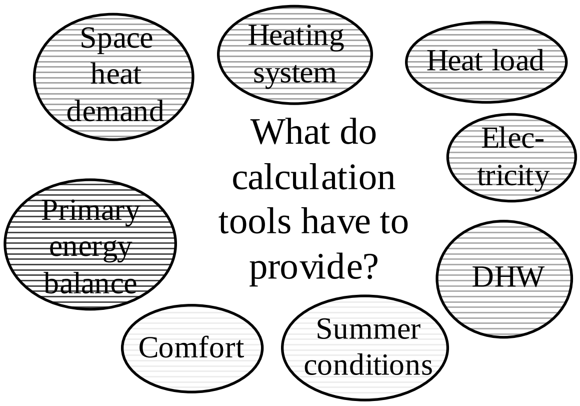
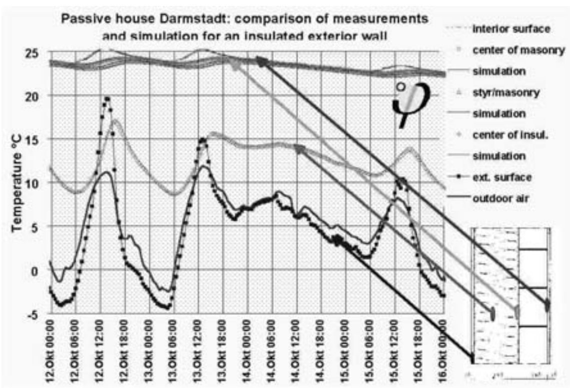
Passive House Design with PHPP
'Passiv House Planning Package'

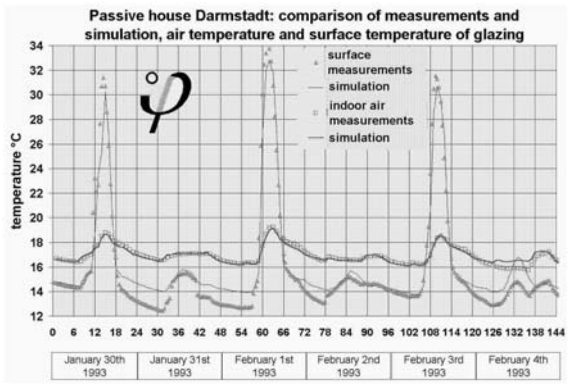
Dynamic vs. steady-state models
Calculation Principles
Main equations
Heat load calculation



Dynamic simulation: Detailed information about thermal processes



Dynamic simulation: Powerful, but time-consuming



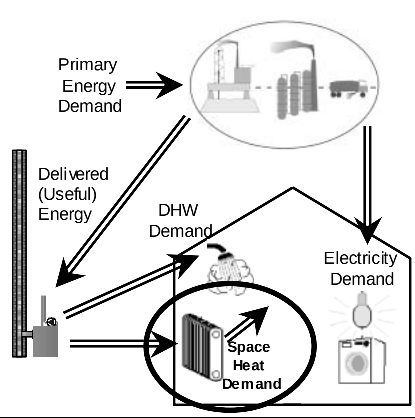
Recommended: Steady-state calculation procedures

Calculates e.g.

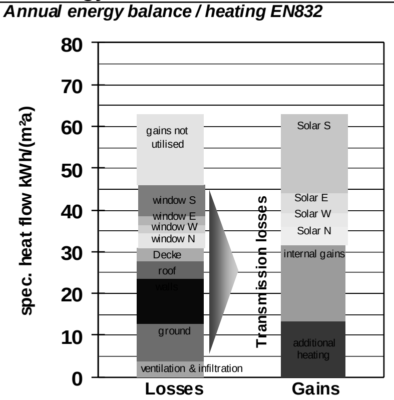
- U-values of the building shell, including windows
- transmission losses to ambient air and ground
- ventilation and infiltration losses
- passive solar and internal gains, including shading
- hot water demand
- household and auxiliary electricity demand
- primary energy demand
- heat load
- summer comfort

Validated against measurements

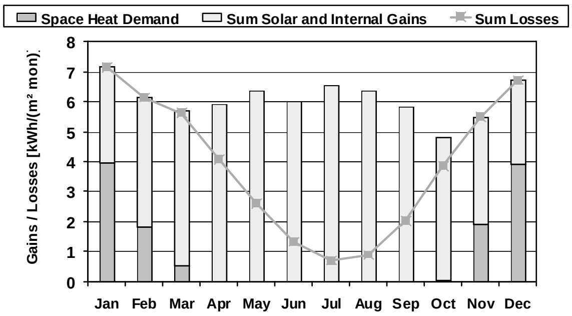
Energy supply chain



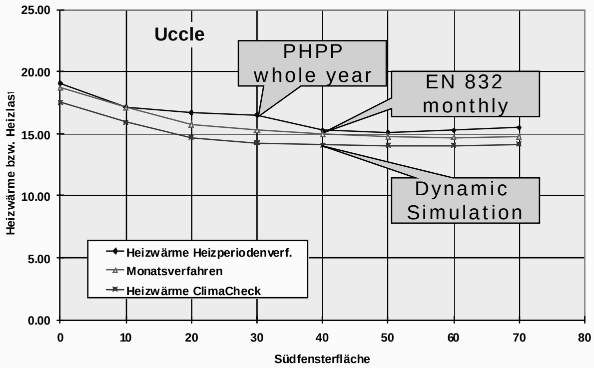
set up an energy balance



Passive House Darmstadt-Kranichstein: Monthly heat balance according to EN 13790



Passive House Planning Package PHPP

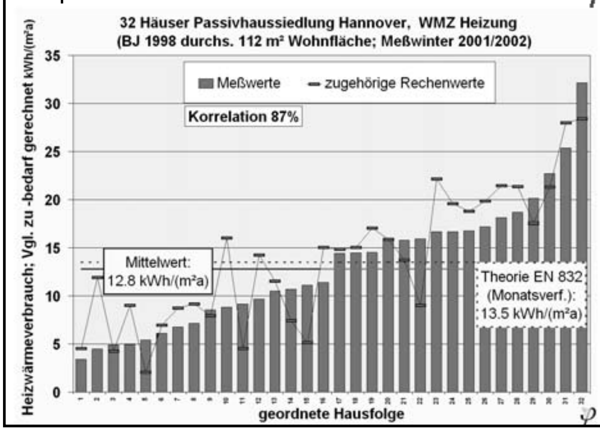


heat energy demand (calculated)

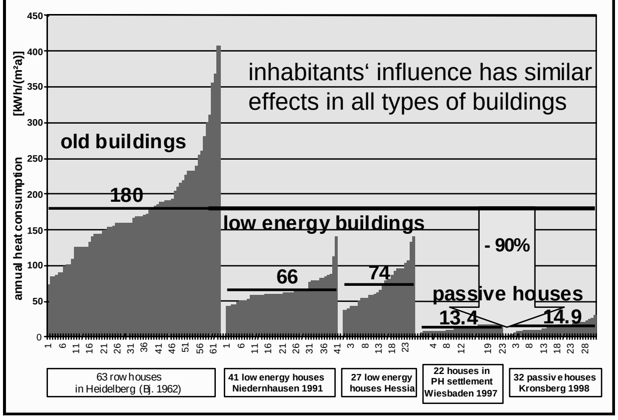
versus

heat energy consumption (measured)

comparison PHPP-calculation and measurement



statistics show: mean values are decisive



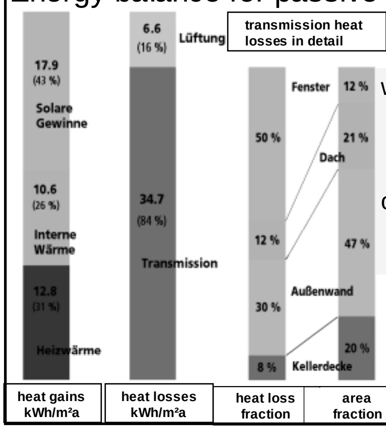
PHPP is a spreadsheet calculation tool

central result: characteristic energy demands

main data are collected in 'verification' sheet

Objekt:	Passivhaus-Endhaus, Jangster de Lüx			
Standort und Klima:	Hannover Kronsberg	Hannover (Region 2)		
Straße:	Sticksfeld			
PLZ/Ort:	D-30539			
Land:	Deutschland			
Objekt-Typ:	Reihenendhaus			
Kennwerte mit Bezug auf Energiebezugsfläche				
Energiebezugsfläche:	118,3	m²		
	Verwendet:	Jahresverfahren		PH-Zertifikat: Erfüllt?
Energiekennwert Heizwärme:	15	kWh/(m²a)	15 kWh/(m²a)	✔
Drucktest-Ergebnis:	0,18	h^{-1}	0,6 h^{-1}	✔
Primärenergie-Kennwert (WW, Heizung, Hilfs- u. Haushalts-Strom):	103	kWh/(m²a)	120 kWh/(m²a)	✔
Primärenergie-Kennwert (WW, Heizung und Hilfsstrom):	51	kWh/(m²a)		
Primärenergie-Kennwert Einsparung durch solar erzeugten Strom:	118	kWh/(m²a)		
Heizlast:	9,5	W/m²		
Übertemperaturhäufigkeit:	0,0%	über	25	°C

Energy balance for passive houses (PHPP)



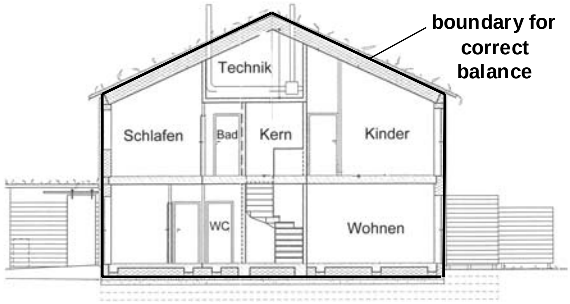
windows:
$U_w \leq$ 0,85 W/m²

opaque areas:
U $\leq$ 0,15 W/m²

all numbers including thermal bridges

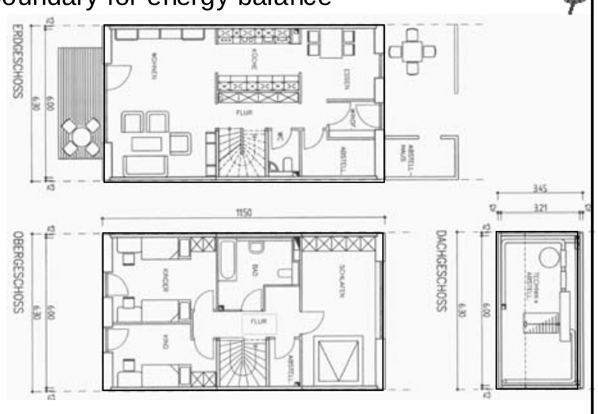
boundary for energy balance

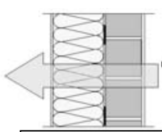
carefully define the boundary of
the building to get a correct energy balance



use exterior dimensions of the building

boundary for energy balance





Transmission:

surface area * U-value * heating degree days

$$Q_T = A \cdot U \cdot \Theta$$

$$61{,}6\ m^2 \cdot 0{,}126\ W/(m^2K) \cdot 84\ kKh/a$$
$$= 652\ kWh/a$$

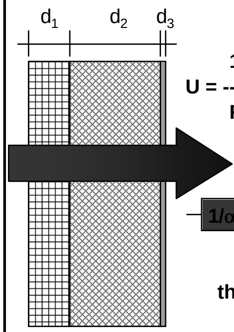
Input of areas in PHPP 2004

Flächeneingabe																
Fläche Nr.	Bauteil Bezeichnung	zu Gruppe Nr.	Zuordnung zu Gruppe	Anzahl	x (	a [m]	x	b [m]	+	Eigene Ermittlung [m²]	-	eigener Abzug [m²]	-	Abzug Fenster [m²]	) =	Fläche [m²]
	Außentür	7	Außentür		x (		x		+		-		-		) =	
1	EG Süd	8	Außenwand Außenluft	1	x (	6,640	x	3,140	+		-		-	7,0	) =	13,8
2	EG Nord	8	Außenwand Außenluft	1	x (	6,640	x	3,140	+		-		-	4,6	) =	16,2
3	OG Süd	8	Außenwand Außenluft	1	x (	6,640	x	3,010	+		-		-	4,4	) =	15,6
4	OG Nord	8	Außenwand Außenluft	1	x (	6,640	x	3,010	+		-		-	4,0	) =	16,0
5					x (		x		+		-		-	0,0	) =	
6	EG	8	Außenwand Außenluft	1	x (	11,450	x	3,140	+		-		-	0,0	) =	36,0
7	OG	8	Außenwand Außenluft	1	x (	11,450	x	2,770	+		-		-	0,0	) =	31,7
8	Giebel	8	Außenwand Außenluft	1	x (	11,450	x	1,300	+		-		-	0,0	) =	14,9
9					x (		x		+		-		-	0,0	) =	
10	Dach	10	Dach/Decken Außenluft	2	x (	6,340	x	6,910	+		-		-	0,0	) =	87,6
11	Dach Versprung	8	Außenwand Außenluft	1	x (	12,670	x	0,240	+		-		-	0,0	) =	3,0
12					x (		x		+		-		-	0,0	) =	
13	Grund	11	Bodenplatte	1	x (	11,450	x	6,640	+		-		-	0,0	) =	76,0
14	Grund Versprung	9	Außenwand Erdreich	1	x (	11,450	x	0,240	+		-		-	0,0	) =	2,7
15					x (		x		+		-		-	0,0	) =	
16	EG	18	Wand zum Nachbarn	1	x (	11,450	x	3,140	+		-		-	0,0	) =	36,0
17	OG	18	Wand zum Nachbarn	1	x (	11,450	x	2,770	+		-		-	0,0	) =	31,7
18	Giebel	18	Wand zum Nachbarn	1	x (	11,450	x	1,300	+		-	3,04	-	0,0	) =	11,8
19					x (		x		+		-		-	0,0	) =	

connect each component area to appropriate group

windows are subtracted automatically

U-value of homogeneous components according to DIN EN 6946

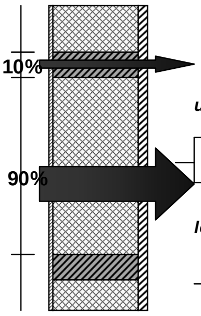


$$U = \frac{1}{R_T} = \frac{1}{1/\alpha_i + d_1/\lambda_1 + d_2/\lambda_2 + d_3/\lambda_3 + 1/\alpha_a}$$

$1/\alpha_i$ – concrete – insul. – plaster – $1/\alpha_a$

thermal conductivity λ according to national or internat. standards

U-value of inhomogeneous components according to DIN EN 6946



$$U = \frac{1}{R_T} = \frac{1}{(R'_T + R''_T) / 2}$$

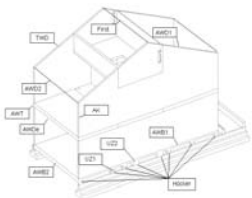
upper limit (estimate) R´ T

$1/\alpha_i$ – OSB – insul. – HWL – $1/\alpha_a$ (parallel to) $1/\alpha_i$ – OSB – wood – HWL – $1/\alpha_a$

lower limit (estimate) R´´ T

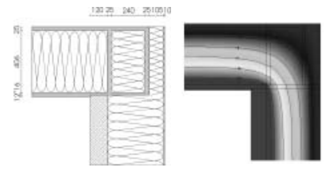
$1/\alpha_i$ – OSB – (insul. / wood) – HWL – $1/\alpha_a$

thermal bridges have to be taken into account

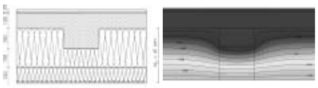


'free of thermal bridges' the criterion is:

all $\Psi \leq 0{,}01$ W/(mK)



Ψ = - 0,055 W/(mK) free of thermal bridge

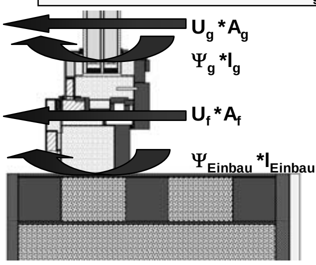


Ψ = + 0,015 W/(mK) thermal bridge

thermal losses via window(frame) 10077

thermal bridge calculation according to DIN EN 10077

$$U_W = \frac{U_g{*}A_g + U_f{*}A_f + \Psi_{Glasrand}{*}\,l_{Glasrand} + \Psi_{Einbau}{*}l_{Einbau}}{A_g + A_f}$$



certified windows can be chosen from list n PHPP:

PASSIVHAUS geeignete Komponente Dr. Wolfgang Feist

e.g. window frame (DIN EN 10077-2):

U_f = 0,57 W/(m²K)

width = 135 mm

Ψ_g = 0,025 W/(mK) (GFK edge)

glazing:

U_g = 0,60 W/(m²K) DIN EN 673

g-Wert = 55% DIN EN 410

Ventilation

air volume * air change * heat cap. air * degree hours

$$Q_L = V \cdot n_{äqui} \cdot c_p\rho \cdot \Theta$$

296 m³ · 0,111 h⁻¹ · 0,33 Wh/(m³K) · 84 kKh/a

= 911 kWh/a

Solar:

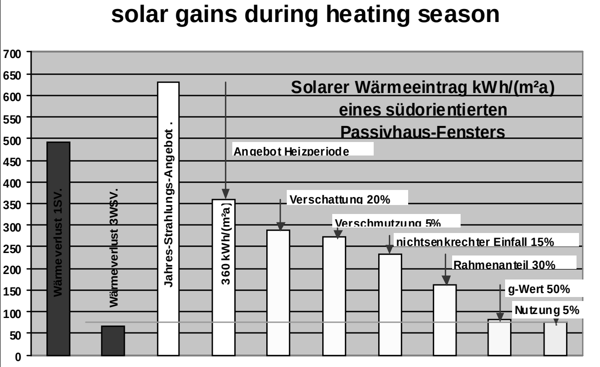
reduction factor * g-value * window area * solar rad.

$$Q_S = r \cdot g \cdot A_F \cdot G$$

0,51 · 0,60 · 11,64 m² · 364 kWh/(m²a)

= 1288 kWh/a

fraction of useful solar gains



Internal Gains

length heating period * spec. power * reference area

$$Q_I = t_{Heiz} \cdot q_I \cdot A_{EB}$$

0,024 kKh/d · 225 d/a · 2,1 W/m² · 118,3 m²

= 1341 kWh/a

Heat demand

Balance difference = transmission + ventilation - η(solar+IHS)

$$Q_H = Q_T + Q_L - \eta(Q_S + Q_I)$$

30,7 + 7,7 - 95,6%·(13,6+11,3) [kWh/(m²a)]

= 14,6 kWh/(m²a)

Heat load calculation