The PHPP System....

....the only way to achieve the Passive House standard???

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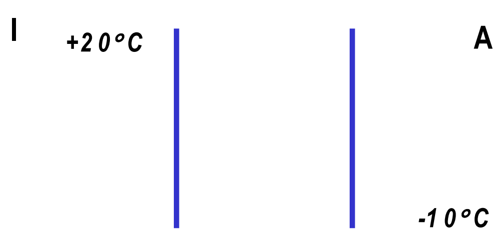
U-Value: [W/m²K]

Definition:Heat quantity in **J** (Joule), which goes in 1 second, by 1°C different temperature, through 1m² wall, from one side to the other.



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Heat transfer coefficient:

- α_a : Heat quantity in **J** (Joule), which goes in 1 second, by 1°C different temperature, through 1m² wall, between the outside surface and the outside air.
- α_i : Heat quantity in **J** (Joule), which goes in 1 second, by 1°C different temperature, through 1m² wall, between the inside surface and the inside air.

- $1/\alpha_a = R_{se}$: exterior heat transfer coefficient
- $1/\alpha_i = R_{si}$: interior heat transfer coefficient

Tableware values out of DIN EN ISO 6046

Tabelle 2: Wärmedurchlaßwiderstand, in m²K/W, von ruhenden Luftschichten – Oberflächen mit hohem Emissionsgrad

Dicke der Luftschicht	Richtung des Wärmestromes		
mm	Aufwärts	Horizontal	Abwärts
0	0,00	0,00	0,00
5	0,11	0,11	0,11
7	0,13	0,13	0,13
10	0,15	0,15	0,15
15	0,16	0,17	0,17
25	0,16	0,18	0,19
50	0,16	0,18	0,21
100	0,16	0,18	0,22
300	0,16	0,18	0,23

ANMERKUNG: Zwischenwerte können mittels linearer Interpolation ermittelt werden.

$1/\Lambda$

$1/\alpha_i$ $1/\alpha_a$

	Direction		
	upwards	horizontal	downwards
R_{si}	0,10	0,13	0,17
R_{se}	0,04	0,04	0,04

For components touching the earth R_{se}=0

Thermal conductivity
λ - value

it is an material constant.

λ: Heat quantity in **J** (Joule), which goes in 1 second, by 1°C different temperature, through 1m² wall per 1 m wall thickness.

Calculating example

known: thickness of the wall d= 0,3m
blockwall
searched: U

- $$\boxed{U = \frac{1}{1/\alpha_i + d/\lambda + 1/\alpha_a}}$$
- Lösung:

U= ____________

U-value for components with several layers

$$U = \frac{1}{1/\alpha_i + d_1/\lambda_1 + d_2/\lambda_2 + \cdots + d_n/\lambda_n + 1/\alpha_a}$$

I +20°C

A

-10°C

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The average U-value

$$U_{average} = \frac{U_1 * A_1 + U_2 * A_2 + U_3 * A_3 + \cdots}{A_1 + A_2 + A_3 + \cdots}$$

Example: geg.: Blockwall 21m²

Window 1m²

U_{mittel} = ______

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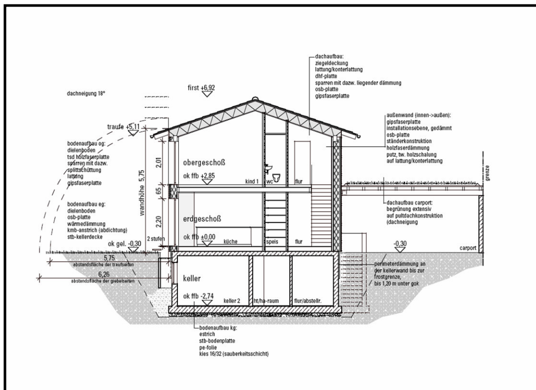
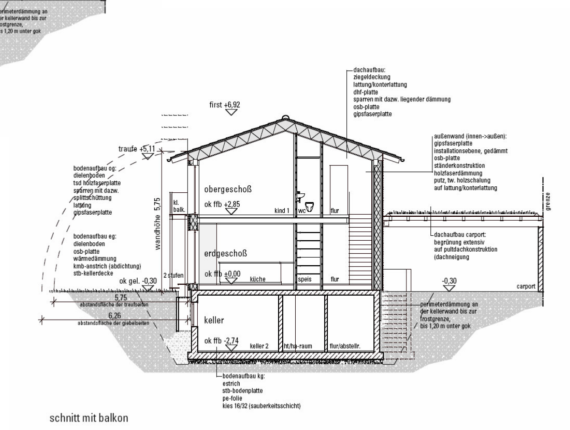


Roof width L+R 4,43m

Hights of the wall L+R 5,94m
ridge 7,11m mean value 6,53m



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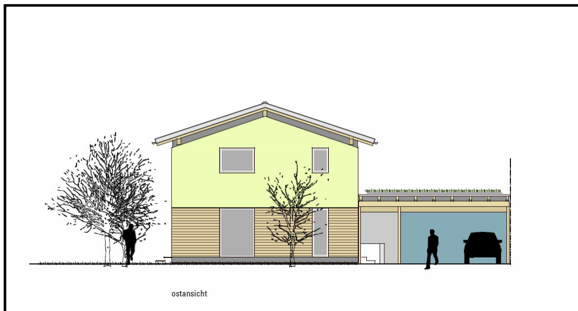
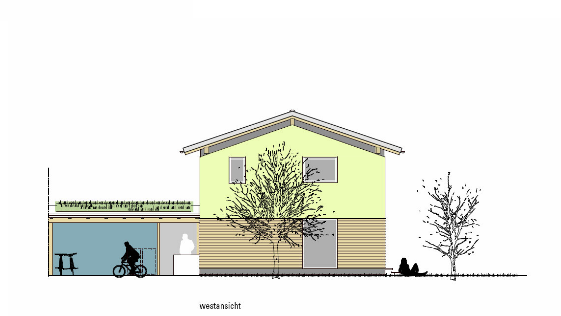


Fixed window first floor 1x 0,75x2,25
1x 1,50x2,25
Normal window top floor 1x 0,75x1,45
1x 1,50x1,45

Normal window top floor 1x 0,75x1,45
1x 1,50x1,45

Fixed window first floor 1x 1,50x2,25



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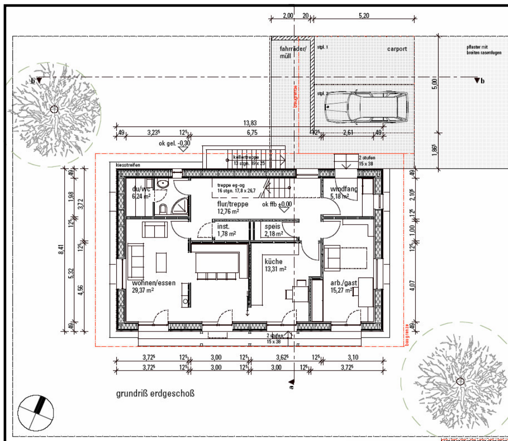
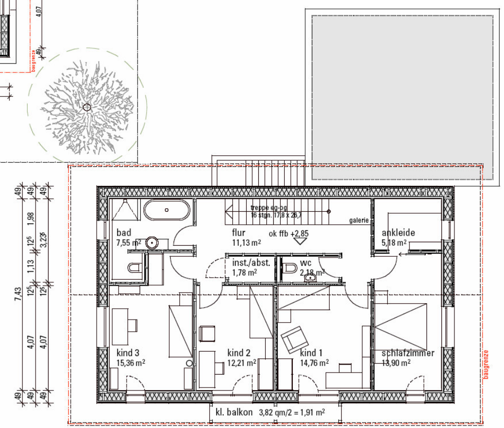


footpoint 13,83 x 8,41

Treated floor area 169,53 m²

U-value wall =0,11 W/m²K, ceiling and roof =0,10 W/m²K



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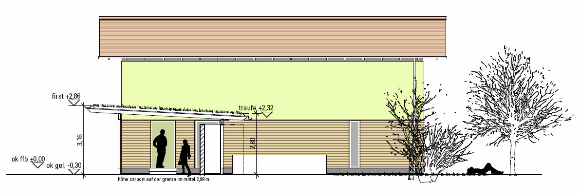
French door 2x 0,925x 2,25
6x 1,85 x 2,25

U_g-value = 0,60 W/m²K

g –value = 60%

U_D-value = 0,65 W/m²K

Outdoor I 1,15x2,25
Tilt window 0,925x2,25
Outdoor II 1,15x2,25



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Inputs to PHPP

- Sheet Verification, Climate Datat
- Calculate the U-values
- Input of the areas (all the walls with outside measure)
- Sheet WinTyp and Windows. Be careful with the orientation (Order east, south, west, north)
- Put in the windows single if they have different shading, make a own line for fixed windows
- Input of the shading
- Sheet ventilation.
- Summer overheating. Summer, Summer.S, SummVent

Excel sheet verification

passive house Freundorfer
Oberbayern Garmisch-P.
Martin Greif Straße 20
83080 Oberaudorf
bavaria
one familiy house

Josefa und Franz Freundorfer
Martin Greif Straße 20
83080 Oberaudorf

Dipl. Ing. Elke Kneißl
Morellstraße 27
86159 Augsburg

B.Tec Dr. Harald Krause
Sonnenfeld 9
83122 Samerberg

2006
1
742,0 m^3
5,0

Interior Temperature: 20,0 °C
Internal Heat Sources: 2,1 W/m²

no standard climate

Internal Heat Sources
Building Type: Residence
Standard Values used? Standard

Planned Number of Occupants:
5 Planning

Choose the climate region.

Passive House Planning

CLIMATE DATA

Standard/Regional Climate: Select Here.

Regional Climate Data

Germany (DIN 4108-6)

Choose the regional climate here:

Garmisch-P.

Climate Data for Heat Load

Heat Load Data Already Assigned

No Choice/Heat Load Data Assigned

Use Regional Data?	Yes
Climate Building	**Garmisch-P.**
Chosen Method Heat Requirement:	**Annual Method**
Monthly Data:	Garmisch-P. (Region
Annual Data:	0
Use Annual Climate Data Set	No
Annual Climate Data	**Carried over into Annual Method**
H_T	**261**
G_t	**107**
East	**428**
South	**693**
West	**416**
North	**227**
Horizontal	**635**

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Calculation of U-Values

1	**wall plastered**
Assembly No.	Building Assembly Description

Heat Transfer Resistance [m²K/W] interior R_{si} : 0,13

exterior R_{se}: 0,04

	Area of Section 1	λ [W/(mK)]	Area of Section 2 (optional)	λ [W/(mK)]	Area of Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	plaster board	0,800					12
2.	fiber board	0,040	lightwood	0,130			60
3.	OSB board	0,170					15
4.	cellulose	0,040			timber frame	0,130	340
5.							
6.	fiber board inthermo	0,050					60
7.	outside plaster	0,600					5
8.							

Percentage of Sec. 2: 7,0%

Percentage of Sec. 3: 17,0%

Total: **49,2** cm

U-Value: **0,107** W/(m²K)

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Excel sheet U -List

Passive House Plann

U - L I S T

Sheet with compilation of calculated assemblies from U-Values worksheet and further assemblies from data banks

Assembly Nr.	Type Assembly Description	Total Thickness	U-Value	Thickness of Insulation Layer	Thermal Conductivity of Insulation Layer	Spec. Capacity C_{eff}	Min. Moisture Diffusion
		m	W/(m²K)	m	W/(mK)	kJ/m²/K	sd_{min} m
1	- none -						
2	wall plastered	0,492	0,11				
3	wall timber	0,462	0,11				
4	ceiling to the basement	0,544	0,10				
5	roof	0,491	0,10				
6							
7							
8							
9							

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Input of the areas

Area Inputs

Area Nr.	Building Element Description	Group Nr.	Assigned to Group	Quantity	x (	a [m]	x	b [m]	+	User-Determined [m²]
	Treated Floor Area	1	Treated Floor Area	1	x (		x		+	165,23
	East Windows	2	East Windows							
	South Windows	3	South Windows							
	West Windows	4	West Windows	Please complete in Windows w						
	North Windows	5	North Windows							
	Horizontal Windows	6	Horizontal Windows							
	Exterior Door	7	Exterior Door	2	x (	1,13	x	2,20	+	
1	wall east 1.floor	8	Exterior Wall - Ambient Air	0,5	x (		x		+	56,13
2	wall west 1.floor	8	Exterior Wall - Ambient Air	0,5	x (		x		+	56,13
3	wall south 1.floor	8	Exterior Wall - Ambient Air	0,5	x (	13,830	x	5,940	+	
4	wall north 1.floor	8	Exterior Wall - Ambient Air	0,5	x (	13,830	x	5,940	+	
5	ceiling basement	9	Exterior Wall - Ground	1	x (	13,830	x	8,410	+	
6	roof	10	Roof/Ceiling - Exterior Air	2	x (	13,830	x	4,430	+	
7	wall east 2.floor	8	Exterior Wall - Ambient Air	0,5	x (		x		+	56,13
8	wall west 2.floor	8	Exterior Wall - Ambient Air	0,5	x (		x		+	56,13
9	wall south 2.floor	8	Exterior Wall - Ambient Air	0,5	x (	13,830	x	5,940	+	
10	wall north 2.floor	8	Exterior Wall - Ambient Air	0,5	x (	13,830	x	5,940	+	

Choose Group Nr. from sheet area A 14 till 17

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Connect the aereas with the U values

User-Determined [m²]	-	User Deduction [m²]	-	Deducted Window Areas [m²]	) =	Area [m²]	Selection of the corresponding building elements	Nr.
165,23	-				) =	165,2		
						0,0	Values from Windows worksheet	
						0,0	Values from Windows worksheet	
dows worksheet only!						0,0	Values from Windows worksheet	
						0,0	Values from Windows worksheet	
						0,0	Values from Windows worksheet	
	-		) -		=	5,0	outdoor	6
56,13	-		) -	0,0	=	28,1	wall plastered	2
56,13	-		) -	0,0	=	28,1	wall plastered	2
	-		) -	0,0	=	41,1	wall plastered	2
	-		) -	0,0	=	41,1	wall plastered	2
	-		) -	0,0	=	116,3	ceiling to the basement	4
	-		) -	0,0	=	122,5	roof	5
56,13	-		) -	0,0	=	28,1	wall timber	3
56,13	-		) -	0,0	=	28,1	wall plastered	2
	-		) -	0,0	=	41,1	wall timber	3
	-		) -	0,0	=	41,1	wall timber	3

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The window: A long way from a „low interest product"...

to a most important component of the Passive House?

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The asymmetric of radiation temperature as a criteria of wellbeing

- The experience of our wellbeing depends deeply on the different temperatures of the walls girdle us.

left half space

right half space

U_W< 0,85 W/m²K
2,5K

Beneath 2,5 K we refer to a wellbeing living climate

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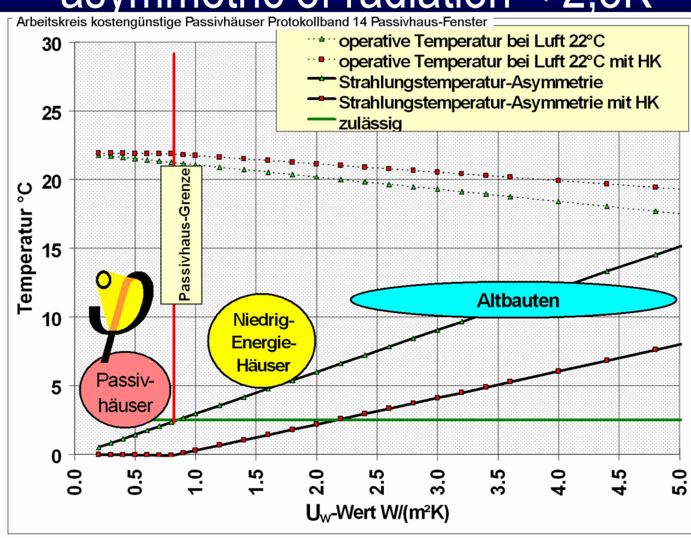
asymmetric of radiation < 2,5K



Only windows with U_w=0,8W/m²K ensure us a radiation asymmetric >2,5K

Utherwise wie have the old tenet of **radiators on the outside wall of the building.**

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Stratification of temperature: a further criteria of wellbeing

- Difference of temperature between the near of the floor (0,1m) and the hight of head looking to a siting person, measured 50cm in front of the window.
- A messure for the danger having cold feet.

We refer to a wellbeing atmosphere if this stratification of temperature is below 1.5 K.

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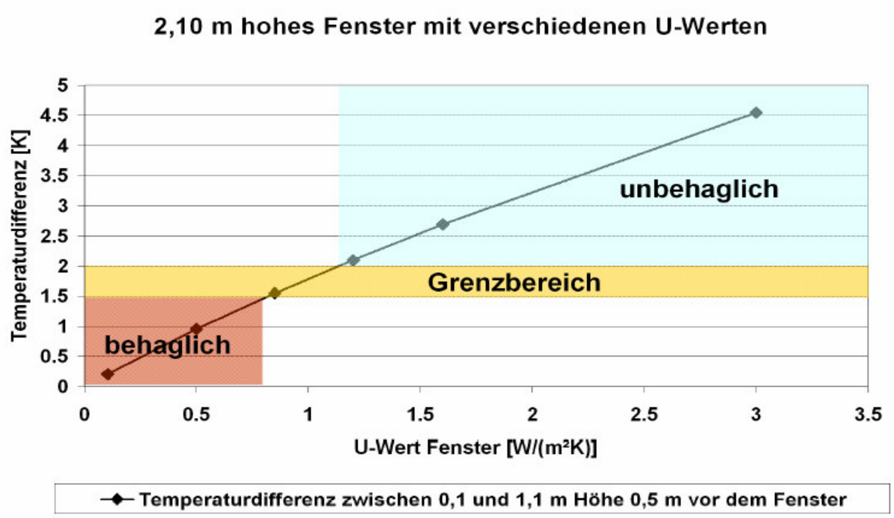
Stratification of temperature depends on the Uw -value



Source: Hiwin PHI

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The difference of the operativ temperature and the room temperature

The operativ temperature is the middle of the radiation temperature of all the walls.

We speak about wellbeing atmosphere, if this difference of the operativ temperature to the room temperature is less then 3K.

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The operative temperature

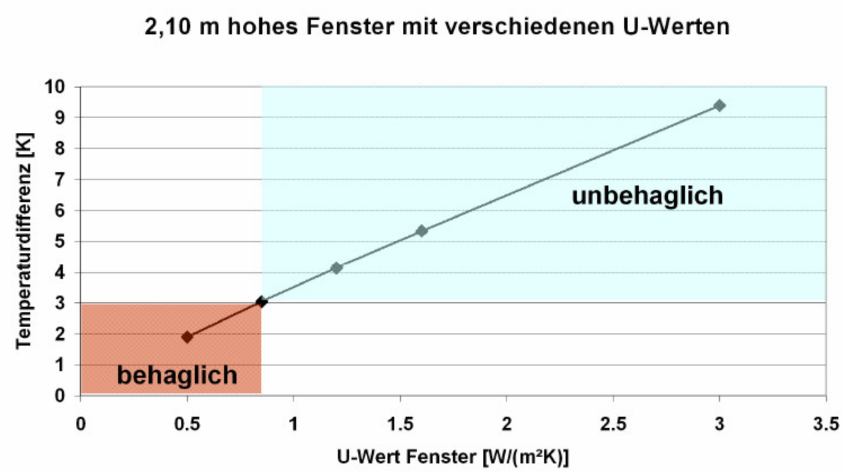

Bild 51 Differenz der maximalen und minimalen operativen Temperaturen im Aufenthalts-bereich

Quelle: Hiwin PHI

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Windows a key position in passive housing

- High quality is postulated, so the wellbeing in close proximity to the windows is estimated as very good without radiators.
- Quasi as a side effect the windows become radiators itself.

Dr. Wolfgang Feist Dezember 1998

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The way to modern insulating glas


Quality assurance

U_g=3.0

U_g=2.3

U_g=2.2

U_g=1.3 bis 0.9

U_g=0.8 bis 0.5

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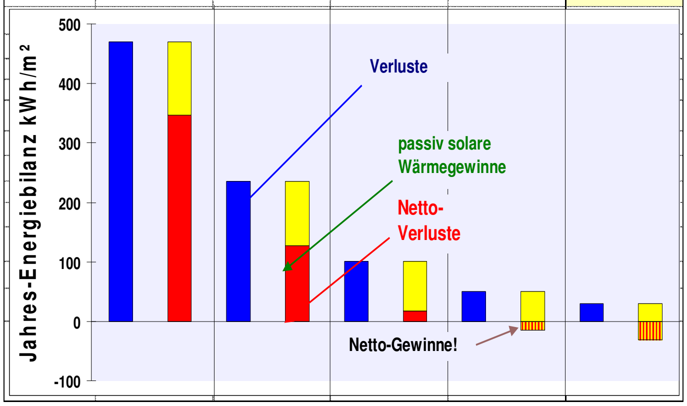
Verglasung	1-Scheibe	2-Isolier	2- Wärme-Schutz	3-Wärme-schutz	Zukunft: Vakuum oder Multifolie
U_g-Wert (W/(m²K))	5,60	2,80	1,20	0,60	0,35
Ob.-Temp.	-1,8 °C	9,1 °C	15,3 °C	17,7 °C	18,6 °C
g-Wert	0,92	0,80	0,62	0,48	0,45



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U_w-Value for windows

$$U_w = \frac{U_g{}^* A_{glas} + U_f{}^* A_{frame} + \Psi_{edge\ glas\text{-}frame}{}^* L_{girth\ glas} + \Psi_{fitting}{}^* L_{girth\ f.}}{A_{window}}$$

Ψ the linear thermal bridge [W/mK]

It is not an material constant!

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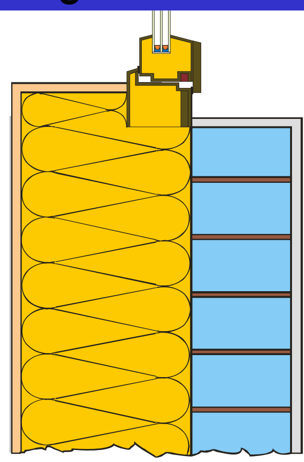
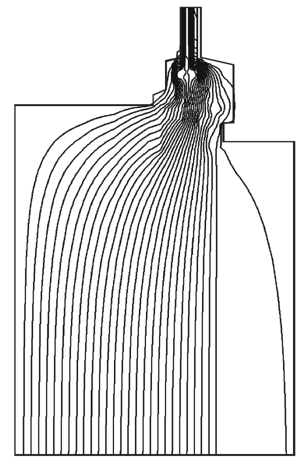
Recommended fitting

Ψ_{Einbau} = 0,005 W/(mK)
$U_{w,\ eff}$ = 0,78 W/(mK)





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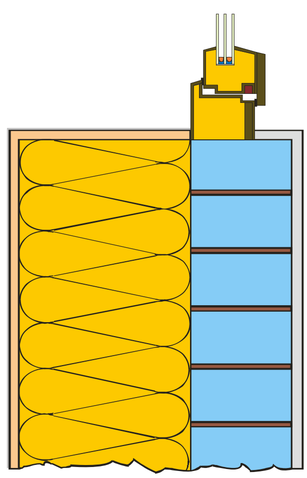
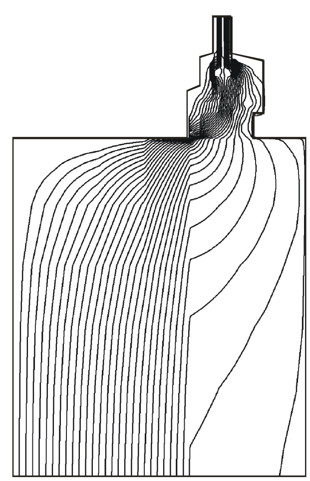
Extremly bad (normal) fitting

Ψ_{Einbau} = 0,15 W/(mK)
$U_{w,\ eff}$ = 1,19 W/(mK)





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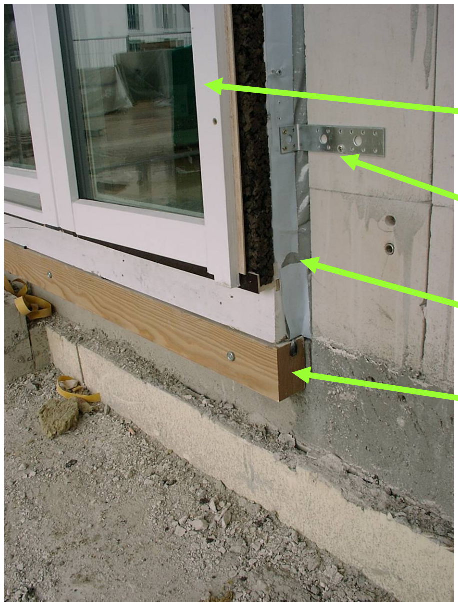
Passivhaus Dienstleistung GmbH
www.passivhaus-info.de



Example of window on wood support

Frame completely covered by insulation

Fixed external to blocks with brackets

Tape for air-tightness

Timber support for weight

Quelle: [PHD]

Excel sheet WinTyp

Pass

GLAZING TYPE IN AC

To the frames from row: 64

Assembly Nr.	Type Glazing	g-Value	U_g-Value W/(m²K)	
1	Triple glass Unitop	0,520	0,600	
2				
3				

Excel sheet WinTyp

F R A M E   T Y P E   I N   A C C O R D A N C E   W

To the glazings from row: 2

	Type	U_w-Value	Frame Measurements				Thermal Bridge
Assembly Nr.	Frame	Frame	Width - Left	Width - Right	Width - Below	Width - Above	$\Psi_{glass\ edge}$
		W/(m²K)	m	m	m	m	W/(mK)
1	Double wood normal	0,950	0,118	0,118	0,118	0,118	0,050
2	Double wood fixed	0,950	0,068	0,068	0,068	0,068	0,050
3							
4							
5							

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Excel sheet Window

					Window Rough Openings		Installed		Glazing		Window Fra
Quantity	Description	Deviation from North	Angle of Inclination Against Horizontal	Orientation	Width	Height	in Area in the Areas worksheet	Nr.	Select glazing from the WinTyp worksheet	Nr.	Select window from the WinTyp worksheet
		Degree	Degree		m	m	Select:		Select:		Select:
1	tilt stair 1	337	90	North	0,925	2,250	wall north 1.floor	4	Triple glass Unito	1	Double wood nor
								0		0	
1	sleeping 2.f	67	90	East	1,500	1,450	wall east 2.floor	7	Triple glass Unito	1	Double wood nor
1	clothing 2.f	67	90	East	0,750	1,450	wall east 2.floor	7	Triple glass Unito	1	Double wood nor
1	fixed office	67	90	East	1,500	2,250	wall east 1.floor	1	Triple glass Unito	1	Double wood fixe
1	fixed entrar	67	90	East	0,750	2,250	wall east 1.floor	1	Triple glass Unito	1	Double wood fixe
2	door sep.2.f	157	90	South	0,925	2,250	wall south 2.floor	9	Triple glass Unito	1	Double wood nor
2	door to fixe	157	90	South	0,925	2,250	wall south 2.floor	9	Triple glass Unito	1	Double wood nor
2	fixed 2.floo	157	90	South	0,925	2,250	wall south 2.floor	9	Triple glass Unito	1	Double wood fixe
2	door middle	157	90	South	0,925	2,250	wall south 1.floor	3	Triple glass Unito	1	Double wood nor
2	fixed middle	157	90	South	0,925	2,250	wall south 1.floor	3	Triple glass Unito	1	Double wood fixe
2	door l+r 1.f	157	90	South	0,925	2,250	wall south 1.floor	3	Triple glass Unito	1	Double wood nor
2	fixed l+r 1.	157	90	South	0,925	2,250	wall south 1.floor	3	Triple glass Unito	1	Double wood fixe
1	living fixed	247	90	West	1,500	2,250	wall west 1.floor	2	Triple glass Unito	1	Double wood fixe
1	children 2.f	247	90	West	1,500	1,450	wall west 2.floor	8	Triple glass Unito	1	Double wood nor
1	bathroom 2.f	247	90	West	0,750	1,450	wall east 2.floor	7	Triple glass Unito	1	Double wood nor

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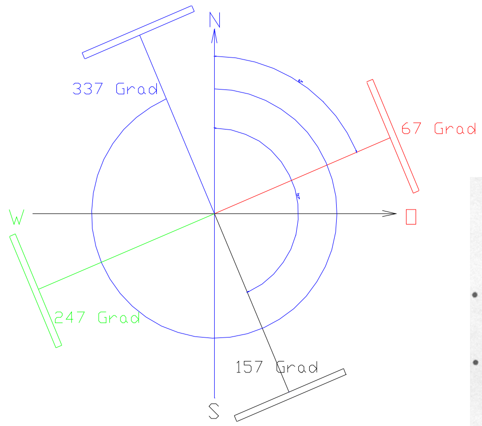
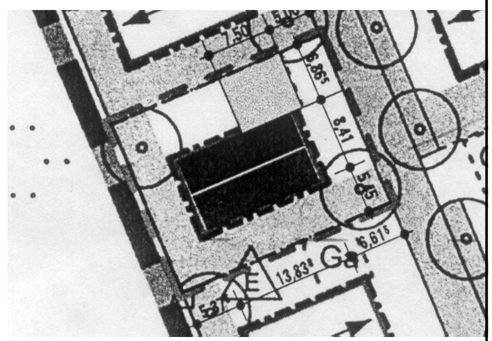
Difference to northern orientation





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Window: installation and result

Installation				Ψ–Value		Results			
Left 1/0	Right 1/0	Para-pet 1/0	Lintel 1/0	Ψ_{Spacer}	$\Psi_{Installation}$	Window Area	Glazing Area	U-Value Window	Glass Per Window
				W/(mK)	W/(mK)	m^2	m^2	$W/(m^2K)$	%
1	1	1	1	0,05	0,01	2,1	1,39	0,89	0,67
				#NV	#NV				
1	1	1	1	0,05	0,01	2,2	1,53	0,85	0,71
1	1	1	1	0,05	0,01	1,1	0,62	0,96	0,57
1	1	1	1	0,05	0,01	3,4	2,88	0,79	0,85
1	1	1	1	0,05	0,01	1,7	1,30	0,89	0,77
1	1	1	1	0,05	0,01	4,2	2,78	0,89	0,67
1	0	1	1	0,05	0,01	4,2	2,78	0,87	0,67
0	1	1	1	0,05	0,01	4,2	3,34	0,84	0,80
1	0	1	1	0,05	0,01	4,2	2,78	0,87	0,67
0	1	1	1	0,05	0,01	4,2	3,34	0,84	0,80
1	0	1	1	0,05	0,01	4,2	2,78	0,87	0,67
0	1	1	1	0,05	0,01	4,2	3,34	0,84	0,80
1	1	1	1	0,05	0,01	3,4	2,88	0,79	0,85
1	1	1	1	0,05	0,01	2,2	1,53	0,85	0,71
1	1	1	1	0,05	0,01	1,1	0,62	0,96	0,57

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Solar heat gain with average shading

g-Value	Reduction Factor for Solar Radiation	Window Areas	Window U-Values	Glazing Area	Average Global Radiation	Transmission Losses	Heat Gains Solar Radiation
						107,2	
		m²	W/(m²K)	m²	kWh/(m²a)	kWh/a	kWh/a
0,52	0,46	8,33	0,85	6,3	337	757	672
0,52	0,44	29,14	0,86	21,1	669	2686	4447
0,52	0,46	6,64	0,84	5,0	519	596	824
0,52	0,40	2,08	0,89	1,4	240	198	105
0,00	0,00	0,00	0,00	0,0	635	0	0
0,52	0,44	46,18	0,86	33,9		4237	6048

EFH Vallentin; Biburg/Alling 2000

Calculation of shading at the windows

- We are looking out of every window and add the values to the PHPP in three cases
- Trees, houses, mountains ......
- Reveal
- Overhang: roof, balkony...

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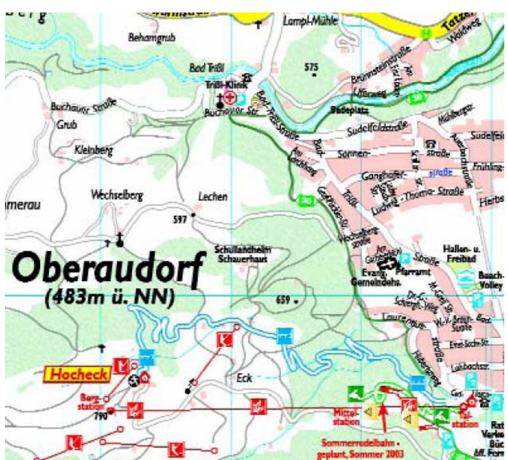
Plan of surrounding area for the shading of mountains



500 m

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The input of mountains

Height of the Shading Object	Horizontal Distance	Window Reveal Depth	Distance from Glazing Edge to Reveal	Overhang Depth	Distance from Upper Glazing Edge to Overhang	Additional Shading Reduction Factor	Horizontal Shading Reduction Factor	Reveal Shading Reduction Factor
m	m	m	m	m	m	%	%	%
h_{Hori}	a_{Hori}	o_{Reveal}	d_{Reveal}	o_{over}	d_{over}	r_{ot}	r_H	r_R
7,00	17,00	0,10	0,00	0,10	0,00	100%	72%	86%
0,00	0,00	0,10	0,05	0,80	1,40	100%	100%	95%
3,25	20,00	0,10	0,05	0,80	1,20	100%	87%	84%
0,00	0,00	0,10	0,00	0,10	0,00	100%	100%	95%
7,00	20,00	0,10	0,00	0,10	0,00	100%	74%	84%
4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
4,25	17,00	0,00	0,00	0,80	0,25	100%	87%	100%
7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
175,00	500,00	0,10	0,00	0,10	0,00	100%	76%	96%
175,00	500,00	0,10	0,05	0,80	1,40	100%	76%	96%
175,00	500,00	0,10	0,05	0,80	1,20	100%	76%	88%

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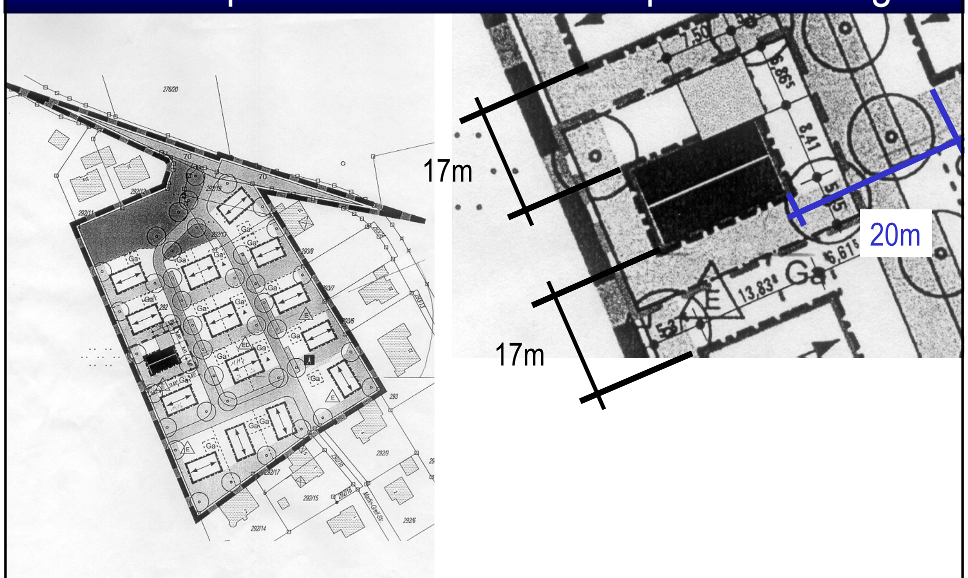
Position plan is needed for the input of shading



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The input of the neighbour houses

	Height of the Shading Object	Horizontal Distance	Window Reveal Depth	Distance from Glazing Edge to Reveal	Overhang Depth	Distance from Upper Glazing Edge to Overhang	Additional Shading Reduction Factor	Horizontal Shading Reduction Factor	Reveal Shading Reduction Factor
	m	m	m	m	m	m	%	%	%
	h_{Hori}	a_{Hori}	o_{Reveal}	d_{Reveal}	o_{over}	d_{over}	r_{ot}	r_H	r_R
North	7,00	17,00	0,10	0,00	0,10	0,00	100%	72%	86%
East	0,00	0,00	0,10	0,05	0,80	1,40	100%	100%	95%
East	3,25	20,00	0,10	0,05	0,80	1,20	100%	87%	84%
East	0,00	0,00	0,10	0,00	0,10	0,00	100%	100%	95%
East	7,00	20,00	0,10	0,00	0,10	0,00	100%	74%	84%
South	4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
South	4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
South	4,25	17,00	0,00	0,00	0,80	0,25	100%	87%	100%
South	7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
South	7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
South	7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
South	7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
West	175,00	500,00	0,10	0,00	0,10	0,00	100%	76%	96%
West	175,00	500,00	0,10	0,05	0,80	1,40	100%	76%	96%
West	175,00	500,00	0,10	0,05	0,80	1,20	100%	76%	88%

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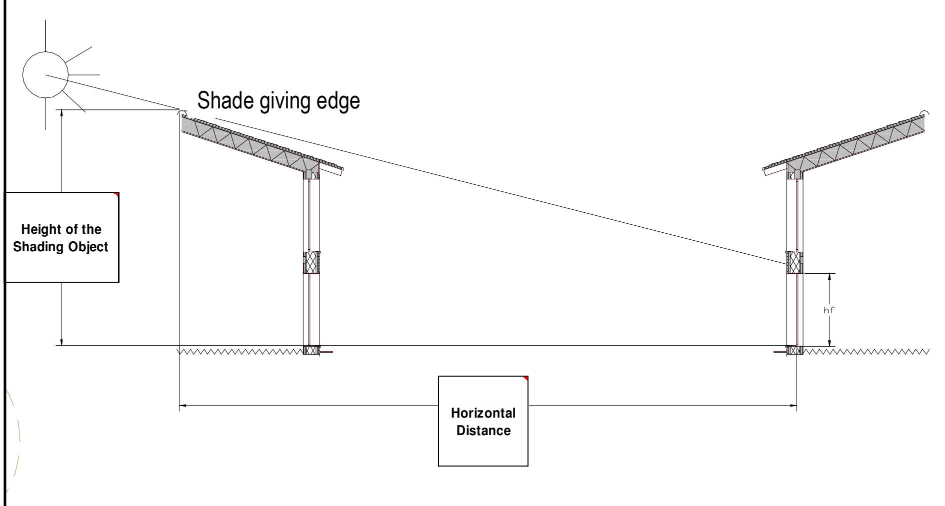
Shading of a house by a window on the first floor



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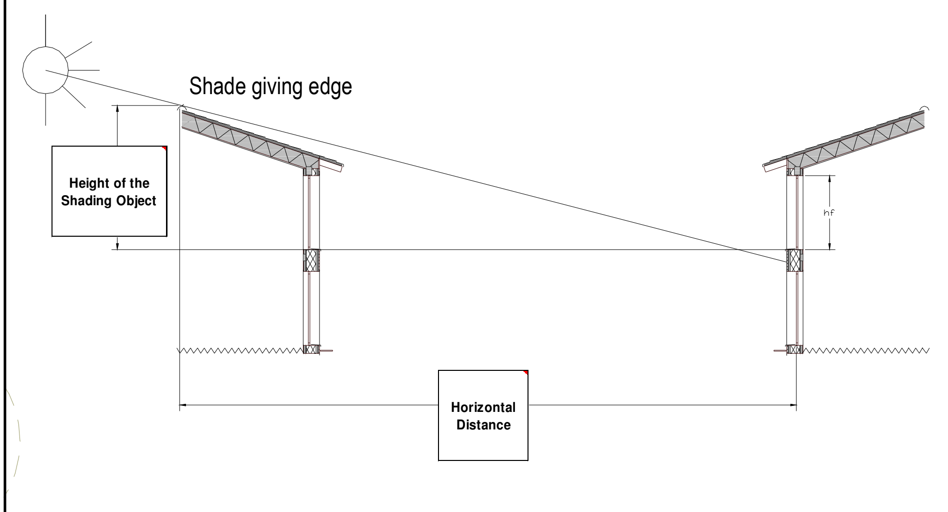
Shading of a house by a window on the second floor



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The input of the window reveal

	Height of the Shading Object	Horizontal Distance	Window Reveal Depth	Distance from Glazing Edge to Reveal	Overhang Depth	Distance from Upper Glazing Edge to Overhang	Additional Shading Reduction Factor	Horizontal Shading Reduction Factor	Reveal Shading Reduction Factor
	m	m	m	m	m	m	%	%	%
	h_{Hori}	a_{Hori}	o_{Reveal}	d_{Reveal}	o_{over}	d_{over}	r_{ot}	r_H	r_R
North	7,00	17,00	0,10	0,00	0,10	0,00	100%	72%	86%
East	0,00	0,00	0,10	0,05	0,80	1,40	100%	100%	95%
East	3,25	20,00	0,10	0,05	0,80	1,20	100%	87%	84%
East	0,00	0,00	0,10	0,00	0,10	0,00	100%	100%	95%
East	7,00	20,00	0,10	0,00	0,10	0,00	100%	74%	84%
South	4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
South	4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
South	4,25	17,00	0,00	0,00	0,80	0,25	100%	87%	100%
South	7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
South	7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
South	7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
South	7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
West	175,00	500,00	0,10	0,00	0,10	0,00	100%	76%	96%
West	175,00	500,00	0,10	0,05	0,80	1,40	100%	76%	96%
West	175,00	500,00	0,10	0,05	0,80	1,20	100%	76%	88%

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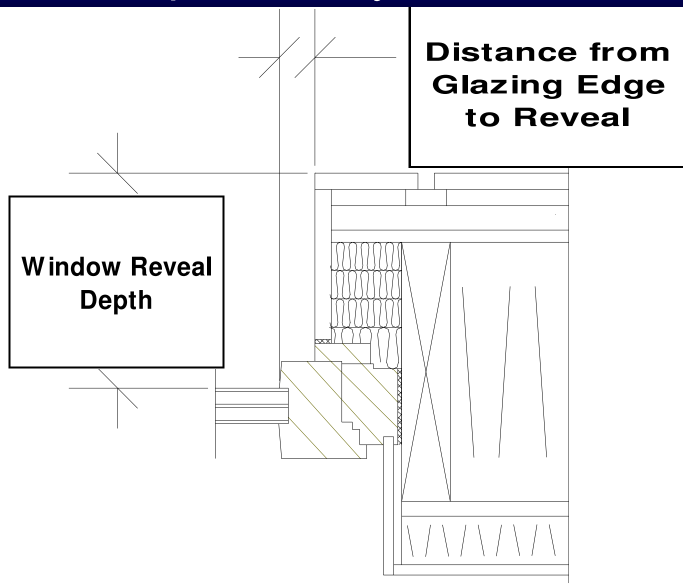
Emprasure by windows



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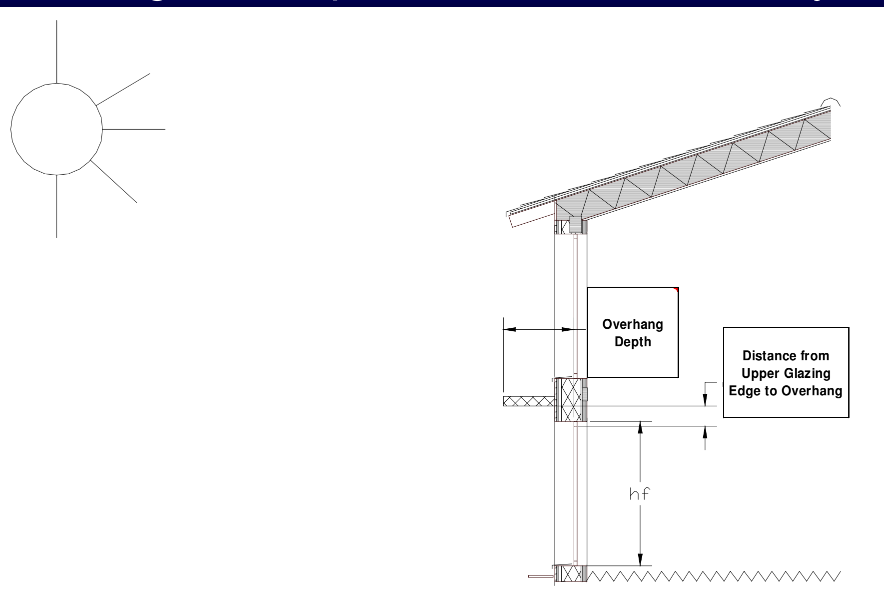
Shading of a supernatant: roof, balkony...



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The input of overhangs

	Height of the Shading Object	Horizontal Distance	Window Reveal Depth	Distance from Glazing Edge to Reveal	Overhang Depth	Distance from Upper Glazing Edge to Overhang	Additional Shading Reduction Factor	Horizontal Shading Reduction Factor	Reveal Shading Reduction Factor
	m	m	m	m	m	m	%	%	%
	h_{Hori}	a_{Hori}	o_{Reveal}	d_{Reveal}	o_{over}	d_{over}	r_{ot}	r_H	r_R
North	7,00	17,00	0,10	0,00	0,10	0,00	100%	72%	86%
East	0,00	0,00	0,10	0,05	0,80	1,40	100%	100%	95%
East	3,25	20,00	0,10	0,05	0,80	1,20	100%	87%	84%
East	0,00	0,00	0,10	0,00	0,10	0,00	100%	100%	95%
East	7,00	20,00	0,10	0,00	0,10	0,00	100%	74%	84%
South	4,25	17,00	0,10	0,05	0,80	0,25	100%	87%	94%
South	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	94%
South	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100%
South	7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
South	7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
South	7,00	17,00	0,10	0,05	0,80	0,25	100%	72%	94%
South	7,00	17,00	0,00	0,00	0,80	0,25	100%	72%	100%
West	175,00	500,00	0,10	0,00	0,10	0,00	100%	76%	96%
West	175,00	500,00	0,10	0,05	0,80	1,40	100%	76%	96%
West	175,00	500,00	0,10	0,05	0,80	1,20	100%	76%	88%

If there is no overhang put in the „reveal on the top!

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Solar heat gain with exact shading

g-Value	Reduction Factor for Solar Radiation	Window Areas	Window U-Values	Glazing Area	Average Global Radiation
		m²	W/(m²K)	m²	kWh/(m²a)
0,52	0,51	8,33	0,85	6,3	337
0,52	0,39	29,14	0,86	21,1	669
0,52	0,43	6,64	0,84	5,0	519
0,52	0,33	2,08	0,89	1,4	240
0,00	0,00	0,00	0,00	0,0	635
0,52	0,42	46,18	0,86	33,9	

Transmission Losses	Heat Gains Solar Radiation
kWh/a	kWh/a
757	745
2686	3991
596	767
198	86
0	0
4237	5589

With average shading the value was: **4237** **6048**

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The input of the ventilation data

Building: passive house Freundorfer

Treated Floor Area A_{TFA}	m²	165	*(Areas worksheet)*
Room Height, h	m	2,5	*(Annual Heat Requirement worksheet)*
Room Ventilation Volume (A_{TFA}*h) = V_{RAX}	m³	413	*(Annual Heat Requirement worksheet)*

Ventilation System Layout - Standard Operation

Occupancy	m²/P	33				
Number of Occupants	P	5,0				
Supply Air per Person	m³/(P*h)	30				
Supply Air Requirement	m³/h	150				
Extract Air Rooms		Kitchen	Bathroom	Shower	WC	thing,wasch
Quantity		1	1	1	1	1
Extract Air Requirement per Room	m³/h	60	40	20	20	25
Total Extract Air Requirement	m³/h	165				

Design Air Flow Rate (Maximum) m³/h 165

Average Air Change Rate Calculation

Type of Operation	Daily Operation Times h/d	Factors Referenced to Maximum	Air Flow Rate m³/h	Air Change Rate 1/h
Maximum	0,0	1,00	165	0,40
Standard	24,0	0,77	127	0,31
Basic	0,0	0,54	89	0,22
Minimum		0,40	66	0,16
x Residential Building		**Average Value** 0,77	Average Airflow Volume (m³/h) 127	Average Air Change Rat 0,31

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The input of the ventilation data

Infiltration Air Change Rate Following DIN EN 832.

Wind Protection Coefficients, e and f, in Accordance With EN 832.		
Coefficient e for Screening Class	Several Sides Exposed	One Side Exposed
No screening	0,10	0,03
Moderate Screening	0,07	0,02
High Screening	0,04	0,01
Coefficient f	15	20

			for Ann. Reqment:	for Heat Load:	Net Air Volume for Press. Test
Wind Protection Coefficient, e			0,07	0,18	
Wind Protection Coefficient, f			15	15	
Air change rate at Press. Test	n_{50}	1/h	0,40	0,40	413

Type of Ventilation System

				for Ann. Reqment:	for Heat Load:
x	Balanced PH Ventilation	*Please check.*			
	Pure Extract Air				
	Excess Extract Air		1/h	0,00	0,00
	Infiltration Air Change Rate	$n_{V,Res}$	1/h	0,028	0,070

Actual efficiency of the ventilation system with heat recovery

	Central unit within the thermal envelope.
x	Central unit outside of the thermal envelope.

Efficiency of Heat Recovery	$\eta_{eff,HR}$		92%	
Conductance Supply Air Duct	Ψ	W/(mK)	0,337	Calculation see Secondary Calculati
Supply Air Duct Length		m	2	
Conductance Extract Air Duct	Ψ	W/(mK)	0,337	Calculation see Secondary Calculati
Extract Air Duct Length		m	2	Room Temperatur
Temperature of Mechanical Service Room		°C	12	Average Exterior T
(Enter only if the central unit is outside of the thermal envelope.)				

Actual Efficiency of Heat Recovery $\eta_{HR,eff}$ 91%

Efficiency of Heat Recovery of Subsoil Heat Exchanger η_{SHX} 20%

Secondary Calculation:

Ψ-Value Supply or Outdoor Air Duct

Nominal Width	160	mm
Insul. Thickness:	60	mm
Reflecting surface? Please mark with an "x"!		
Yes		
x No		
Thermal Conductivity	0,035	W/(mK)
Nominal Air Flow Rate	127	m³/h
$\Delta\vartheta$	8	K
Interior Duct Diameter	0,160	m
Exterior Duct Diameter	0,160	m
Exterior Diameter	0,280	m
α–Interior	8,71	W/(m²K)
α–Surface Area	5,77	W/(m²K)
Ψ-Value	**0,337**	**W/(mK)**
Surface temperature difference	1,145	K

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Wellbeing without overheating (sheet Summer)

Interior Heat Sources Q_I 2,10 * 165 = 347 2,1

Frequency of Overheating $h_{\vartheta \geq \vartheta max}$ **43,9%** **at an overheating limit of ϑ_{max} = 25 °C**

If the "frequency over 25°C" exceeds 10%, additional measures to protect against summer heat are necessary.

S U M M E R

Climate:	Garmisch-P.	Interior Temperature:	20 °C
Building:	passive house Freundorfer	Building Type/Use:	one familiy house
Location:	Oberbayern	Treated Floor Area A_{TFA}:	165,2 m²
Specific Capacity	84 Wh/K per m² FS	Standard Occupancy:	5,0 Pers
Overheating Limit:	25 °C		

	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Red. Factor fT,Summer		H_{Summer} Heat Conducance
1.	Exterior Wall - Ambie	A	230,4	*	0,108	*	0,92	=	23,0
2.	Exterior Wall - Groun	B	116,3	*	0,099	*	1,00	=	11,5
6.		A		*		*	0,92	=	
7.		X		*		*	0,69	=	
8.	Windows	A	46,2	*	0,856	*	1,00	=	39,5
9.	Exterior Door	A	5,0	*	0,650	*	1,00	=	3,2
10.	Exterior Thermal Brid	A	158,2	*	-0,032	*	0,92	=	-4,7
11.	Perimeter Thermal Bri	P	43,7	*	-0,020	*	1,00	=	-0,9
12.	Ground Thermal Bridge	B		*		*	1,00	=	

Exterior Heat Flow Coefficient, $H_{T,e}$ 68,4 W/K

Ground Heat Flow Coefficient, $H_{T,g}$ 10,6 W/K

The capacity for buffering energie depends on the used materials.

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Wellbeing without overheating (sheet Summer)

Exterior Heat Flow Coefficient, $H_{T,e}$ 68,4 W/K

Ground Heat Flow Coefficient, $H_{T,g}$ 10,6 W/K

Efficiency of Heat Recovery of the plate heat exchanger η_{HR} 91%

effective Air Volume V_V = A_{TFA} 165,2 m² * Room Clearance 2,50 m = 413 m³

Mark with 'x':

	Free Ventilation (Windows + Cracks):	**Summer Air Change Rate:** 1/h 0,60
	Mech. Exhaust Only 0,60 1/h	
	Supply and Exhaust Air as During Winter Operation, With HR.	
x	**Supply/Exh. w/o HR** 0,20	η_{SHX} **Subsoil Heat Excha**

Energetically Effective Air Exchange n_V 0,000 + 0,600 * (1 - 0,000 η_{HR}) + 0,028 $n_{V,Rest}$ 1/h

V_V m³ $n_{V,equi\ Portion}$ 1/h c_{Air} Wh/(m³K)

Ext. ...

Grou...

Can come from natur or mechanical Ventilation (without heat recovery)

Q_T W/K Q_L W/K kWh/a

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Wellbeing without overheating (sheet Summer)

	Orientation of the Area	Angle Factor Summer		Shading Factor Summer		Back Reflection		g-Value (perp. radiation)		Area m²		Glazing Fraction		Aperture m²
1.	East	0,84	*	0,87	*	0,95	*	0,52	*	8,3	*	76%	=	2,3
2.	South	0,84	*	0,55	*	0,95	*	0,52	*	29,1	*	72%	=	4,9
3.	West	0,84	*	0,76	*	0,95	*	0,52	*	6,6	*	76%	=	1,6
4.	North	0,84	*	0,63	*	0,95	*	0,52	*	2,1	*	67%	=	0,4
5.	Horizontal	0,84	*	1,00	*	0,95	*	0,00	*	0,0	*	0%	=	0,0

Heat Gains Solar Radiation Q_S Total 9,1

	Specif. Power q_I W/m²		A_{TFA} m²		W
Interior Heat Sources Q_I	2,10	*	165	=	347

Frequency of Overheating $h_{\vartheta \geq \vartheta max}$ **0,0%** **at an overheating limit of ϑ_{max} = 25 °C**

If the "frequency over 25 °C" exceeds 10%, additional measures to protect against summer heat are necessary.

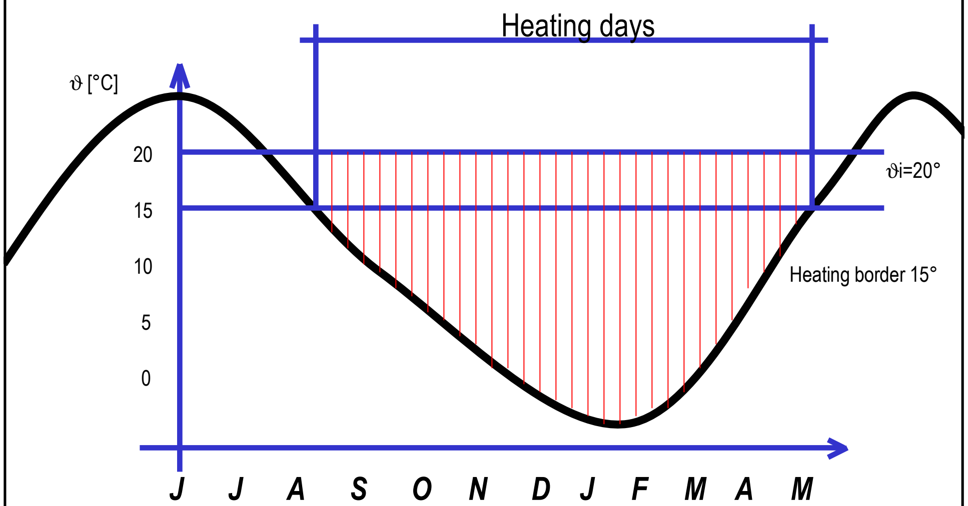
If the value is over 10% goto sheet Summer-S and put in some roller blinds.

Input sheet Summer-Shading

			Summer	Summer			
	Distance from Upper Glazing Edge to Overhang	Additional Shading Reduction Factor (Summer)	Temporary Shading Reduction Factor, z	Horizontal Shading Reduction Factor	Reveal Shading Reduction Factor	Overhang Shading Reduction Factor	Total Summer Shading Reduction Factor
	m	%	%	%	%	%	%
	d_{Over}			r_H	r_L	r_O	r_V
North	0,00	100%	100%	78%	83%	98%	63%
East	1,40	100%	100%	100%	96%	93%	89%
East	1,20	100%	100%	93%	90%	92%	77%
East	0,00	100%	10%	100%	96%	99%	10%
East	0,00	100%	100%	82%	90%	99%	73%
South	0,25	100%	100%	92%	89%	66%	54%
South	0,25	100%	100%	92%	89%	66%	54%
South	0,25	100%	100%	92%	100%	67%	61%
South	0,25	100%	100%	87%	89%	66%	51%
South	0,25	100%	100%	87%	100%	67%	58%
South	0,25	100%	100%	87%	89%	66%	51%
South	0,25	100%	100%	[illegible]7%	100%	67%	58%
West	0,00	100%	10%	8[illegible]%	96%	99%	8%
West	1,40	100%	100%	85[illegible]	96%	87%	72%
West	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]%

East and west windows are typical overheating elements. Put in the z value of the used shading system.

Heating degree hours



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Specific annual Heat Requirement

A passive house is a building with such a low heating load that it can be heated by the anyway existing ventilation system.

Criteria 1: energy used for space heating is 15 kWh/(m² a) (normally 180!)

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	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Temp. factor f_t		G_t kKh/a		kWh/a	Treated Floor Area
1.	Exterior Wall - Ambient Ai	A	228,2	*	0,104	*	1,00	*	84,0	=	1997	
2.	Exterior Wall - Ground	B	116,3	*	0,120	*	0,50	*	84,0	=	588	
3.	Roof/Ceiling - Exterior Ai	D	122,5	*	0,101	*	1,00	*	84,0	=	1040	
4.	Floor Slab	B		*		*	0,50	*		=		
5.		A		*		*	1,00	*		=		
6.		A		*		*	1,00	*		=		
7.		X		*		*	0,75	*		=		
8.	Windows	A	48,4	*	0,717	*	1,00	*	84,0	=	2915	
9.	Exterior Door	A	2,5	*	0,647	*	1,00	*	84,0	=	135	
10.	Exterior Thermal Bridge (l	A	162,0	*	-0,036	*	1,00	*	84,0	=	-493	
11.	Perimeter Thermal Bridge (	P	44,5	*	-0,020	*	0,50	*	84,0	=	-37	
12.	Ground Thermal Bridge (len	B		*		*	0,50	*		=		
		Total of all building envelope areas	515,4									kWh/(m²a)
	Transmission Heat Losses Q_T									Total	6147	36,3

$$Q_T = A * U * f_T * G_T$$

$$\text{oder } Q_T = \Sigma(U_i * A_i * G_{Ti} + \Sigma(\Psi_i * l_i * G_{Ti})$$

f_T Temp. Factor (reduction faktor)

G_T Heating degree hours: Difference of the temperature between inside and outside added up hour by hour all over the heating time.

(different in different climate regions)

					A_{TFA} m²		Room Clearance m		m³	
Ventilation System:	Effective Air Volume V_{RAX}				169,5	*	2,50	=	423,8	
Actual Efficiency of Heat Recovery	η_{eff}	83%								
Efficiency of Subsoil Heat Exchanger	η_{SHX}	20%		$n_{V,system}$ 1/h		Φ_{HR}		$n_{V,Res}$ 1/h	1/h	
	Energetically Effective Air Exchange n_V			0,309	(1	0,86	) +	0,028	= 0,071	
		V_V m³		n_V 1/h		c_{Air} Wh/(m³K)		G_t kKh/a	kWh/a	kWh/(m²a)
Ventilation Heat Losses Q_V		424	*	0,071	*	0,33	*	84,0	= 831	4,9
				Q_T kWh/a		Q_V kWh/a		Reduction Factor Night/Weekend Economy	kWh/a	kWh/(m²a)
Total Heat Losses Q_L			(	6147	+	831	)	1,0	= 6978	41,2

$$Q_V = V_V * n_V * c_p\rho * G_T$$

V_V: exchange volume of the ventilation system

n_V: energetic operative air change

$c_p\rho$: specific heat capacity of air (capability of containing heat = 0.33 Wh/m³K (the potential))

		kWh/a		kWh/a	Economy	kWh/a	kWh/(m²a)
Total Heat Losses Q_L	(	6147	+	831	) 1,0	= 6978	41,2

$$Q_L = Q_T + Q_V$$

Orientation of the Area	Reduction Factor see Windows		g-Value (perp. radiation)		Area m²		Global Radiation Heating Period kWh/(m²a)		kWh/a
1. East	0,50	*	0,52	*	8,33	*	185	=	402
2. South	0,40	*	0,52	*	29,14	*	356	=	2149
3. West	0,42	*	0,52	*	6,64	*	275	=	399
4. North	0,30	*	0,52	*	4,28	*	145	=	97
5. Horizontal	0,40	*	0,00	*	0,00	*	360	=	0

Gross Solar Heat Gains Q_S Total 3047 kWh/(m²a) 18,0

$$Q_S = r * g * A_F * G$$

r: reductionsfactor of shading, dirt and angle to the sun

g: solar heat gain coefficient of the glases with vertical sun transit

G: global radiation during the heating days. (slide climate data)

	kh/d		Heating Period d/a		Specif. Power q_I W/m²		A_{TFA} m²		kWh/a	kWh/(m²a)
Internal Heat Sources Q_I	0,024	*	225	*	2,10	*	169,5	=	1922	11,3

			kWh/a	kWh/(m²a)
	Free Heat Q_F	$Q_S + Q_I$ =	4969	29,3
	Ratio of Free Heat to Losses	Q_F / Q_L =	0,71	
Utilization Factor Heat Gains η_G		$(1 - (Q_F/Q_L)^5) / (1 - (Q_F/Q_L)^6)$ =	94%	
Heat Gains Q_G		$\eta_G * Q_F$ =	4668	27,5

Heating of persons and equipment

Slide IHS

Annual Heat Requirement Q_H $Q_L - Q_G$ = 2310 **14**

Limit 15 kWh/(m²a) **Requirement met?** (Yes/No) **Yes**

$$Q_H = Q_T + Q_V - \eta^*(Q_S + Q_I)$$

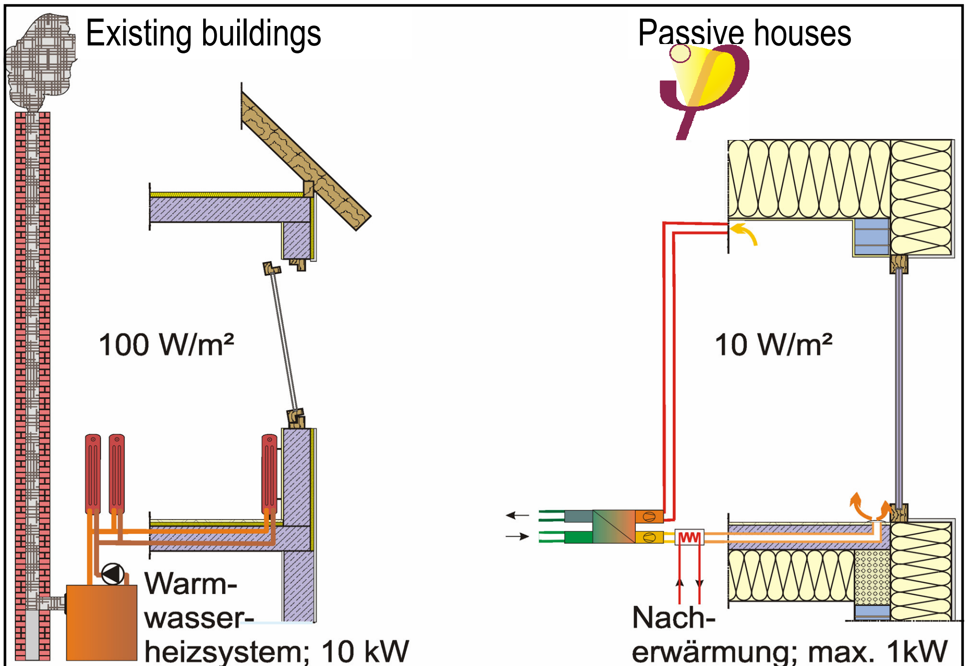
η : utilization factor heat gains

The heat load

Criteria 2:

power is used to heat the building is 10 W/m²
(normally 100!)

The critical days are
•A very cold but sunny day
•or a moderat cold day but nearly without any sun



cold but clear day | moderat but bleak day

Nr. Heat Load Region | 0 | Standard chosen | Cl

Design Temperature			Radiation:	East	South	West	North	Horizontal	
Weather Condition 1:	-6,0	°C		15	50	15	5	5	W/m²
Weather Condition 2:	-1,0	°C		5	5	5	5	5	W/m²
Ground Design Temperature	10,0	°C							

	Building Elements	Temperature Zone	Area m²		U-Value W/(m²K)		Factor always 1 (except "X")		Temp. Diff. 1 K		Temp. Diff. 2 K		P_T 1 Watt		P_T 2 Watt
1.	Exterior Wall - Ambient	A	228,2	*	0,104	*	1,00	*	26,0	or	21,0	=	618	or	499
2.	Exterior Wall - Ground	B	116,3	*	0,120	*	1,00	*	10,0	or	10,0	=	140	or	140
3.	Roof/Ceiling - Exterior	D	122,5	*	0,101	*	1,00	*	26,0	or	21,0	=	322	or	260
4.	Floor Slab	B		*		*	1,00	*	10,0	or	10,0	=		or	
5.		A		*		*	1,00	*	26,0	or	21,0	=		or	
6.		A		*		*	1,00	*	26,0	or	21,0	=		or	
7.		X		*		*	0,75	*	26,0	or	21,0	=		or	
8.	Windows	A	48,4	*	0,717	*	1,00	*	26,0	or	21,0	=	902	or	729
9.	Exterior Door	A	2,5	*	0,647	*	1,00	*	26,0	or	21,0	=	42	or	34
10.	Exterior Thermal Bridge (le	A	162,0	*	-0,036	*	1,00	*	26,0	or	21,0	=	-153	or	-123
11.	Perimeter Thermal Bridge (l	P	44,5	*	-0,020	*	1,00	*	10,0	or	10,0	=	-9	or	-9
12.	Ground Thermal Bridge (leng	B		*		*	1,00	*	10,0	or	10,0	=		or	
13.	House/Apartment Separating	I	0,0	*		*	1,00	*	3	or	3	=		or	

Transmission Heat Losses P_T Total = 1863 or 1530

Ventilation System:

Effective Air Volume, V_{RAX}: 169,5 m² * 2,50 m = 424 m³

Efficiency of Heat Recovery of the Heat Exchanger η_{HR} 83%

Efficiency of Heat Recovery of the Subsoil Heat Exchanger η_{SHX} 20%

Energetically Effective Air Exchange n_V: $n_{V,system}$ 0,309 1/h * (1 - Φ_{HR} 0,86) + $n_{V,Res\ (Heat\ Load)}$ 0,070 1/h = 0,113 1/h

Ventilation Heat Load P_V	V_V m³		n_V 1/h		c_{Air} Wh/(m³K)		Temp. Diff. 1 K		Temp. Diff. 2 K		P_V 1 W		P_V 2 W
	423,8	*	0,113	*	0,33	*	26,0	or	21,0	=	410	or	331

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Total Heat Load P_L

$P_T + P_V$ = 2273 W or 1861 W

	Orientation of the Area	Area m²		g-Value (perp. radiation)		Reduction Factor see Windows		Radiation 1 W/m²		Radiation 2 W/m²		P_S 1 W		P_S 2 W
1.	East	8,3	*	0,5	*	0,5	*	15,0	or	5	=	33	or	11
2.	South	29,1	*	0,5	*	0,4	*	50,0	or	5	=	302	or	30
3.	West	6,6	*	0,5	*	0,4	*	25,7	or	5	=	37	or	7
4.	North	4,3	*	0,5	*	0,3	*	5,0	or	5	=	3	or	3
5.	Horizontal	0,0	*	0,0	*	0,4	*	5,0	or	5	=	0	or	0

Heat Gain - Solar Heat Load, P_S Total = 375 or 52

Internal Heat Load P_I: Specif. Power 1,6 W/m² * A_{TFA} 170 m² = P_I 1: 271 W or P_I 2: 271 W

Heat Gains P_G: $P_S + P_I$ = P_G 1: 646 W or P_G 2: 323 W

$P_L - P_G$ = 1627 or 1538

Annual Heat Load P_H = 1627 W

Floor Space Specific Annual Heat Load P_H / A_{TFA} = 9,6 W/m²

P_H: Heat load. Maximum „very cold but sunny day“ oder „moderat day without sun“

A_{TFA}: Treated floor area (TFA)

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PHPP heat load last line

	$P_L - P_G$	=	1627	or	1538	
Annual Heat Load P_H		=			1627	W
Floor Space Specific Annual Heat Load P_H / A_{TFA}		=			9,6	W/m²

Max. supply air temperature input 52 °C

Supply air temp. w/o supplementary heating $\vartheta_{supply,min}$ 16 °C Max. Supply Air Temp. $\vartheta_{sup,max}$ 52 °C

Compare: Heat load that can be transported by supply air. $P_{Supply\ Air,Max}$ = 1536 W specific: 9,1 W/m²

In this case the heat load is to small. $P_{Supply\ Air,\ max.} < P_H$

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The PHPP System....

....the only way to achieve the Passive House standard!!!

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