
Place : Architecture
26 Westgate Lincoln LN1 3BD

Site: St John's Church Hall, Ermine, Lincoln
Job: Energy Audit
Job number: P336

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Building Summary

		Orient	Area m ²		U-value	Total heat loss W/K
			Gross	Open		
Wall	1: North Wall 1	N	47.30	5.72	1.56	87.90
	2: East Wall 1	E	42.80	1.89	1.56	69.49
	3: North Wall 2	N	11.30	2.10	1.56	20.65
	4: East Wall 2	E	79.80	7.89	1.56	139.17
	5: South Wall	S	67.00	2.98	1.56	108.81
	6: West Wall	W	106.70	25.57	1.56	225.17
GdFlr	1: Ground Floor Slab	N/A	320.50	0.00	0.50	161.84
Roof	1: Pitched Roof	E/W	372.60	0.00	0.35	130.41
Total:						<u>943.44</u>

Breakdown by element type:

		Area	U-value	Total heat loss W/K
Wall	User-entered U-value	308.76	1.56	481.66
Gd floor	U-value based on shape factor	320.50	0.50	161.84
Roof	User-entered U-value	372.60	0.35	130.41
Window	Single-glazed wood frame	30.29	4.03	122.05
Door	Solid wood	15.86	3.00	47.58

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

Average/maximum U-values: Walls: 1.56/1.56 **FAIL**; Floors: 0.50/0.50 **FAIL**
 Roofs: 0.35/0.35 **FAIL**; Openings: 4.18/4.80 **FAIL**

Floor area: 352.20m² Living area fraction: 0.53 Internal volume: 1522m³

Front faces: S

Storeys: 2 Chimneys: 0 Flues: 4 Fans: 1 Flueless gas heaters: 0 Sheltered sides: 1

Pressure test: None - default infiltration used:

Masonry construction; sealed timber ground floor; draught lobby; 0% draught stripping:

Natural ventilation with intermittent extract fans

Low energy lighting: 10% of fixed lighting points (30% assumed for DER/TER calculations)

Primary heating system: Ducted on/off control pre 1998
 No thermostatic control
 Fuel: Mains Gas

Secondary heating system: Electric convector or radiant panel heaters
 Fuel: Electricity (standard tariff)

Domestic hot water supply: Point of use
 Mains Gas

SAP 2005 Rating 27 Band F
EI Rating 29 Band F

Total CO₂ emissions = 25.07 tonnes/year

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

Important design features (L1A Appendix B)

None

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Elements of construction used in building

Ground floor

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

Location: Ground Floor Slab

Solid ground floor: exposed perimeter = 83.83m Area = 320.50m²

$B = 320.50 / (0.5 \times 83.83) = 7.646$

Subsoil type: Sand/gravel $\lambda = 2.0$ External wall thickness: 253mm

O/A insulation: 25mm Timber floor/deck/sheathing

Thermal resistance of insulation, $R_f = 25 \times 1 / 0.13 \times 1000 = 0.192$

$d_f = 1.06m$.

U-value of insulated floor = 0.50

Doors and windows

	<i>U-value</i>	<i>Solar Transmittance</i>	<i>Frame Factor</i>
Single-glazed wood frame window	4.80	0.85	0.70
Solid wood door	3.00	0.00	0.70

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Building heat loss calculations

Building use: Existing dwelling

Walls

Location: **North Wall 1** Orientation: N

User-entered U-value : 1.560

Areas (m²) :- Gross: 47.30 Opening(s): 5.72 Net: 41.58

Heat loss through solid area

Area x U-value W/K
41.58 x 1.56 = 64.86

Heat loss through openings:

- 1: Single-glazed wood frame window
- 2: Single-glazed wood frame window

3x0.95x1.05=2.99 x 4.027 (4.8)= 12.05
2x1.3x1.05=2.73 x 4.027 (4.8)= 10.99

Total heat loss = 87.90

Location: **East Wall 1**

Orientation: E

User-entered U-value : 1.560

Areas (m²) :- Gross: 42.80 Opening(s): 1.89 Net: 40.91

Heat loss through solid area

Area x U-value W/K
40.91 x 1.56 = 63.82

Heat loss through openings:

- 1: Solid wood door

0.9x2.1=1.89 x 3.0 = 5.67

Total heat loss = 69.49

Location: **North Wall 2**

Orientation: N

User-entered U-value : 1.560

Areas (m²) :- Gross: 11.30 Opening(s): 2.10 Net: 9.20

Heat loss through solid area

Area x U-value W/K
9.20 x 1.56 = 14.35

Heat loss through openings:

- 1: Solid wood door

1.0x2.1=2.10 x 3.0 = 6.30

Total heat loss = 20.65

Location: **East Wall 2**

Orientation: E

User-entered U-value : 1.560

Areas (m²) :- Gross: 79.80 Opening(s): 7.89 Net: 71.91

Heat loss through solid area

Area x U-value W/K
71.91 x 1.56 = 112.18

Heat loss through openings:

- 1: Single-glazed wood frame window
- 2: Single-glazed wood frame window
- 3: Solid wood door

1.41x1.125=1.59 x 4.027 (4.8)= 6.39

1.46x1.125=1.64 x 4.027 (4.8)= 6.61

2x1.11x2.1=4.66 x 3.0 = 13.99

Total heat loss = 139.17

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Location: **South Wall**

Orientation: S

User-entered U-value : 1.560

Areas (m²) :- Gross: 67.00 Opening(s): 2.98 Net: 64.02

Area x U-value W/K
64.02 x 1.56 = 99.88

Heat loss through solid area

Heat loss through openings:

1: Solid wood door

1.417x2.1=2.98 x 3.0 = 8.93
Total heat loss = 108.81

Location: **West Wall**

Orientation: W

User-entered U-value : 1.560

Areas (m²) :- Gross: 106.70 Opening(s): 25.57 Net: 81.13

Area x U-value W/K
81.13 x 1.56 = 126.57

Heat loss through solid area

Heat loss through openings:

- 1: Single-glazed wood frame window
- 2: Single-glazed wood frame window
- 3: Single-glazed wood frame window
- 4: Single-glazed wood frame window
- 5: Solid wood door

2x1.41x2.925=8.25 x 4.027 (4.8)= 33.22
0.9x0.6=0.54 x 4.027 (4.8)= 2.17
4.0x2.925=11.70 x 4.027 (4.8)= 47.11
1.41x0.6=0.85 x 4.027 (4.8)= 3.41
2.015x2.1=4.23 x 3.0 = 12.69
Total heat loss = 225.17

Ground Floor

Location: **Ground Floor Slab**

Floor type: Solid ground floor: exposed perimeter = 83.83m Area = 320.50m²

O/A insulation: 25mm Timber floor/deck/sheathing

U-value of insulated floor = 0.50

Area = 320.50 m²

Heat loss = 320.50 x 0.50 = 161.84 W/K

Roof

Location: **Pitched Roof**

Orientation: E/W

User-entered U-value : 0.350

Area = 372.60 m²

Heat loss = 372.60 x 0.35 = 130.41 W/K

Total building heat loss = 943.44 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 1048.00 = **83.84 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)

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Solar-related calculations
Solar gains through openings during heating season

#	Opening	Orientation	0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
North Wall 1 Orientation: N (North ±30°)				
1	Single-glazed window		$0.9 \times 2.99 \times 29 \times 0.85 \times 0.7 \times 0.77 =$	36
2	do.		$0.9 \times 2.73 \times 29 \times 0.85 \times 0.7 \times 0.77 =$	33
East Wall 1 Orientation: E (E/W)				
North Wall 2 Orientation: N (North ±30°)				
East Wall 2 Orientation: E (E/W)				
1	Single-glazed window		$0.9 \times 1.59 \times 48 \times 0.85 \times 0.7 \times 0.77 =$	31
2	do.		$0.9 \times 1.64 \times 48 \times 0.85 \times 0.7 \times 0.77 =$	33
South Wall Orientation: S (South ±30°)				
West Wall Orientation: W (E/W)				
1	Single-glazed window		$0.9 \times 8.25 \times 48 \times 0.85 \times 0.7 \times 0.77 =$	163
2	do.		$0.9 \times 0.54 \times 48 \times 0.85 \times 0.7 \times 0.77 =$	11
3	do.		$0.9 \times 11.70 \times 48 \times 0.85 \times 0.7 \times 0.77 =$	232
4	do.		$0.9 \times 0.85 \times 48 \times 0.85 \times 0.7 \times 0.77 =$	17
Total Solar Gain C/F to SAP/DER worksheets [65]				555W

Lighting

Light transmission through windows and rooflights

North Wall 1 Orientation: N (North ±30°)				
1	Single-glazed wood frame window		$0.9 \times 2.99 \times 0.7 \times 0.90 \times 0.83 =$	1.41
2	do.		$0.9 \times 2.73 \times 0.7 \times 0.90 \times 0.83 =$	1.28
East Wall 1 Orientation: E (E/W)				
1	Solid wood door			0.00
North Wall 2 Orientation: N (North ±30°)				
1	Solid wood door			0.00
East Wall 2 Orientation: E (E/W)				
1	Single-glazed wood frame window		$0.9 \times 1.59 \times 0.7 \times 0.90 \times 0.83 =$	0.75
2	do.		$0.9 \times 1.64 \times 0.7 \times 0.90 \times 0.83 =$	0.77
3	Solid wood door			0.00
South Wall Orientation: S (South ±30°)				
1	Solid wood door			0.00
West Wall Orientation: W (E/W)				
1	Single-glazed wood frame window		$0.9 \times 8.25 \times 0.7 \times 0.90 \times 0.83 =$	3.88
2	do.		$0.9 \times 0.54 \times 0.7 \times 0.90 \times 0.83 =$	0.25
3	do.		$0.9 \times 11.70 \times 0.7 \times 0.90 \times 0.83 =$	5.51
4	do.		$0.9 \times 0.85 \times 0.7 \times 0.90 \times 0.83 =$	0.40
5	Solid wood door			0.00
Total light input				14.25

$G_L = 14.25/352.20 = 0.040 \quad C_2 = 1.116$

Low energy lighting fixed outlets: 10% $C_1 = 1 - 0.50 \times 10/100 = 0.95$

Electricity used for lighting, $E_L = E_B.TFA.C_1.C_2 = 9.3 \times 352.2 \times 0.95 \times 1.116 = 3473$ C/F to SAP worksheet [93]

Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B.TFA.(1-C_1).C_2 = 9.3 \times 352.2 \times (1-0.95) \times 1.116 = 183$

Reduction in gains, $\Delta_{gains} = 0.15\Delta_{EL} = 0.15 \times 183 = 27$ C/F to SAP worksheet [53a]

DER calculation assumes 30% low energy lighting fixed outlets $C_1 = 1 - 0.50 \times 30/100 = 0.85$

Electricity used for lighting, $E_L = E_B.TFA.C_1.C_2 = 9.3 \times 352.2 \times 0.85 \times 1.116 = 3108$ C/F to DER worksheet [109]

Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B.TFA.(1-C_1).C_2 = 9.3 \times 352.2 \times (1-0.85) \times 1.116 = 548$

Reduction in gains, $\Delta_{gains} = 0.15\Delta_{EL} = 0.15 \times 548 = 82$ C/F to DER worksheet [53a]

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Solar Panel: none

Solar gains through openings during summer

Windows: Dark-coloured curtain or roller blind assumed

Rooflights: 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 = $0.33 \times 8.0 \times 1521.5 [6] = 4017$

Total summer heat loss = $1027 [35] + 4017 = 5044\text{W/K}$

# Opening		0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
North Wall 1 Orientation: N (North ±30°)			
1	Single-glazed window	Average: $0.9 \times 2.99 \times 75 \times 0.85 \times 0.7 \times 0.85 =$	102
2	do.	Average: $0.9 \times 2.73 \times 75 \times 0.85 \times 0.7 \times 0.85 =$	93
East Wall 1 Orientation: E (E/W)			
1	Solid door		0
North Wall 2 Orientation: N (North ±30°)			
1	Solid door		0
East Wall 2 Orientation: E (E/W)			
1	Single-glazed window	Average: $0.9 \times 1.59 \times 109 \times 0.85 \times 0.7 \times 0.85 =$	78
2	do.	Average: $0.9 \times 1.64 \times 109 \times 0.85 \times 0.7 \times 0.85 =$	81
3	Solid door		0
South Wall Orientation: S (South ±30°)			
1	Solid door		0
West Wall Orientation: W (E/W)			
1	Single-glazed window	Average: $0.9 \times 8.25 \times 109 \times 0.85 \times 0.7 \times 0.85 =$	407
2	do.	Average: $0.9 \times 0.54 \times 109 \times 0.85 \times 0.7 \times 0.85 =$	27
3	do.	Average: $0.9 \times 11.70 \times 109 \times 0.85 \times 0.7 \times 0.85 =$	578
4	do.	Average: $0.9 \times 0.85 \times 109 \times 0.85 \times 0.7 \times 0.85 =$	42
5	Solid door		0
Total Solar Gain			<u>1407W</u>

Total summer gains, $G = 1407 + 1581 [55] = 2988$

Summer Gain/Loss ratio = $2988/5044 = 0.59$

Region: Midlands Mean summer air temperature = 15.5°C

Thermal mass parameter, TMP = 7 (Table P7)

$\Delta T_{\text{mass}} = 0.6$

$T_{\text{threshold}} = 15.50 + 0.59 + 0.6 = 16.69^\circ\text{C}$

Likelihood of high internal temperatures during summer weather: **Not significant**

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SAP Worksheet (Version 9.80)

Calculation of Energy Rating

Overall Dwelling Dimensions

	Area m ²	Avg ht m.	Vol. m ³	
Ground/entrance level:	320.50	4.50	1442.25	[1]
First:	<u>31.70</u>	2.50	<u>79.25</u>	[2]
Total floor area:	352.20 [5]	Volume:	1521.50	[6]

Ventilation Rate

		ACH	
Flues:	4 x 20/1521.50 =	0.05	[8]
Fans and passive vents:	1 x 10/1521.50 =	<u>0.01</u>	[9]
Infiltration due to chimneys, flues and fans:		0.06	[10]
2 storeys: additional infiltration:	(2 - 1) x 0.1 =	0.10	[12]
Structural infiltration (masonry):		0.35	[13]
Infiltration through sealed suspended wood floor:		0.10	[14]
0% of windows and doors are draught stripped:			[16]
Resulting infiltration:	0.25 - (0.2 x 0/100) =	<u>0.25</u>	[17]
Infiltration rate:		<u>0.86</u>	[19]
1 sheltered side: shelter factor = 0.925			[21]
Adjusted infiltration rate = 0.86 x 0.93		0.79	[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):		943.44	[33]
Thermal bridges 0.08 x 1048.00:		<u>83.84</u>	[34]
Total fabric heat loss:		1027.28	[35]
Ventilation heat loss:	0.82 [25] x 0.33 x 1521.50 [6] =	409.60	[36]
Specific heat loss:		<u>1436.88</u>	[37]
Heat loss parameter:	1436.88/352.2 =	4.08	[38]

Water Heating Energy Requirements

		kWh/year	
Source: Point of use			
Fuel: Mains Gas			
Energy content of heated water (Table 1a N=7.613):		4143	[39]
Primary circuit loss :		0	[48]
Solar input:		<u>0</u>	[50]
Required output from water heater:		4143	[51]
Heat gains from water heating:	0.25 x 4143 + 0.8 x 0 =	1036	[52]

Gains

		Watts	
Lighting, appliance & metabolic gains (Table 5 N=7.613):		1,399	[53]
Reduction due to low energy lighting (10%):		-27	[53a]
Heating system fan: 91.3			
Total additional gains		91	[53b]
Water heating:	1036/8.72 =	118	[54]
Total internal gains:		<u>1,581</u>	[55]
Total solar gains (B/F from solar-related report):		555	[65]
Total gains		<u>2,135</u>	[66]
Gains/Loss ratio (GLR) = 2135/1436.9 [37] =			1.486 [67]
Utilisation factor (Table 7): 1.00			[68]
Useful gains:	2135 x 1.00 =	2,135	[69]

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Mean internal temperature

	°C	
Living area mean temperature: Table 8 col.1; HLP [38] = 4.08	18.46	[70]
Control adjustment (Table 4e)	0.00	[71]
Heating system responsiveness (R) = 1.00 (Table 4a)		
Adjustment for gains:	$0.2 \times R \times ((2135 [69]/1436.9 [37]) - 4.0) = -0.50$	[72]
Adjusted living room temperature:	17.95	[73]
Temperature difference between zones : (Table 9 col 1)	1.50	[74]
Living area fraction: 0.53		[75]
Rest-of-house fraction: 0.47		[76]
Mean internal temperature:	$17.95 - (1.50 \times 0.47) = 17.25$	[77]

Degree Days

Temperature rise from gains:	$2135 [69]/1436.9 [37] = 1.49$	[78]
Base temperature:	$17.25 - 1.49 = 15.76$	[79]
Degree days (Table 10):	2193	[80]

Space heating requirements

		kWh/year
Energy requirement (useful):	$0.024 \times 2193 \times 1436.9 [37] = 75616$	[81]
Heat from secondary system: 10% (Table 11)		[82]
Primary system:	Ducted on/off control pre 1998 Controls: No thermostatic control Fuel: Mains Gas Efficiency: 70% (Table 4a)	
Fuel required:	$75616 \times 0.90 \times 100/70 = 97221$	[83] [85]
Secondary system:	Electric convector or radiant panel heaters Fuel: Electricity (standard tariff) Efficiency: 100% (Table 4a)	
Fuel required:	$75616 \times 0.10 \times 100/100 = 7562$	[84] [85a]

Water heating energy requirement (net): 4143 kW [51]

Source: Point of use

Efficiency : 70%

Energy required: $4143 [51] \times 100/70 = 5919$ [86]
[86a]

Electricity for pumps & fans: 958 [87]

Electricity for lighting (B/F from Solar report) 3473

Fuel Costs

		£/year
Space heating: Primary system:	$97221 \times 1.63p =$	1584.69 [88]
Secondary system:	$7562 \times 7.12p =$	538.39 [89]
Water heating:	$5919 \times 1.63p =$	96.47 [91b]
Pump/fan energy cost:	$958 \times 7.12p =$	68.20 [92]
Lighting energy cost:	$3473 \times 7.12p =$	247.30 [93]
Additional standing charges (Table 12): Gas	<u>34.00</u>	[94]
Total heating cost:		<u>2569.06</u> [97]

SAP Rating

Energy cost deflator (Table 12, footnote 2):	0.91	[98]
Energy cost factor (ECF) £/m ² :	$(2569.06 \times 0.91 - 30)/(352.20 + 45.0) = 5.81$	[99]
SAP value = 26.9383		[100]

SAP Rating = 27 Band F

CO₂ Emissions

		kg/year
Primary heating system (mains gas)	$97221 [85] \times 0.194 =$	18,861 [101]
Secondary heating system (electricity)	$7562 [85a] \times 0.422 =$	3,191 [102]
Water heating (mains gas)	$5919 [86a] \times 0.194 =$	1,148 [103]
Total for space and water heating	<u>23200</u>	[107]
Electricity for pumps and fans	$958 [87] \times 0.422 =$	404 [108]
Electricity for lighting, C _L	$3473 \times 0.422 =$	1,466 [109]
New technology: None:		

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Total: 25,070 [112]

Carbon Factor, CF = 25070/(352.20 + 45) = 63.12 EI = 29.00

EI Rating = 29 Band F

Primary energy

	Energy kWh/Yr	Primary Factor	P.Energy kWh/yr	
Space heating	97221	1.15	111804	[101]
Secondary heating	7562	2.80	21172	[102]
Water heating	5919	1.15	6806	[103]
Electricity for pumps and fans	958	2.80	2682	[108]
Electricity for lighting	3473	2.80	9725	[109]
New Technology: Energy saved	0	0.00	0	[110]
New Technology: Energy used	0	0.00	0	[111]
			<u>152,190</u>	[112]
			432	[113]

Primary energy kWh/year
Primary energy kWh/year/m²

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SAP Worksheet (Version 9.80)

Dwelling Carbon Dioxide Emission Rate (DER) Calculation

Overall Dwelling Dimensions

	Area m ²	Avg ht m.	Vol. m ³	
Ground/entrance level:	320.50	4.50	1442.25	[1]
First:	<u>31.70</u>	2.50	<u>79.25</u>	[2]
Total floor area:	352.20 [5]	Volume:	1521.50	[6]

Ventilation Rate

		ACH	
Flues:		4 x 20/1521.50 = 0.05	[8]
Fans and passive vents:		1 x 10/1521.50 = 0.01	[9]
Infiltration due to chimneys, flues and fans:		0.06	[10]
2 storeys: additional infiltration:		(2 - 1) x 0.1 = 0.10	[12]
Structural infiltration (masonry):		0.35	[13]
Infiltration through sealed suspended wood floor:		0.10	[14]
0% of windows and doors are draught stripped:			[16]
Resulting infiltration:		0.25 - (0.2 x 0/100) = 0.25	[17]
Infiltration rate:		<u>0.86</u>	[19]
1 sheltered side: shelter factor = 0.925			[21]
Adjusted infiltration rate = 0.86 x 0.93		0.79	[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):		943.44	[33]
Thermal bridges 0.08 x 1048.00:		<u>83.84</u>	[34]
Total fabric heat loss:		1027.28	[35]
Ventilation heat loss:	0.82 [25] x 0.33 x 1521.50 [6] =	409.60	[36]
Specific heat loss:		<u>1436.88</u>	[37]
Heat loss parameter:		1436.88/352.2 = 4.08	[38]

Water Heating Energy Requirements

		kWh/year	
Source: Point of use			
Fuel: Mains Gas			
Energy content of heated water (Table 1a N=7.613):		4143	[39]
Primary circuit loss :		0	[48]
Solar input:		<u>0</u>	[50]
Required output from water heater:		4143	[51]
Heat gains from water heating:	0.25 x 4143 + 0.8 x 0 =	1036	[52]

Gains

		Watts	
Lighting, appliance & metabolic gains (Table 5 N=7.613):		1,399	[53]
Reduction due to low energy lighting (30% assumed):		-82	[53a]
Heating system fan: 91.3			
Total additional gains		91	[53b]
Water heating:		1036/8.72 = 118	[54]
Total internal gains:		<u>1,526</u>	[55]
Total solar gains (B/F from solar-related report):		555	[65]
Total gains		<u>2,081</u>	[66]
Gains/Loss ratio (GLR) = 2081/1436.9 [37] = 1.448			[67]
Utilisation factor (Table 7): 1.00			[68]
Useful gains:		2081 x 1.00 = 2,081	[69]

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Mean internal temperature		°C
Living area mean temperature: Table 8 col.1; HLP [38] = 4.08		18.46 [70]
Control adjustment (Table 4e)		0.00 [71]
Heating system responsiveness (R) = 1.00 (Table 4a)		
Adjustment for gains:	$0.2 \times R \times ((2081 [69]/1436.9 [37]) - 4.0) = -0.51$	[72]
Adjusted living room temperature:		17.95 [73]
Temperature difference between zones : (Table 9 col 1)		1.50 [74]
Living area fraction: 0.53		[75]
Rest-of-house fraction: 0.47		[76]
Mean internal temperature:	$17.95 - (1.50 \times 0.47) = 17.24$	[77]
Degree Days		
Temperature rise from gains:	$2081 [69]/1436.9 [37] = 1.45$	[78]
Base temperature:	$17.24 - 1.45 = 15.79$	[79]
Degree days (Table 10):		2200 [80]
Space heating requirements		kWh/year
Energy requirement (useful):	$0.024 \times 2200 \times 1436.9 [37] = 75869$	[81]
Heat from secondary system: 10% (Table 11)		[82]
Primary system:	Ducted on/off control pre 1998	
	Controls: No thermostatic control	
	Fuel: Mains Gas	
	Efficiency: 70% (Table 4a)	[83]
	Fuel required:	$75869 \times 0.90 \times 100/70 = 97545$ [85]
Secondary system:	Electric convector or radiant panel heaters	
	Fuel: Electricity (standard tariff)	
	Efficiency: 100% (Table 4a)	[84]
	Fuel required:	$75869 \times 0.10 \times 100/100 = 7587$ [85a]
Water heating energy requirement (net): 4143 kW [51]		
Source: Point of use		
Efficiency : 70%		[86]
Energy required:	$4143 [51] \times 100/70 = 5919$	[86a]
Electricity for pumps & fans:		958 [87]
Electricity for lighting (B/F from Solar report)		3108
CO₂ Emissions		kg/year
Primary heating system (mains gas)	$97545 [85] \times 0.194 = 18,924$	[101]
Secondary heating system (electricity)	$7587 [85a] \times 0.422 = 3,202$	[102]
Water heating (mains gas)	$5919 [86a] \times 0.194 = 1,148$	[103]
Total for space and water heating		<u>23274</u> [107]
Electricity for pumps and fans	$958 [87] \times 0.422 = 404$	[108]
Electricity for lighting, C _L	$3108 \times 0.422 = 1311$	[109]
New technology: None:		
	Total: <u>24,989</u>	[112]
Dwelling Carbon Dioxide Emission Rate (DER) = 70.95		(24,989/352.20)

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SAP Worksheet (Version 9.80)

Target Carbon Dioxide Emission Rate (TER) Calculation

	Area	U-Value	Heat Loss W/K
Walls (net)	266.85	0.35	93.40
DG wood frame window 16mm gap low-E glass (en=0.2)	86.20	2.00	159.63
Solid wood door	1.85	2.00	3.70
Floors	320.50	0.25	80.13
Roofs	372.60	0.16	<u>59.62</u>
Total heat loss (C/F to [33])			396.47

Overall Dwelling Dimensions

	Area m ²	Avg ht m.	Vol. m ³	
Ground/entrance level:	320.50	4.50	1442.25	[1]
First:	<u>31.70</u>	2.50	<u>79.25</u>	[2]
Total floor area:	352.20 [5]	Volume:	1521.50	[6]

Ventilation Rate

	ACH	
Fans and passive vents:	3 x 10/1521.50 = 0.02	[9]
Infiltration due to chimneys, flues and fans:	<u>0.02</u>	[10]
Default q ₅₀ value = 10.00	10.00/20 = 0.50	
Infiltration rate:	0.52	[19]
2 sheltered sides: shelter factor = 0.85		[21]
Adjusted infiltration rate = 0.52 x 0.85	0.44	[22]
Natural ventilation:		
Effective air change rate	0.60	[24]
	0.60	[25]

Heat Loss Summary

	W/K	
Heat loss through structure (from above):	396.47	[33]
Thermal bridges 0.11 x 1048.00:	115.28	[34]
Total fabric heat loss:	<u>511.75</u>	[35]
Ventilation heat loss:	0.60 [25] x 0.33 x 1521.50 [6] = 300.04	[36]
Specific heat loss:	811.79	[37]
Heat loss parameter:	811.79/352.2 = 2.30	[38]

Water Heating Energy Requirements

	kWh/year	
Source: Primary heating system (Gas boiler, automatic ignition, 1998 or later)		
Fuel: Mains Gas		
Energy content of heated water (Table 1a N=7.613):	4143	[39]
Distribution loss (Table 1b):	731	[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:	<u>6008</u>	[51]
Heat gains from water heating:	0.25 x 4143 + 0.8 x (731+524+610) = 2528	[52]

Gains

	Watts	
Lighting, appliance & metabolic gains (Table 5 N=7.613):	1,399	[53]
Reduction due to low energy lighting (30% assumed):	-71	[53a]
Central heating pump: 10.0		
Total additional gains	10	[53b]
Water heating:	2528/8.72 = 289	[54]
Total internal gains:	<u>1,627</u>	[55]

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Total solar gains (B/F from solar-related report):		1,445	[65]
Total gains		3,072	[66]
Gains/Loss ratio (GLR) = 3072/811.8 [37] = 3.784			[67]
Utilisation factor (Table 7): 0.99			[68]
Useful gains:	3072 x 0.99 = 3,045		[69]
Mean internal temperature		°C	
Living area mean temperature: Table 8 col.1; HLP [38] = 2.30		18.83	[70]
Control adjustment (Table 4e)		0.00	[71]
Heating system responsiveness (R) = 1.00 (Table 4d)			
Adjustment for gains:	$0.2 \times R \times ((3045 [69]/811.8 [37]) - 4.0) = -0.05$		[72]
Adjusted living room temperature:		18.78	[73]
Temperature difference between zones : (Table 9 col 2)		1.62	[74]
Living area fraction: 0.53			[75]
Rest-of-house fraction: 0.47			[76]
Mean internal temperature:	$18.78 - (1.62 \times 0.47) = 18.02$		[77]
Degree Days			
Temperature rise from gains:	$3045 [69]/811.8 [37] = 3.75$		[78]
Base temperature:	$18.02 - 3.75 = 14.26$		[79]
Degree days (Table 10):		1844	[80]
Space heating requirements		kWh/year	
Energy requirement (useful):	$0.024 \times 1844 \times 811.8 [37] = 35917$		[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%		
Fuel required:	$35917 \times 0.90 \times 100/78 = 41443$		[83] [85]
Secondary system:	Portable electric heaters Fuel: Electricity (standard tariff) Efficiency: 100% (Table 4a)		
Fuel required:	$35917 \times 0.10 \times 100/100 = 3592$		[84] [85a]
Water heating energy requirement (net): 6008 kW [51]			
Source: Primary heating system			
Efficiency : 78% (Manufacturer's declared value)			[86]
Energy required:	$6008 [51] \times 100/78 = 7703$		[86a]
Electricity for pumps & fans:		175	[87]
Electricity for lighting (B/F from Solar report)		2673	
CO₂ Emissions			kg/year
Primary heating system (mains gas)	$41443 [85] \times 0.194 = 8,040$		[101]
Secondary heating system (electricity)	$3592 [85a] \times 0.422 = 1,516$		[102]
Water heating (mains gas)	$7703 [86a] \times 0.194 = 1494$		[103]
Total for space and water heating		11050	[107]
Electricity for pumps and fans	$175 [87] \times 0.422 = 74$		[108]
Electricity for lighting, C _L	$2673 \times 0.422 = 1128$		[109]
New technology: None			
		Total: 12,252	[112]

$$C_H = (11050 + 74)/352.20 = 31.58 \quad C_L = 1128/352.20 = 3.20$$

Fuel: Mains Gas : Fuel Factor = 1.00 Improvement Factor = 0.20

$$\text{Target CO}_2 \text{ Emission Rate (TER)} = (C_H \times \text{Fuel Factor} + C_L) \times (1 - \text{imp factor}) \\ = (31.58 \times 1.00 + 3.20) \times (1 - 0.20) = \mathbf{27.83}$$