
Place : Architecture
26 Westgate Lincoln LN1 3BD

Site: St John's Church, 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: West Wall 01	W	20.10	9.68	0.29	28.57
	2: West Wall 02	W	63.00	62.88	0.29	163.44
	3: North West Wall	NW	57.50	16.97	0.29	55.86
	4: North Wall 01	N	41.80	16.97	0.29	51.31
	5: North Wall 02	N	14.61	0.00	0.29	4.24
	6: East Wall 01	E	45.45	2.10	0.29	18.87
	7: East Wall 02	E	63.00	62.88	0.29	163.44
	8: South Wall 01 (sx)	S	57.50	16.97	0.29	55.86
	9: South East Wall (sx)	SE	41.80	16.97	0.29	51.31
	10: South Wall 02	S	14.61	0.00	0.29	4.24
Floor	1: Ground Floor (Insulated + UFH)	N/A	493.50	0.00	0.22	108.57
Roof	1: West - Flat Roof	W	48.50	0.00	0.23	11.15
	2: East - Flat Roof	E	63.71	2.00	0.23	22.67
	3: South - Hyperbolic Roof	S	222.50	0.00	0.24	53.40
	4: North - Hyperbolic Roof	N	222.50	0.00	0.24	53.40

Total: 846.34

Breakdown by element type:

		Area		
Wall	User-entered U-value	213.93	0.29	62.04
Floor	User-entered U-value	493.50	0.22	108.57
Roof	User-entered U-value	110.21	0.23	25.35
Roof	User-entered U-value	445.00	0.24	106.80
Rooflight	Single-glazed PVC frame	2.00	4.24	8.48
Window	TG metal frame 6mm gap low-E glass (en=0.2)	193.67	2.60	503.54
Door	Solid wood	2.10	3.00	6.30
Window	DG wood frame 6mm gap low-E glass (en=0.2)	4.90	2.44	11.96
Door	DG wood half-glazed 6mm gap low-E (en=0.2)	4.78	2.85	13.61

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

Average/maximum U-values: Walls: 0.29/0.29 OK; Floors: 0.22/0.22 OK
 Roofs: 0.24/0.24 OK; Openings: 2.92/5.10 **FAIL**

Floor area: 489.00m² Living area fraction: 0.78 Internal volume: 2694m³

Front faces: W

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

Pressure test: None - default infiltration used:

Masonry construction; draught lobby; 100% draught stripping:

Natural ventilation with intermittent extract fans

Low energy lighting: 90% of fixed lighting points (30% assumed for DER/TER calculations)

Primary heating system: Gas boiler, automatic ignition, 1998 or later
 Underfloor heating, pipes in screed
 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
 Electricity (standard tariff)

SAP 2005 Rating 38 Band F
EI Rating 40 Band E

Total CO₂ emissions = 25.86 tonnes/year

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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, windows and rooflights

	<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
TG metal frame window 6mm gap low-E glass (en=0.2)	2.90	0.64	0.80
Solid wood door	3.00	0.00	0.70
DG wood half-glazed door 6mm gap low-E (en=0.2)	2.85	0.00	0.70
Single-glazed PVC frame rooflight	5.10	0.85	0.70

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Building heat loss calculations

Building use: Existing dwelling

Walls

Location: **West Wall 01** Orientation: W

User-entered U-value : 0.290

Areas (m²) :- Gross: 20.10 Opening(s): 9.68 Net: 10.43

Heat loss through solid area

Area x U-value W/K
10.43 x 0.29 = 3.02

Heat loss through openings:

1: DG wood frame window 6mm gap low-E glass (en=0.2) 2x0.98x2.5=4.90 x 2.437 (2.7)= 11.94

2: DG wood half-glazed door 6mm gap low-E (en=0.2) 1.91x2.5=4.78 x 2.85 = 13.61

Total heat loss = 28.57

Location: **West Wall 02** Orientation: W

User-entered U-value : 0.290

Areas (m²) :- Gross: 63.00 Opening(s): 62.88 Net: 0.12

Heat loss through solid area

Area x U-value W/K
0.12 x 0.29 = 0.03

Heat loss through openings:

1: TG metal frame window 6mm gap low-E glass (en=0.2) 7.93x7.93=62.88 x 2.599 (2.9)= 163.41

Total heat loss = 163.44

Location: **North West Wall** Orientation: NW

User-entered U-value : 0.290

Areas (m²) :- Gross: 57.50 Opening(s): 16.97 Net: 40.53

Heat loss through solid area

Area x U-value W/K
40.53 x 0.29 = 11.75

Heat loss through openings:

1: TG metal frame window 6mm gap low-E glass (en=0.2) 4.12x4.12=16.97 x 2.599 (2.9)= 44.11

Total heat loss = 55.86

Location: **North Wall 01** Orientation: N

User-entered U-value : 0.290

Areas (m²) :- Gross: 41.80 Opening(s): 16.97 Net: 24.83

Heat loss through solid area

Area x U-value W/K
24.83 x 0.29 = 7.20

Heat loss through openings:

1: TG metal frame window 6mm gap low-E glass (en=0.2) 4.12x4.12=16.97 x 2.599 (2.9)= 44.11

Total heat loss = 51.31

Location: **North Wall 02** Orientation: N

User-entered U-value : 0.290

Area = 14.61 m²

Heat loss = 14.61 x 0.29 = 4.24 W/K

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Location: **East Wall 01**

Orientation: E

User-entered U-value : 0.290

Areas (m²) :- Gross: 45.45 Opening(s): 2.10 Net: 43.35

Area x U-value W/K
43.35 x 0.29 = 12.57

Heat loss through solid area

Heat loss through openings:

1: Solid wood door

1.0x2.1=2.10 x 3.0 = 6.30

Total heat loss = 18.87

Location: **East Wall 02**

Orientation: E

User-entered U-value : 0.290

Areas (m²) :- Gross: 63.00 Opening(s): 62.88 Net: 0.12

Area x U-value W/K
0.12 x 0.29 = 0.03

Heat loss through solid area

Heat loss through openings:

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

7.93x7.93=62.88 x 2.599 (2.9)= 163.41

Total heat loss = 163.44

Location: **South Wall 01**

Orientation: S

User-entered U-value : 0.290

Areas (m²) :- Gross: 57.50 Opening(s): 16.97 Net: 40.53

Area x U-value W/K
40.53 x 0.29 = 11.75

Heat loss through solid area

Heat loss through openings:

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

4.12x4.12=16.97 x 2.599 (2.9)= 44.11

Total heat loss = 55.86

Location: **South East Wall**

Orientation: SE

User-entered U-value : 0.290

Areas (m²) :- Gross: 41.80 Opening(s): 16.97 Net: 24.83

Area x U-value W/K
24.83 x 0.29 = 7.20

Heat loss through solid area

Heat loss through openings:

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

4.12x4.12=16.97 x 2.599 (2.9)= 44.11

Total heat loss = 51.31

Location: **South Wall 02**

Orientation: S

User-entered U-value : 0.290

Area = 14.61 m²

Heat loss = 14.61 x 0.29 = 4.24 W/K

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Other Floors

Location: **Ground Floor (Insulated + UFH)**

Orientation: N/A

User-entered U-value : 0.220

Area = 493.50 m²

Heat loss = 493.50 x 0.22 = 108.57 W/K

Roofs

Location: **West - Flat Roof**

Orientation: W

User-entered U-value : 0.230

Area = 48.50 m²

Heat loss = 48.50 x 0.23 = 11.15 W/K

Location: **East - Flat Roof**

Orientation: E

User-entered U-value : 0.230

Areas (m²) :- Gross: 63.71 Opening(s): 2.00 Net: 61.71

Heat loss through solid area

Area x U-value W/K
61.71 x 0.23 = 14.19

Heat loss through openings:

1: Single-glazed PVC frame rooflight

5x0.4x1.0=2.00 x 4.236 (5.1)= 8.47

Total heat loss = 22.67

Location: **South - Hyperbolic Roof**

Orientation: S

User-entered U-value : 0.240

Area = 222.50 m²

Heat loss = 222.50 x 0.24 = 53.40 W/K

Location: **North - Hyperbolic Roof**

Orientation: N

User-entered U-value : 0.240

Area = 222.50 m²

Heat loss = 222.50 x 0.24 = 53.40 W/K

Total building heat loss = 846.34 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 1470.08 = **117.61 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)
West Wall 01	Orientation: W (E/W)		
1	Double-glazed (Low-E hard coat) window	0.9 x 4.90 x 48 x 0.72 x 0.7 x 1.00 =	107
West Wall 02	Orientation: W (E/W)		
1	Triple-glazed (Low-E hard coat) window	0.9 x 62.88 x 48 x 0.64 x 0.8 x 1.00 =	1391
North West Wall	Orientation: NW (NE/NW)		
1	Triple-glazed (Low-E hard coat) window	0.9 x 16.97 x 34 x 0.64 x 0.8 x 0.54 =	144
North Wall 01	Orientation: N (North ±30°)		
1	Triple-glazed (Low-E hard coat) window	0.9 x 16.97 x 29 x 0.64 x 0.8 x 0.54 =	122
East Wall 01	Orientation: E (E/W)		
East Wall 02	Orientation: E (E/W)		
1	Triple-glazed (Low-E hard coat) window	0.9 x 62.88 x 48 x 0.64 x 0.8 x 1.00 =	1391
South Wall 01	Orientation: S (South ±30°)		
1	Triple-glazed (Low-E hard coat) window	0.9 x 16.97 x 72 x 0.64 x 0.8 x 0.77 =	434
South East Wall	Orientation: SE (SE/SW)		
1	Triple-glazed (Low-E hard coat) window	0.9 x 16.97 x 64 x 0.64 x 0.8 x 0.77 =	385
East - Flat Roof	Orientation: E (E/W)		
1	Single-glazed rooflight	0.9 x 2.00 x 75 x 0.85 x 0.7 x 1.00 =	80
Total Solar Gain C/F to SAP/DER worksheets [65]			<u>4054W</u>

Lighting

Light transmission through windows and rooflights

West Wall 01	Orientation: W (E/W)		
1	DG wood frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 4.90 x 0.7 x 0.80 x 1.00 =	2.47
2	DG wood half-glazed door 6mm gap low-E ($\epsilon_n=0.2$)		0.00
West Wall 02	Orientation: W (E/W)		
1	TG metal frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 62.88 x 0.8 x 0.70 x 1.00 =	31.69
North West Wall	Orientation: NW (NE/NW)		
1	TG metal frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 16.97 x 0.8 x 0.70 x 0.67 =	5.73
North Wall 01	Orientation: N (North ±30°)		
1	TG metal frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 16.97 x 0.8 x 0.70 x 0.67 =	5.73
East Wall 01	Orientation: E (E/W)		
1	Solid wood door		0.00
East Wall 02	Orientation: E (E/W)		
1	TG metal frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 62.88 x 0.8 x 0.70 x 1.00 =	31.69
South Wall 01	Orientation: S (South ±30°)		
1	TG metal frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 16.97 x 0.8 x 0.70 x 0.83 =	7.10
South East Wall	Orientation: SE (SE/SW)		
1	TG metal frame window 6mm gap low-E glass ($\epsilon_n=0.2$)	0.9 x 16.97 x 0.8 x 0.70 x 0.83 =	7.10
East - Flat Roof	Orientation: E (E/W)		
1	Single-glazed PVC frame rooflight	0.9 x 2.00 x 0.7 x 0.90 x 1.00 =	1.13
Total light input			<u>92.66</u>

$G_L = 92.66/489.00 = 0.189$ $C_2 = 0.96$

Low energy lighting fixed outlets: 90% $C_1 = 1 - 0.50 \times 90/100 = 0.55$

Electricity used for lighting, $E_L = E_B \cdot TFA \cdot C_1 \cdot C_2 = 9.3 \times 489.0 \times 0.55 \times 0.96 = 2401$ C/F to SAP worksheet [93]

Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B \cdot TFA \cdot (1 - C_1) \cdot C_2 = 9.3 \times 489.0 \times (1 - 0.55) \times 0.96 = 1965$

Reduction in gains, $\Delta_{gains} = 0.15 \Delta_{EL} = 0.15 \times 1965 = 295$ C/F to SAP worksheet [53a]

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

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Electricity used for lighting, $E_L = E_B.TFA.C_1.C_2 = 9.3 \times 489.0 \times 0.85 \times 0.96 = 3711$ C/F to DER worksheet [109]
 Reduction in energy use due to low energy lights, $\Delta_{EL} = E_B.TFA.(1-C_1).C_2 = 9.3 \times 489.0 \times (1-0.85) \times 0.96 = 655$
 Reduction in gains, $\Delta_{gains} = 0.15\Delta_{EL} = 0.15 \times 655 = 98$ C/F to DER worksheet [53a]

Solar Panel: none

Solar gains through openings during summer

No daytime shading assumed

Ventilation: trickle vents only Single storey Cross-ventilation possible: Y

Ventilation rate in hot weather = 0.1 ACH

Summer ventilation heat loss = $0.33 \times 0.1 \times 2694.39 [6] = 89$

Total summer heat loss = $964 [35] + 89 = 1053W/K$

# Opening		0.9 x Area x Flux x Trans x FF x SAF	Gain (W)
West Wall 01	Orientation: W (E/W)		
1	Double-glazed (Low-E hard coat) window	Little: $0.9 \times 4.90 \times 109 \times 0.72 \times 0.7 \times 1.00 =$	242
2	Half-glazed door		0
West Wall 02	Orientation: W (E/W)		
1	Triple-glazed (Low-E hard coat) window	Little: $0.9 \times 62.88 \times 109 \times 0.64 \times 0.8 \times 1.00 =$	3159
North West Wall	Orientation: NW (NE/NW)		
1	Triple-glazed (Low-E hard coat) window	More: $0.9 \times 16.97 \times 89 \times 0.64 \times 0.8 \times 0.70 =$	487
North Wall 01	Orientation: N (North ±30°)		
1	Triple-glazed (Low-E hard coat) window	More: $0.9 \times 16.97 \times 75 \times 0.64 \times 0.8 \times 0.70 =$	411
East Wall 01	Orientation: E (E/W)		
1	Solid door		0
East Wall 02	Orientation: E (E/W)		
1	Triple-glazed (Low-E hard coat) window	Little: $0.9 \times 62.88 \times 109 \times 0.64 \times 0.8 \times 1.00 =$	3159
South Wall 01	Orientation: S (South ±30°)		
1	Triple-glazed (Low-E hard coat) window	Average: $0.9 \times 16.97 \times 107 \times 0.64 \times 0.8 \times 0.90 =$	753
South East Wall	Orientation: SE (SE/SW)		
1	Triple-glazed (Low-E hard coat) window	Average: $0.9 \times 16.97 \times 112 \times 0.64 \times 0.8 \times 0.90 =$	788
East - Flat Roof	Orientation: E (E/W)		
1	Single-glazed PVC frame rooflight	Little: $0.9 \times 2.00 \times 187 \times 0.85 \times 0.7 \times 0.87 =$	173
Total Solar Gain			<u>9172W</u>

Total summer gains, $G = 9172 + 1267 [55] = 10439$

Summer Gain/Loss ratio = $10439/1053 = 9.91$

Region: Midlands Mean summer air temperature = 15.5°C

Thermal mass parameter, TMP = 12 (user-entered value)

$\Delta T_{mass} = 0$

$T_{threshold} = 15.50 + 9.91 + 0 = 25.41^\circ C$

Likelihood of high internal temperatures during summer weather: **HIGH !**

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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:	489.00	5.51	2694.39	[1]
Total floor area:	489.00 [5]	Volume:	2694.39	[6]

Ventilation Rate

Infiltration due to chimneys, flues and fans:	ACH	0.00	[10]
Number of storeys: 1			[1])
Structural infiltration (masonry):	0.35		[13]
100% of windows and doors are draught stripped:			[16]
Resulting infiltration:	$0.25 - (0.2 \times 100/100) = 0.05$		[17]
Infiltration rate:	0.40		[19]
1 sheltered side: shelter factor = 0.925			[21]
Adjusted infiltration rate = 0.40 x 0.93		0.37	[22]
Natural ventilation:			
Effective air change rate		0.57	[24]
		0.57	[25]

Heat Loss Summary

Heat loss through structure (b/f from building summary):	W/K	846.34	[33]
Thermal bridges 0.08 x 1470.08:		117.61	[34]
Total fabric heat loss:		963.94	[35]
Ventilation heat loss:	$0.57 [25] \times 0.33 \times 2694.39 [6] = 505.44$		[36]
Specific heat loss:		1469.38	[37]
Heat loss parameter:		$1469.38/489.0 = 3.00$	[38]

Water Heating Energy Requirements

Source: Point of use			
Fuel: Electricity (standard tariff)			
Energy content of heated water (Table 1a N=8.000):		4319	[39]
Primary circuit loss :		0	[48]
Solar input:		0	[50]
Required output from water heater:		4319	[51]
Heat gains from water heating:	$0.25 \times 4319 + 0.8 \times 0 = 1080$		[52]

Gains

Lighting, appliance & metabolic gains (Table 5 N=8.000):	Watts	1,428	[53]
Reduction due to low energy lighting (90%):		-295	[53a]
Central heating pump: 10.0			
Total additional gains		10	[53b]
Water heating:	$1080/8.72 = 123$		[54]
Total internal gains:		1,267	[55]
Total solar gains (B/F from solar-related report):		4,054	[65]
Total gains		5,321	[66]
Gains/Loss ratio (GLR) = 5321/1469.4 [37] = 3.621			[67]
Utilisation factor (Table 7): 0.99			[68]
Useful gains:	$5321 \times 0.99 = 5,284$		[69]

Mean internal temperature

Living area mean temperature: Table 8 col.4; HLP [38] = 3.00	°C	20.13	[70]
Control adjustment (Table 4e)		0.00	[71]
Heating system responsiveness (R) = 0.25 (Table 4d)			
Adjustment for gains:	$0.2 \times R \times ((5284 [69]/1469.4 [37]) - 4.0) = -0.02$		[72]
Adjusted living room temperature:		20.11	[73]
Temperature difference between zones : (Table 9 col 1)		1.15	[74]
Living area fraction: 0.78			[75]

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Rest-of-house fraction: 0.22 [76]
 Mean internal temperature: 20.11 - (1.15 x 0.22) = 19.86 [77]

Degree Days

Temperature rise from gains: 5284 [69]/1469.4 [37] = 3.60 [78]
 Base temperature: 19.86 - 3.60 = 16.26 [79]
 Degree days (Table 10): 2313 [80]

Space heating requirements

Energy requirement (useful): 0.024 x 2313 x 1469.4 [37] = 81579 [81]
 Heat from secondary system: 10% (Table 11) [82]

Primary system: Gas boiler, automatic ignition, 1998 or later
 Underfloor heating, pipes in screed
 Controls: Programmer + roomstat
 Fuel: Mains Gas
 Efficiency: 73% (Table 4b) [83]
 Fuel required: 81579 x 0.90 x 100/73 = 100577 [85]

Secondary system: Electric convector or radiant panel heaters
 Fuel: Electricity (standard tariff)
 Efficiency: 100% (Table 4a) [84]
 Fuel required: 81579 x 0.10 x 100/100 = 8158 [85a]

Water heating energy requirement (net): 4319 kW [51]
 Source: Point of use
 Efficiency : 100% [86]
 Energy required: 4319 [51] x 100/100 = 4319 [86a]
 Electricity for pumps & fans: 175 [87]
 Electricity for lighting (B/F from Solar report) 2401

Fuel Costs

Space heating: Primary system: 100577 x 1.63p = 1639.41 [88]
 Secondary system: 8158 x 7.12p = 580.84 [89]
 Water heating: 4319 x 7.12p = 307.49 [91b]
 Pump/fan energy cost: 175 x 7.12p = 12.46 [92]
 Lighting energy cost: 2401 x 7.12p = 170.96 [93]
 Additional standing charges (Table 12): Gas 34.00 [94]
 Total heating cost: 2745.16 [97]

SAP Rating

Energy cost deflator (Table 12, footnote 2): 0.91 [98]
 Energy cost factor (ECF) £/m²: (2745.16 x 0.91 - 30)/(489.00 + 45.0) = 4.62 [99]
 SAP value = 37.8697 [100]

SAP Rating = 38 Band F

CO₂ Emissions

Primary heating system (mains gas) 100577 [85] x 0.194 = 19,512 [101]
 Secondary heating system (electricity) 8158 [85a] x 0.422 = 3,443 [102]
 Water heating (electricity) 4319 [86a] x 0.422 = 1822 [103]
 Total for space and water heating 24777 [107]
 Electricity for pumps and fans 175 [87] x 0.422 = 74 [108]
 Electricity for lighting, C_L 2401 x 0.422 = 1013 [109]
 New technology: None:
 Total: 25,864 [112]

Carbon Factor, CF = 25864/(489.00 + 45) = 48.43 EI = 40.00

EI Rating = 40 Band E

Primary energy

	Energy kWh/Yr	Primary Factor	P.Energy kWh/yr	
Space heating	100577	1.15	115664	[101]

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Secondary heating	8158	2.80	22842	[102]
Water heating	4319	2.80	12092	[103]
Electricity for pumps and fans	175	2.80	490	[108]
Electricity for lighting	2401	2.80	6723	[109]
New Technology: Energy saved	0	0.00	0	[110]
New Technology: Energy used	0	0.00	0	[111]
			157,811	[112]
			323	[113]

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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:	489.00	5.51	2694.39	[1]
Total floor area:	489.00 [5]	Volume:	2694.39	[6]

Ventilation Rate

Infiltration due to chimneys, flues and fans:		ACH	0.00	[10]
Number of storeys: 1				[11]
Structural infiltration (masonry):		0.35		[13]
100% of windows and doors are draught stripped:				[16]
Resulting infiltration:		$0.25 - (0.2 \times 100/100) = 0.05$		[17]
Infiltration rate:		0.40		[19]
1 sheltered side: shelter factor = 0.925				[21]
Adjusted infiltration rate = 0.40 x 0.93		0.37		[22]
Natural ventilation:				
Effective air change rate		0.57		[24]
		0.57		[25]

Heat Loss Summary

Heat loss through structure (b/f from building summary):		W/K	846.34	[33]
Thermal bridges 0.08 x 1470.08:			117.61	[34]
Total fabric heat loss:			963.94	[35]
Ventilation heat loss:		$0.57 [25] \times 0.33 \times 2694.39 [6] = 505.44$		[36]
Specific heat loss:			1469.38	[37]
Heat loss parameter:			$1469.38/489.0 = 3.00$	[38]

Water Heating Energy Requirements

Source: Point of use				
Fuel: Electricity (standard tariff)				
Energy content of heated water (Table 1a N=8.000):			4319	[39]
Primary circuit loss :			0	[48]
Solar input:			0	[50]
Required output from water heater:			4319	[51]
Heat gains from water heating:		$0.25 \times 4319 + 0.8 \times 0 = 1080$		[52]

Gains

Lighting, appliance & metabolic gains (Table 5 N=8.000):		Watts	1,428	[53]
Reduction due to low energy lighting (30% assumed):			-98	[53a]
Central heating pump: 10.0				
Total additional gains			10	[53b]
Water heating:		$1080/8.72 = 123$		[54]
Total internal gains:			1,463	[55]
Total solar gains (B/F from solar-related report):			4,054	[65]
Total gains			5,517	[66]
Gains/Loss ratio (GLR) = 5517/1469.4 [37] = 3.755				[67]
Utilisation factor (Table 7): 0.99				[68]
Useful gains:		$5517 \times 0.99 = 5,471$		[69]

Mean internal temperature

Living area mean temperature: Table 8 col.4; HLP [38] = 3.00		°C	20.13	[70]
Control adjustment (Table 4e)			0.00	[71]
Heating system responsiveness (R) = 0.25 (Table 4d)				
Adjustment for gains:		$0.2 \times R \times ((5471 [69]/1469.4 [37]) - 4.0) = -0.01$		[72]
Adjusted living room temperature:			20.12	[73]
Temperature difference between zones : (Table 9 col 1)			1.15	[74]
Living area fraction: 0.78				[75]

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Rest-of-house fraction: 0.22 [76]
 Mean internal temperature: 20.12 - (1.15 x 0.22) = 19.87 [77]

Degree Days

Temperature rise from gains: 5471 [69]/1469.4 [37] = 3.72 [78]
 Base temperature: 19.87 - 3.72 = 16.14 [79]
 Degree days (Table 10): 2284 [80]

Space heating requirements

kWh/year

Energy requirement (useful): 0.024 x 2284 x 1469.4 [37] = 80552 [81]
 Heat from secondary system: 10% (Table 11) [82]

Primary system: Gas boiler, automatic ignition, 1998 or later
 Underfloor heating, pipes in screed
 Controls: Programmer + roomstat
 Fuel: Mains Gas
 Efficiency: 73% (Table 4b) [83]
 Fuel required: 80552 x 0.90 x 100/73 = 99311 [85]

Secondary system: Electric convector or radiant panel heaters
 Fuel: Electricity (standard tariff)
 Efficiency: 100% (Table 4a) [84]
 Fuel required: 80552 x 0.10 x 100/100 = 8055 [85a]

Water heating energy requirement (net): 4319 kW [51]

Source: Point of use
 Efficiency : 100% [86]
 Energy required: 4319 [51] x 100/100 = 4319 [86a]

Electricity for pumps & fans: 175 [87]
 Electricity for lighting (B/F from Solar report) 3711

CO₂ Emissions

kg/year

Primary heating system (mains gas) 99311 [85] x 0.194 = 19,266 [101]
 Secondary heating system (electricity) 8055 [85a] x 0.422 = 3,399 [102]
 Water heating (electricity) 4319 [86a] x 0.422 = 1822 [103]
 Total for space and water heating 24488 [107]
 Electricity for pumps and fans 175 [87] x 0.422 = 74 [108]
 Electricity for lighting, C_L 3711 x 0.422 = 1566 [109]

Total: 26,128 [112]

Dwelling Carbon Dioxide Emission Rate (DER) = 53.43

(26,128/489.00)

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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)	297.12	0.35	103.99
DG wood frame window 16mm gap low-E glass (en=0.2)	120.40	2.00	222.96
Solid wood door	1.85	2.00	3.70
Floors	493.50	0.25	123.38
Roofs	557.21	0.16	89.15
Total heat loss (C/F to [33])			543.18

Overall Dwelling Dimensions

	Area m ²	Avg ht m.	Vol. m ³	
Ground/entrance level:	489.00	5.51	2694.39	[1]
Total floor area:	489.00 [5]	Volume:	2694.39	[6]

Ventilation Rate

Fans and passive vents:	ACH			
Infiltration due to chimneys, flues and fans:	3 x 10/2694.39 = 0.01			[9]
Default q ₅₀ value = 10.00	0.01			[10]
Infiltration rate:	10.00/20 = 0.50			
2 sheltered sides: shelter factor = 0.85	0.51			[19]
Adjusted infiltration rate = 0.51 x 0.85	0.43			[22]
Natural ventilation:				
Effective air change rate	0.59			[24]
	0.59			[25]

Heat Loss Summary

Heat loss through structure (from above):		W/K		
Thermal bridges 0.11 x 1470.08:		543.18		[33]
Total fabric heat loss:		161.71		[34]
Ventilation heat loss:		704.89		[35]
Specific heat loss:	0.59 [25] x 0.33 x 2694.39 [6] = 528.49			[36]
Heat loss parameter:		1233.38		[37]
		1233.38/489.0 = 2.52		[38]

Water Heating Energy Requirements

Source: Primary heating system (Gas boiler, automatic ignition, 1998 or later)		kWh/year		
Fuel: Mains Gas				
Energy content of heated water (Table 1a N=8.000):		4319		[39]
Distribution loss (Table 1b):		762		[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:		6215		[51]
Heat gains from water heating:	0.25 x 4319 + 0.8 x (762+524+610) = 2597			[52]

Gains

Lighting, appliance & metabolic gains (Table 5 N=8.000):		Watts		
Reduction due to low energy lighting (30% assumed):		1,428		[53]
Central heating pump: 10.0		-98		[53a]
Total additional gains		10		[53b]
Water heating:		2597/8.72 = 296		[54]
Total internal gains:		1,636		[55]

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Total solar gains (B/F from solar-related report):		2,019	[65]
Total gains		3,655	[66]
Gains/Loss ratio (GLR) = 3655/1233.4 [37] = 2.963			[67]
Utilisation factor (Table 7): 1.00			[68]
Useful gains:	3655 x 1.00 = 3,646		[69]
Mean internal temperature		°C	
Living area mean temperature: Table 8 col.1; HLP [38] = 2.52		18.81	[70]
Control adjustment (Table 4e)		0.00	[71]
Heating system responsiveness (R) = 1.00 (Table 4d)			
Adjustment for gains:	$0.2 \times R \times ((3646 [69]/1233.4 [37]) - 4.0) = -0.21$		[72]
Adjusted living room temperature:		18.60	[73]
Temperature difference between zones : (Table 9 col 2)		1.65	[74]
Living area fraction: 0.78			[75]
Rest-of-house fraction: 0.22			[76]
Mean internal temperature:	$18.60 - (1.65 \times 0.22) = 18.24$		[77]
Degree Days			
Temperature rise from gains:	$3646 [69]/1233.4 [37] = 2.96$		[78]
Base temperature:	$18.24 - 2.96 = 15.28$		[79]
Degree days (Table 10):		2080	[80]
Space heating requirements		kWh/year	
Energy requirement (useful):	$0.024 \times 2080 \times 1233.4 [37] = 61576$		[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:	$61576 \times 0.90 \times 100/78 = 71050$		[83] [85]
Secondary system:	Portable electric heaters Fuel: Electricity (standard tariff) Efficiency: 100% (Table 4a)		
Fuel required:	$61576 \times 0.10 \times 100/100 = 6158$		[84] [85a]
Water heating energy requirement (net): 6215 kW [51]			
Source: Primary heating system			
Efficiency : 78% (Manufacturer's declared value)			[86]
Energy required:	$6215 [51] \times 100/78 = 7968$		[86a]
Electricity for pumps & fans:		175	[87]
Electricity for lighting (B/F from Solar report)		3711	
CO₂ Emissions			kg/year
Primary heating system (mains gas)	$71050 [85] \times 0.194 = 13,784$		[101]
Secondary heating system (electricity)	$6158 [85a] \times 0.422 = 2,599$		[102]
Water heating (mains gas)	$7968 [86a] \times 0.194 = 1546$		[103]
Total for space and water heating	<u>17928</u>		[107]
Electricity for pumps and fans	$175 [87] \times 0.422 = 74$		[108]
Electricity for lighting, C _L	$3711 \times 0.422 = 1566$		[109]
New technology: None			
	Total:	<u>19,568</u>	[112]

$$C_H = (17928 + 74)/489.00 = 36.81 \quad C_L = 1566/489.00 = 3.20$$

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

$$\text{Target CO}_2 \text{ Emission Rate (TER)} = (C_H \times \text{Fuel Factor} + C_L) \times (1 - \text{imp factor}) \\ = (36.81 \times 1.00 + 3.20) \times (1 - 0.20) = \mathbf{32.01}$$