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Introduction

This report concerns an energy assessment of the SBSA benchmark building, performed according to the Danish building regulations. These regulations specify an upper limit for the annual amount of energy demanded per unit of heated gross floor area for new buildings. The upper limit is known as the *energy frame*. This means that Denmark do not have very strict requirements for the thermal envelope of new buildings, e.g. U-values of external walls must not exceed 0.4 W/m²K and the total design transmission loss of opaque part of the thermal envelope must not exceed 6 W/m².

The annual amount of energy demanded in a new building must be assessed using the Danish software Be06 [2], which are in accordance with CEN EPBD standards. The input to Be06 is, as far it is possible, based on the input to the SAP software, which is used for assessing the energy performance of buildings according to the Scottish building regulations.

Be06 and SAP are based on different calculation methods, and therefore require different input. Some of the input required by Be06 is not required by SAP, and vice versa. If input required by Be06 can not be found among the input to SAP, reasonable assumptions are made in order to provide input for Be06.

The report describes the input to Be06, the assumptions used in case of missing data, and the results of the calculations.

Summary of energy frame calculations for the SBSA benchmark building

The annual amount of energy demanded in a new building must be assessed using the Danish software Be06 [2], which are in accordance with CEN EPBD standards. The input to Be06 is, as far it is possible, based on the input to the SAP software, which is used for assessing the energy performance of buildings according to the Scottish building regulations. The most important changes compared to the Scottish calculation are:

– In the Danish standard, gross areas are being used in the calculation,
– In the Danish standard calculation the garage is assumed to be unheated,
– Light is not part of the calculations with respect to residential buildings,
– The minimum ventilation rate according to Danish building code is 0.5 air-changes per hour, corresponding to 0.3 l/s per m² gross floor area.
– Electricity consumption for running the house is part of the energy frame after being multiplied with a factor 2.5 to compensate for the efficiency of the power plants,
– Night set back of the internal temperature is not possible in the Danish calculation method,
– Internal heating set point temperature in Denmark is 20 °C,
– Internal gains in the Danish method is 1.5 W/m² (180 W total) from persons and 3.5 W/m² (420 W total) from appliances,
– Energy consumptions in Denmark includes all losses (recoverable and non recoverable) from the technical installations,
– The Danish climate (see Annex 3) deviates from the Scottish climate,
– Thermal bridges are being calculated individually in the Danish method.

The energy requirements, as being calculated in the Danish Be06 shows that the SBSA house has an energy consumption of 144.5 kWh/m² per year. The Danish energy frame for this building is calculated to be 88.3 kWh/m² per year. The energy performance does thus not fulfill the Danish energy regulation for a new building.

Energy carrier	Scottish	Danish
Net space heating 1)	67	90.0
Domestic hot water heating	36	16.7 2)
Lighting	7	0 3)
Total electricity consumption	-	43.3 4)

Table 1. Comparison of the Scottish and Danish calculations.1) Thermal space heating only, electrical part is included in total electricity consumption. 2) Net energy consumption for DHW heating. 3) Electricity consumption for lighting is not part of the Danish energy frame for residential buildings, but the free gain is accounted for by 3.5 W/m² from light and appliances. 4) Total (for running the house, e.g. pumps, fans, electric stoves, mechanical cooling) electricity consumption multiplied by a factor 2.5.

To understand why the benchmark Scottish house does not satisfy the Danish building regulations it is interesting to compare the parameters defined by the Danish building regulations and those delivered by the Scottish Building Standards Agency.

Parameter		Scottish	Danish Extensions	Danish Back stop value
U-value [1)]	External walls	0.25	0.20	0.40
	Roof	0.16	0.15	0.25
	Ground floor	0.22	0.15	0.30
	Windows and doors	1.80	1.50	2.3/2.0
Ventilation rate, natural ventilation [ac/h]		0.675	0.5	
Infiltration at 50 Pa [ac/h]		3.9	2.5	
Heat recovery mechanical ventilation [%]		-	65	

Table 2. Parameters used for comparison of Scottish and Danish building code. 1) The U-values shown are not the requirements for new buildings, but the values for extensions of existing buildings. The U-value requirements for new buildings are not that strict as the energy frame sets the overall insulation level, but also allows for architectural freedom. Back stop value for windows in new houses changes by January 1. 2008 to 2.0 W/m²K.

The main results of the Be06 energy frame calculations are given in two screen-dumps with a translation of the most important output fields shown in italics in the figure captions from Be06 in Figure 1 and Figure 2.

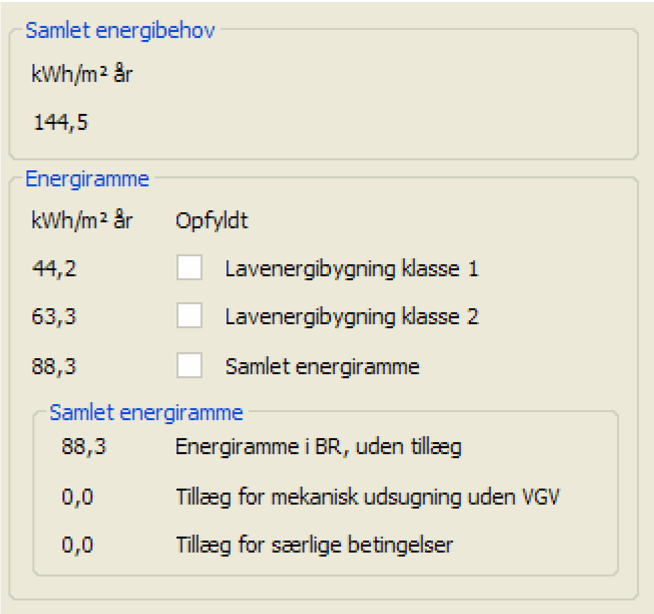


Figure 1. The energy frame calculations provided by Be06. *Top - Total energy calculated consumption is 144.5 kWh/m² per year. Centre - The energy frame for this size of building is calculated to be 88.3 kWh/m² per year. To meet the requirements for low energy class 2 and 1 respectively, the calculated energy consumption must be below 63.3 kWh/m² per year and 44.2 kWh/m² per year respectively. At the middle of the screen are the energy frames for low-energy class 1 (44.2 kWh//m² per year), low-energy class 2 (63.3 kWh/m² per year), and the maximum energy frame for a new building according to the current building code (88.3 kWh/m² per year). Bottom - Resulting energy frame is shown in case of extensions of the energy frame due to special circumstances, of which there are none in this case.*

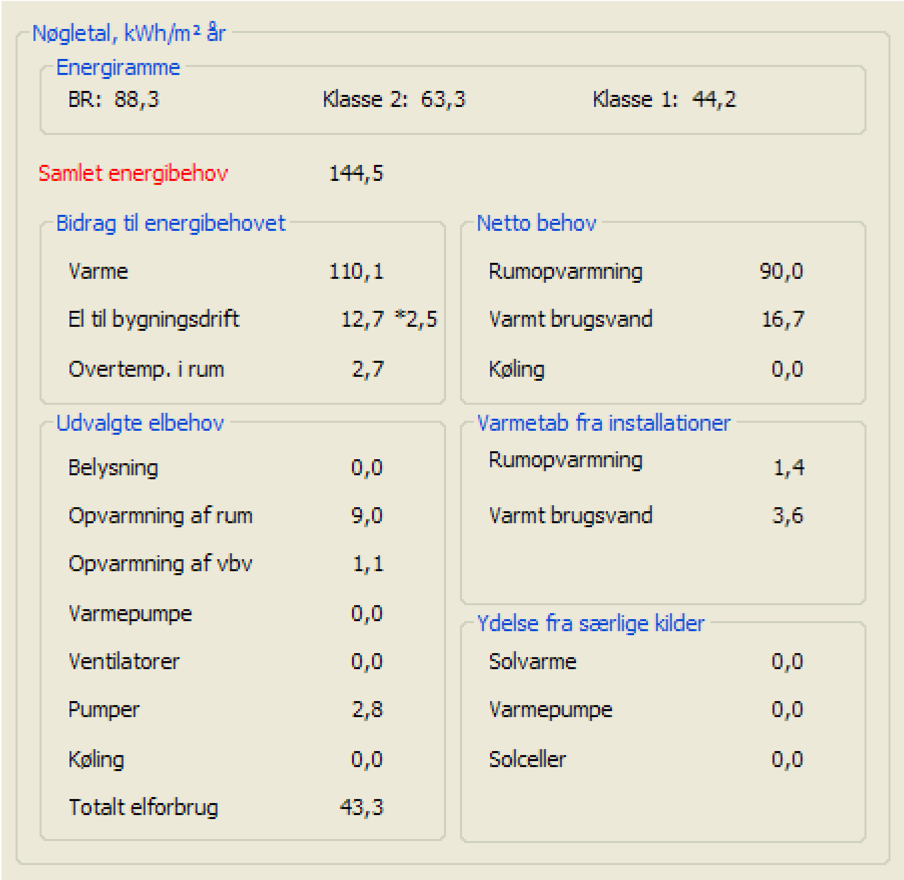


Figure 2. Key figures for the building. Output fields are: **Middle left** – contribution to heating demand; Heating: 110.1 kWh/m² per year, Electricity for running the building: 12.7 times 2.5 (national conversion factor for electricity to other energy sources), Over-temperatures in rooms 2.7 kWh/m² per year (if the indoor temperature is calculated to be exceeding 26 °C, the energy consumption in a mechanical cooling system to keep the temperature below 26 °C is added to the calculated energy consumption. **Bottom left** - Selected electricity consumptions: Lighting (0 kWh/m²), Electrical stoves (9.0 kWh/m²), DHW heating (1.1 kWh/m²), Heat pump (0 kWh/m²), Fans (0 kWh/m²), Pumps (2.8 kWh/m²), Cooling (0 kWh/m²), Total electricity consumption (43.3 kWh/m²). **Top right** - Net energy demand for: Space heating (90.0 kWh/m²), Domestic hot water (16.7 kWh/m²), Cooling (0 kWh/m²). **Middle right** – Heat losses from installations: Space heating (1.4 kWh/m²), Domestic hot water (3.6 kWh/m²). **Bottom right** – Output from special sources: Thermal solar heating, Heat pump, Photo voltaic systems.

Input to the Be06 software

Be06 is organized in a set of dialogs (translation of the different input and output fields are shown in italics in the figure captions), where different types of information for the building can be specified. The dialogs that are relevant for the SBSA benchmark building are described in the following. Note that the Danish building regulations do not include the energy used for artificial lighting when assessing residential buildings.

General

The building has the following general properties:

1 It is a detached building with 120 m^2 of heated gross floor area
2 The building is used 24 hours per day, 7 days per week, which gives a total of 168 hours per week
3 The heat capacity of the building is assumed to be 60 Wh/Km^2, corresponding to a building made of very light materials
4 The building is heated by a condensing gas boiler
5 There are no contributions from sustainable energy systems, wood burners or solar cells.
6 10 % of the energy used for heating the building is provided by electrical heaters

The dialog containing general building information is shown in Figure 3.

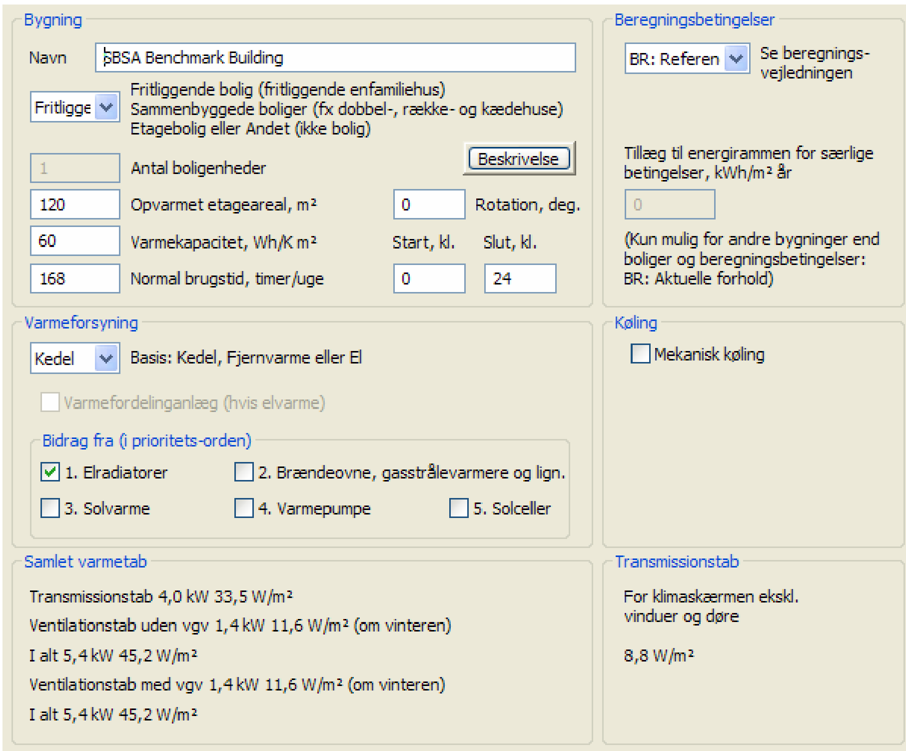


Figure 3. Dialog with general information about the building. *Top left field: 120 m² heated gross floor area; Heat capacity 60 Wh/K m²; 168 hours normal usage time per week; start and end hour for normal usage time (0 resp. 24) 0 ° rotation of the building. Middle, left field: Type of primary heating system: Boiler; Additional heating sources: Electric stoves. Bottom, left field: Transmission loss: 35.4 W/m²; ventilation loss without heat recovery (winter): 11.6 W/m². Bottom right: Design transmission loss through opaque part of thermal envelope, 8.8 W/m².*

Building envelope

The building envelope is specified in four dialogs in Be06, containing information about opaque building elements, thermal bridges, windows and doors, and shadows, respectively. U-values for the building envelope are given in 1, p. 1 and 3.

Opaque building elements

Be06 uses gross areas for transmission through the constructions, except for the slab on ground. For detailed information about the calculation of the transmission areas see Annex 1.

Besides this, Be06 uses a so-called temperature factor *b* in order to compensate for situations where the internal or external temperatures deviate from the design temperatures (20/-12 °C respectively). The majority of the building envelope does not require this feature, which means that usually *b* = 1 is being used.

However, for constructions facing unheated rooms (in this case the garage), the temperature factor is used for compensating for the fact that the air temperature in the garage is higher than the external air temperature. When calculating the heat loss through the ground slab, the temperature factor is used for compensating for the fact that the temperature of the surrounding ground (on average) is higher than the external air temperature during winter.

For the above mentioned constructions, a temperature factor *b* = 0.7 can be used. If a more detailed calculation is required, Be06 provides a dialog for unheated rooms, where the temperature factor can be calculated based on a heat balance for the room.

The latter approach requires the U-values for all constructions facing the unheated room. The U-value for the internal wall between the garage and the rest of the building is estimated to be:

$$U_{int} = \frac{1}{d_{ins}/\lambda_{ins} + d_{pb}/\lambda_{pb} + 2 \cdot R_{int}} = 0.39\ W/m^2K$$

where:

d_{ins} = 0.089 m is the thickness of the insulation,
λ_{ins} = 0.039 W/mK is the thermal conductivity of the insulation,
d_{pb} = 0.013 m is the thickness of the plasterboard,
λ_{pb} = 1.3 W/mK is the thermal conductivity of the plasterboard,
R_{int} = 0.13 m²K/W is the internal surface resistance (Danish default value).

The U-value for the slap over the garage is calculated as shown above to be 0.15 W/m²K.

The dialog for calculating the temperature factor for the constructions facing the unheated garage is shown in Figure 4. The U-value for the garage door is assumed to be 1.8 W/m^{2}K. The resulting temperature factor b is then 0.645.

Uopvarmet rum

Navn	Bruttoareal (m²)
Garage	17,56

Ventilationstab

Vent (l/s m²)	Varmetab (W/K)
0,6	12,7486

Varmebalance

Hi 15,8 W/K
Hu 28,8 W/K
Temp faktor 0,645

	Bygningsdel	Areal (m²)	U (W/m²K)	Ht (W/K)
	Transmissionstab fra bygningen			15,8379
+1	First floor over garage	17,56	0,15	2,634
2	Internal wall J	6,24	0,39	2,4336
3	Internal wall K	12,57	0,39	4,9023
4	Door d3	1,63	1,8	2,934
5	Door d4	1,63	1,8	2,934
6				
7				
8				

	Bygningsdel	Areal (m²)	U (W/m²K)	Ht (W/K)
	Transmissionstab til omgivelserne			16,0047
+1	Ground slab	14,66	0,22	3,2252
2	External wall E1b	14,2	0,25	3,55
3	External wall P	2,43	0,25	0,6075
4	Garage door	4,79	1,8	8,622
5				
6				
7				
8				

Figure 4. Dialog for specifying the heat balance for unheated rooms. *Top: Gross floor area, 17.56 m²; Ventilation rate in garage, 0.6 l/s m²; Heat balance: Hi specific heat loss to building 15.8 W/K and specific heat loss to the ambient: 28.8 W/K. First table (each line) divisions between garage and house: Name, transmission area [m²], U-value [W/m²K], Specific heat loss coefficient (calculated) [W/K]. Second table shows divisions between garage and ambient with the same entries as in the table above.*

The dialog for specifying the opaque parts of the building envelope is shown in Figure 5.

	Ydervægge, tage og gulve	Areal (m²)	U (W/m²K)	b	Ht (W/K)	Dim.Inde	Dim.Ude	Tab (W)
		322,52		CtrlClick	67,0235			2132,58
+1	Ground slab	46	0,22	0,70	7,084		10	101,2
2	Walls type 1 (ex. glazing and doors)	167,63	0,25	1,00	41,9075			1341,04
3	Walls type 3 (ex. glazing and doors)	18,81	0,39	0,64	4,73033			234,749
4	First floor over garage	17,56	0,15	0,64	1,69846			84,288
5	Roof	72,52	0,16	1,00	11,6032			371,302

Figure 5. Dialog with input for the opaque parts of the building envelope. *Each line: Name, Transmission area [m²], U-value [W/m² K], b-factor [-] (as user input or calculated from the unheated zone dialog), Specific transmission coefficient [W/K] (calculated], Dimensioning indoor temperature (default = 20 °C) for dimensioning heat loss calculations, Dimensioning outdoor temperature (default = -12 °C) for dimensioning heat loss calculations, Dimensioning heat loss [W].*

Thermal bridges

According to the Danish building regulations, thermal bridges for the thermal interaction between the foundation and external walls, as well as thermal bridges for the thermal interaction between windows and the external walls must be specified.

The required data for this approach is not available, so the heat loss due to thermal bridges is instead estimated by specifying a thermal bridge that gives the same contribution to the heat loss parameter, as the input to the SAP software provides, namely 22.33 W/K.

This contribution is provided by a thermal bridge with a length of 82.71 m, and a linear thermal transmittance of 0.27 W/mK, which are the values used as input to Be06.

	Fundamenter og samlinger ved vindu	l (m)	Tab (W/mK)	b	Ht (W/K)	Dim.Inde	Dim.Ude	Tab (W)
		82,71		CtrlClick	22,3317			714,614
+1	All thermal bridges	82,71	0,27	1,00	22,3317			714,614

Figure 6. Dialog with input for the thermal bridges. *Name, Length of thermal bridge [m], b-factor [-] (as user input or calculated from the unheated zone dialog), Specific heat loss coefficient [W/K] (calculated), Dimensioning indoor temperature (default = 20 °C) for dimensioning heat loss calculations, Dimensioning outdoor temperature (default = -12 °C) for dimensioning heat loss calculations, Dimensioning heat loss [W].*

Windows and doors

The U-values for the windows are adjusted for an external surface resistance of 0.04 W/m^{2}K (Danish default value), which gives:

$$U_{adj} = \frac{1}{1/U + 0.04} \, W/m^2K = \frac{1}{1/1.8 + 0.04} \, W/m^2K = 1.68 W/m^2K$$

where U_{adj} is the adjusted U-value, and where U = 1.8 W/m²K is the unadjusted U-value for the window, which does not include the external surface resistance.

When calculating the direct solar gain, Be06 only includes contributions from the visible part of the sky, which is specified in terms of angles to obstacles in the vertical and horizontal planes, as well as the relative depth of the window measured from the outer face of the facade. The following five parameters are being used for that purpose:

1 Shading from distant obstacles (horizon), see Figure 7,
2 Shading from overhangs (Figure 8),
3 Shading from side fins to the left (seen from inside) of the window (Figure 9),
4 Shading from side fins to the right (seen from inside) of the window,
5 Shading due to glazing location compared to outer surface of the surrounding constructions (Figure 10).

The angles are illustrated in the following three figures. The angle to the horizon is assumed to be 15 ° for all windows and doors, which is the default value suggested by Be06.

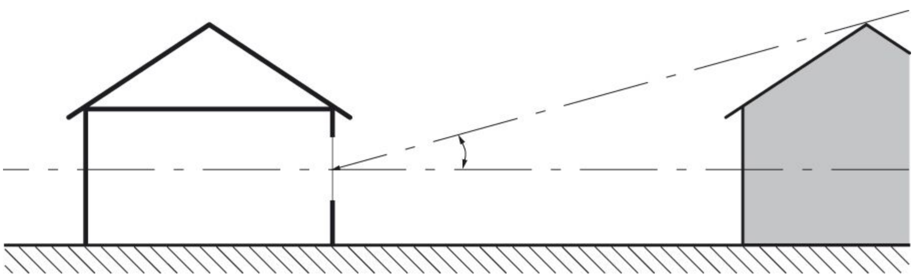


Figure 7. Angle to horizon (source: Aggerholm & Grau 2).

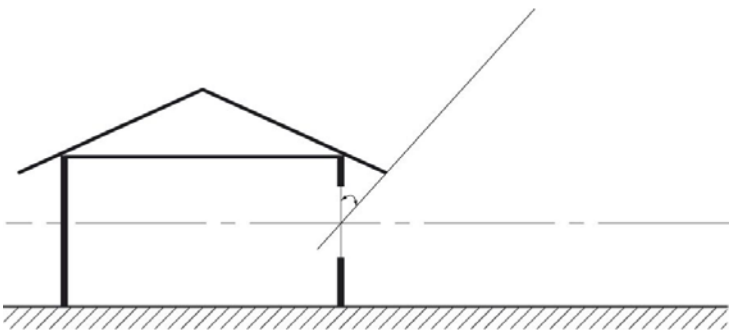


Figure 8. Angle to overhang (source: Aggerholm & Grau 2).

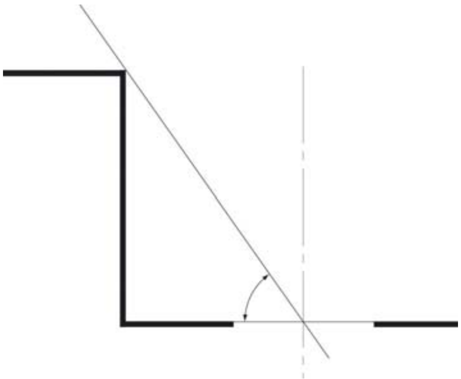


Figure 9. Angle to left side fin (source: Aggerholm & Grau 2).

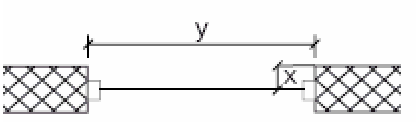


Figure 10. Relative depth (x/y) of the glazing compared to the minimum of width or height of the window, measured at the outer face of the window.

The angles to the overhangs are given in the table below. Details about the calculations are given in Annex 2.

Description	Angle [°]
w1	49,1
w2	4,5
w3	2,9
w4	4,0
w5	4,7
d2	2,1
w6	21,3
w7	21,3
w8	7,1
w9	3,9
w10	23,6
w11	23,6

Table 3. Angles to overhangs.

There is only one window, where the solar gain is obstructed by a side fin, namely "w2". The angle to the side fin for this window is 60.52 °.

The relative depth of the window rabbet is calculated as the distance from the external wall to the window pane, divided by the smallest of the width and height of the window. The windows used on the SBSA building are narrow windows, meaning that they are higher than they are wide. The relative depth of the window rabbet is therefore in all cases given as the depth of the rabbet divided by the width of the window. These parameters are measured on drawings, and the results are given in the table below. More details are provided in Annex 2.

Building element	Relative depth [%]
w1	29,3
w2	8,1
w3	19,8
w4	6,9
w5	10,4
d2	20,6
w6	7,6
w7	8,6
w8	20,2
w9	20,2
w10	10,4
w11	20,2

Table 4. Relative depths of window rabbets.

Be06 also requires information about the solar transmittance, solar shading devices, as well as the relative glazing areas. This information is given in 1.

The solar transmittance is given to be 0.63. The solar shading factor is given to be 0.9, due to the use of curtains. The relative glazing areas (frame factors) are given to be 0.7, meaning that 30 % of the window opening is opaque frame material.

The frame factor for "door2" is 0.5, since the areas of the opaque and transparent parts are the same. The U-value for this door is estimated to be 1.7 W/m^{2}K, which is the average of the U-values for the opaque and transparent parts.

	Vinduer og yderdøre	Antal	Orient	Hældn.	Areal (m²)	U (W/m²K)	b	Ht (W/K)	Ff (-)	g (-)	Skygge	Fc (-)	Dim.Inc	Dim.Ud	Tab (W)
		16			23,133		CtrlClic	37,5434			CtrlClic				1268,17
+1	glz1	1	S	90	0,652	1,679	1,00	1,09471	0,7	0,63	w1	0,9			35,0307
2	glz2	1	S	90	2,3898	1,679	1,00	4,01247	0,7	0,63	w2	0,9			128,399
3	glz3	1	V	90	0,8911	1,679	1,00	1,49616	0,7	0,63	w3	0,9			47,877
4	glz4	1	N	90	3,2	1,679	1,00	5,3728	0,7	0,63	w4	0,9			171,93
5	glz5	1	N	90	1,1314	1,679	1,00	1,89962	0,7	0,63	w5	0,9			60,7879
6	door1	1	S	90	1,632	1,8	1,00	2,9376	0	0		1			94,0032
7	door2	1	V	90	1,632	1,7395	1,00	2,83886	0,5	0,63	d2	1			90,8436
8	glz door	1	V	90	1,632	1,7395	1,00	2,83886	0,5	0,63	d2	1			90,8436
9	glz6	1	S	90	1,8	1,679	1,00	3,0222	0,7	0,63	w6	0,9			96,7104
10	glz7	1	S	90	1,8	1,679	1,00	3,0222	0,7	0,63	w7	0,9			96,7104
11	glz8	1	V	90	0,6264	1,679	1,00	1,05173	0,7	0,63	w8	0,9			33,6552
12	glz9	1	V	90	0,6264	1,679	1,00	1,05173	0,7	0,63	w9	0,9			33,6552
13	glz10	1	N	90	1,3026	1,679	1,00	2,18707	0,7	0,63	w10	0,9			69,9861
14	glz11	1	N	90	0,5533	1,679	1,00	0,928991	0,7	0,63	w11	0,9			29,7277
15	door3	1	S	90	1,632	1,8	0,64	1,89422	0	0		1			94,0032
16	door4	1	V	90	1,632	1,8	0,64	1,89422	0	0		1			94,0032

Figure 11. Dialog with input for the windows and doors. *Each row: Name, Number of identical windows, Orientation (S=South, V=West, N=North), Tilt (90=vertical), Area [m²], overall U-value [W/m²K], b-factor [-], Specific transmission coefficient [W/K], Frame factor = share of glazing in window [-], g-value for glazing [-], Shading name (defined in separate dialog), Solar protection factor [-],Dimensioning indoor temperature (default = 20 °C) for dimensioning heat loss calculations, Dimensioning outdoor temperature (default = -12 °C) for dimensioning heat loss calculations, Dimensioning heat loss [W].*

	Skygger	Horisont (°)	Udhæng (°)	Venstre (°)	Højre (°)	Vindueshul (%)
1	w1	15	49,1	0	0	29,3
2	w2	15	4,6	0	60,5	8,1
3	w3	15	2,9	0	0	20
4	w4	15	4	0	0	6,9
5	w5	15	4,7	0	0	10,4
6	d2	15	2,1	0	0	20,6
7	w6	15	21,3	0	0	7,6
8	w7	15	21,3	0	0	8,6
9	w8	15	7,1	0	0	20,2
10	w9	15	3,9	0	0	20,2
11	w10	15	23,6	0	0	10,4
12	w11	15	23,6	0	0	20,2

Figure 12. Dialog with input for the shadows. *Name, Angle to horizon, Angle to overhang, Angle to left side fin, Angle to right side fin, Relative depth of glazing compared to facade.*

Ventilation

The SBSA building uses natural ventilation, which means that only the ventilation rates during winter and summer needs to be specified in Be06. Ventilation rates are in Be06 specified in terms of air flow per unit floor area, which is measured in l/s per m^2. The default values of 0.3 l/s per m^2 are used for both ventilation rates, which include infiltration. The ventilated area is assumed to be the same as the heated floor area.

	Ventilation	Areal (m	qm (l/s m	n vgv (-)	ti (°C	El-Vl	qn (l/s m	qi,n (l/s r	SEL (kJ/n	qm,s (l/s	qn,s (l/s	qm,n (l/s	qn,n (l/s
	Zone	120	Vinter			0/1	Vinter	Vinter		Sommer	Sommer	Nat	Nat
1	Heated floor area	120	0	0	0	0	0,3	0	0	0	0,3	0	0

Figure 13. Dialog with input for specifying the ventilation. *Name, Area [m²], Mechanical ventilation during winter [l/s m²], Efficiency of heat exchanger [-], Inlet air temperature [°C], Presence of electric heating coil, Natural ventilation in winter [l/s m²], fan efficiency [kJ/m³], Mechanical ventilation in summer [l/s m²], Natural ventilation in summer [l/s m²], Mechanical ventilation in summer nights [l/s m²], Natural ventilation in summer nights [l/s m²].*

Internal loads

Internal loads can in Be06 be specified for people and equipment, and is specified in terms of load (power) per unit area, which is measured in W/m^2. The default values are 1.5 W/m^2 for people and 3.5 W/m^2 for lighting and appliances, which are the values used as input to Be06. The area with internal loads is assumed to be the same as the heated floor area.

	Internt varmetilskud	Areal (m²)	Personer (W/m²)	App. (W/m²)	App,nat (W/m²)
	Zone	120,0	180,0 W	420,0 W	0,0 W
1	Heated floor area	120	1,5	3,5	0

Figure 14. Dialog with input for the internal loads. *Name, Area [m²], Heat loads from persons [W/m²], Heat load from appliances [W/m²], Heat load from appliances during non-use hours W/m²] (not applicable for residential buildings).*

Heating distribution system

The heating distribution system is assumed to be a two-pipe system, with supply and return temperatures of 80 °C and 40 °C, respectively. It is furthermore assumed to have a pressure-controlled pump, with a nominal power of 60 W, and a reduction factor (indicates the ration between used power as an average over the running time of the pump to the nominal power of the pump) of 0.4 for an automatically controlled pump.

Be06 provides a dialog for specifying heat losses from heat and/or domestic hot water pipes outside the building envelope. This dialog must also be used if the heat delivery system does not have outdoor temperature compensation or heating circulation is closed during summer. If the external air temperature and the supply temperature are high, then there will be a heat loss from the pipes that does not benefit the building, which according to the Danish building regulations must be included in the energy frame calculations.

However, the piping for the SBSA building is assumed to be inside the building envelope, and the heat delivery system is assumed to have external temperature compensation. It is therefore not necessary to specify the piping in this dialog.

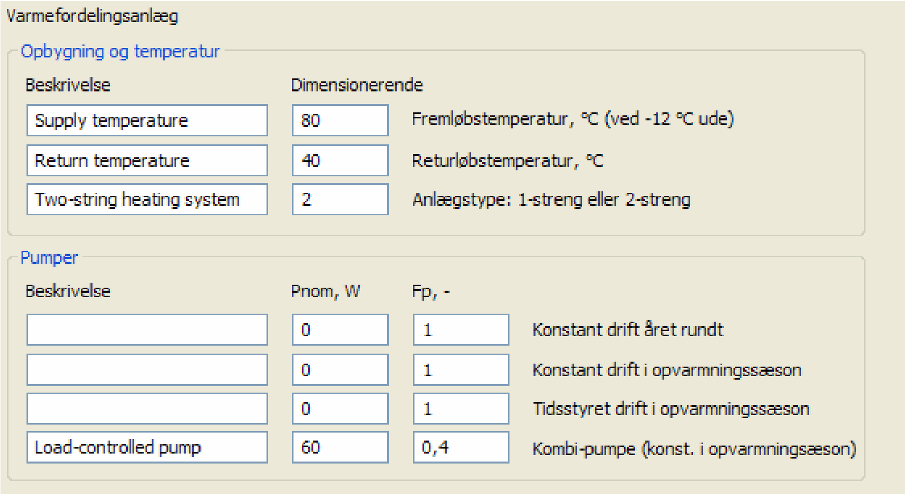


Figure 15. Dialog for the heat delivery system. *Top field: Supply temperature from boiler – 80 °C, Return temperature from radiator system – 40 °C, Type of heating distribution system – two string system. Bottom field: Consumption in a combined domestic hot water and heating circulation pump at a nominal power of 60 W and a reduction factor depending on the type and control of the pump.*

Domestic hot water

The energy used for producing domestic hot water is included in the Danish energy frame calculations. It is assumed that residential buildings annually require 250 liters of hot water per m^2 of heated floor area.

The hot water is assumed to be produced by the gas boiler, and heated to 55 °C. The building is assumed not to have an electrical water heater, which means that the gas boiler also runs during the summer. The supply temperature from the heating system to the hot water tank is assumed to be 60 °C.

The hot water tank has a volume of 150 liters, with an annual heat loss of 417 kWh, as specified in 1, which corresponds to 47.6 W. The temperature difference that causes this heat loss is 35 °C, corresponding to the difference between the 55 °C water and the internal air temperature, which is 20 °C. The conductance K_{tank} for the heat loss from the hot water tank is thus 1.4 W/K.

There is an annual heat loss of 360 kWh from the primary piping between boiler and tank, which corresponds to 2 m pipe with a heat loss of 0.2 W/mK (in this case the heat loss is caused by a 40 °C temperature difference).

A charge circuit for the domestic hot water tank is not anticipated in the building.

The circulation pump requires 130 kWh annually, corresponding to an average power consumption of 15 W.

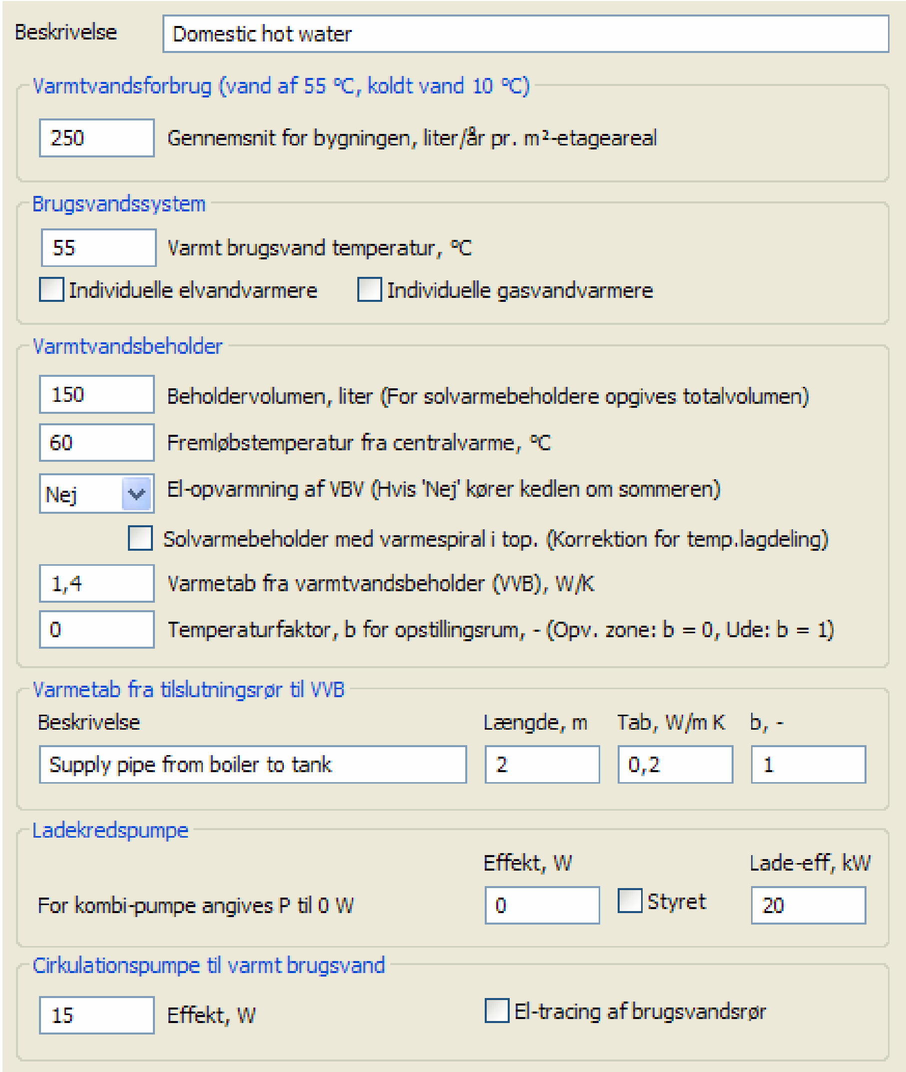


Figure 16. Dialog for the domestic hot water. *Field 1 - Domestic hot water consumption for the building: 250 l/year per m². Field 2 - Temperature of DHW: 55 °C, Indications for individual electric DHW heaters and gas heaters. Field 3 - Volume of DHW tank: 150 litres, Supply temperature from boiler – 60 °C, Presence of electric heater in top of DHW tank (No = boiler runs over summer), Tank applicable for thermal solar collectors with coil in the top, Heat loss from tank (1.4 W/K), Temperature factor for tank location (0 = inside the heated area of the house). Field 4 - Heat loss from pipes to tank: Name, Length [m], Loss coefficient [W/m K], Temperature factor for pipes 1=in house. Field 5 - Charge circuit pump: Nominal power [W], Controlled or not, Charge power [kW]. Field 6 - Circulation pump: Nominal power – 15 W, Indictor for presence of electrical tracing on DHW pipes.*

Energy supply system

The energy required by the building for heating and producing domestic hot water is provided by a gas boiler, with an efficiency of 91.5 %. The nominal output of the boiler is assumed to be 25 kW. The annual auxiliary electricity used by the boiler is 45 kWh, corresponding to an average power consumption of 5 W. The remaining parameters are adopted from the calculation example from Be06.

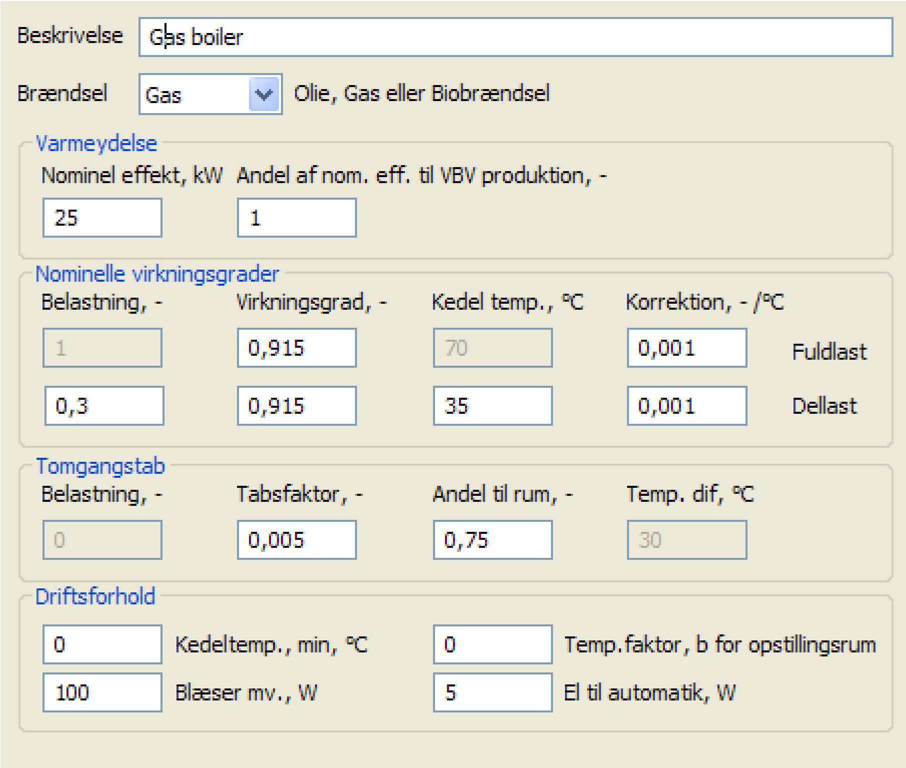


Figure 17. Dialog for the gas boiler. *Top: Fuel type (Gas/Oil/Bio-fuel). Field 1 - Nominal power of boiler – 25 kW, Share of DHW production produced by boiler. Field 2 - Nominal efficiencies measured at test conditions for full and part load. Fields from left to right: Load, Efficiency, Boiler temperature, Correction factor, determining how the efficiency varies when the boiler temperature varies. Field 3 - Idle run losses: Load, Loss factor (share compared to nominal power), Fraction to boiler room, Used temperature difference. Field 4 – Running conditions: Minimum boiler temperature [°C], Temperature factor for boiler [-], Power of fans [W], Electric power for automatics etc [W].*

The 10 % of electric energy used for heating can be specified in a dialog for auxiliary room heating. Here the percentage of the heated floor area, which is heated by the auxiliary heating system, can be specified, in this case 10 %.

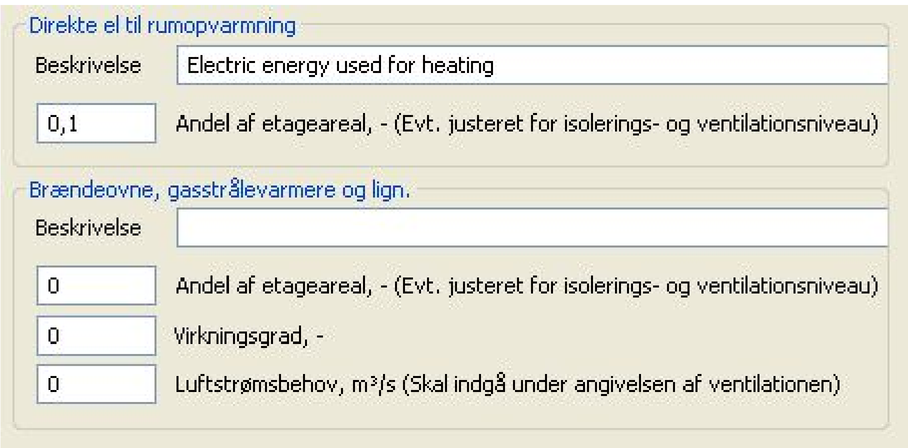


Figure 18. Dialog for auxiliary heating systems. *Field 1: Area share heated by electric heaters. Field 2: Area share heated by wood burning stoves, gas stoves, etc. (Not used in this calculation).*

References

1 Energy Standards in Scotland and Scandinavia, Annex B, Benchmark house: Additional information.
2 S. Aggerholm, & K. Grau (2005-2007). SBi Direction 213 – Energy consumption of buildings, Users guide (In Danish). Danish Building Research Institute, Aalborg University, Hørsholm, Denmark.

Annex 1

Calculation of areas

Gross heated floor areas are being used in the Danish calculation method. According to the Danish Building Regulation gross floor areas shall be calculated by adding together the gross areas of all storeys. The gross floor area is measured in a plane defined by the top side of finished floor to the outer surface of external walls. Only exception is the slab on ground, which is measured to inner surface of the external walls. This is done due to the way thermal bridges are being treated in Denmark.

This section concerns calculations of gross transmission areas for the building and linear thermal bridges, e.g. foundation. In order to calculate horizontal transmission areas, the floor plans are subdivided into a set of rectangular areas, as shown in Figure 19 and Figure 20.

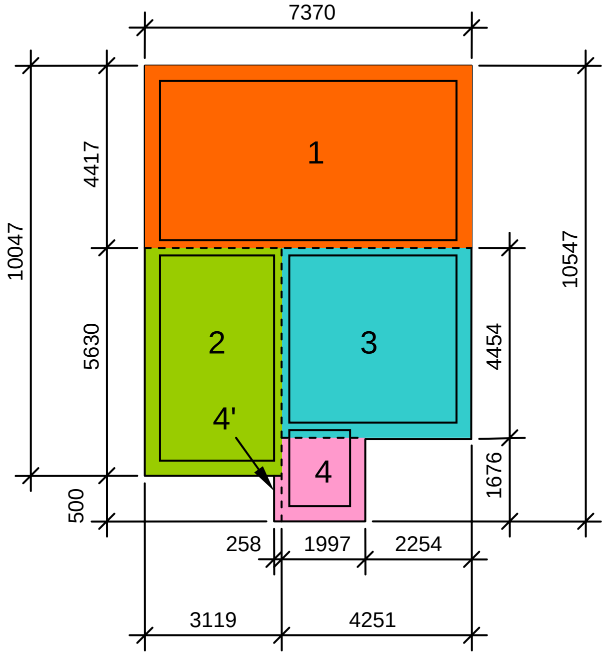


Figure 19. Subdivision of the ground floor plan into five rectangles.

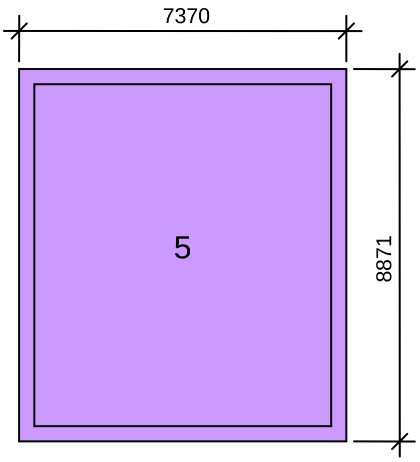


Figure 20. Dimensions of the first floor plan.

The horizontal transmission areas are calculated in the following tables.

Description	Width [mm]	Length [mm]	Area [m²]
Area 1	7370	4417	32,55
Area 2	3119	5630	17,56
Area 3	4251	4454	18,93
Area 4	1997	1676	3,35
Area 4'	258	500	0,13
Area 5	7370	8871	65,38
Total area			137,90

Table 5. The areas of the rectangles.

Description	Heated	Heated area [m²]	Unheated area [m²]
Area 1	yes	32,55	
Area 2	no		17,56
Area 3	yes	18,93	
Area 4	yes	3,35	
Area 4'	yes	0,13	
Area 5	yes	65,38	
Total area		120,34	17,56

Table 6. Heated and unheated areas.

Description	Area [m²]
Area 1	32,55
Area 2	17,56
Area 3	18,93
Area 4	3,35
Area 4'	0,13
Total area	72,52

Table 7. The area of the roof construction.

When calculating the transmission loss through the ground slab, only the parts inside the external walls are included. For this purpose, the ground floor plan is divided into the rectangles shown in Figure 21. The areas of the rectangles are calculated in Table 8, and the areas of the ground slab under the unheated garage and under the rest of the building is calculated in Table 9.

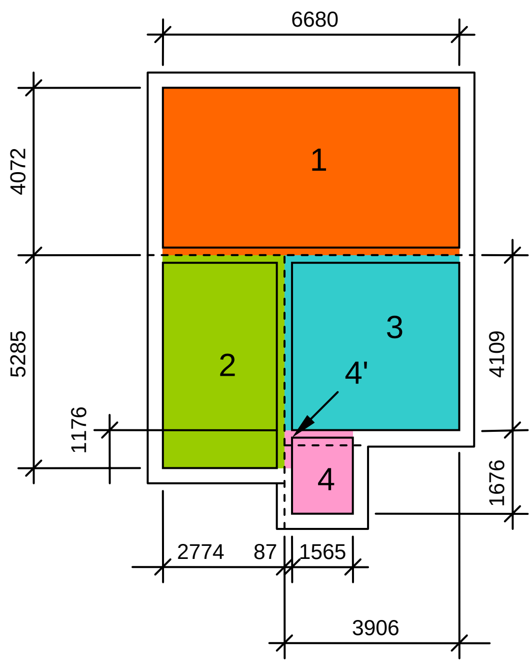


Figure 21. Subdivision of the ground floor plan used for calculating the area of the ground slab.

Description	Width [mm]	Length [mm]	Area [m²]
Area 1	6680	4072	27,20
Area 2	2774	5285	14,66
Area 3	3906	4109	16,05
Area 4	1565	1676	2,62
Area 4'	87	1176	0,10
Total area			60,64

Table 8. Areas of rectangles.

Description	Belongs to garage	Ground slab under garage [m²]	Remaining ground slab [m²]
Area 1	no		27,20
Area 2	yes	14,66	
Area 3	no		16,05
Area 4	no		2,62
Area 4'	no		0,10
Total area		14,66	45,98

Table 9. Areas of ground slab under the garage and under the rest of the building.

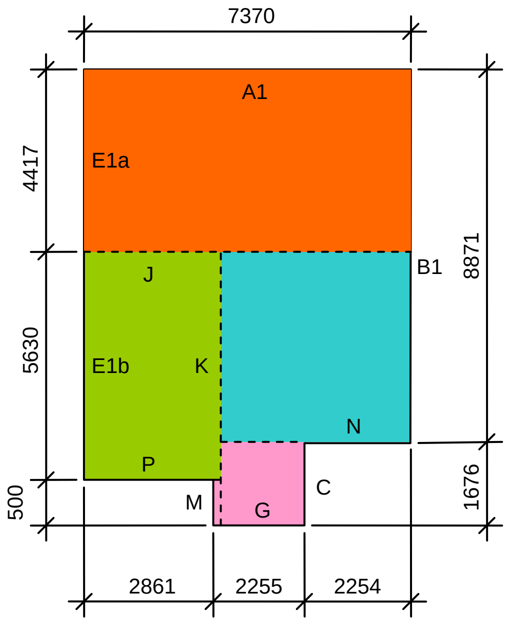


Figure 22. Lengths and notations for walls on the ground floor.

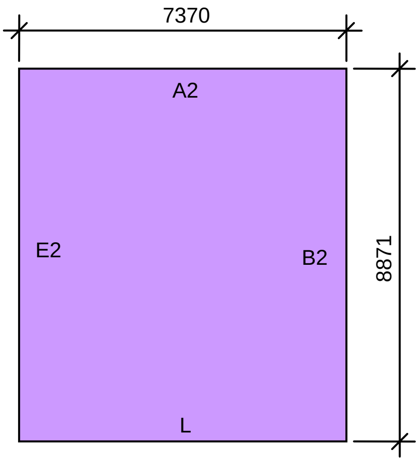


Figure 23. Lengths and notations for walls on the first floor.

The heights of the walls are based on the dimensions given in Figure 24. When calculating the transmission loss through the external walls according to the Danish building regulations, the external walls are defined to start at the same level as the floor surface above the ground slab (at the ground floor level in this case), and end at the same level as the upper surface of the insulation used in the roof construction.

The roof construction consists of a layer of insulated plaster boards, and a 300 mm layer of timber kit trusses with insulation quilt over. The plaster boards are assumed to be 13 mm thick, which is a commonly used plaster board thickness in Denmark.

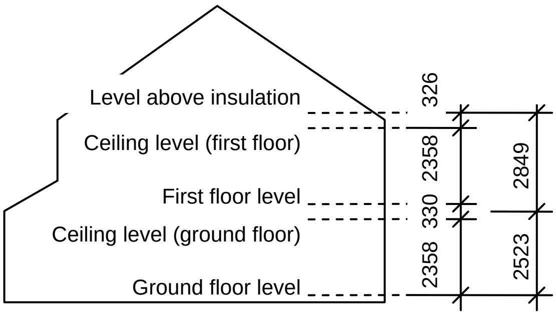


Figure 24. Heights of floors and decks.

The total wall areas, including windows and doors, are calculated in Table 10. The areas of windows and doors are calculated in Table 11. The notation used for windows and doors is adopted from 1. The dimensions of the garage door are estimated by measuring on drawings.

Description	Length [mm]	Height [mm]	Area [m²]
Wall A1	7370	2523	18,59
Wall E1a	4417	2523	11,14
Wall E1b	5630	2523	14,20
Wall J	3119	2523	7,87
Wall K	5630	2523	14,20
Wall P	2861	2523	7,22
Wall M	500	2523	1,26
Wall G	2255	2523	5,69
Wall C	1676	2523	4,23
Wall N	2254	2523	5,69
Wall B1	8871	2523	22,38
Wall A2	7370	2849	21,00
Wall E2	8871	2849	25,27
Wall L	7370	2849	21,00
Wall B2	8871	2849	25,27
Total area			205,02

Table 10. The total wall areas.

Description	Length [mm]	Height [mm]	Area [m²]
w1	326	2000	0,65
w2	1400	1707	2,39
w3	522	1707	0,89
w4	1600	2000	3,20
w5	1090	1038	1,13
w6	1500	1200	1,80
w7	1500	1200	1,80
w8	522	1200	0,63
w9	522	1200	0,63
w10	1090	1195	1,30
w11	522	1060	0,55
d1	816	2000	1,63
d2	816	2000	1,63
d3	816	2000	1,63
glz door	816	2000	1,63
d4	816	2000	1,63
Garage door	2106	2276	4,79
Total area			27,93

Table 11. The areas of windows and doors.

Description	Total wall area [m²]	Area excluding windows and doors [m²]
Wall A1	18,59	
w4	-3,20	
w5	-1,13	14,26
Wall E1a	11,14	
w3	-0,89	
d2	-1,63	8,62
Wall E1b	14,20	14,20
Wall J	7,87	
d3	-1,63	6,24
Wall K	14,20	
d4	-1,63	12,57
Wall P	7,22	
Garage door	-4,79	2,43
Wall M	1,26	1,26
Wall G	5,69	
w1	-0,65	
d1	-1,63	3,41
Wall C	4,23	4,23
Wall N	5,69	
w2	-2,39	3,30
Wall B1	22,38	22,38
Wall A2	21,00	
w10	-1,30	
w11	-0,55	19,14
Wall E2	25,27	
w8	-0,63	
w9	-0,63	24,02
Wall L	21,00	
w6	-1,80	
w7	-1,80	17,40
Wall B2	25,27	25,27
Total area		178,73

Table 12. Wall areas excluding windows and doors.

In
Table 13, the wall areas are divided into the following three types:
- Type 1: External walls separating heated floor areas and the surroundings,
- Type 2: External walls separating the garage and the surroundings,
- Type 3: Internal walls separating the garage and the heated floor areas.

Description	Walls type 1 [m²]	Walls type 2 [m²]	Walls type 3 [m²]
Wall A1	14,26		
Wall E1a	8,62		
Wall E1b		14,20	
Wall J			6,24
Wall K			12,57
Wall P		2,43	
Wall M	1,26		
Wall G	3,41		
Wall C	3,30		
Wall N	3,30		
Wall B1	22,38		
Wall A2	19,14		
Wall E2	24,02		
Wall L	42,67		
Wall B2	25,27		
Total area	167,63	16,63	18,81

Table 13. Areas of the three types of walls used in the building.

Annex 2

Details regarding shadows

This section provides details about the input used for specifying shadows. The angle to an obstacle is calculated by measuring the length and height of the right-angled triangle containing the angle, as shown in Figure 25.

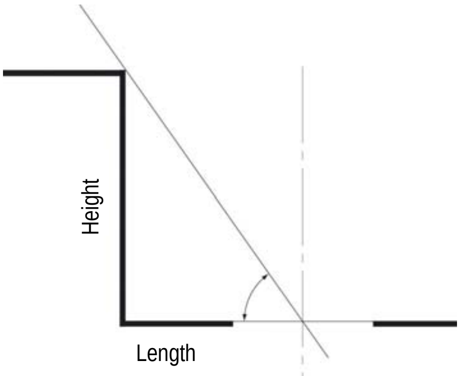


Figure 25. Measuring angles to obstacles. The length is measured, parallel to the glazing, from the centre of the glazing to a line perpendicular to the edge of the obstacle that cast the fist shadow on the glazing. The height is measured perpendicular to the glazing from the centre of the transparent element to the edge of the obstacle that cast the fist shadow on the glazing.

The angle is given by:

$$\text{Angle} = \frac{180}{\pi} \text{Arc}\tan\frac{\text{height}}{\text{length}}$$

The angles for the windows and doors with transparent parts are given in Table 14. All angles are vertical angles to the overhang, except for "w2", which is the horizontal angle to the side fin.

Description	Length [mm]	Height [mm]	Angle [°]
w1	13,0	15,0	49,09
w2	44,0	3,5	4,55
w2 (horizontal)	13,0	23,0	60,52
w3	60,0	3,0	2,86
w4	50,0	3,5	4,00
w5	43,0	3,5	4,65
d2	81,0	3,0	2,12
w6	9,0	3,5	21,25
w7	9,0	3,5	21,25
w8	24,0	3,0	7,13
w9	44,0	3,0	3,90
w10	8,0	3,5	23,63
w11	8,0	3,5	23,63

Table 14. Angles to obstacles.

The relative depth of the window rabbet is calculated as the distance from the external wall to the window pane, divided by the smallest of the width and height of the window. The windows used on the SBSA building are narrow windows, meaning they are higher than they are wide. The relative depth of the window rabbet is therefore given as the depth of the rabbet divided by the width of the window. These parameters are measured on drawings, and the results are given in Table 15.

Building element	Depth [mm]	Width [mm]	Rel. depth [%]
w1	8,5	29	29,31
w2	8,5	105	8,10
w3	8,5	43	19,77
w4	8,5	124	6,85
w5	8,5	82	10,37
d2	13	63	20,63
w6	8,5	112	7,59
w7	8,5	99	8,59
w8	8,5	42	20,24
w9	8,5	42	20,24
w10	8,5	82	10,37
w11	8,5	42	20,24

Table 15. Relative depths of window rabbets.

Annex 3

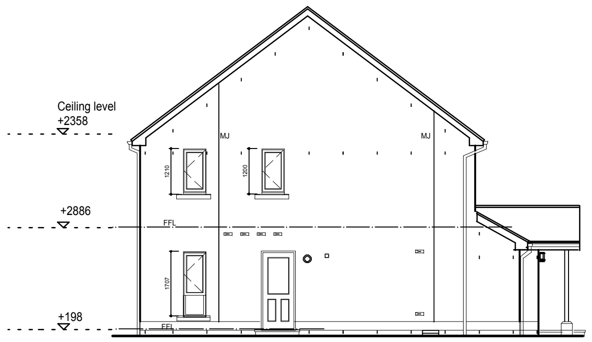
Danish climate

The table below shows the Danish climate used in the Danish calculation tool, Be06. Solar radiation on surfaces with other tilts than the ones shown in the table is generally being used by the tool, but not in this building example.

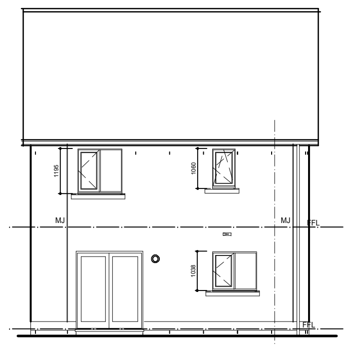
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Outdoor temp.	-1.0	-0.5	1.9	5.9	10.9	15.7	16.4	16.7	12.9	8.9	4.5	0.8
N	6.1	11.1	21.9	36.1	53.9	60.0	56.9	41.1	26.1	13.9	6.9	3.9
NE	6.1	11.9	26.9	51.1	76.1	78.9	76.1	56.1	35.0	16.1	6.9	3.9
E	13.1	23.9	46.1	76.9	106.1	103.1	100.0	83.9	58.1	31.1	13.9	8.1
SE	30.0	45.0	68.1	93.9	115.0	105.0	103.9	103.1	80.0	53.9	31.9	20.0
S	40.0	58.1	80.0	96.9	108.1	96.1	96.9	106.9	88.9	66.9	43.1	26.9
SW	30.0	45.0	68.1	93.9	115.0	105.0	103.9	103.1	80.0	53.9	31.9	20.0
W	13.1	23.9	46.1	76.9	106.1	103.1	100.0	83.9	58.1	31.1	13.9	8.1
NW	6.1	11.9	26.9	51.1	76.1	78.9	76.1	56.1	35.0	16.1	6.9	3.9

Table 16. Danish climate used in calculations. Outdoor temperature shows the monthly average outdoor temperature [°C]. The following rows show the monthly sum of solar radiation on vertical faces with the orientation given in the first column [kWh/m²].

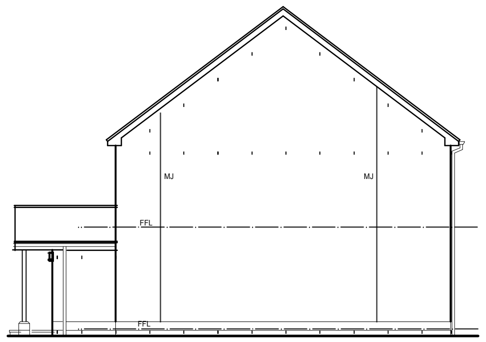
Front Elevation



Side 1 Elevation



Rear Elevation



Side 2 Elevation

DETACHED HOUSE (to comply with Gas package 1)
[AREA - 100 m²]

Boiler, heating and hot water system and controls:
- Gas condensing boiler, 90%eff
- Radiator space heat system, programmer, room stat, trv's and interlock
- Stored HW system, separate time control from space heating
- 10% electric secondary heating

Structure
- Timber kit
- Blockwork substructure on strip founds

Ground floor [U Value = 0.22 W/m²K]
- Minimum 150mm vented solum space over 50mm concrete screed over dpm over sub-base
- Timber joist floor filled with mineral wool insulation on netting (say 200mm)
- 15mm OSB board
- Insulation board
- 22mm chipboard flooring panels

First floor
- 15mm plasterboard
- Timber joist
- 22mm chipboard flooring panels

First floor over garage
2 No. layers 12.5mm fire resistant plasterboard
- Timber joist packed with mineral wool
- 22mm chipboard flooring panels

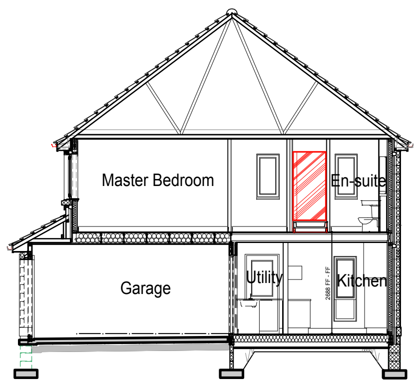
Roof [U Value = 0.16 W/m²K]
- Insulated plasterboard
- Timber kit trusses with 300mm insulation quilt over
- Vented roof void
- 12mm plywood sarking
- Roofing felt
- Battens and counter battens
- Concrete roofing tiles

External wall [U Value = 0.25 W/m²K]
- 15mm foil backed plasterboard
- Timber stud with mineral wool insulation infill
- 10mm OSB board sheathing
- Breather membrane
- Insulation board
- 50mm cavity
- Facing brick/block / Rendered blockwork

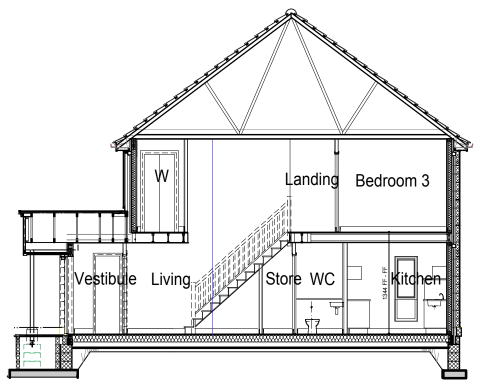
Integral Garage walls [U Value = 0.25W/m²K]
- 15mm plasterboard
- 89mm timber kit with mineral wool insulation
- 15mm plasterboard
- Insulated plasterboard

Glazing and doors [U Value = 1.8 W/m²K]
- PVC windows with trickle vents
- Insulated doors with glazing

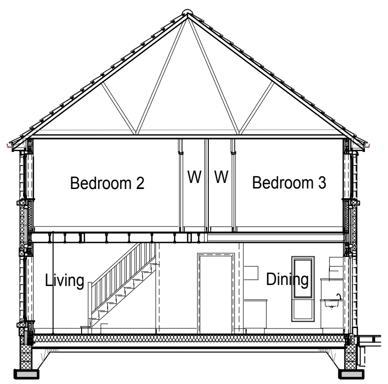
Thermal bridging and air tightness
- Good construction details
- Thermal bridge 0.08xexposed surface area
- Air tightness 10m3/m2.h at 50Pa.



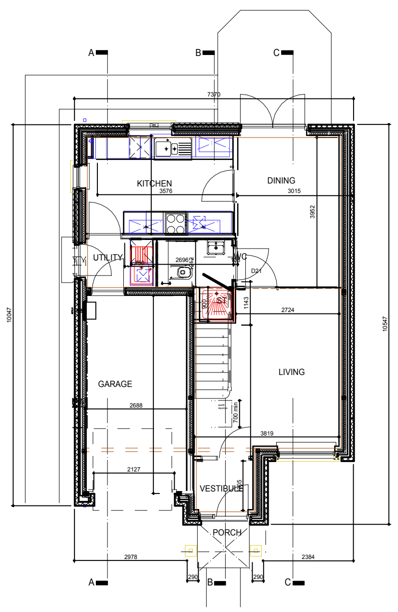
Section AA



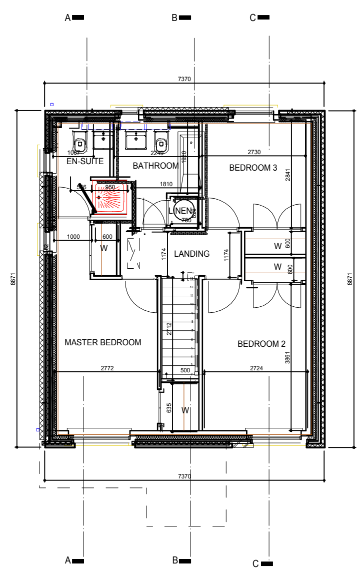
Section BB



Section CC



Ground Floor Plan



First Floor Plan

NOTES

DO NOT SCALE: Use figured dimensions only.

REV	NOTES	DATE DRAWN CHECKED
A	General revision.	2/3/07

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PROJECT
SBSA RESEARCH PROJECT

DRAWING
HOUSE BENCHMARK

SCALE	DRAWN	CHECKED	DATE
A1 1 : 100 A3 1 : 200	SH		16.02.07

NUMBER
2170 - 101 A

SAP calculation sheet

Benchmark house SAP calculation sheet

ACTUAL DETACHED DWELLING - MEET 2007 REGS.

Changes to NOTIONAL in PINK

1. Overall dwelling dimensions:

		area(m2)	h (m)	vol (m3)
1	Ground floor	45	2.586	116.37
2	First floor	55	2.658	146.19
5	Total floor area	100		
6	Total volume			262.56

2. Ventilation rate:

				m3/h		ac/h
7	Chimneys	0.00	40.00	0.00		
8	Open flues	0.00	20.00	0.00		
9	Intermit fan /pass vents	4.00	10.00	40.00		
9a	flueless gas fires	0.00	40.00	0.00		
10	Inf ch/f/f			40.00	div(6)	0.15

Fabric infiltration: if no permeability number avail (else skip to 19)

11	Storeys	2.00				
12	Inf storeys					0.10
13	Struct inf (0.25 steel/timber, 0.35 masonry)					0.25
14	Floor inf (susp wooden 0.2 unsealed, 0.1 sealed)					0.10
15	Draught lobby (no 0.05, yes 0)					0.05
16	Percent wiondows /doors ds (100 new build)				100.00	
17	Window inf					0.05
18	Inf rate calc					0.70
		y/n	Q50			
19	Permeability known (pressure test or design)	y	10.00			0.65
20	sheltered sides (2 for unknown location)			2		
21	shelter factor			0.85		
22	adjusted inf for shelter					0.554494
				y/n		
23	whole house MVHR			n		na
23a	whole house balanced MV			n		na
23b	whole house extract or +ve from outside			n		na
24	nat vent or +ve vent from loft			y		0.653732
25	Effective air change rate					0.653732

3. Heat loss parameters and heat losses:

	element		area	Uvalue	AU W/K	
26	Doors		5.71	1.8	10.2816	
27	windows type1		19.32	1.8	32.43834	1/((1/U)+.04)
27a	windows type 2		0.00		0	1/((1/U)+.04)
27b	rooflights		0.00		0	1/((1/U)+.04)
28	ground floor		45.47	0.22	10.00433	
29	walls type 1 (ex glz,dr)		121.90	0.25	30.47429	
29a	walls type 2(ex glz,dr)		17.12	0.25	4.28036	
30	roof type 1 (ex rooflight)		57.21	0.16	9.153257	
30a	roof type 2(ex rooflight)		0.00		0	
31	other - exposed 1st floor		11.46	0.22	2.521456	
32	total area (m2)		278.1927			
33	fabric heat loss (ex thbr)				99.15364	
34	thermal bridges	Y=	0.08		22.25542	
35	total fabric losses				121.4091	
36	vent heat loss				56.64247	
37	heat los sco-efficient (W/K)				178.0515	
38	heat loss parameter HLP W/m2K				1.780515	

SAP calculation sheet

	4. Water heating energy requirements:				
	Occupancy (tfa)				3.12
					kWh/year
39	Energy content of hot water used (tfa)				2102
			y/n		
40	Distribution losses (tfa)	inst pou?	n		371
			y/n		
	Combi system		n		
	Storage losses		y/n		
	manufacturers data available?		n		
41	manufacturers kWh/day				
41a	Temp factor Table 2b				
42	Energy lost from storage				0
	If no manufacturers data				
43	Cylinder volume (litres)			150	
44	Storage loss factor Table 2 (kWh/l/day)			0.0152	
44a	Volume factor Table 2a			0.928318	
44b	Temp factor Table 2b			0.54	
45	Energy lost from storage				417.1749
46	Storage losses				417.1749
	Solar hot water (appendix H)				
H11	dedicated solar storage volume (litres)			n	
			y/n		
47	dedicated solar storage?		n	Storage loss	417.1749
48	primary circuit losses Table 3				360
49	combi loss Table 3a				0
50	Solar DHW input (appendix H)				0
51	Output from water heater Kwh/year				3250
52	Heat gains from water heating kWh/year				1444.053
	(assumes cylinder inside dwelling)				
	5. Internal gains:				
53	Lights appliances cooking and metabolic Table 5				575.56
	lighting consumption /m2 (EB)			L1	9.3
	% LEL				50
	correction factor C1=1-0.5*NLE/N			L2	0.75
	light transmittance (6b)				0.8
	frame factor (6c)				0.7
	light access factor (6d)				0.83
	glazing ratio GL			L5	0.080815
	correction factor C2 dep on GL><.095			L3,L4	0.970621
	annual lighting energy used EL kWh/yr			L6	677.0082
	Reduction in lighting energy for LEL			L7	225.6694
53a	Reduction in gains due to LEL (Appendix L)			L8	33.85041
53b	Additional gains Table 5a				10
54	Water heating				164.8463
55	Total internal gains				716.5559

SAP calculation sheet

6. Solar gains:

		access Tab 6d	area m2	flux Tab 6a		G_L Tab 6b.	FF Tab 6c	Gains W
56	North	0.77		29	0.9	0.72	0.7	0
57	Northeast	0.77		34	0.9	0.72	0.7	0
58	East	0.77	19.32	48	0.9	0.72	0.7	323.8813
59	Southeast	0.77		64	0.9	0.72	0.7	0
60	South	0.77		72	0.9	0.72	0.7	0
61	Southwest	0.77		64	0.9	0.72	0.7	0
62	West	0.77		48	0.9	0.72	0.7	0
63	Northwest	0.77		34	0.9	0.72	0.7	0
64	Rooflights	0.77		75	0.9	0.72	0.7	0
65	Total solar gains							323.8813

66	Total gains W	1040.437
67	Gain to Loss ratio (GLR) Gains / Heat Loss Co-eff (K)	5.843461
68	Utilisation factor Table 7.	0.95
69	Useful gains W	992.6369

7. Mean internal temperature:

	Heating type (table 4a, 4d)		1
	Control (table 4e)		2
	Responsiveness (table 4a, 4d)		1
	HLP =	1.780515	C
70	Mean internal temp of living area Table 8		18.87
71	Temp adjustment from Table 4e		0
72	Adjustment for gains		0.315
73	Adjusted living temp C		19.18966
74	Temp difference between zones Table 9		1.54
75	Living area fraction (0 to 1)		0.16
76	Rest of house fraction		0.837244
77	Mean internal temperature		17.8998

8. Defree days:

78	Temp rise from gains	5.574998
79	Base temp (Mean int - Temp rise from gains = heat temp)	12.32481
80	Degree days Table 10.	1435.59

9. Space heating required:

81	Space heating required (useful) kWh/year	6134.633

SAP calculation sheet

9a. Energy requirement (individual heating systems):

	Space heating	
82	Fraction from secondary	0.1
83	Efficiency for main system (%) (SEDBUK plus adjustments)	91
84	Efficiency of secondary	100
85	Space heat fuel (main) kWh/year	6134.633
85a	Space heat fuel (secondary) kWh/yr	613.4633
	Water heating	
86	Efficiency of water heater	90
86a	Energy required for water heating kWh/year	3611.442
	Electricity for pumps and fans	kWh/yr
87a	central heating pumps Table 4f	130
87b	boiler with fan assisted flue Table 4f	45
87c	warm air heating fans Table 4f	0
87d	mech vent (balanced, extract or +ve from outside Table 4f	0
87e	keep hot for combi boiler Table 4f	0
87f	pump for solar water heating Table 4f	0
87	Total electricity for above kWh/year	175

10a Costs (individual heating systems):

11a SAP rating (individual heating systems):

12a DCER (individual heating systems):

		Energy kWh/year	Emm Fact CO2/kWh	Emm CO2/year
101	Space heating from main	6134.633	0.194	1190.12
102	Space heating from secondary	613.4633	0.422	258.88
103	Energy for water heating	3611.442	0.194	700.62
107	Space and water heating			2149.62
108	Electicity for pumps and fans	175	0.422	73.85
109	Energy for lighting (Appendix L)	677.0082	0.422	285.70
110	Energy produced or saved in dwelling	0		0.00
111	Energy consumed by above technology	0		0.00
112	Total CO2 kg/year			2509.17
113	Dwelling CO2 Emission Rate (DER) kg/m2.year			25.1
	Carbon factor			17.3
	EI			76.8
	rating			C

Building volume	building-m³	411	
Gross Area (outside wall)	gross m²	136.85	*including garage*
Net room area (heated space)	m²	100	
Storey hight	m	2.871	*Average value*
Room height	m	2.472	*Average value*
Total outer wall area (incl.doors&windows)	m²	180.0	
Total window area	m²	11.77	*(15.8 with glazing in doors)*
Total door area	m²	10.52	
Total outer wall area (without doors&windows)	m²	157.7	
Roof (inner side of outer walls)	m²	54.6	
Base floor (inner side of outer walls)	m²	58.7	

heigh	*width*	*area*
8.181	*6.68*	*54.64908*
1.676	*1.565*	*2.62294*
0.5	*2.861*	*1.4305*

ground floor

hight	m	3.323	
Floor Area (outside wall)	m²	71.47	
external perimeter (outside)	m	35.834	
Total wall area (incl.doors&windows)	m²	103.4169	
Total window area	m²	5.06	
Total door area	m²	6.52	*(4.02 m2 of this is with glazing)*
Garage door	m²	4	

2nd floor

hight	m	2.658
Floor Area (outside wall)	m²	65.38
external perimeter (outside)	m	32.482
Total wall area (incl.doors&windows)	m²	76.59256
Total window area	m²	6.71
Total door area	m²	0

D5-2007 energiankulutuslaskelma energiatodistusta varten

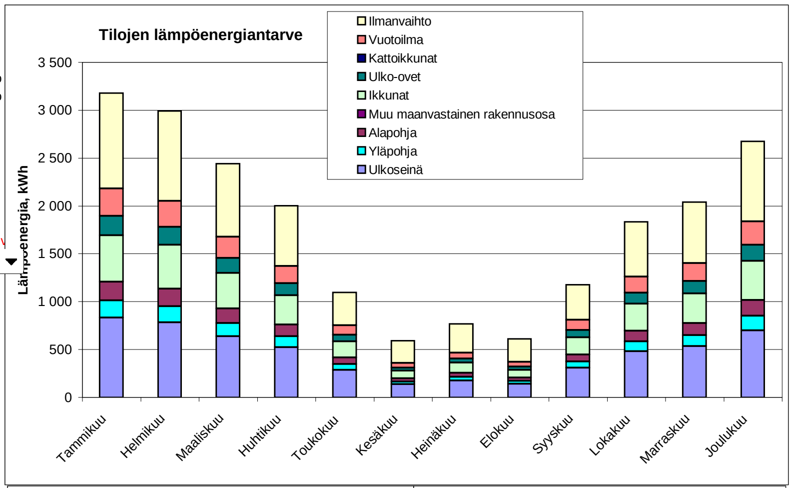
Säätiedot:		1	**Kaukolämpö**
I Helsinki-Vantaa, 1979	NORMITALO 2007 Yksikkö	LASKENTASARAKE 2 krs OKT UK-FI	Vesiradiaattorit, 70/40 °C

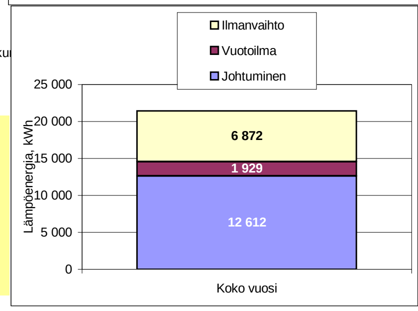
Energiatehokkuusluokka on D? (191 kWh/brm² vuodessa)

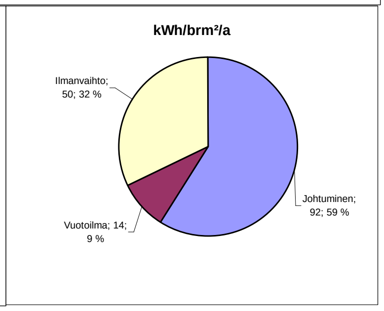
Laskennan lähtötiedot

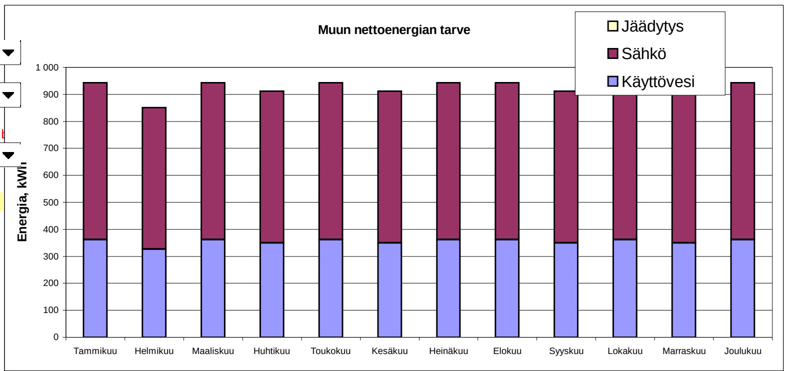
Rakennustyyppi (mm. sähkönkulutustiedot)	Pientalo		
Rakennustilavuus	rak-m³	411	
Bruttoala	brm²	136.8	autotalli
Huoneala, lämpimät tilat	m²	100	*73.1 %*
Julkisivujen pinta-ala	m²	180	
Kerroskorkeus	m	2.9	keskiarvo
Huonekorkeus	m	2.5	keskiarvo
Ilmatilavuus, lämpimät tilat	m³	247	
Rakennusosien pinta-alat			
Lämpimät tilat			
Ulkoseinä	m²	158	
Yläpohja	m²	55	
Alapohja (ulkoilmaan rajoittuva)	m²		
Alapohja (ryömintätilaan rajoittuva)	m²	59	
Alapohja (maanvastainen)	m²		Maalaji ei v
Maalaji:	2. hiesu, moreeni, hieta, salaojittamaton hiekka ja sora		
Muu maanvastainen rakennusosa	m²		
Ikkunat yhteensä	m²	15.8	*11.5 %*
Varjostukset: sivu / ylä / ympäristö			
pohjoinen 0° 0° 15°	m²	6.2	
koillinen 0° 0° 15°	m²		
itä 0° 0° 15°	m²	0.0	
kaakko 0° 0° 15°	m²		
etelä 0° 0° 15°	m²	6.6	
lounas 0° 0° 15°	m²		
länsi 0° 0° 15°	m²	3.0	
luode 0° 0° 15°	m²		
Ulko-ovet	m²	6.5	minus ikku
Kattoikkunat	m²		
Rakennusosien U-arvot			
Lämpimät tilat			
Ulkoseinä	W/m²K	0.24	0.24
Yläpohja	W/m²K	0.15	0.15
Alapohja (ulkoilmaan rajoittuva)	W/m²K		0.15
Alapohja (ryömintätilaan rajoittuva)	W/m²K	0.19	0.19
Alapohja (maanvastainen), ilman maan lämmönvastusta)	W/m²K		0.24
Muu maanvastainen rakennusosa	W/m²K		0.24
Ikkunat	W/m²K	1.4	1.4
Ulko-ovet	W/m²K	1.4	1.4
Kattoikkunat	W/m²K		1.5
Vaipan ominaislämpöhäviö	**W/K**	**86.2**	
Maanvastaisen alapohjan ominaislämpöhäviö		**0.0**	
Ikkunoiden auringon säteilyn läpäisy			
Ikkunalasituksen tyyppi:	Eristyslasi, matalaemissiviteettipinnoite + erillislasi (U=1,0 - 1,4)		
g-arvo		0.50	
Verhot ja aurinkosuojat:	Ei verhoa		
Verhokerroin, F_{verho}	touko-syys =1	1	
Kehäkerroin, $F_{kehä}$		0.7	timber kit, t
Rakennustyyppi ja massiivisuus:	Pientalot, kevytrakenteinen		
Tehollinen lämpökapasiteetti	Wh/(brm² K)	40	
Ulkovaipan ilmanvuotoluku	n_{50}-luku, 1/h	**4.0**	4.0
Vuotoilmakerroin	1/h	0.16	
Vuotoilmavirta	m³/s	0.0110	
Vuotoilman ominaislämpöhäviö	**W/K**	**13.2**	
Ilmanvaihdon ilmavirta	m³/s	**0.054**	
Ilmanvaihtokerroin	1/h	0.79	
Ilmanvaihtokerroin	dm³/s/m²	0.54	
Ilmanvaihdon käyttöaika		jatkuva käyttö	
Vuorokautinen käyntiaika, td	h	24	
Viikottainen käyntiaika, tv	vrk	7	
Käyttöaika	kellonaika	0-24	
Käyttöajan muuntokerroin, r		1	
Käyttöajalla painotettu ilmanvaihdon ilmavirta,	m³/s	0.054	
Ilmanvaihdon LTO:n vuosihyötysuhde	%	**30**	30
Ilmanvaihdon ominaislämpöhäviö	**W/K**	**45.4**	
Ilmanvaihdon ominaissähköteho	kW/(m³/s)	0	2.02
Vedenkulutus:	Asuinrakennus (huoneistokohtainen mittaus ja laskutus)/henk.		
- lämpimän veden kulutus	dm³/henk/vrk	50	
	dm³/brm²/a	534	
	m³/a	73	
- lämpimän veden osuus koko kulutuksesta	%	40	
- koko veden kulutus	dm³/henk/vrk	125	
	dm³/brm²/a	1 334	
	m³/a	183	
Käyttöveden kiertopiiri:			pitäisikö olla
	Asuinrakennus tai vast. (kiertopiiriin ei ole kytketty märkätilojen lämmityslaitteita)		
Lämmitysjärjestelmä			
Tilojen lämmitysjärjestelmä:	Vesiradiaattorit, 70/40 °C		
Lämmöntuottotapa:	Kaukolämpö		
Lämmönlähde:	*Kaukolämpö*		
Tilojen lämmönkehityslaitteiden lukumäärä		1	
Lämmitysvesivaraajan koko	m³	2	
Lämmitysvesivaraajien lukumäärä		0	
Lämpimän käyttöveden varaajan koko	dm³	300	
Lämpimän käyttöveden varaajien lukumäärä		0	
Erillisten käyttöveden lämmönkehityslaitteiden lukumäärä		0	
Jäähdytysjärjestelmä			
Jäähdytysjärjestelmän hyötysuhde		0.7	
Kylmätuottolaitteen vuotuinen kylmäkerroin		1	
Henkilöiden lukumäärä		4	
Huoneistojen lukumäärä		1	
Kerrosten lukumäärä		2	
Sisälämpötila, lämmitys	°C	21	
Sisälämpötila, jäähdytys	°C	99	
Mitoitusulkolämpötila	°C	-26	

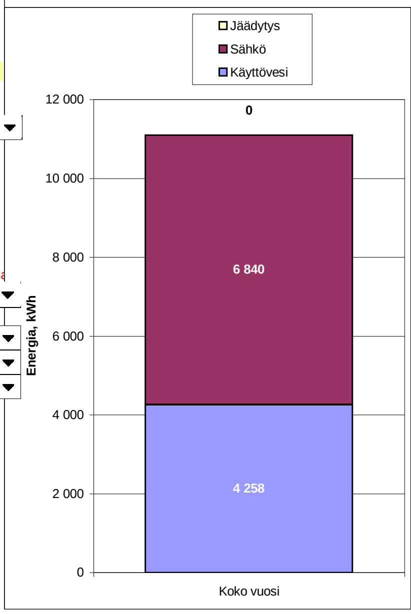
Energiantarve

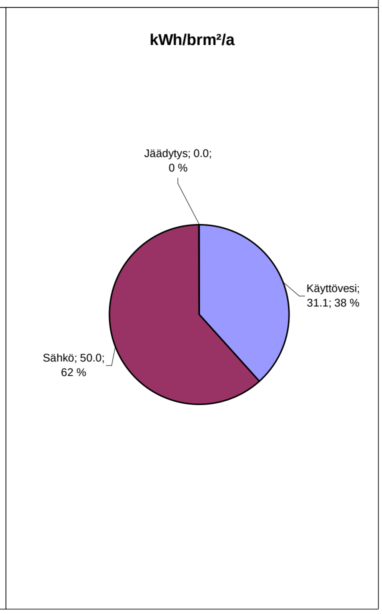












D5-2007 energiankulutuslaskelma energiatodistusta varten

Säätiedot: | 1 | **Kaukolämpö**

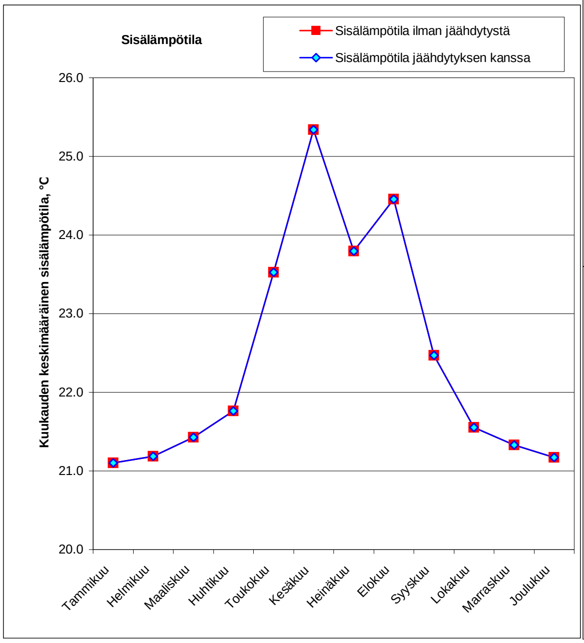
I Helsinki-Vantaa, 1979 | NORMITALO 2007 Yksikkö | LASKENTASARAKE 2 krs OKT UK-FI | Vesiradiaattorit, 70/40 °C

"Energiatehokkuusluokka" on D? (191 kWh/brm² vuodessa)

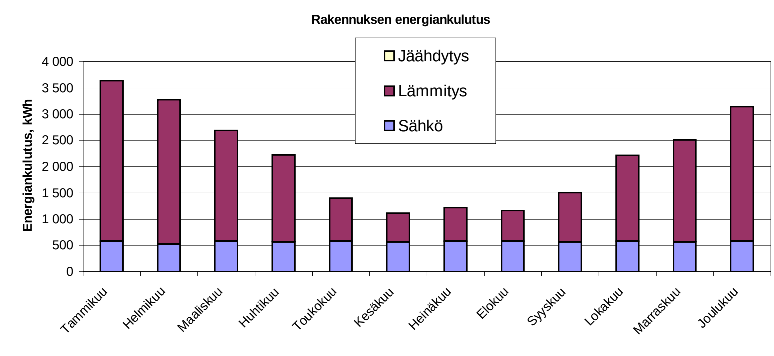
Laskennan tulokset

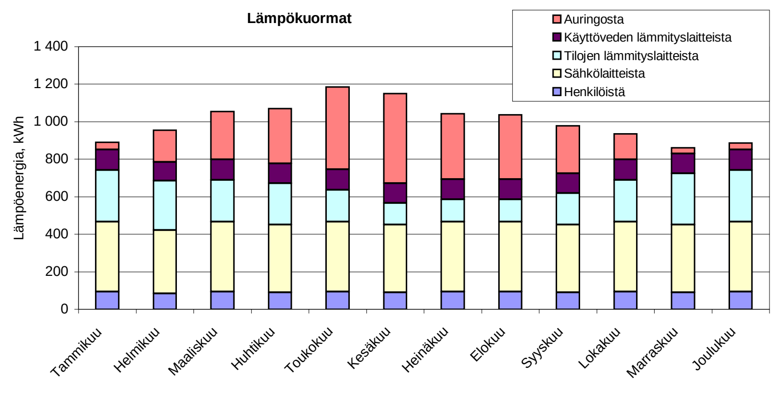
			kWh/brm², a
A Energiantarve			
Vaippa	kWh/a	12 612	*92*
Ilmavuodot	kWh/a	1 929	*14*
Ilmanvaihto	kWh/a	6 872	*50*
Tilojen lämpöenergiantarve	kWh/a	**21 413**	***157***
Lämminkäyttövesi (LKV)	kWh/a	4 258	*31*
Sähkö	kWh/a	6 840	*50*
Jäähdytys	kWh/a	0	*0*
B Rakennuksen energiankulutus			
Lämmitysenergiankulutus	**kWh/a**	**19 249**	***141***
Sähköenergiankulutus	kWh/a	6 840	*50*
Energiatodistusta vastaava rakennuksen energiankulutus	**kWh/a**	**26 089**	***191***
Jäähdytysenergiankulutus	kWh/a	0	*0*
C Ostoenergiankulutus			
Ostettava lämmitysenergia	kWh/a	19 249	*141*
Ostettava sähköenergia	kWh/a	6 840	*50*
Ostettava jäähdytysenergia	Kaukokylmä kWh/a	0	*0*
Ostettava lämmityspolttoaine	*Kaukolämpö*, kWh	19 249	*141*
Lämpökuormat			
Henkilöistä	kWh/a	1 094	*8*
Sähkölaitteista	kWh/a	4 391	*32*
Lämmityslaitteista	kWh/a	2 453	*18*
LKV-laitteista	kWh/a	1 278	*9*
Auringon säteilyenergia ikkunoista	kWh/a	2 829	*21*
Lämpökuormat yhteensä	kWh/a	12 045	*88*
Lämpökuormien hyödyntämisaste		**82 %**	
Hyödynnetyt lämpökuormat	kWh/a	9 926	*73*
Tilojen lämmitysenergiankulutus	**kWh/a**	**11 486**	***84***
Lämmitysjärjestelmän lämpöhäviöt			
Tilojen lämmönkehitys	kWh/a	2 000	*15*
Tilojen lämmitysjärjestelmä	kWh/a	1 505	*11*
Lämmitysvesivaraaja	kWh/a	0	*0*
Käyttöveden lämmönkehitys	kWh/a	0	*0*
Lämpimän käyttöveden varaaja	kWh/a	0	*0*
Lämpimän käyttöveden kierto	kWh/a	0	*0*
Lämmityksen lämpöhäviö yhteensä	kWh/a	3 505	*26*
Lämmöntuottolaitteen vuosihyötysuhde	**%**	**100**	
Lämmitysjärjestelmän hyötysuhde	**%**	**82**	
Sähköenergiankulutus			
Valaistusjärjestelmä	kWh/a	958	*7*
Ilmanvaihtojärjestelmä	kWh/a	958	*7*
Muut laitteet	kWh/a	4 925	*36*

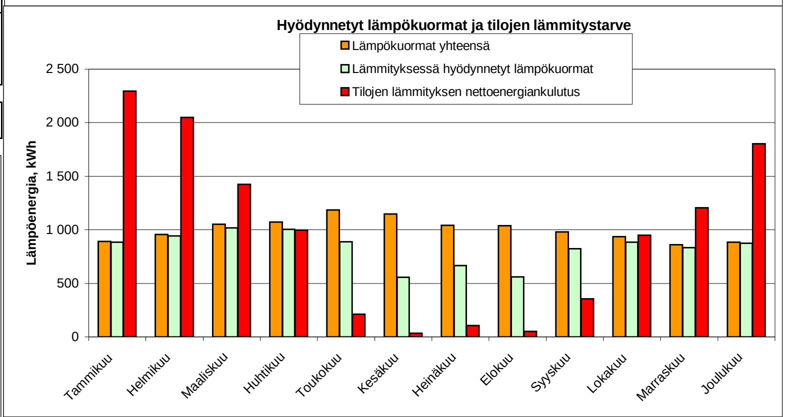
Sisälämpötila, korkein laskettu kuukausikeskiarvo ilman jäähdytystä	°C	25.3

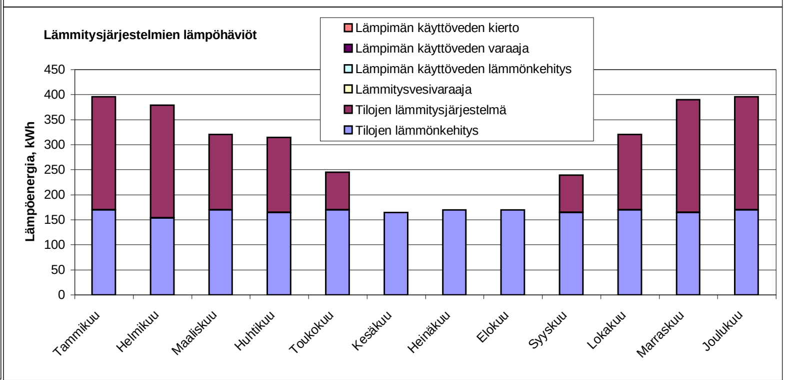


B Rakennuksen energiankulutus









Säätiedot: I Helsinki-Vantaa, 1979

1

NORMITALO 2007
Yksikkö

LASKENTASARAKE
2 krs OKT UK-FI

Kaukolämpö
Vesiradiaattorit, 70/40 °C

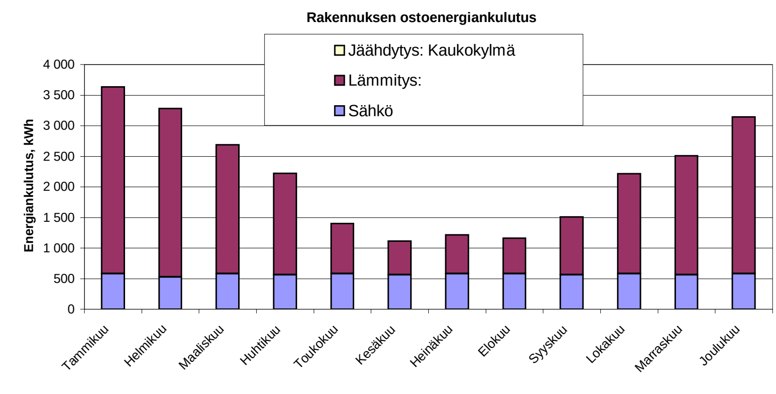
"Energiatehokkuusluokka" on "D?" (191 kWh/brm² vuodessa)

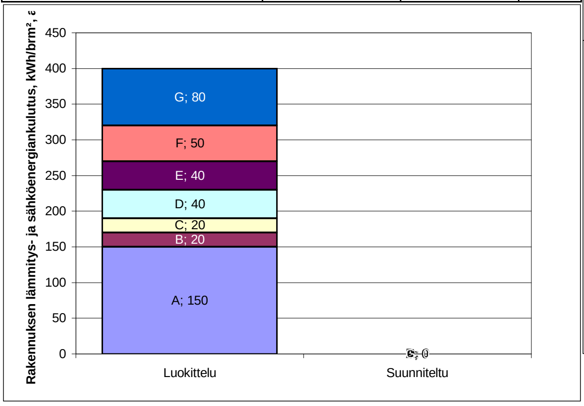
B2 Rakennuksen energiankulutus energiatodistusta varten

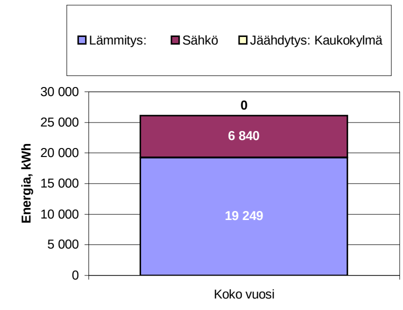
20 207
19 249
26 089

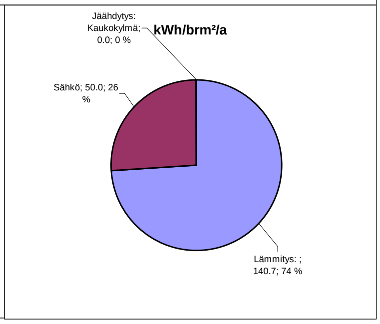
		kWh/a	kWh/brm²
Energiatodistusta vastaava rakennuksen energiankulutus		26 089	191
Lämmitysenergiankulutus		19 249	141
Tilojen lämmitysenergiankulutus		11 486	84
Lämmityksen lämpöhäviö yhteensä		3 505	26
Lämminkäyttövesi (LKV), netto		4 258	31
Sähköenergiankulutus		6 840	50
Lämpökuormien hyödyntämisaste		82 %	
Hyödynnetyt lämpökuormat		9 926	73
Jäähdytysenergiankulutus		0	0
kuukausikeskiarvo ilman jäähdytystä	°C	25.3	D?
Ostettava lämmitysenergia		19 249	141
Ostettava sähköenergia		6 840	50
Ostettava jäähdytysenergia	Kaukokylmä kWh/a	0	0
Ostettava lämmityspolttoaine	*Kaukolämpö*, kWh	19 249	141

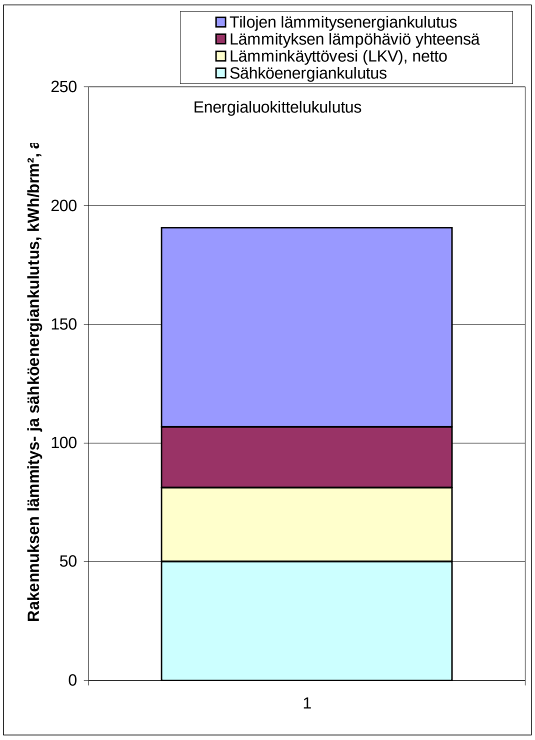
C Ostoenergiankulutus











Rakennuskohde	**Esimerkkipientalo**
Rakennustyyppi	1-kerroksinen pientalo, ikkunapinta-ala 12 % kerrostasoalasta.
Pääsuunnittelija	
Tasauslaskelman tekijä	
Päiväys	
Tulos: Suunnitteluratkaisu	**TÄYTTÄÄ VAATIMUKSET**

Rakennuksen yleistiedot

Rakennustilavuus	411	rak-m³
Maanpäälliset kerrostasoalat yhteensä	136.8	krs-taso-m²
Huoneala	100	m²
Julkisivujen pinta-ala	180	m²
Kerroskorkeus	2.9	m
Huonekorkeus	2.472	m
Ilmatilavuus, lämpimät tilat	247	m³
Ilmatilavuus, puolilämpimät tilat		m³

100 %

Perustiedot	**Pinta-alat, m² [A]**		**U-arvot, W/(m² K) [U]**			**Lämpöhäviöiden tasaus** Ominaislämpöhäviö, W/K $[H_{joht} = A \times U]$	
RAKENNUSOSAT	**Vertailu-arvo**	**Suunnittelu-arvo**	**Vertailu-arvo**	*Enimmäis-arvo*	**Suunnittelu-arvo**	**Vertailu-ratkaisu**	**Suunnittelu-ratkaisu**
Lämpimät tilat							
Ulkoseinä	152	161	**0.24**	*0.60*	0.23	36.4	36.9
Yläpohja	55	55	**0.15**	*0.60*	0.10	8.3	5.5
Alapohja (ulkoilmaan rajoittuva)			**0.15**	*0.60*		-	-
Alapohja (ryömintätilaan rajoittuva)	59		**0.19**	*0.60*	0.19	9.0 1)	9.0 1)
Alapohja (maanvastainen)			**0.24**	*0.60*		-	-
Muu maanvastainen rakennusosa			**0.24**	*0.60*		-	-
Ikkunat	20.5	11.8	**1.40**	*1.80*	1.20	28.7	14.1
Ulko-ovet	10.5		**1.40**	*-*	1.40	14.7	14.7
Kattoikkunat			**1.50**	*1.80*		-	-
Lämpimät tilat yhteensä	**297**	**297**				**97.1**	**80.2**
Puolilämpimät tilat							
Ulkoseinä			**0.38**	*0.60*		-	-
Yläpohja			**0.28**	*0.60*		-	-
Alapohja			**0.28**	*0.60*		-	-
Alapohja (maanvastainen)			**0.34**	*0.60*		-	-
Muu maanvastainen rakennusosa			**0.34**	*0.60*		-	-
Ikkunat			**1.80**	*2.80*		-	-
Ulko-ovet			**1.80**	*-*		-	-
Puolilämpimät tilat yhteensä	**-**	**-**				**-**	**-**

	Vaipan ilmanvuotoluku, $[n_{50}]$		**Vuotoilmavirta, m³/s $[q_{v,v} = n_{50}/25 \times V/3600]$**		**Ominaislämpöhäviö, W/K $[H_{vuotoilma} = 1200 \times q_{v,v}]$**	
VAIPAN ILMAVUODOT / **Vuotoilma**	**Vertailu-arvo**	**Suunnittelu-arvo**	**Vertailu-arvo**	**Suunnittelu-arvo**	**Vertailu-ratkaisu**	**Suunnittelu-ratkaisu**
Lämpimät tilat	**4.0**	4.0	0.0110	0.0110	13.2	13.2
Puolilämpimät tilat	**4.0**				-	-

	Poistoilmavirta, m³/s $[q_{v,p}]$		**LTO:n vuosihyötysuhde, % $[\eta_a]$**		**Ominaislämpöhäviö, W/K $[H_{iv} = 1200 \times q_{v,p} \times (1-\eta_a)]$**	
ILMANVAIHTO / **Hallittu ilmanvaihto**	**Vertailu-arvo**	**Suunnittelu-arvo**	**Vertailu-arvo**	**Suunnittelu-arvo**	**Vertailu-ratkaisu**	**Suunnittelu-ratkaisu**
Lämpimät tilat	0.046		**30**	0	38.6	55.2
Lämpimät toissijaiset tilat (ei LTO:a)			**0**	**0**	-	-
Puolilämpimät tilat			**30**		-	-

Rakennuksen lämpöhäviöiden tasaus	**Ominaislämpöhäviö, W/K $[H = H_{joht} + H_{vuotoilma} + H_{iv}]$** Vertailu-ratkaisu	Suunnittelu-ratkaisu
Lämpimien tilojen ominaislämpöhäviö yhteensä	**149**	**149**
Puolilämpimien tilojen ominaislämpöhäviö yhteensä	**-**	**-**

1) Lämpimissä tiloissa ryömintätilaan rajoittuvan alapohjan lämpöhäviö kerrotaan luvulla 0,8 rakentamismääräykokoelman osan D3 mukaisesti.