Review of RBKC Basement Publication Policy, Operational Carbon emissions, July 2013

Prepared by Bespoke Builder Services Ltd
on behalf of Cranbrook
August 2013

ROPP6682 Issue 1

Contents

I. Executive Summary

This document reviews the planning consultation document, regarding Basements, published by The Royal Borough of Kensington and Chelsea July 2013 in relation to the Operations Carbon dioxide emissions. The keys conclusions are stated below.

- Operational Carbon dioxide emissions analysis used to support consultation document is flawed
- Calculation methodology is totally inappropriate
- Actual quoted assessed dwellings differ from the SAP calculations

This report details an appropriate calculation approach, assessing like for like extensions below & above ground level.

- Illustrates key thermal performance factors that will affect operational Carbon dioxide emissions within SAP2009 methodology.
- Completes analysis that demonstrates that there is no fundamental variation in emissions building below or above ground level.

About Bespoke Builder Services Ltd

Bespoke Builder Services Ltd is a construction consultancy specialising in sustainability, energy conservation and the application of renewable energy technologies. As a consultancy we do not sell products, so we are able to take an objective view of a development to assist developers in incorporating the most cost effective and practical solutions.

Our range of services includes specialist pre-planning reports, energy consumption calculations for Building Regulations purposes, and broader environmental and sustainability studies and reports and CSH, EcoHomes and Breeam assessments. Our team of consultants includes registered SAP Assessors, registered CSH, EcoHomes and Breeam Assessors, Planning Specialists, Chartered Engineers and Chartered Surveyors.

A sister consultancy is a Corporate Approved Inspector – approved to provide Building Control services in the residential sector, and where necessary we are able to draw on this additional expertise to ensure that all advice given in respect of energy conservation and sustainability will also meet all other constraints imposed by the Building regulations.

Established in 2001 by two directors with many years experience in the construction industry, and latterly, with the NHBC, the practice has grown steadily since, and to date has carried out hundreds of EcoHomes assessments, and many thousands of SAP assessments. By applying this expertise to assist developers to understand and meet the new obligations for sustainability, energy conservation and on-site renewable energy systems, we are able to help ensure that these vitally important issues are addressed in a transparent way, where the needs and responsibilities of all the stakeholders are fully respected.

Report prepared by:	Andrew Mitchell BEng
	15th August 2013
Assessment type:	Review of planning consultation document, regarding the Basement, published by The Royal Borough of Kensington and Chelsea July 2013

1. Introduction

This document reviews the planning consultation document, regarding Basements, published by The Royal Borough of Kensington and Chelsea July 2013.

It specifically looks at the statement detailed within paragraph 34.3.53,–

> *The carbon emissions of basements are greater than those of above ground development per square metre over the life cycle*

The consultation document quotes the following document as part of the evidence to support this statement –

> *Life Cycle carbon Analysis of Extensions & Subterranean Development in RBK&C, Eight associates, August 2010*

This review analysis's the operation carbon emissions as defined by building regulations and associated British and ISO standards and demonstrates that there is no fundament variation in the operational carbon dioxide emission of a construction built over or below ground.

2. Document review

The Eight associates' document reviews two contrasting improvements to existing properties –

- Case study 1, subterranean development of 75m^2
- Case study 2, ground level development of 10.35m^2

The report concludes that study 1 (basement) has an operation carbon emission of 1065 $kgCO_2/m^2$ compared to the ground level study 2 of 780 $kgCO_2/m^2$.

Following a Freedom of information request we have obtained the SAP calculations used for the Eight Associate reports. These SAP results do not correspond with the quoted extensions stated with the report. The floor areas differ.

The key area of concern regarding this analysis is that the two assessed developments are totally different in size and style. This review will highlight a more robust assessment methodology.

3. Assessment analysis

Operational carbon emissions are calculated via the approved building regulations methodology, SAP2009 as defined within part L2010 of the building regulations.

SAP2009 calculates total carbon dioxide emission for a dwelling. The key data inputs are –

- Dwelling fabric performance - U values, air tightness & thermal bridging
- Energy consumption – heating systems, lighting & ventilation

The above details are defined and entering into the approved software. From this a dwelling emissions (carbon dioxide) rate is calculated.

In order for the Eight associates analysis to be robust I suggest that the two reviewed properties need to have be fundamental the same, but one being a basement & the second at ground level.

Published analysis does not indicate the heat loss envelope U values, heating system or lighting details. The large variation in floor area effects the floor to heat loss ratio.

In order to complete this analysis correctly the same extension needs to be reviewed above & below ground. All the following elements need to remain constant in order for the SAP analysis to assessment which is more operationally Carbon efficient

- Constant heat loss areas
- Constant construction thermal build up
- Same heating & lighting strategy

4. Amended calculation methodology

The keys SAP performance variation between the ‘constant’ subterranean extension to the ground level one will be the actual thermal performance of the element below ground, for the same ‘constant’ construction. The insulated floor and walls below ground will have an improved U value, compared to there above ground version. This is due to the additional insulating properties of the surrounding ground and increased surface resistances (as the elements below ground are protected from wind).

This is illustrated by the following analysis.

Ground floor construction-	Slab on ground, 100mm celotex (K=0.023) & screed
Wall construction-	200mm masonry, 100mm battens with mineral wool (K = 0.038) & Plasterboard

At ground level U[1,2] values are	Floor = 0.16 W/m^{2}K Wall = 0.32 W/m^{2}K
1 metre below ground level	Floor = 0.15 W/m^{2}K Wall = 0.32 W/m^{2}K
2 metres below ground level	Floor = 0.14 W/m^{2}K Wall = 0.27 W/m^{2}K

If we assume that the extension has the following dimensions we can work out the area weighted U value at each depth –

Floor Area = 25 m2
Perimeter = 10 m
Wall height = 2.6 m

1. U values calculation methodology has been completed as defined within BS EN ISO 6946
2. U values calculation outputs in Appendix A

At ground level area weighted U value = 0.242 W/m^2K

1 metre below ground level area weighted U value = 0.236 W/m^2K

2 metre below ground level area weighted U value = 0.212 W/m^2K

From this thermal element performance analysis is it evident that for a given extension (constant size, construction and heating lighting details) there is a thermal improvement in constructing it below ground level. For a given construction the resulting U value will improve and this will be evident within the SAP2009 calculations.

5. SAP 2009 Analysis

Taking the same extension as detailed in section 4, SAP2009 analysis has been completed for the construction above ground and 2 metres below. The only variation being the improvement to floor & wall for the basement option as details in section 4.

SAP results

Extension at ground level[3] = Dwelling Emissions Rate (DER) 29.89 $kgCO_2/m^2$

2 metres below ground level = Dwelling Emissions Rate (DER) 29.13 $kgCO_2/m^2$

SAP improvement for basement extension = 2.54%

In order to complete the above analysis SAP2009 required the inclusion of windows. Within the approved calculation methodology windows have two key properties within the assessment. Firstly they result in an area of increased heat loss (due to there higher U values when compared to wall constructions) and secondly they offer solar gain which in turn reduces heating demand.

In the example above both reviewed extension have the same windows area and therefore this will not affect the comparative results.

SAP2009 calculates the solar gain via the window area, geographical location of the property and the orientation of the windows. Calculated solar gain reduced the heating demand, which therefore reduces demand on space heating fuel, improving the DER.

3. SAP2009 calculation worksheets in Appendix A

All the calculation analysis has been completed on the ‘same’ extension at ground level & two metre below. The only variation within the analysis to date has been the improved wall & floor U value as a result of basement construction. We also need to account for the likely variation in delivered solar gains, as the basement is very likely to have windows that are shaded, reducing the solar gain affect. SAP2009 allows for shading of windows to be included within the calculation.

SAP results (including over shading for basement window)

Extension at ground level[2] = Dwelling Emissions Rate (DER) 29.89 $kgCO_2/m^2$

2 metres below ground level = Dwelling Emissions Rate (DER) 29.71 $kgCO_2/m^2$

SAP improvement for basement extension = 0.6%

The above illustrates that a subterranean development has no notable effect on the annual carbon dioxide emission for a give extension. The two key SAP2009 variables when constructing below ground, improved U values and lowering of solar gains, will offset each other.

6. Conclusion

The above analysis concludes that a subterranean extension has a neutral effect of the operational carbon dioxide emissions when compared to a ground level extension.

Analysis completed by Eight associates' used to support the argument within the planning consultation document, regarding operation CO_2 emissions for Basements is flawed. The two examples reviewed are totally different in all terms of, size, form & construction therefore they do not offer a realistic assessment.

The above analysis concludes that only two key properties included within the SAP2009 calculation methodology are affected by building under ground.

1. Below ground construction elements have improved U values, reducing CO_2 emissions.
2. Solar gains are reduced, below ground, increasing CO_2 emissions

The net result is that there is no fundament variation in the operational carbon dioxide emission of a construction built over or below ground. The savings from improve thermal performance are off set be the reduced solar gains.

U-value calculation
by BRE U-value Calculator version 2.02
Printed on 15 Aug 2013 at 09:55

Filename: M:\EcoHomes Jobs\Cranbrook Basements\BBS 6682 Review of K & C planning\Basements U values.uva (File saved: 14 Aug 2013 18:29)

Element type: Heated basement
Calculation Method: BS EN ISO 6946, BS EN ISO 13370

Basements

Thermal resistance of basement floor construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.170		Rsi
1	75	1.200			1800	1000	0.062		screed
2	100	0.023			20	1030	4.348		insulation board
	175 mm						4.580		

Total resistance: Upper limit: 4.580 Lower limit: 4.580 Ratio: 1.000 Average: 4.580 m²K/W

Thermal resistance of basement wall construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.130		Rsi
1	12.5	0.210			700	1000	0.060		Plasterboard
2									Vapour control layer
3	100	0.038	0.130	0.118	20	1030	2.632	0.769	insulation between battens
4	200	1.210			2000	1000	0.165		masonry
	313 mm						2.986		

Total resistance: Upper limit: 2.498 Lower limit: 2.402 Ratio: 1.040 Average: 2.450 m²K/W

Ground parameters:

Perimeter P:	10.00 m	Wall thickness:	300 mm
Area A:	25.00 m²	Ground type:	Clay/silt (λ = 1.5 W/m·K)
P/A:	0.400	Rse:	0.04 m²K/W
Average basement depth:	0.000 m		
Area of basement walls:	0.00 m²		

	Floor	Walls	Overall (area-weighted average)
U-value	0.158	0.000	0.158
U-value (rounded)	**0.16**	**0.00**	**0.16 W/m²K**
Heat capacity per m² (κ)	135.0	8.8	135.0 Btu/ft²·°F

Calculated by:
Andy Mitchell

U-value calculation
by BRE U-value Calculator version 2.02
Printed on 15 Aug 2013 at 09:55

Filename: M:\EcoHomes Jobs\Cranbrook Basements\BBS 6682 Review of K & C planning\Basements U values.uva (File saved: 14 Aug 2013 18:29)

Element type: Heated basement
Calculation Method: BS EN ISO 6946, BS EN ISO 13370

Basements

Thermal resistance of basement floor construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.170		Rsi
1	75	1.200			1800	1000	0.062		screed
2	100	0.023			20	1030	4.348		insulation board
	175 mm						4.580		

Total resistance: Upper limit: 4.580 Lower limit: 4.580 Ratio: 1.000 Average: 4.580 m²K/W

Thermal resistance of basement wall construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.130		Rsi
1	12.5	0.210			700	1000	0.060		Plasterboard
2									Vapour control layer
3	100	0.038	0.130	0.118	20	1030	2.632	0.769	insulation between battens
4	200	1.210			2000	1000	0.165		masonry
	313 mm						2.986		

Total resistance: Upper limit: 2.498 Lower limit: 2.402 Ratio: 1.040 Average: 2.450 m²K/W

Ground parameters:

Perimeter P:	10.00 m	Wall thickness:	300 mm
Area A:	25.00 m²	Ground type:	Clay/silt (λ = 1.5 W/m·K)
P/A:	0.400	Rse:	0.04 m²K/W
Average basement depth:	1.000 m		
Area of basement walls:	10.00 m²		

	Floor	Walls	Overall (area-weighted average)
U-value	0.150	0.316	0.197
U-value (rounded)	**0.15**	**0.32**	**0.20 W/m²K**
Heat capacity per m² (κ)	135.0	8.8	98.9 Btu/ft²·°F

Calculated by:
Andy Mitchell

U-value calculation
by BRE U-value Calculator version 2.02
Printed on 15 Aug 2013 at 09:56

Filename: M:\EcoHomes Jobs\Cranbrook Basements\BBS 6682 Review of K & C planning\Basements U values.uva (File saved: 14 Aug 2013 18:29)

Element type: Heated basement
Calculation Method: BS EN ISO 6946, BS EN ISO 13370

Basements

Thermal resistance of basement floor construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.170		Rsi
1	75	1.200			1800	1000	0.062		screed
2	100	0.023			20	1030	4.348		insulation board
	175 mm						4.580		

Total resistance: Upper limit: 4.580 Lower limit: 4.580 Ratio: 1.000 Average: 4.580 m²K/W

Thermal resistance of basement wall construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.130		Rsi
1	12.5	0.210			700	1000	0.060		Plasterboard
2									Vapour control layer
3	100	0.038	0.130	0.118	20	1030	2.632	0.769	insulation between battens
4	200	1.210			2000	1000	0.165		masonry
	313 mm						2.986		

Total resistance: Upper limit: 2.498 Lower limit: 2.402 Ratio: 1.040 Average: 2.450 m²K/W

Ground parameters:

Perimeter P: 10.00 m
Area A: 25.00 m²
P/A: 0.400
Average basement depth: 2.000 m
Area of basement walls: 20.00 m²

Wall thickness: 300 mm
Ground type: Clay/silt (λ = 1.5 W/m·K)
Rse: 0.04 m²K/W

	Floor	Walls	Overall (area-weighted average)
U-value	0.143	0.271	0.200
U-value (rounded)	**0.14**	**0.27**	**0.20 W/m²K**
Heat capacity per m² (κ)	135.0	8.8	78.9 Btu/ft²·°F

Calculated by:
Andy Mitchell

U-value calculation
by BRE U-value Calculator version 2.02
Printed on 15 Aug 2013 at 09:56

Filename: M:\EcoHomes Jobs\Cranbrook Basements\BBS 6682 Review of K & C planning\wall construction.uva (File saved: 14 Aug 2013 18:29)

Element type: Wall - Timber framed - insulation between studs
Calculation Method: BS EN ISO 6946

wall construction

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.130		Rsi
1	12.5	0.210			700	1000	0.060		Plasterboard
2									Vapour control layer
3	140	0.038	0.130	0.150	20	1030	3.684	1.077	insulation / timber frame
4	200	1.210			1700	800	0.165		Brick outer leaf
							0.040		Rse
	353 mm (total wall thickness)						4.079		

Total resistance: Upper limit: 3.223 Lower limit: 3.098 Ratio: 1.040 Average: 3.160 m^2K/W

U-value (uncorrected) 0.3164

U-value corrections
Air gaps in layer 3 ΔU = 0.0082 (Level 1)

Total ΔU 0.0082

U-value (corrected) 0.325 (0.3246)
U-value (rounded) 0.32 W/m^2K

Heat capacity per m^2 (κ) 8.8 kJ/m^2K

Calculated by:
Andy Mitchell

U-value calculation
by BRE U-value Calculator version 2.02
Printed on 15 Aug 2013 at 09:57

Filename: M:\EcoHomes Jobs\Cranbrook Basements\BBS 6682 Review of K & C planning\Basements U values.uva (File saved: 14 Aug 2013 18:29)

Element type: Heated basement
Calculation Method: BS EN ISO 6946, BS EN ISO 13370

Basements

Thermal resistance of basement floor construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.170		Rsi
1	75	1.200			1800	1000	0.062		screed
2	100	0.023			20	1030	4.348		insulation board
	175 mm						4.580		

Total resistance: Upper limit: 4.580 Lower limit: 4.580 Ratio: 1.000 Average: 4.580 m²K/W

Thermal resistance of basement wall construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.130		Rsi
1	12.5	0.210			700	1000	0.060		Plasterboard
2									Vapour control layer
3	100	0.038	0.130	0.118	20	1030	2.632	0.769	insulation between battens
4	200	1.210			2000	1000	0.165		masonry
	313 mm						2.986		

Total resistance: Upper limit: 2.498 Lower limit: 2.402 Ratio: 1.040 Average: 2.450 m²K/W

Ground parameters:

Perimeter P:	10.00 m	Wall thickness:	300 mm
Area A:	25.00 m²	Ground type:	Clay/silt (λ = 1.5 W/m·K)
P/A:	0.400	Rse:	0.04 m²K/W
Average basement depth:	1.000 m		
Area of basement walls:	10.00 m²		

	Floor	Walls	Overall (area-weighted average)
U-value	0.150	0.316	0.197
U-value (rounded)	**0.15**	**0.32**	**0.20 W/m²K**
Heat capacity per m² (κ)	135.0	8.8	98.9 Btu/ft²·°F

Calculated by:
Andy Mitchell

U-value calculation
by BRE U-value Calculator version 2.02
Printed on 15 Aug 2013 at 09:57

Filename: M:\EcoHomes Jobs\Cranbrook Basements\BBS 6682 Review of K & C planning\Basements U values.uva (File saved: 14 Aug 2013 18:29)

Element type: Heated basement
Calculation Method: BS EN ISO 6946, BS EN ISO 13370

Basements

Thermal resistance of basement floor construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.170		Rsi
1	75	1.200			1800	1000	0.062		screed
2	100	0.023			20	1030	4.348		insulation board
	175 mm						4.580		

Total resistance: Upper limit: 4.580 Lower limit: 4.580 Ratio: 1.000 Average: 4.580 m^2K/W

Thermal resistance of basement wall construction:

Layer	d (mm)	λ layer	λ bridge	Fraction	Density	Sp. heat	R layer	R bridge	Description
							0.130		Rsi
1	12.5	0.210			700	1000	0.060		Plasterboard
2									Vapour control layer
3	100	0.038	0.130	0.118	20	1030	2.632	0.769	insulation between battens
4	200	1.210			2000	1000	0.165		masonry
	313 mm						2.986		

Total resistance: Upper limit: 2.498 Lower limit: 2.402 Ratio: 1.040 Average: 2.450 m^2K/W

Ground parameters:

Perimeter P:	10.00 m	Wall thickness:	300 mm
Area A:	25.00 m^2	Ground type:	Clay/silt ($\lambda = 1.5$ W/m·K)
P/A:	0.400	Rse:	0.04 m^2K/W
Average basement depth:	2.000 m		
Area of basement walls:	20.00 m^2		

	Floor	Walls	Overall (area-weighted average)
U-value	0.143	0.271	0.200
U-value (rounded)	**0.14**	**0.27**	**0.20 W/m²K**
Heat capacity per m² (κ)	135.0	8.8	78.9 Btu/ft²·°F

Calculated by:
Andy Mitchell

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:		**Stroma Number:**	
Software Name:	Stroma FSAP 2009	**Software Version:**	Version: 1.5.0.49

Property Address: Base ground level

Address : Base ground level , TN3 8LA

1. Overall dwelling dimensions:

	Area(m²)			Ave Height(m)			Volume(m³)	
Ground floor	25	(1a)	x	2.6	(2a)	=	65	(3a)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	25	(4)						
Dwelling volume					(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)	=	65	(5)

2. Ventilation rate:

	main heating		Secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							1	x 10 =	10	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	10	÷ (5) =	0.15	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction *if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35*		0	(11)
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		7	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.5	(18)

Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used

Number of sides on which sheltered		0	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	1	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.5	(21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.4	5.1	5.1	4.5	4.1	3.9	3.7	3.7	4.2	4.5	4.8	5.1
Wind Factor (22a)m = (22)m ÷ 4												
(22a)m=	1.35	1.27	1.27	1.12	1.02	0.98	0.92	0.92	1.05	1.12	1.2	1.27

DER WorkSheet: New dwelling design stage

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.68	0.64	0.64	0.57	0.52	0.49	0.47	0.47	0.53	0.57	0.6	0.64

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside

if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft

if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.73	0.71	0.71	0.66	0.63	0.62	0.61	0.61	0.64	0.66	0.68	0.71	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.73	0.71	0.71	0.66	0.63	0.62	0.61	0.61	0.64	0.66	0.68	0.71	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Windows Type 1			1.44	x1/[1/(1.8)+ 0.04]		=	2.42			(27)
Windows Type 2			1.44	x1/[1/(1.8)+ 0.04]		=	2.42			(27)
Floor			25	x	0.16	=	4			(28)
Walls	26	2.88	23.12	x	0.32	=	7.4			(29)
Total area of elements, m²			51							(31)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*

*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 16.23 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 2958.08 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 4.08 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 20.31 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	15.69	15.15	15.15	14.17	13.59	13.31	13.05	13.05	13.73	14.17	14.65	15.15	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	36	35.47	35.47	34.49	33.9	33.63	33.37	33.37	34.04	34.49	34.96	35.47	

Average = Sum(39)$_{1..12}$ /12= 34.55 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.44	1.42	1.42	1.38	1.36	1.35	1.33	1.33	1.36	1.38	1.4	1.42	

Average = Sum(40)$_{1..12}$ /12= 1.38 (40)

DER WorkSheet: New dwelling design stage

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N	1.0885	(42)
if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)		
if TFA £ 13.9, N = 1		
Annual average hot water usage in litres per day Vd,average = (25 x N) + 36	60.052	(43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)														
(44)m=	66.06	63.66	61.25	58.85	56.45	54.05	54.05	56.45	58.85	61.25	63.66	66.06		
										Total = Sum(44)$_{1...12}$ =			720.6243	(44)
Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)														
(45)m=	98.2	85.88	88.62	77.26	74.14	63.97	59.28	68.03	68.84	80.22	87.57	95.1		
										Total = Sum(45)$_{1...12}$ =			947.1126	(45)
If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)														
(46)m=	14.73	12.88	13.29	11.59	11.12	9.6	8.89	10.2	10.33	12.03	13.14	14.26		(46)

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day):		0	(47)
Temperature factor from Table 2b		0	(48)
Energy lost from water storage, kWh/year	(47) x (48) =	0	(49)
If manufacturer's declared cylinder loss factor is not known:			
Cylinder volume (litres) including any solar storage within same		0	(50)

If community heating and no tank in dwelling, enter 110 litres in box (50)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in box (50)

Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	((50) x (51) x (52) x (53) =	0	(54)
Enter (49) or (54) in (55)		0	(55)
Water storage loss calculated for each month	((56)m = (55) × (41)m		

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(56)m=	0	0	0	0	0	0	0	0	0	0	0	0	(56)
If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H													
(57)m=	0	0	0	0	0	0	0	0	0	0	0	0	(57)
Primary circuit loss (annual) from Table 3												0	(58)
Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m (modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)													
(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)
Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m													
(61)m=	33.66	29.3	31.21	29.02	28.77	26.65	27.54	28.77	29.02	31.21	31.39	33.66	(61)
Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m													
(62)m=	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)

(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76	

Output from water heater (annual)1…12 | 1307.3261 | (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	41.07	35.88	37.27	32.95	31.84	27.93	26.6	29.81	30.14	34.48	36.97	40.04	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m=	8.62	7.65	6.22	4.71	3.52	2.97	3.21	4.18	5.61	7.12	8.31	8.86	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m=	86.3	87.2	84.94	80.14	74.07	68.37	64.56	63.67	65.93	70.73	76.8	82.5	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m=	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	(69)
Pumps and fans gains (Table 5a)													
(70)m=	10	10	10	10	10	10	10	10	10	10	10	10	(70)
Losses e.g. evaporation (negative values) (Table 5)													
(71)m=	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	(71)
Water heating gains (Table 5)													
(72)m=	55.2	53.39	50.09	45.76	42.8	38.8	35.75	40.07	41.87	46.34	51.34	53.81	(72)
Total internal gains =						(66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m							
(73)m=	199.44	197.57	190.59	179.94	169.72	159.47	152.85	157.24	162.73	173.52	185.77	194.49	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:		Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
East	0.9x	1	x	1.44	x	19.87	x	0.63	x	0.7	=	8.75	(76)
East	0.9x	1	x	1.44	x	38.52	x	0.63	x	0.7	=	16.95	(76)
East	0.9x	1	x	1.44	x	61.57	x	0.63	x	0.7	=	27.09	(76)
East	0.9x	1	x	1.44	x	91.41	x	0.63	x	0.7	=	40.23	(76)
East	0.9x	1	x	1.44	x	111.22	x	0.63	x	0.7	=	48.95	(76)
East	0.9x	1	x	1.44	x	116.05	x	0.63	x	0.7	=	51.07	(76)
East	0.9x	1	x	1.44	x	112.64	x	0.63	x	0.7	=	49.57	(76)
East	0.9x	1	x	1.44	x	98.03	x	0.63	x	0.7	=	43.14	(76)
East	0.9x	1	x	1.44	x	73.6	x	0.63	x	0.7	=	32.39	(76)
East	0.9x	1	x	1.44	x	46.91	x	0.63	x	0.7	=	20.64	(76)

East	0.9x	1	x	1.44	x	24.71	x	0.63	x	0.7	=	10.87	(76)
East	0.9x	1	x	1.44	x	16.39	x	0.63	x	0.7	=	7.21	(76)
West	0.9x	0.77	x	1.44	x	19.87	x	0.63	x	0.7	=	8.75	(80)
West	0.9x	0.77	x	1.44	x	38.52	x	0.63	x	0.7	=	16.95	(80)
West	0.9x	0.77	x	1.44	x	61.57	x	0.63	x	0.7	=	27.09	(80)
West	0.9x	0.77	x	1.44	x	91.41	x	0.63	x	0.7	=	40.23	(80)
West	0.9x	0.77	x	1.44	x	111.22	x	0.63	x	0.7	=	48.95	(80)
West	0.9x	0.77	x	1.44	x	116.05	x	0.63	x	0.7	=	51.07	(80)
West	0.9x	0.77	x	1.44	x	112.64	x	0.63	x	0.7	=	49.57	(80)
West	0.9x	0.77	x	1.44	x	98.03	x	0.63	x	0.7	=	43.14	(80)
West	0.9x	0.77	x	1.44	x	73.6	x	0.63	x	0.7	=	32.39	(80)
West	0.9x	0.77	x	1.44	x	46.91	x	0.63	x	0.7	=	20.64	(80)
West	0.9x	0.77	x	1.44	x	24.71	x	0.63	x	0.7	=	10.87	(80)
West	0.9x	0.77	x	1.44	x	16.39	x	0.63	x	0.7	=	7.21	(80)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	17.49	33.9	54.19	80.46	97.89	102.14	99.14	86.29	64.78	41.29	21.75	14.43	(83)

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	216.93	231.48	244.78	260.39	267.61	261.62	252	243.53	227.51	214.81	207.52	208.92	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) | 21 | (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	0.99	0.99	0.98	0.95	0.88	0.73	0.53	0.54	0.82	0.95	0.99	0.99	(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.65	19.79	20.05	20.36	20.71	20.91	20.98	20.98	20.85	20.47	19.98	19.7	(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.74	19.75	19.75	19.78	19.8	19.81	19.82	19.82	19.8	19.78	19.77	19.75	(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	0.99	0.98	0.97	0.93	0.83	0.63	0.38	0.4	0.73	0.93	0.98	0.99	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	18.54	18.69	18.95	19.28	19.61	19.77	19.81	19.81	19.72	19.38	18.89	18.61	(90)

fLA = Living area ÷ (4) = | 0.4 | (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	18.99	19.13	19.39	19.71	20.05	20.23	20.28	20.28	20.17	19.82	19.33	19.04	(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	18.84	18.98	19.24	19.56	19.9	20.08	20.13	20.13	20.02	19.67	19.18	18.89	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

Utilisation factor for gains, hm:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(94)m=	0.98	0.98	0.96	0.93	0.83	0.65	0.42	0.44	0.75	0.92	0.98	0.99	(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	213.64	226.59	235.53	241.4	222.19	170.69	106.44	106.22	169.81	198.65	202.61	205.86	(95)

Monthly average external temperature from Table 8

(96)m=	4.5	5	6.8	8.7	11.7	14.6	16.9	16.9	14.3	10.8	7	4.9	(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	516.08	495.81	441.32	374.59	277.85	184.14	107.85	107.81	194.69	305.8	425.71	496.23	(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	225.02	180.92	153.11	95.9	41.41	0	0	0	0	79.72	160.63	216.03

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 1152.74 (98)

Space heating requirement in kWh/m²/year 46.11 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system 0 (201)

Fraction of space heat from main system(s) (202) = 1 – (201) = 1 (202)

Fraction of total heating from main system 1 (204) = (202) × [1 – (203)] = 1 (204)

Efficiency of main space heating system 1 84.8 (206)

Efficiency of secondary/supplementary heating system, % 0 (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)	225.02	180.92	153.11	95.9	41.41	0	0	0	0	79.72	160.63	216.03	
(211)m = {[(98)m x (204)] + (210)m } x 100 ÷ (206) (211)	265.35	213.35	180.55	113.08	48.83	0	0	0	0	94.01	189.43	254.75	

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= 1359.36 (211)

Space heating fuel (secondary), kWh/month
= {[(98)m x (201)] + (214) m } x 100 ÷ (208)

(215)m=	0	0	0	0	0	0	0	0	0	0	0	0

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= 0 (215)

Water heating

Output from water heater (calculated above)

131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76

Efficiency of water heater 80.5 (216)

(217)m=	86.12	85.94	85.46	84.66	82.97	80.5	80.5	80.5	80.5	84.13	85.59	86.09	(217)

Fuel for water heating, kWh/month
(219)m = (64)m x 100 ÷ (217)m

(219)m=	153.1	134.03	140.22	125.55	124.03	112.58	107.85	120.24	121.57	132.45	138.99	149.57

Total = Sum(219a)$_{1...12}$ = 1560.17 (219)

Annual totals	**kWh/year**	**kWh/year**	
Space heating fuel used, main system 1		1359.36	
Water heating fuel used		1560.17	
Electricity for pumps, fans and electric keep-hot			
central heating pump:	130		(230c)

boiler with a fan-assisted flue		45		(230e)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =		175	(231)
Electricity for lighting			152.19	(232)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year	**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x	0.198	=	269.15	(261)
Space heating (secondary)	(215) x	0	=	0	(263)
Water heating	(219) x	0.198	=	308.91	(264)
Space and water heating	(261) + (262) + (263) + (264) =			578.07	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.517	=	90.48	(267)
Electricity for lighting	(232) x	0.517	=	78.68	(268)
Total CO2, kg/year		sum of (265)…(271) =		747.22	(272)
Dwelling CO2 Emission Rate		(272) ÷ (4) =		29.89	(273)
EI rating (section 14)				86	(274)

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:		**Stroma Number:**	
Software Name:	Stroma FSAP 2009	**Software Version:**	Version: 1.5.0.49

Property Address: 2 metres below ground

Address : 2 metres below ground, TN3 8LA

1. Overall dwelling dimensions:

	Area(m²)			Ave Height(m)			Volume(m³)	
Ground floor	25	(1a)	x	2.6	(2a)	=	65	(3a)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	25	(4)						
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)		=	65	(5)

2. Ventilation rate:

	main heating		Secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							1	x 10 =	10	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	10	÷ (5) =	0.15	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction		0	(11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35			
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		7	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.5	(18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used			
Number of sides on which sheltered		0	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	1	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.5	(21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.4	5.1	5.1	4.5	4.1	3.9	3.7	3.7	4.2	4.5	4.8	5.1
Wind Factor (22a)m = (22)m ÷ 4												
(22a)m=	1.35	1.27	1.27	1.12	1.02	0.98	0.92	0.92	1.05	1.12	1.2	1.27

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.68	0.64	0.64	0.57	0.52	0.49	0.47	0.47	0.53	0.57	0.6	0.64

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside

if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft

if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.73	0.71	0.71	0.66	0.63	0.62	0.61	0.61	0.64	0.66	0.68	0.71	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.73	0.71	0.71	0.66	0.63	0.62	0.61	0.61	0.64	0.66	0.68	0.71	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Windows Type 1			1.44	x1/[1/(1.8)+ 0.04]		=	2.42			(27)
Windows Type 2			1.44	x1/[1/(1.8)+ 0.04]		=	2.42			(27)
Floor			25	x	0.14	=	3.5			(28)
Walls Type1	6	2.88	3.12	x	0.32	=	1			(29)
Walls Type2	20	0	20	x	0.27	=	5.4			(29)
Total area of elements, m²			51							(31)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*

*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 14.73 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 2958.08 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 4.08 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 18.81 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	15.69	15.15	15.15	14.17	13.59	13.31	13.05	13.05	13.73	14.17	14.65	15.15	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	34.5	33.97	33.97	32.99	32.4	32.13	31.87	31.87	32.54	32.99	33.46	33.97	

Average = $Sum(39)_{1...12}$ /12= 33.05 (39)

DER WorkSheet: New dwelling design stage

Heat loss parameter (HLP), W/m²K — (40)m = (39)m ÷ (4)

(40)m=	1.38	1.36	1.36	1.32	1.3	1.29	1.27	1.27	1.3	1.32	1.34	1.36

Average = $Sum(40)_{1...12}$ /12= 1.32 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N — 1.0885 (42)

if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)

if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 — 60.052 (43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)													
(44)m=	66.06	63.66	61.25	58.85	56.45	54.05	54.05	56.45	58.85	61.25	63.66	66.06	
											Total = $Sum(44)_{1...12}$ =	720.6243	(44)
Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)													
(45)m=	98.2	85.88	88.62	77.26	74.14	63.97	59.28	68.03	68.84	80.22	87.57	95.1	
											Total = $Sum(45)_{1...12}$ =	947.1126	(45)
If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)													
(46)m=	14.73	12.88	13.29	11.59	11.12	9.6	8.89	10.2	10.33	12.03	13.14	14.26	(46)

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day): — 0 (47)

Temperature factor from Table 2b — 0 (48)

Energy lost from water storage, kWh/year — (47) x (48) = — 0 (49)

If manufacturer's declared cylinder loss factor is not known:

Cylinder volume (litres) including any solar storage within same — 0 (50)

If community heating and no tank in dwelling, enter 110 litres in box (50)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in box (50)

Hot water storage loss factor from Table 2 (kWh/litre/day) — 0 (51)

Volume factor from Table 2a — 0 (52)

Temperature factor from Table 2b — 0 (53)

Energy lost from water storage, kWh/year — ((50) x (51) x (52) x (53) = — 0 (54)

Enter (49) or (54) in (55) — 0 (55)

Water storage loss calculated for each month — ((56)m = (55) × (41)m

(56)m=	0	0	0	0	0	0	0	0	0	0	0	0	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	0	0	0	0	0	0	0	0	0	0	0	0	(57)

Primary circuit loss (annual) from Table 3 — 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m

(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	33.66	29.3	31.21	29.02	28.77	26.65	27.54	28.77	29.02	31.21	31.39	33.66	(61)

DER WorkSheet: New dwelling design stage

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)

(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76

Output from water heater (annual)$_{1...12}$ 1307.3261 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	41.07	35.88	37.27	32.95	31.84	27.93	26.6	29.81	30.14	34.48	36.97	40.04	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m=	8.62	7.65	6.22	4.71	3.52	2.97	3.21	4.18	5.61	7.12	8.31	8.86	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m=	86.3	87.2	84.94	80.14	74.07	68.37	64.56	63.67	65.93	70.73	76.8	82.5	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m=	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	(69)
Pumps and fans gains (Table 5a)													
(70)m=	10	10	10	10	10	10	10	10	10	10	10	10	(70)
Losses e.g. evaporation (negative values) (Table 5)													
(71)m=	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	(71)
Water heating gains (Table 5)													
(72)m=	55.2	53.39	50.09	45.76	42.8	38.8	35.75	40.07	41.87	46.34	51.34	53.81	(72)
Total internal gains =						(66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m							
(73)m=	199.44	197.57	190.59	179.94	169.72	159.47	152.85	157.24	162.73	173.52	185.77	194.49	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:		Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
East	0.9x	1	x	1.44	x	19.87	x	0.63	x	0.7	=	8.75	(76)
East	0.9x	1	x	1.44	x	38.52	x	0.63	x	0.7	=	16.95	(76)
East	0.9x	1	x	1.44	x	61.57	x	0.63	x	0.7	=	27.09	(76)
East	0.9x	1	x	1.44	x	91.41	x	0.63	x	0.7	=	40.23	(76)
East	0.9x	1	x	1.44	x	111.22	x	0.63	x	0.7	=	48.95	(76)
East	0.9x	1	x	1.44	x	116.05	x	0.63	x	0.7	=	51.07	(76)
East	0.9x	1	x	1.44	x	112.64	x	0.63	x	0.7	=	49.57	(76)
East	0.9x	1	x	1.44	x	98.03	x	0.63	x	0.7	=	43.14	(76)

DER WorkSheet: New dwelling design stage

East	0.9x	1	x	1.44	x	73.6	x	0.63	x	0.7	=	32.39	(76)
East	0.9x	1	x	1.44	x	46.91	x	0.63	x	0.7	=	20.64	(76)
East	0.9x	1	x	1.44	x	24.71	x	0.63	x	0.7	=	10.87	(76)
East	0.9x	1	x	1.44	x	16.39	x	0.63	x	0.7	=	7.21	(76)
West	0.9x	0.77	x	1.44	x	19.87	x	0.63	x	0.7	=	8.75	(80)
West	0.9x	0.77	x	1.44	x	38.52	x	0.63	x	0.7	=	16.95	(80)
West	0.9x	0.77	x	1.44	x	61.57	x	0.63	x	0.7	=	27.09	(80)
West	0.9x	0.77	x	1.44	x	91.41	x	0.63	x	0.7	=	40.23	(80)
West	0.9x	0.77	x	1.44	x	111.22	x	0.63	x	0.7	=	48.95	(80)
West	0.9x	0.77	x	1.44	x	116.05	x	0.63	x	0.7	=	51.07	(80)
West	0.9x	0.77	x	1.44	x	112.64	x	0.63	x	0.7	=	49.57	(80)
West	0.9x	0.77	x	1.44	x	98.03	x	0.63	x	0.7	=	43.14	(80)
West	0.9x	0.77	x	1.44	x	73.6	x	0.63	x	0.7	=	32.39	(80)
West	0.9x	0.77	x	1.44	x	46.91	x	0.63	x	0.7	=	20.64	(80)
West	0.9x	0.77	x	1.44	x	24.71	x	0.63	x	0.7	=	10.87	(80)
West	0.9x	0.77	x	1.44	x	16.39	x	0.63	x	0.7	=	7.21	(80)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	17.49	33.9	54.19	80.46	97.89	102.14	99.14	86.29	64.78	41.29	21.75	14.43	(83)

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	216.93	231.48	244.78	260.39	267.61	261.62	252	243.53	227.51	214.81	207.52	208.92	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) | 21 | (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	0.99	0.99	0.97	0.95	0.87	0.71	0.51	0.52	0.8	0.95	0.99	0.99	(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.72	19.86	20.12	20.42	20.74	20.93	20.99	20.99	20.87	20.52	20.04	19.77	(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.78	19.8	19.8	19.83	19.85	19.86	19.86	19.86	19.84	19.83	19.81	19.8	(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	0.99	0.98	0.97	0.93	0.81	0.61	0.37	0.38	0.71	0.92	0.98	0.99	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	18.65	18.8	19.06	19.37	19.68	19.82	19.86	19.86	19.78	19.47	18.99	18.71	(90)

fLA = Living area ÷ (4) = | 0.4 | (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	19.08	19.23	19.48	19.79	20.11	20.27	20.31	20.31	20.21	19.89	19.41	19.14	(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	18.93	19.08	19.33	19.64	19.96	20.12	20.16	20.16	20.06	19.74	19.26	18.99	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Utilisation factor for gains, hm:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(94)m=	0.98	0.98	0.96	0.92	0.82	0.64	0.41	0.42	0.73	0.92	0.98	0.99	(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	213.61	226.49	235.21	240.44	219.53	166.47	102.94	102.77	166.81	197.85	202.49	205.83	(95)

Monthly average external temperature from Table 8

(96)m=	4.5	5	6.8	8.7	11.7	14.6	16.9	16.9	14.3	10.8	7	4.9	(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	497.88	478.06	425.6	360.87	267.47	177.19	103.96	103.93	187.57	294.76	410.33	478.45	(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	211.5	169.05	141.65	86.71	35.67	0	0	0	0	72.1	149.64	202.83

Total per year (kWh/year) = Sum(98)1...5,9...12 = 1069.15 (98)

Space heating requirement in kWh/m²/year 42.77 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system		0	(201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1	(202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1	(204)
Efficiency of main space heating system 1		84.8	(206)
Efficiency of secondary/supplementary heating system, %		0	(208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)													
	211.5	169.05	141.65	86.71	35.67	0	0	0	0	72.1	149.64	202.83	
(211)m = {[(98)m x (204)] + (210)m } x 100 ÷ (206)													(211)
	249.41	199.35	167.04	102.25	42.06	0	0	0	0	85.02	176.47	239.18	

Total (kWh/year) =Sum(211)1...5,10...12= 1260.79 (211)

Space heating fuel (secondary), kWh/month

= {[(98)m x (201)] + (214) m } x 100 ÷ (208)

(215)m=	0	0	0	0	0	0	0	0	0	0	0	0

Total (kWh/year) =Sum(215)1...5,10...12= 0 (215)

Water heating

Output from water heater (calculated above)

	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76

Efficiency of water heater 80.5 (216)

(217)m=	85.99	85.78	85.28	84.43	82.7	80.5	80.5	80.5	80.5	83.91	85.43	85.94	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

(219)m=	153.35	134.27	140.51	125.89	124.42	112.58	107.85	120.24	121.57	132.8	139.25	149.82

Total = Sum(219a)1...12 = 1562.55 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		1260.79
Water heating fuel used		1562.55
Electricity for pumps, fans and electric keep-hot		

central heating pump:		130	(230c)
boiler with a fan-assisted flue		45	(230e)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =	175	(231)
Electricity for lighting		152.19	(232)

12a. CO_2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO2/kWh		Emissions kg CO2/year	
Space heating (main system 1)	(211)	x	0.198	=	249.64	(261)
Space heating (secondary)	(215)	x	0	=	0	(263)
Water heating	(219)	x	0.198	=	309.39	(264)
Space and water heating	(261) + (262) + (263) + (264) =				559.02	(265)
Electricity for pumps, fans and electric keep-hot	(231)	x	0.517	=	90.48	(267)
Electricity for lighting	(232)	x	0.517	=	78.68	(268)
Total CO2, kg/year			sum of (265)…(271) =		728.18	(272)
Dwelling CO2 Emission Rate			(272) ÷ (4) =		29.13	(273)
EI rating (section 14)					86	(274)

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:		**Stroma Number:**	
Software Name:	Stroma FSAP 2009	**Software Version:**	Version: 1.5.0.49

Property Address: 2 metres below ground shaded

Address : 2 metres below ground shaded, TN3 8LA

1. Overall dwelling dimensions:

	Area(m²)			Ave Height(m)			Volume(m³)	
Ground floor	25	(1a)	x	2.6	(2a)	=	65	(3a)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	25	(4)						
Dwelling volume					(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)	=	65	(5)

2. Ventilation rate:

	main heating		Secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							1	x 10 =	10	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

DRAFT

			Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	10	÷ (5) =	0.15	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction *if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35*		0	(11)
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		7	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.5	(18)

Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used

Number of sides on which sheltered		0	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	1	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.5	(21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.4	5.1	5.1	4.5	4.1	3.9	3.7	3.7	4.2	4.5	4.8	5.1
Wind Factor (22a)m = (22)m ÷ 4												
(22a)m=	1.35	1.27	1.27	1.12	1.02	0.98	0.92	0.92	1.05	1.12	1.2	1.27

DER WorkSheet: New dwelling design stage

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.68	0.64	0.64	0.57	0.52	0.49	0.47	0.47	0.53	0.57	0.6	0.64

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside

if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft

if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0.73	0.71	0.71	0.66	0.63	0.62	0.61	0.61	0.64	0.66	0.68	0.71	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.73	0.71	0.71	0.66	0.63	0.62	0.61	0.61	0.64	0.66	0.68	0.71	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Windows Type 1			1.44	x1/[1/(1.8)+ 0.04]		=	2.42			(27)
Windows Type 2			1.44	x1/[1/(1.8)+ 0.04]		=	2.42			(27)
Floor			25	x	0.14	=	3.5			(28)
Walls Type1	6	2.88	3.12	x	0.32	=	1			(29)
Walls Type2	20	0	20	x	0.27	=	5.4			(29)
Total area of elements, m²			51							(31)

** for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*

*** include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 14.73 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 2958.08 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 4.08 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 18.81 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	15.69	15.15	15.15	14.17	13.59	13.31	13.05	13.05	13.73	14.17	14.65	15.15	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	34.5	33.97	33.97	32.99	32.4	32.13	31.87	31.87	32.54	32.99	33.46	33.97	

Average = Sum(39)₁…₁₂ /12= 33.05 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.38	1.36	1.36	1.32	1.3	1.29	1.27	1.27	1.3	1.32	1.34	1.36

Average = Sum(40)$_{1...12}$ /12= 1.32 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 1.0885 (42)

if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)

if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 60.052 (43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)

(44)m=	66.06	63.66	61.25	58.85	56.45	54.05	54.05	56.45	58.85	61.25	63.66	66.06

Total = Sum(44)$_{1...12}$ = 720.6243 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	98.2	85.88	88.62	77.26	74.14	63.97	59.28	68.03	68.84	80.22	87.57	95.1

Total = Sum(45)$_{1...12}$ = 947.1126 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	14.73	12.88	13.29	11.59	11.12	9.6	8.89	10.2	10.33	12.03	13.14	14.26	(46)

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day): 0 (47)

Temperature factor from Table 2b 0 (48)

Energy lost from water storage, kWh/year (47) x (48) = 0 (49)

If manufacturer's declared cylinder loss factor is not known:

Cylinder volume (litres) including any solar storage within same 0 (50)

If community heating and no tank in dwelling, enter 110 litres in box (50)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in box (50)

Hot water storage loss factor from Table 2 (kWh/litre/day) 0 (51)

Volume factor from Table 2a 0 (52)

Temperature factor from Table 2b 0 (53)

Energy lost from water storage, kWh/year ((50) x (51) x (52) x (53) = 0 (54)

Enter (49) or (54) in (55) 0 (55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	0	0	0	0	0	0	0	0	0	0	0	0	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	0	0	0	0	0	0	0	0	0	0	0	0	(57)

Primary circuit loss (annual) from Table 3 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m

(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	33.66	29.3	31.21	29.02	28.77	26.65	27.54	28.77	29.02	31.21	31.39	33.66	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)

(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76

Output from water heater (annual)$_{1...12}$ 1307.3261 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	41.07	35.88	37.27	32.95	31.84	27.93	26.6	29.81	30.14	34.48	36.97	40.04	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	54.43	(66)

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

(67)m=	9.02	8.01	6.51	4.93	3.69	3.11	3.36	4.37	5.87	7.45	8.7	9.27	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	86.3	87.2	84.94	80.14	74.07	68.37	64.56	63.67	65.93	70.73	76.8	82.5	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

(69)m=	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	28.44	(69)

Pumps and fans gains (Table 5a)

(70)m=	10	10	10	10	10	10	10	10	10	10	10	10	(70)

Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	-43.54	(71)

Water heating gains (Table 5)

(72)m=	55.2	53.39	50.09	45.76	42.8	38.8	35.75	40.07	41.87	46.34	51.34	53.81	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	199.85	197.93	190.88	180.16	169.89	159.61	153	157.44	162.99	173.85	186.16	194.9	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:		Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
East	0.9x	1	x	1.44	x	19.87	x	0.63	x	0.7	=	6.13	(76)
East	0.9x	1	x	1.44	x	38.52	x	0.63	x	0.7	=	11.89	(76)
East	0.9x	1	x	1.44	x	61.57	x	0.63	x	0.7	=	19	(76)
East	0.9x	1	x	1.44	x	91.41	x	0.63	x	0.7	=	28.21	(76)
East	0.9x	1	x	1.44	x	111.22	x	0.63	x	0.7	=	34.33	(76)
East	0.9x	1	x	1.44	x	116.05	x	0.63	x	0.7	=	35.82	(76)
East	0.9x	1	x	1.44	x	112.64	x	0.63	x	0.7	=	34.76	(76)
East	0.9x	1	x	1.44	x	98.03	x	0.63	x	0.7	=	30.26	(76)

East	0.9x	1	x	1.44	x	73.6	x	0.63	x	0.7	=	22.72	(76)
East	0.9x	1	x	1.44	x	46.91	x	0.63	x	0.7	=	14.48	(76)
East	0.9x	1	x	1.44	x	24.71	x	0.63	x	0.7	=	7.63	(76)
East	0.9x	1	x	1.44	x	16.39	x	0.63	x	0.7	=	5.06	(76)
West	0.9x	0.54	x	1.44	x	19.87	x	0.63	x	0.7	=	6.13	(80)
West	0.9x	0.54	x	1.44	x	38.52	x	0.63	x	0.7	=	11.89	(80)
West	0.9x	0.54	x	1.44	x	61.57	x	0.63	x	0.7	=	19	(80)
West	0.9x	0.54	x	1.44	x	91.41	x	0.63	x	0.7	=	28.21	(80)
West	0.9x	0.54	x	1.44	x	111.22	x	0.63	x	0.7	=	34.33	(80)
West	0.9x	0.54	x	1.44	x	116.05	x	0.63	x	0.7	=	35.82	(80)
West	0.9x	0.54	x	1.44	x	112.64	x	0.63	x	0.7	=	34.76	(80)
West	0.9x	0.54	x	1.44	x	98.03	x	0.63	x	0.7	=	30.26	(80)
West	0.9x	0.54	x	1.44	x	73.6	x	0.63	x	0.7	=	22.72	(80)
West	0.9x	0.54	x	1.44	x	46.91	x	0.63	x	0.7	=	14.48	(80)
West	0.9x	0.54	x	1.44	x	24.71	x	0.63	x	0.7	=	7.63	(80)
West	0.9x	0.54	x	1.44	x	16.39	x	0.63	x	0.7	=	5.06	(80)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	12.27	23.78	38	56.42	68.65	71.63	69.53	60.51	45.43	28.95	15.25	10.12	(83)

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	212.11	221.71	228.88	236.58	238.54	231.25	222.53	217.95	208.42	202.8	201.41	205.02	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) | 21 | (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	0.99	0.99	0.98	0.96	0.9	0.77	0.57	0.58	0.84	0.96	0.99	0.99	(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.71	19.83	20.07	20.35	20.68	20.9	20.98	20.98	20.84	20.48	20.02	19.76	(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.78	19.8	19.8	19.83	19.85	19.86	19.86	19.86	19.84	19.83	19.81	19.8	(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	0.99	0.98	0.97	0.95	0.86	0.67	0.42	0.43	0.76	0.94	0.98	0.99	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	18.64	18.77	19.01	19.31	19.63	19.81	19.86	19.86	19.76	19.43	18.97	18.7	(90)

fLA = Living area ÷ (4) = | 0.4 | (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	19.06	19.19	19.43	19.72	20.05	20.24	20.31	20.31	20.19	19.85	19.39	19.12	(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	18.91	19.04	19.28	19.57	19.9	20.09	20.16	20.16	20.04	19.7	19.24	18.97	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Utilisation factor for gains, hm:

(94)m=	0.99	0.98	0.97	0.94	0.86	0.7	0.46	0.47	0.77	0.93	0.98	0.99	(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	209.1	217.59	221.66	222.86	205.58	161.06	102.2	102.05	161.02	189.22	197	202.19	(95)

Monthly average external temperature from Table 8

(96)m=	4.5	5	6.8	8.7	11.7	14.6	16.9	16.9	14.3	10.8	7	4.9	(96)

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]

(97)m=	497.32	476.94	423.89	358.68	265.76	176.52	103.85	103.83	186.85	293.68	409.65	478	(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	214.43	174.29	150.46	97.79	44.77	0	0	0	0	77.72	153.11	205.2

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 1117.77 (98)

Space heating requirement in kWh/m²/year 44.71 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system		0	(201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1	(202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1	(204)
Efficiency of main space heating system 1		84.8	(206)
Efficiency of secondary/supplementary heating system, %		0	(208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)	214.43	174.29	150.46	97.79	44.77	0	0	0	0	77.72	153.11	205.2	
(211)m = {[(98)m x (204)] + (210)m } x 100 ÷ (206)	252.86	205.53	177.43	115.32	52.79	0	0	0	0	91.65	180.55	241.98	(211)

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= 1318.12 (211)

Space heating fuel (secondary), kWh/month

= {[(98)m x (201)] + (214) m } x 100 ÷ (208)

(215)m=	0	0	0	0	0	0	0	0	0	0	0	0

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= 0 (215)

Water heating

Output from water heater (calculated above)

131.86	115.18	119.84	106.29	102.9	90.63	86.82	96.79	97.86	111.44	118.96	128.76

Efficiency of water heater 80.5 (216)

(217)m=	86.02	85.85	85.42	84.7	83.11	80.5	80.5	80.5	80.5	84.08	85.48	85.97	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

(219)m=	153.29	134.16	140.28	125.48	123.82	112.58	107.85	120.24	121.57	132.54	139.17	149.77

Total = Sum(219a)$_{1...12}$ = 1560.75 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		1318.12
Water heating fuel used		1560.75
Electricity for pumps, fans and electric keep-hot		

DER WorkSheet: New dwelling design stage

central heating pump:		130	(230c)
boiler with a fan-assisted flue		45	(230e)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =	175	(231)
Electricity for lighting		159.28	(232)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO2/kWh		Emissions kg CO2/year	
Space heating (main system 1)	(211)	x	0.198	=	260.99	(261)
Space heating (secondary)	(215)	x	0	=	0	(263)
Water heating	(219)	x	0.198	=	309.03	(264)
Space and water heating	(261) + (262) + (263) + (264) =				570.02	(265)
Electricity for pumps, fans and electric keep-hot	(231)	x	0.517	=	90.48	(267)
Electricity for lighting	(232)	x	0.517	=	82.35	(268)
Total CO2, kg/year			sum of (265)…(271) =		742.84	(272)
Dwelling CO2 Emission Rate			(272) ÷ (4) =		29.71	(273)
EI rating (section 14)					86	(274)