E (en=0.05)	1.80	0.63	0.70
Solid wood door	3.00	0.00	0.70
DG wood frame door 16mm gap low-E glass (en=0.05)	1.80	0.00	0.70

Building heat loss calculations

Building use: **New dwelling (as designed)**

Walls

Location: **South Elevation** Orientation: B

Bag End, External Walls U-Value = 0.175

Areas (m^2) :- Gross: 50.01 Opening(s): 9.85 Net: 40.15

	Area x U-value	W/K
Heat loss through solid area	40.15 x 0.175 =	7.01
Heat loss through openings:		
1: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
2: DG wood frame window 16mm gap low-E (en=0.05)	1.35x0.9=1.22 x 1.679 (1.8)=	2.04
3: DG wood frame door 16mm gap low-E glass (en=0.05)	1.8x2.1=3.78 x 1.8 =	6.80
4: DG wood frame window 16mm gap low-E (en=0.05)	1.35x0.9=1.22 x 1.679 (1.8)=	2.04
5: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
6: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
7: DG wood frame window 16mm gap low-E (en=0.05)	1.35x0.9=1.22 x 1.679 (1.8)=	2.04
	Total heat loss =	**24.02**

Location: **North Elevation** Orientation: F

Bag End, External Walls U-Value = 0.175

Areas (m^2) :- Gross: 18.56 Opening(s): 4.59 Net: 13.97

	Area x U-value	W/K
Heat loss through solid area	13.97 x 0.175 =	2.44
Heat loss through openings:		
1: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
2: DG wood frame window 16mm gap low-E (en=0.05)	0.6x0.9=0.54 x 1.679 (1.8)=	0.91
3: Solid wood door	0.9x2.1=1.89 x 3.0 =	5.67
4: DG wood frame window 16mm gap low-E (en=0.05)	0.6x0.9=0.54 x 1.679 (1.8)=	0.91
5: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
	Total heat loss =	**12.64**

Location: **East Elevation** Orientation: L

Bag End, External Walls U-Value = 0.175

Areas (m^2) :- Gross: 29.44 Opening(s): 3.37 Net: 26.07

	Area x U-value	W/K
Heat loss through solid area	26.07 x 0.175 =	4.55
Heat loss through openings:		
1: Solid wood door	0.9x2.1=1.89 x 3.0 =	5.67
2: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
3: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.75=0.67 x 1.679 (1.8)=	1.13
	Total heat loss =	**12.72**

Location: **West Elevation** Orientation: R

Bag End, External Walls U-Value = 0.175

Areas (m^2) :- Gross: 31.26 Opening(s): 2.03 Net: 29.24

	Area x U-value	W/K
Heat loss through solid area	29.24 x 0.175 =	5.11
Heat loss through openings:		
1: DG wood frame window 16mm gap low-E (en=0.05)	1.35x0.9=1.22 x 1.679 (1.8)=	2.04
2: DG wood frame window 16mm gap low-E (en=0.05)	0.9x0.9=0.81 x 1.679 (1.8)=	1.36
	Total heat loss =	**8.51**

Location: **Basement Walls**

User-entered U-value : 0.250

Area = 50.58 m^2 **Heat loss = 50.58 x 0.25 = 12.65 W/K**

Location: **East Facing Dormer Cheeks** Orientation: R

Bag End, Dormer Cheek U-Value = 0.322

Area = 2.73 m^2 **Heat loss = 2.73 x 0.322 = 0.88 W/K**

Location: **West Facing Dormer Cheeks** Orientation: L

Bag End, Dormer Cheek U-Value = 0.322

Area = 2.73 m^2 **Heat loss = 2.73 x 0.322 = 0.88 W/K**

Ground Floor

Location: **Ground Floor**

Floor type: Solid ground floor: exposed perimeter = 46.10m Area = 85.03m^2

O/A insulation: 60mm Celotex tuff-R GA3000

U-value of insulated floor = 0.24

Area = 85.03 m^2 **Heat loss = 85.03 x 0.24 = 20.53 W/K**

Roofs

Location: **South Facing** Orientation: B

Bag End Roof U-Value = 0.140

Area = 47.00 m^2 **Heat loss = 47.00 x 0.14 = 6.60 W/K**

Location: **North Facing** Orientation: F

Bag End Roof U-Value = 0.140

Area = 37.18 m^2 **Heat loss = 37.18 x 0.14 = 5.22 W/K**

Location: **East Facing** Orientation: L

Bag End Roof U-Value = 0.140

Area = 24.52 m^2 **Heat loss = 24.52 x 0.14 = 3.44 W/K**

Location: **West Facing** Orientation: R

Bag End Roof U-Value = 0.140

Area = 24.52 m^2 **Heat loss = 24.52 x 0.14 = 3.44 W/K**

Total building heat loss = 111.52 W/K *C/F to SAP/DER worksheets [33]*

Thermal bridges: Use default loss of 0.08 x ΣA_{exp} *(Accredited Construction Details)* = 0.08 x 403.56 = **32.28 W/K**

C/F to SAP/DER worksheets [34]

Window U-values include curtain factor adjustment; unadjusted U-value shown in brackets (# denotes user-entered U-value)

Solar-related calculations
Solar gains through openings during heating season

#	Opening	0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
South Elevation	**Orientation: B (South ±30º)**		
1	Double-glazed (Low-E soft coat) window	0.9 x 0.81 x 72 x 0.63 x 0.7 x 0.77 =	18
2	do.	0.9 x 1.22 x 72 x 0.63 x 0.7 x 0.77 =	27
4	do.	0.9 x 1.22 x 72 x 0.63 x 0.7 x 0.77 =	27
5	do.	0.9 x 0.81 x 72 x 0.63 x 0.7 x 0.77 =	18
6	do.	0.9 x 0.81 x 72 x 0.63 x 0.7 x 0.77 =	18
7	do.	0.9 x 1.22 x 72 x 0.63 x 0.7 x 0.77 =	27
North Elevation	**Orientation: F (North ±30º)**		
1	Double-glazed (Low-E soft coat) window	0.9 x 0.81 x 29 x 0.63 x 0.7 x 0.77 =	7
2	do.	0.9 x 0.54 x 29 x 0.63 x 0.7 x 0.77 =	5
4	do.	0.9 x 0.54 x 29 x 0.63 x 0.7 x 0.77 =	5
5	do.	0.9 x 0.81 x 29 x 0.63 x 0.7 x 0.77 =	7
East Elevation	**Orientation: L (E/W)**		
2	Double-glazed (Low-E soft coat) window	0.9 x 0.81 x 48 x 0.63 x 0.7 x 0.77 =	12
3	do.	0.9 x 0.67 x 48 x 0.63 x 0.7 x 0.77 =	10
West Elevation	**Orientation: R (E/W)**		
1	Double-glazed (Low-E soft coat) window	0.9 x 1.22 x 48 x 0.63 x 0.7 x 0.77 =	18
2	do.	0.9 x 0.81 x 48 x 0.63 x 0.7 x 0.77 =	12
		Total Solar Gain *C/F to SAP/DER worksheets [65]*	**209W**

Lighting

Light transmission through windows and rooflights

South Elevation	**Orientation: B (South ±30º)**		
1	DG wood frame window 16mm gap low-E (ε_n=0.05)	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
2	do.	0.9 x 1.22 x 0.7 x 0.80 x 0.83 =	0.51
3	DG wood frame door 16mm gap low-E glass (ε_n=0.05)		0.00
4	DG wood frame window 16mm gap low-E (ε_n=0.05)	0.9 x 1.22 x 0.7 x 0.80 x 0.83 =	0.51
5	do.	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
6	do.	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
7	do.	0.9 x 1.22 x 0.7 x 0.80 x 0.83 =	0.51
North Elevation	**Orientation: F (North ±30º)**		
1	DG wood frame window 16mm gap low-E (ε_n=0.05)	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
2	do.	0.9 x 0.54 x 0.7 x 0.80 x 0.83 =	0.23
3	Solid wood door		0.00
4	DG wood frame window 16mm gap low-E (ε_n=0.05)	0.9 x 0.54 x 0.7 x 0.80 x 0.83 =	0.23
5	do.	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
East Elevation	**Orientation: L (E/W)**		
1	Solid wood door		0.00
2	DG wood frame window 16mm gap low-E (ε_n=0.05)	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
3	do.	0.9 x 0.67 x 0.7 x 0.80 x 0.83 =	0.28
West Elevation	**Orientation: R (E/W)**		
1	DG wood frame window 16mm gap low-E (ε_n=0.05)	0.9 x 1.22 x 0.7 x 0.80 x 0.83 =	0.51
2	do.	0.9 x 0.81 x 0.7 x 0.80 x 0.83 =	0.34
		Total light input	5.14

G_L = 5.14/162.93 = 0.032 C_2 = 1.171

Low energy lighting fixed outlets: 30% C_1 = 1 - 0.50 x30/100 = 0.85
Electricity used for lighting, $E_L = E_B.TFA.C_1.C_2$ = 9.3 x 162.9 x 0.85 x 1.171 = **1509**

C/F to SAP worksheet [93]/DER worksheet [109]

Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B.TFA.(1-C_1).C_2 = 9.3 \times 162.9 \times (1-0.85) \times 1.171 = 266$
Reduction in gains, $\Delta_{gains} = 0.15\Delta E_L = 0.15 \times 266 =$ **40** *C/F to SAP/DER worksheets [53a]*

Solar Panel

Type: Flat plate

Net area = 0.72 x 3.00 = 2.70m^2	(H1)
Zero-loss collector efficiency = 0.75 (Table H1)	(H2)
Collector heat loss coefficient = 6 (Table H1)	(H3)
Collector performance ratio = 8.00	(H4)
Annual solar radiation/m^2 = 1023 (Table H2)	(H5)
Overshading factor = 1.00 (Table H3)	(H6)
Solar energy available = 2.70 x 0.75 x 1023 x 1.00 = 2072	(H7)
Solar-to-load ratio = 2072/(2817 [39] + 497 [40]) = 0.63	(H8)
Utilisation factor = 0.80	(H9)
Collector performance factor = 0.87 - 0.034 x8.00 + 0.0006 x 8.00^2 = 0.64	(H10)
Combined cylinder solar storage volume, V_s = 150 litres	(H11)
Total volume = 150 litres	(H12)
Effective solar volume, V_{eff} = 150 litres	(H13)
Daily hot water demand, V_d = 155.3 litres	(H14)
Volume ratio, V_{eff}/V_d = 0.9656	(H15)
Solar storage volume factor, f(V_{eff}/V_d) = 0.9930	(H16)
Solar input, Q_s = 2,072 x 0.7981 x 0.6364 x 0.9930 = **1,045**	(H17)

C/F to SAP/DER worksheets [50]

Solar gains through openings during summer

No daytime shading assumed
Ventilation: windows fully open 2-storeys Cross-ventilation possible: Y
Ventilation rate in hot weather = 8.0 ACH
Summer ventilation heat loss = 0.33 x 8.0 x 417.83 [6] = 1103
Total summer heat loss = 144 [35] + 1103 = 1247W/K

#	Opening	0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
South Elevation	**Orientation: B (South ±30º)**		
1	Double-glazed (Low-E soft coat) window	Average: 0.9 x 0.81 x 107 x 0.63 x 0.7 x 0.90 =	31
2	do.	Average: 0.9 x 1.22 x 107 x 0.63 x 0.7 x 0.90 =	46
3	Glazed door		0
4	Double-glazed (Low-E soft coat) window	Average: 0.9 x 1.22 x 107 x 0.63 x 0.7 x 0.90 =	46
5	do.	Average: 0.9 x 0.81 x 107 x 0.63 x 0.7 x 0.90 =	31
6	do.	Average: 0.9 x 0.81 x 107 x 0.63 x 0.7 x 0.90 =	31
7	do.	Average: 0.9 x 1.22 x 107 x 0.63 x 0.7 x 0.90 =	46
North Elevation	**Orientation: F (North ±30º)**		
1	Double-glazed (Low-E soft coat) window	Average: 0.9 x 0.81 x 75 x 0.63 x 0.7 x 0.90 =	22
2	do.	Average: 0.9 x 0.54 x 75 x 0.63 x 0.7 x 0.90 =	14
3	Solid door		0
4	Double-glazed (Low-E soft coat) window	Average: 0.9 x 0.54 x 75 x 0.63 x 0.7 x 0.90 =	14
5	do.	Average: 0.9 x 0.81 x 75 x 0.63 x 0.7 x 0.90 =	22
East Elevation	**Orientation: L (E/W)**		
1	Solid door		0
2	Double-glazed (Low-E soft coat) window	Average: 0.9 x 0.81 x 109 x 0.63 x 0.7 x 0.90 =	32
3	do.	Average: 0.9 x 0.67 x 109 x 0.63 x 0.7 x 0.90 =	26
West Elevation	**Orientation: R (E/W)**		
1	Double-glazed (Low-E soft coat) window	Average: 0.9 x 1.22 x 109 x 0.63 x 0.7 x 0.90 =	47
2	do.	Average: 0.9 x 0.81 x 109 x 0.63 x 0.7 x 0.90 =	32

Total Solar Gain **441W**

Total summer gains, G = 441 + 981 [55] = 1422

Summer Gain/Loss ratio = 1422/1247 = 1.14
Region: Severn Valley Mean summer air temperature = 16°C
Thermal mass parameter, TMP = 1 (user-entered value)
ΔT_{mass} = 1.8
$T_{threshold}$ = 16.00 + 1.14 + 1.8 = 18.94°C
Likelihood of high internal temperatures during summer weather: **Not significant**

SAP Worksheet (Version 9.80)

Calculation of Energy Rating: Dwelling as designed

Overall Dwelling Dimensions

Floor areas, m^2:		
Ground/entrance level:	85.03	
First:	77.90	
Total floor area:	162.93	[5]
Dwelling volume, m^3:	417.83	[6]

Ventilation Rate ACH

Flues:	2 x 20/417.83 = 0.10	[8]
Fans and passive vents:	4 x 10/417.83 = 0.10	[9]
Infiltration due to chimneys, flues and fans:	0.19	[10]
Design q_{50} value = 15.00	15.00/20 = 0.75	
Infiltration rate:	0.94	[19]
2 sheltered sides: shelter factor = 0.85		[21]
Adjusted infiltration rate = 0.94 x 0.85	0.80	[22]
Natural ventilation:		
Effective air change rate	0.82	[24]
	0.82	[25]

Heat Loss Summary W/K

Heat loss through structure (b/f from building summary):	111.52	[33]
Thermal bridges 0.08 x 403.56:	32.28	[34]
Total fabric heat loss:	143.80	[35]
Ventilation heat loss:	0.82 [25] x 0.33 x 417.83 [6] = 113.09	[36]
Specific heat loss:	256.89	[37]
Heat loss parameter:	256.89/162.9 = 1.58	[38]

Water Heating Energy Requirements kW/year

Source: Primary heating system (Ground-to-air heat pump warm air)		
Fuel: Electricity (standard tariff)		
Energy content of heated water (Table 1a N=4.694):	2817	[39]
Distribution loss (Table 1b):	497	[40]
Cylinder volume = 150 litres		[43]
Cylinder loss factor: 0.0152 (Table 2)		[44]
Volume factor: 0.9283 (Table 2a)		[44a]
Temperature factor: 0.54 (Table 2b)		[44b]
Energy lost from store:	150 x 0.0152 x 0.9283 x 0.54 x 365 = 0	[47]
Primary circuit loss :	360	[48]
Solar input (B/F from Solar gains worksheet):	-1045	[50]
Required output from water heater:	2629	[51]
Heat gains from water heating:	0.25 x 2817 + 0.8 x (497+360) = 1390	[52]

Gains Watts

Lighting, appliance & metabolic gains (Table 5 N=4.694):	862	[53]
Reduction due to low energy lighting (30%):	-40	[53a]
Total additional gains	0	[53b]
Water heating:	1390/8.72 = 159	[54]
Total internal gains:	981	[55]
Total solar gains (B/F from solar-related report):	209	[65]
Total gains	1,190	[66]
Gains/Loss ratio (GLR) = 1190/256.9 [37] = 4.631		[67]
Utilisation factor (Table 7): 0.98		[68]
Useful gains:	1190 x 0.98 = 1,165	[69]

Mean internal temperature		ºC	
Living area mean temperature: Table 8 col.1; HLP [38] = 1.58		18.88	[70]
Control adjustment (Table 4e)		-0.15	[71]
Heating system responsiveness (R) = 1.00 (Table 4a)			
Adjustment for gains:	0.2 x R x ((1165 [69]/256.9 [37]) - 4.0) =	0.11	[72]
Adjusted living room temperature:		18.83	[73]
Temperature difference between zones : (Table 9 col 3)		1.94	[74]
Living area fraction: 0.20			[75]
Rest-of-house fraction: 0.80			[76]
Mean internal temperature:	18.83 - (1.94 x 0.80) =	17.28	[77]
Degree Days			
Temperature rise from gains:	1165 [69]/256.9 [37] =	4.54	[78]
Base temperature:	17.28 - 4.54 =	12.74	[79]
Degree days (Table 10):		1503	[80]
Space heating requirements		kW/year	
Energy requirement (useful):	0.024 x 1503 x 256.9 [37] =	9265	[81]
Heat from secondary system: 10% (Table 11)			[82]
Primary system: Ground-to-air heat pump warm air Controls: Zone control Fuel: Electricity (standard tariff) Efficiency: 320% (Table 4a)			[83]
Fuel required:	9265 x 0.90 x 100/320 =	2606	[85]
Secondary system: Closed room heater Fuel: Wood Efficiency: 60% (Table 4a)			[84]
Fuel required:	9265 x 0.10 x 100/60 =	1544	[85a]
Water heating energy requirement (net): 2629 kW [51] Source: Primary heating system Efficiency (DHW net see G1): 224% (Table 4a)			[86]
Energy required:	2629 [51] x 100/224 =	1174	[86a]
Electricity for pumps & fans:		251	[87]
Electricity for lighting (B/F from Solar report)		1509	
Fuel Costs		£/year	
Space heating: Primary system:	2606 x 7.12p =	185.53	[88]
Secondary system:	1544 x 2.20p =	33.97	[89]
Water heating:	1174 x 7.12p =	83.58	[91b]
Pump/fan energy cost:	251 x 7.12p =	17.85	[92]
Lighting energy cost:	1509 x 7.12p =	107.42	[93]
Total heating cost:		428.34	[97]
SAP Rating			
Energy cost deflator (Table 12, footnote 2):		0.91	[98]
Energy cost factor (ECF) £/m^2:	(428.34 x 0.91 - 30)/(162.93 + 45.0) =	1.73	[99]
SAP value = 75.8442			[100]

SAP Rating = 76 Band C

CO_2 Emissions		kg/year	
Primary heating system (electricity)	2606 [85] x 0.422 =	1,100	[101]
Secondary heating system (wood)	1544 [85a] x 0.025 =	39	[102]
Water heating (electricity)	1174 [86a] x 0.422 =	495	[103]
Total for space and water heating		1634	[107]
Electricity for pumps and fans	251 [87] x 0.422 =	106	[108]
Electricity for lighting, C_L	1509 x 0.422 =	637	[109]
New technology: None:			

Total: 2,376 [112]

Carbon Factor, CF = 2376/(162.93 + 45) = 11.43 EI = 85.00

EI Rating = 85 Band B

Primary energy	Energy kWh/Yr	Primary Factor	P.Energy kWh/yr	
Space heating	2606	2.80	7296	[101]
Secondary heating	1544	1.10	1699	[102]
Water heating	1174	2.80	3287	[103]
Electricity for pumps and fans	251	2.80	702	[108]
Electricity for lighting	1509	2.80	4224	[109]
New Technology: Energy saved	0	0.00	0	[110]
New Technology: Energy used	0	0.00	0	[111]
	Primary energy kWh/year		**17,208**	[112]
	Primary energy kWh/year/m^2		**106**	[113]

SAP Worksheet (Version 9.80)

Dwelling Carbon Dioxide Emission Rate (DER) Calculation: Dwelling as designed

Overall Dwelling Dimensions		
Floor areas, m^2:		
Ground/entrance level:	85.03	
First:	77.90	
Total floor area:	162.93	[5]
Dwelling volume, m^3:	417.83	[6]
Ventilation Rate	ACH	
Flues:	2 x 20/417.83 = 0.10	[8]
Fans and passive vents:	4 x 10/417.83 = 0.10	[9]
Infiltration due to chimneys, flues and fans:	0.19	[10]
Design q_{50} value = 15.00	15.00/20 = 0.75	
Infiltration rate:	0.94	[19]
2 sheltered sides: shelter factor = 0.85		[21]
Adjusted infiltration rate = 0.94 x 0.85	0.80	[22]
Natural ventilation:		
Effective air change rate	0.82	[24]
	0.82	[25]
Heat Loss Summary	W/K	
Heat loss through structure (b/f from building summary):	111.52	[33]
Thermal bridges 0.08 x 403.56:	32.28	[34]
Total fabric heat loss:	143.80	[35]
Ventilation heat loss:	0.82 [25] x 0.33 x 417.83 [6] = 113.09	[36]
Specific heat loss:	256.89	[37]
Heat loss parameter:	256.89/162.9 = 1.58	[38]
Water Heating Energy Requirements	kW/year	
Source: Primary heating system (Ground-to-air heat pump warm air)		
Fuel: Electricity (standard tariff)		
Energy content of heated water (Table 1a N=4.694):	2817	[39]
Distribution loss (Table 1b):	497	[40]
Cylinder volume = 150 litres		[43]
Cylinder loss factor: 0.0152 (Table 2)		[44]
Volume factor: 0.9283 (Table 2a)		[44a]
Temperature factor: 0.54 (Table 2b)		[44b]
Energy lost from store:	150 x 0.0152 x 0.9283 x 0.54 x 365 = 0	[47]
Primary circuit loss :	360	[48]
Solar input (B/F from Solar gains worksheet):	-1045	[50]
Required output from water heater:	2629	[51]
Heat gains from water heating:	0.25 x 2817 + 0.8 x (497+360) = 1390	[52]
Gains	Watts	
Lighting, appliance & metabolic gains (Table 5 N=4.694):	862	[53]
Reduction due to low energy lighting (30% assumed):	-40	[53a]
Total additional gains	0	[53b]
Water heating:	1390/8.72 = 159	[54]
Total internal gains:	981	[55]
Total solar gains (B/F from solar-related report):	209	[65]
Total gains	1,190	[66]
Gains/Loss ratio (GLR) = 1190/256.9 [37] = 4.631		[67]
Utilisation factor (Table 7): 0.98		[68]
Useful gains:	1190 x 0.98 = 1,165	[69]

Mean internal temperature ºC

Living area mean temperature: Table 8 col.1; HLP [38] = 1.58		18.88	[70]
Control adjustment (Table 4e)		-0.15	[71]
Heating system responsiveness (R) = 1.00 (Table 4a)			
Adjustment for gains:	0.2 x R x ((1165 [69]/256.9 [37]) - 4.0) =	0.11	[72]
Adjusted living room temperature:		18.83	[73]
Temperature difference between zones : (Table 9 col 3)		1.94	[74]
Living area fraction: 0.20			[75]
Rest-of-house fraction: 0.80			[76]
Mean internal temperature:	18.83 - (1.94 x 0.80) =	17.28	[77]

Degree Days

Temperature rise from gains:	1165 [69]/256.9 [37] = 4.54	[78]
Base temperature:	17.28 - 4.54 = 12.74	[79]
Degree days (Table 10):	1503	[80]

Space heating requirements kW/year

Energy requirement (useful):	0.024 x 1503 x 256.9 [37] = 9265	[81]
Heat from secondary system: 10% (Table 11)		[82]
Primary system: Ground-to-air heat pump warm air Controls: Zone control Fuel: Electricity (standard tariff) Efficiency: 320% (Table 4a)		[83]
Fuel required:	9265 x 0.90 x 100/320 = 2606	[85]
Secondary system: Closed room heater Fuel: Wood Efficiency: 60% (Table 4a)		[84]
Fuel required:	9265 x 0.10 x 100/60 = 1544	[85a]
Water heating energy requirement (net): 2629 kW [51] Source: Primary heating system Efficiency (DHW net see G1): 224% (Table 4a)		[86]
Energy required:	2629 [51] x 100/224 = 1174	[86a]
Electricity for pumps & fans:	251	[87]
Electricity for lighting (B/F from Solar report)	1509	

CO_2 Emissions kg/year

Primary heating system (electricity)	2606 [85] x 0.422 =	1,100	[101]
Secondary heating system (wood)	1544 [85a] x 0.025 =	39	[102]
Water heating (electricity)	1174 [86a] x 0.422 =	495	[103]
Total for space and water heating		1634	[107]
Electricity for pumps and fans	251 [87] x 0.422 =	106	[108]
Electricity for lighting, C_L	1509 x 0.422 =	637	[109]
New technology: None:			
	Total:	2,376	[112]

Dwelling Carbon Dioxide Emission Rate (DER) = 14.58 (2,376/162.93)

SAP Worksheet (Version 9.80)

Target Carbon Dioxide Emission Rate (TER) Calculation

	Area	U-Value	Heat Loss W/K	
Walls (net)	144.58	0.35	50.60	
DG wood frame window 16mm gap low-E glass (en=0.2)	38.88	2.00	72.00	
Solid wood door	1.85	2.00	3.70	
Floors	85.03	0.25	21.26	
Roofs	133.22	0.16	21.32	
Total heat loss (C/F to [33]			168.88	

Overall Dwelling Dimensions

Floor areas, m^2:		
Ground/entrance level:	85.03	
First:	77.90	
Total floor area:	162.93	[5]
Dwelling volume, m^3:	417.83	[6]

Ventilation Rate	ACH	
Fans and passive vents:	3 x 10/417.83 = 0.07	[9]
Infiltration due to chimneys, flues and fans:	0.07	[10]
Default q_{50} value = 10.00	10.00/20 = 0.50	
Infiltration rate:	0.57	[19]
2 sheltered sides: shelter factor = 0.85		[21]
Adjusted infiltration rate = 0.57 x 0.85	0.49	[22]
Natural ventilation:		
Effective air change rate	0.62	[24]
	0.62	[25]

Heat Loss Summary	W/K	
Heat loss through structure (from above):	168.88	[33]
Thermal bridges 0.11 x 403.56:	44.39	[34]
Total fabric heat loss:	213.27	[35]
Ventilation heat loss:	0.62 [25] x 0.33 x 417.83 [6] = 85.23	[36]
Specific heat loss:	298.50	[37]
Heat loss parameter:	298.50/162.9 = 1.83	[38]

Water Heating Energy Requirements	kW/year	
Source: Primary heating system (Gas boiler, automatic ignition, 1998 or later)		
Fuel: Mains Gas		
Energy content of heated water (Table 1a N=4.694):	2817	[39]
Distribution loss (Table 1b):	497	[40]
Cylinder volume = 150 litres		[43]
Cylinder loss factor: 0.0191 (Table 2)		[44]
Volume factor: 0.9283 (Table 2a)		[44a]
Temperature factor: 0.54 (Table 2b)		[44b]
Energy lost from store:	150 x 0.0191 x 0.9283 x 0.54 x 365 = 524	[47]
Primary circuit loss :	610	[48]
Solar input:	0	[50]
Required output from water heater:	4448	[51]
Heat gains from water heating:	0.25 x 2817 + 0.8 x (497+524+610) = 2009	[52]

Gains		Watts	
Lighting, appliance & metabolic gains (Table 5 N=4.694):		862	[53]
Reduction due to low energy lighting (30% assumed):		-33	[53a]
Central heating pump: 10.0			
Total additional gains		10	[53b]
Water heating:		2009/8.72 = 229	[54]
Total internal gains:		1,068	[55]
Total solar gains (B/F from solar-related report):		652	[65]
Total gains		1,720	[66]
Gains/Loss ratio (GLR) = 1720/298.5 [37] = 5.763			[67]
Utilisation factor (Table 7): 0.96			[68]
Useful gains:		1720 x 0.96 = 1,645	[69]
Mean internal temperature		ºC	
Living area mean temperature: Table 8 col.1; HLP [38] = 1.83		18.86	[70]
Control adjustment (Table 4e)		0.00	[71]
Heating system responsiveness (R) = 1.00 (Table 4d)			
Adjustment for gains:	0.2 x R x ((1645 [69]/298.5 [37]) - 4.0) =	0.30	[72]
Adjusted living room temperature:		19.16	[73]
Temperature difference between zones : (Table 9 col 2)		1.54	[74]
Living area fraction:	0.20		[75]
Rest-of-house fraction:	0.80		[76]
Mean internal temperature:	19.16 - (1.54 x 0.80) =	17.93	[77]
Degree Days			
Temperature rise from gains:	1645 [69]/298.5 [37] =	5.51	[78]
Base temperature:	17.93 - 5.51 =	12.42	[79]
Degree days (Table 10):		1433	[80]
Space heating requirements		kW/year	
Energy requirement (useful):	0.024 x 1433 x 298.5 [37] =	10262	[81]
Heat from secondary system: 10% (Table 11)			[82]
Primary system: Gas boiler, automatic ignition, 1998 or later			
Controls: Programmer + roomstat + TRV's			
Fuel: Mains Gas			
Notional efficiency: 78%			[83]
Fuel required:	10262 x 0.90 x 100/78 =	11841	[85]
Secondary system: Portable electric heaters			
Fuel: Electricity (standard tariff)			
Efficiency: 100% (Table 4a)			[84]
Fuel required:	10262 x 0.10 x 100/100 =	1026	[85a]
Water heating energy requirement (net): 4448 kW [51]			
Source: Primary heating system			
Efficiency : 78% (Manufacturer's declared value)			[86]
Energy required:	4448 [51] x 100/78 =	5703	[86a]
Electricity for pumps & fans:		175	[87]
Electricity for lighting (B/F from Solar report)		1236	

CO_2 Emissions			kg/year	
Primary heating system (mains gas)	11841 [85] x 0.194 =	2,297	[101]
Secondary heating system (electricity)	1026 [85a] x 0.422 =	433	[102]
Water heating (mains gas)	5703 [86a] x 0.194 =	1106	[103]
Total for space and water heating		3837	[107]
Electricity for pumps and fans	175 [87] x 0.422 =	74	[108]
Electricity for lighting, C_L	1236 x 0.422 =	522	[109]

New technology: None

Total: 4,432 [112]

C_H = (3837 + 74)/162.93 = 24.00 C_L = 522/162.93 = 3.20

Fuel: Electricity (standard tariff) : Fuel Factor = 1.47 Improvement Factor = 0.20

Target CO_2 Emission Rate (TER) = (C_H x Fuel Factor + C_L) x (1 - imp factor)

= (24.00 x 1.47 + 3.20) x (1 - 0.20) = **30.79**