
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	0.57	37.64
	2: East Wall 1	E	42.80	1.89	0.57	28.99
	3: North Wall 2	N	11.30	2.10	0.57	11.54
	4: East Wall 2	E	79.80	7.89	0.57	62.84
	5: South Wall	S	67.00	2.98	0.57	43.75
	6: West Wall	W	106.70	25.57	0.57	110.93
Floor	1: Ground Floor Slab	N/A	320.50	0.00	0.22	70.51
Roof	1: Pitched Roof	E/W	372.60	0.00	0.16	59.62
Total:						<u>425.82</u>

Breakdown by element type:

		Area	U-value	Total heat loss W/K
Wall	User-entered U-value	308.76	0.57	175.99
Floor	User-entered U-value	320.50	0.22	70.51
Roof	User-entered U-value	372.60	0.16	59.62
Window	DG wood frame 6mm gap low-E glass (en=0.2)	33.26	2.44	81.16
Door	Solid wood	12.88	3.00	38.65

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

Average/maximum U-values: Walls: 0.57/0.57 **FAIL**; Floors: 0.22/0.22 OK
 Roofs: 0.16/0.16 OK; Openings: 2.78/3.00 **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; 100% draught stripping:

Natural ventilation with intermittent extract fans

Low energy lighting: 100% of fixed lighting points (30% assumed for DER/TER calculations)

Primary heating system: Ducted modulating control 1998 or later
 Programmer + roomstat
 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 53 Band E
EI Rating 52 Band E

Total CO₂ emissions = 14.36 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

Doors and windows

	<i>U-value</i>	<i>Solar Transmittance</i>	<i>Frame Factor</i>
DG wood frame window 6mm gap low-E glass (en=0.2)	2.70	0.72	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 : 0.570
Areas (m²) :- Gross: 47.30 Opening(s): 5.72 Net: 41.58

	Area x U-value	W/K
Heat loss through solid area	41.58 x 0.57 =	23.70
Heat loss through openings:		
1: DG wood frame window 6mm gap low-E glass (en=0.2)	3x0.95x1.05=2.99 x 2.437 (2.7)=	7.29
2: DG wood frame window 6mm gap low-E glass (en=0.2)	2x1.3x1.05=2.73 x 2.437 (2.7)=	6.65
	Total heat loss =	37.64

Location: **East Wall 1** Orientation: E
User-entered U-value : 0.570
Areas (m²) :- Gross: 42.80 Opening(s): 1.89 Net: 40.91

	Area x U-value	W/K
Heat loss through solid area	40.91 x 0.57 =	23.32
Heat loss through openings:		
1: Solid wood door	0.9x2.1=1.89 x 3.0 =	5.67
	Total heat loss =	28.99

Location: **North Wall 2** Orientation: N
User-entered U-value : 0.570
Areas (m²) :- Gross: 11.30 Opening(s): 2.10 Net: 9.20

	Area x U-value	W/K
Heat loss through solid area	9.20 x 0.57 =	5.24
Heat loss through openings:		
1: Solid wood door	1.0x2.1=2.10 x 3.0 =	6.30
	Total heat loss =	11.54

Location: **East Wall 2** Orientation: E
User-entered U-value : 0.570
Areas (m²) :- Gross: 79.80 Opening(s): 7.89 Net: 71.91

	Area x U-value	W/K
Heat loss through solid area	71.91 x 0.57 =	40.99
Heat loss through openings:		
1: DG wood frame window 6mm gap low-E glass (en=0.2)	1.41x1.125=1.59 x 2.437 (2.7)=	3.87
2: DG wood frame window 6mm gap low-E glass (en=0.2)	1.46x1.125=1.64 x 2.437 (2.7)=	4.00
3: Solid wood door	2x1.11x2.1=4.66 x 3.0 =	13.99
	Total heat loss =	62.84

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Location: **South Wall**

Orientation: S

User-entered U-value : 0.570

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

Area x U-value W/K
64.02 x 0.57 = 36.49

Heat loss through solid area

Heat loss through openings:

1: DG wood frame window 6mm gap low-E glass (en=0.2)

1.417x2.1=2.98 x 2.437 (2.7)= 7.25

Total heat loss = 43.75

Location: **West Wall**

Orientation: W

User-entered U-value : 0.570

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

Area x U-value W/K
81.13 x 0.57 = 46.25

Heat loss through solid area

Heat loss through openings:

1: DG wood frame window 6mm gap low-E glass (en=0.2)

2x1.41x2.925=8.25 x 2.437 (2.7)= 20.10

2: DG wood frame window 6mm gap low-E glass (en=0.2)

0.9x0.6=0.54 x 2.437 (2.7)= 1.32

3: DG wood frame window 6mm gap low-E glass (en=0.2)

4.0x2.925=11.70 x 2.437 (2.7)= 28.51

4: DG wood frame window 6mm gap low-E glass (en=0.2)

1.41x0.6=0.85 x 2.437 (2.7)= 2.06

5: Solid wood door

2.015x2.1=4.23 x 3.0 = 12.69

Total heat loss = 110.93

Other Floors

Location: **Ground Floor Slab**

Orientation: N/A

User-entered U-value : 0.220

Area = 320.50 m²

Heat loss = 320.50 x 0.22 = 70.51 W/K

Roof

Location: **Pitched Roof**

Orientation: E/W

User-entered U-value : 0.160

Area = 372.60 m²

Heat loss = 372.60 x 0.16 = 59.62 W/K

Total building heat loss = 425.82 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		0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
North Wall 1 Orientation: N (North ±30°)			
1	Double-glazed (Low-E hard coat) window	0.9 x 2.99 x 29 x 0.72 x 0.7 x 0.77 =	30
2	do.	0.9 x 2.73 x 29 x 0.72 x 0.7 x 0.77 =	28
East Wall 1 Orientation: E (E/W)			
North Wall 2 Orientation: N (North ±30°)			
East Wall 2 Orientation: E (E/W)			
1	Double-glazed (Low-E hard coat) window	0.9 x 1.59 x 48 x 0.72 x 0.7 x 0.77 =	27
2	do.	0.9 x 1.64 x 48 x 0.72 x 0.7 x 0.77 =	28
South Wall Orientation: S (South ±30°)			
1	Double-glazed (Low-E hard coat) window	0.9 x 2.98 x 72 x 0.72 x 0.7 x 0.77 =	75
West Wall Orientation: W (E/W)			
1	Double-glazed (Low-E hard coat) window	0.9 x 8.25 x 48 x 0.72 x 0.7 x 0.77 =	138
2	do.	0.9 x 0.54 x 48 x 0.72 x 0.7 x 0.77 =	9
3	do.	0.9 x 11.70 x 48 x 0.72 x 0.7 x 0.77 =	196
4	do.	0.9 x 0.85 x 48 x 0.72 x 0.7 x 0.77 =	14
Total Solar Gain C/F to SAP/DER worksheets [65]			<u>545W</u>

Lighting

Light transmission through windows and rooflights

North Wall 1 Orientation: N (North ±30°)			
1	DG wood frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 2.99 x 0.7 x 0.80 x 0.83 =	1.25
2	do.	0.9 x 2.73 x 0.7 x 0.80 x 0.83 =	1.14
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	DG wood frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 1.59 x 0.7 x 0.80 x 0.83 =	0.66
2	do.	0.9 x 1.64 x 0.7 x 0.80 x 0.83 =	0.69
3	Solid wood door		0.00
South Wall Orientation: S (South ±30°)			
1	DG wood frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 2.98 x 0.7 x 0.80 x 0.83 =	1.24
West Wall Orientation: W (E/W)			
1	DG wood frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 8.25 x 0.7 x 0.80 x 0.83 =	3.45
2	do.	0.9 x 0.54 x 0.7 x 0.80 x 0.83 =	0.23
3	do.	0.9 x 11.70 x 0.7 x 0.80 x 0.83 =	4.89
4	do.	0.9 x 0.85 x 0.7 x 0.80 x 0.83 =	0.35
5	Solid wood door		<u>0.00</u>
Total light input			13.91

$G_L = 13.91/352.20 = 0.040$ $C_2 = 1.122$

Low energy lighting fixed outlets: 100% $C_1 = 1 - 0.50 \times 100/100 = 0.5$

Electricity used for lighting, $E_L = E_B.TFA.C_1.C_2 = 9.3 \times 352.2 \times 0.5 \times 1.122 = 1837$ C/F to SAP worksheet [93]

Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B.TFA.(1-C_1).C_2 = 9.3 \times 352.2 \times (1-0.5) \times 1.122 = 1837$

Reduction in gains, $\Delta_{gains} = 0.15\Delta_{EL} = 0.15 \times 1837 = 276$ 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, $E_L = E_B.TFA.C_1.C_2 = 9.3 \times 352.2 \times 0.85 \times 1.122 = 3123$ C/F to DER worksheet [109]

Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B.TFA.(1-C_1).C_2 = 9.3 \times 352.2 \times (1-0.85) \times 1.122 = 551$

Reduction in gains, $\Delta_{gains} = 0.15\Delta_{EL} = 0.15 \times 551 = 83$ 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 = $510 [35] + 4017 = 4526\text{W/K}$

# Opening		0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
North Wall 1 Orientation: N (North ±30°)			
1	Double-glazed (Low-E hard coat) window	Average: $0.9 \times 2.99 \times 75 \times 0.72 \times 0.7 \times 0.85 =$	86
2	do.	Average: $0.9 \times 2.73 \times 75 \times 0.72 \times 0.7 \times 0.85 =$	79
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	Double-glazed (Low-E hard coat) window	Average: $0.9 \times 1.59 \times 109 \times 0.72 \times 0.7 \times 0.85 =$	66
2	do.	Average: $0.9 \times 1.64 \times 109 \times 0.72 \times 0.7 \times 0.85 =$	69
3	Solid door		0
South Wall Orientation: S (South ±30°)			
1	Double-glazed (Low-E hard coat) window	Average: $0.9 \times 2.98 \times 107 \times 0.72 \times 0.7 \times 0.85 =$	122
West Wall Orientation: W (E/W)			
1	Double-glazed (Low-E hard coat) window	Average: $0.9 \times 8.25 \times 109 \times 0.72 \times 0.7 \times 0.85 =$	345
2	do.	Average: $0.9 \times 0.54 \times 109 \times 0.72 \times 0.7 \times 0.85 =$	23
3	do.	Average: $0.9 \times 11.70 \times 109 \times 0.72 \times 0.7 \times 0.85 =$	489
4	do.	Average: $0.9 \times 0.85 \times 109 \times 0.72 \times 0.7 \times 0.85 =$	35
5	Solid door		0
Total Solar Gain			<u>1314W</u>

Total summer gains, $G = 1314 + 1333 [55] = 2647$

Summer Gain/Loss ratio = $2647/4526 = 0.58$

Region: Midlands Mean summer air temperature = 15.5°C

Thermal mass parameter, TMP = 7 (Table P7)

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

$T_{\text{threshold}} = 15.50 + 0.58 + 0.6 = 16.68^\circ\text{C}$

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 = 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]
100% of windows and doors are draught stripped:			[16]
Resulting infiltration:	0.25-(0.2 x 100/100) =	0.05	[17]
Infiltration rate:		<u>0.66</u>	[19]
1 sheltered side: shelter factor = 0.925			[21]
Adjusted infiltration rate = 0.66 x 0.93		0.61	[22]
Natural ventilation:			
Effective air change rate		0.69	[24]
		0.69	[25]

Heat Loss Summary

		W/K	
Heat loss through structure (b/f from building summary):		425.82	[33]
Thermal bridges 0.08 x 1048.00:		<u>83.84</u>	[34]
Total fabric heat loss:		509.66	[35]
Ventilation heat loss:	0.69 [25] x 0.33 x 1521.50 [6] =	344.38	[36]
Specific heat loss:		<u>854.03</u>	[37]
Heat loss parameter:		854.03/352.2 = 2.42	[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 (100%):		-276	[53a]
Heating system fan: 91.3			
Total additional gains		91	[53b]
Water heating:		1036/8.72 = 118	[54]
Total internal gains:		<u>1,333</u>	[55]
Total solar gains (B/F from solar-related report):		545	[65]
Total gains		<u>1,877</u>	[66]
Gains/Loss ratio (GLR) = 1877/854.0 [37] = 2.198			[67]
Utilisation factor (Table 7): 1.00			[68]
Useful gains:		1877 x 1.00 = 1,877	[69]

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Mean internal temperature

°C

Living area mean temperature: Table 8 col.1; HLP [38] = 2.42	18.82	[70]
Control adjustment (Table 4e)	0.00	[71]
Heating system responsiveness (R) = 1.00 (Table 4a)		
Adjustment for gains:	$0.2 \times R \times ((1877 [69]/854.0 [37]) - 4.0) = -0.36$	[72]
Adjusted living room temperature:	18.46	[73]
Temperature difference between zones : (Table 9 col 1)	0.94	[74]
Living area fraction: 0.53		[75]
Rest-of-house fraction: 0.47		[76]
Mean internal temperature:	$18.46 - (0.94 \times 0.47) = 18.01$	[77]

Degree Days

Temperature rise from gains:	$1877 [69]/854.0 [37] = 2.20$	[78]
Base temperature:	$18.01 - 2.20 = 15.82$	[79]
Degree days (Table 10):	2206	[80]

Space heating requirements

kWh/year

Energy requirement (useful):	$0.024 \times 2206 \times 854.0 [37] = 45210$	[81]
Heat from secondary system: 10% (Table 11)		[82]
Primary system:	Ducted modulating control 1998 or later	
	Controls: Programmer + roomstat	
	Fuel: Mains Gas	
	Efficiency: 78% (Table 4a)	
	$45210 \times 0.90 \times 100/78 = 52165$	[83]
		[85]
Secondary system:	Electric convector or radiant panel heaters	
	Fuel: Electricity (standard tariff)	
	Efficiency: 100% (Table 4a)	
	$45210 \times 0.10 \times 100/100 = 4521$	[84]
		[85a]

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

Source: Point of use

Efficiency : 70%

Energy required: 4143 [51] x 100/70 = 5919 [86a]

Electricity for pumps & fans: 958 [87]

Electricity for lighting (B/F from Solar report) 1837

Fuel Costs

£/year

Space heating:	Primary system:	$52165 \times 1.63p =$	850.29	[88]
	Secondary system:	$4521 \times 7.12p =$	321.89	[89]
Water heating:		$5919 \times 1.63p =$	96.47	[91b]
Pump/fan energy cost:		$958 \times 7.12p =$	68.20	[92]
Lighting energy cost:		$1837 \times 7.12p =$	130.81	[93]
Additional standing charges (Table 12): Gas			34.00	[94]
Total heating cost:			<u>1501.66</u>	[97]

SAP Rating

Energy cost deflator (Table 12, footnote 2): 0.91 [98]

Energy cost factor (ECF) £/m²: $(1501.66 \times 0.91 - 30)/(352.20 + 45.0) = 3.36$ [99]

SAP value = 53.0269 [100]

SAP Rating = 53 Band E

CO₂ Emissions

kg/year

Primary heating system (mains gas)	$52165 [85] \times 0.194 =$	10,120	[101]
Secondary heating system (electricity)	$4521 [85a] \times 0.422 =$	1,908	[102]
Water heating (mains gas)	$5919 [86a] \times 0.194 =$	1148	[103]
Total for space and water heating		<u>13176</u>	[107]
Electricity for pumps and fans	$958 [87] \times 0.422 =$	404	[108]
Electricity for lighting, C _L	$1837 \times 0.422 =$	775	[109]
New technology: None:			

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Total: 14,356 [112]

Carbon Factor, CF = 14356/(352.20 + 45) = 36.14 EI = 52.00

EI Rating = 52 Band E

Primary energy	Energy kWh/Yr	Primary Factor	P.Energy kWh/yr	
Space heating	52165	1.15	59990	[101]
Secondary heating	4521	2.80	12659	[102]
Water heating	5919	1.15	6806	[103]
Electricity for pumps and fans	958	2.80	2682	[108]
Electricity for lighting	1837	2.80	5144	[109]
New Technology: Energy saved	0	0.00	0	[110]
New Technology: Energy used	0	0.00	0	[111]
			<u>87,281</u>	[112]
			248	[113]

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SAP Worksheet (Version 9.80)

Dwelling Carbon Dioxide Emission Rate (DER) Calculation

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	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]
100% of windows and doors are draught stripped:			[16]
Resulting infiltration:		0.25-(0.2 x 100/100) = 0.05	[17]
Infiltration rate:		<u>0.66</u>	[19]
1 sheltered side: shelter factor = 0.925			[21]
Adjusted infiltration rate = 0.66 x 0.93		0.61	[22]
Natural ventilation:			
Effective air change rate		0.69	[24]
		0.69	[25]

Heat Loss Summary

		W/K	
Heat loss through structure (b/f from building summary):		425.82	[33]
Thermal bridges 0.08 x 1048.00:		<u>83.84</u>	[34]
Total fabric heat loss:		509.66	[35]
Ventilation heat loss:	0.69 [25] x 0.33 x 1521.50 [6] =	344.38	[36]
Specific heat loss:		<u>854.03</u>	[37]
Heat loss parameter:		854.03/352.2 = 2.42	[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):		-83	[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):		545	[65]
Total gains		<u>2,070</u>	[66]
Gains/Loss ratio (GLR) = 2070/854.0 [37] = 2.424			[67]
Utilisation factor (Table 7): 1.00			[68]
Useful gains:		2070 x 1.00 = 2,069	[69]

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Mean internal temperature

°C

Living area mean temperature: Table 8 col.1; HLP [38] = 2.42	18.82	[70]
Control adjustment (Table 4e)	0.00	[71]
Heating system responsiveness (R) = 1.00 (Table 4a)		
Adjustment for gains:	$0.2 \times R \times ((2069 [69]/854.0 [37]) - 4.0) = -0.32$	[72]
Adjusted living room temperature:	18.50	[73]
Temperature difference between zones : (Table 9 col 1)	0.94	[74]
Living area fraction: 0.53		[75]
Rest-of-house fraction: 0.47		[76]
Mean internal temperature:	$18.50 - (0.94 \times 0.47) = 18.06$	[77]

Degree Days

Temperature rise from gains:	$2069 [69]/854.0 [37] = 2.42$	[78]
Base temperature:	$18.06 - 2.42 = 15.64$	[79]
Degree days (Table 10):	2162	[80]

Space heating requirements

kWh/year

Energy requirement (useful):	$0.024 \times 2162 \times 854.0 [37] = 44324$	[81]
Heat from secondary system: 10% (Table 11)		[82]
Primary system:	Ducted modulating control 1998 or later	
	Controls: Programmer + roomstat	
	Fuel: Mains Gas	
	Efficiency: 78% (Table 4a)	
	$44324 \times 0.90 \times 100/78 = 51143$	[83]
		[85]
Secondary system:	Electric convector or radiant panel heaters	
	Fuel: Electricity (standard tariff)	
	Efficiency: 100% (Table 4a)	
	$44324 \times 0.10 \times 100/100 = 4432$	[84]
		[85a]

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

Source: Point of use

Efficiency : 70%

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

Electricity for pumps & fans: 958 [87]

Electricity for lighting (B/F from Solar report) 3123

CO₂ Emissions

kg/year

Primary heating system (mains gas)	$51143 [85] \times 0.194 =$	9,922	[101]
Secondary heating system (electricity)	$4432 [85a] \times 0.422 =$	1,870	[102]
Water heating (mains gas)	$5919 [86a] \times 0.194 =$	1148	[103]
Total for space and water heating		<u>12940</u>	[107]
Electricity for pumps and fans	$958 [87] \times 0.422 =$	404	[108]
Electricity for lighting, C _L	$3123 \times 0.422 =$	1318	[109]
New technology: None:			

Total: 14,663 [112]

Dwelling Carbon Dioxide Emission Rate (DER) = 41.63

(14,663/352.20)

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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

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