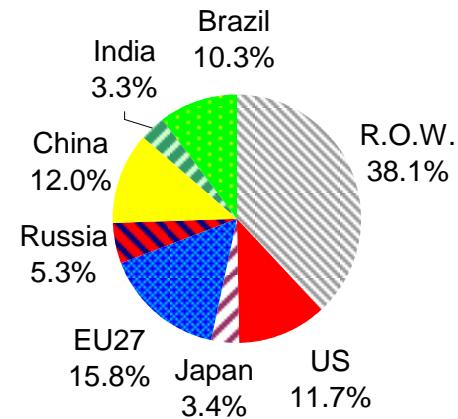


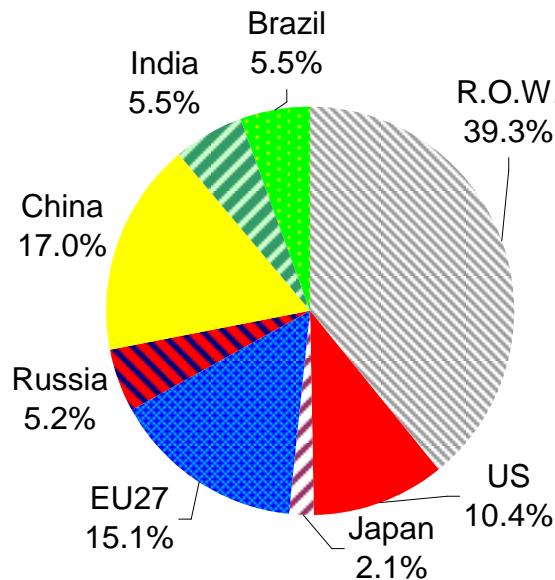
EE measures and Implementation - Trainings Program for Construction Companies and Supervisors

10/11/2016

Potentials for world-wide electricity generation from RES up to 2050

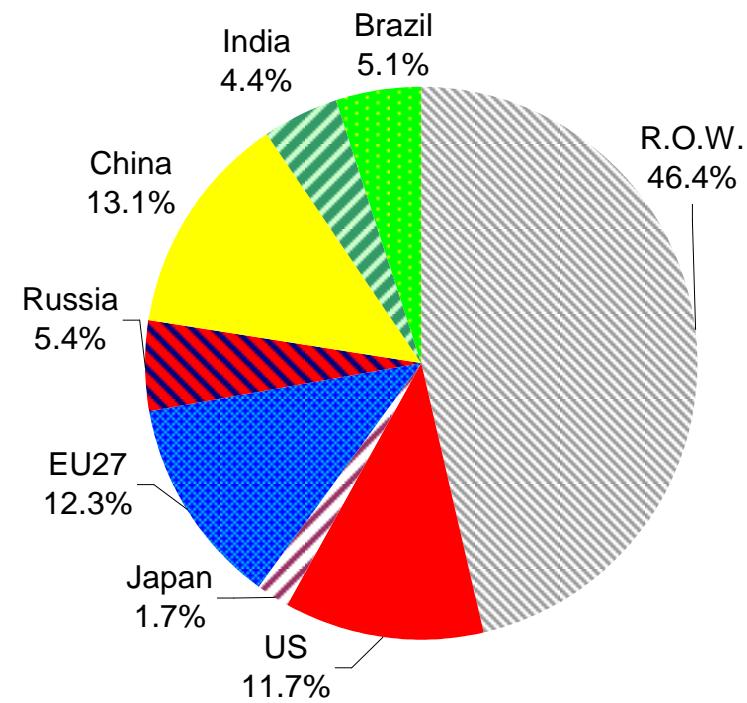


Total RES (2005): 3,401 TWh



Mid-term potential (in total)

Total RES (2020): 11,777 TWh



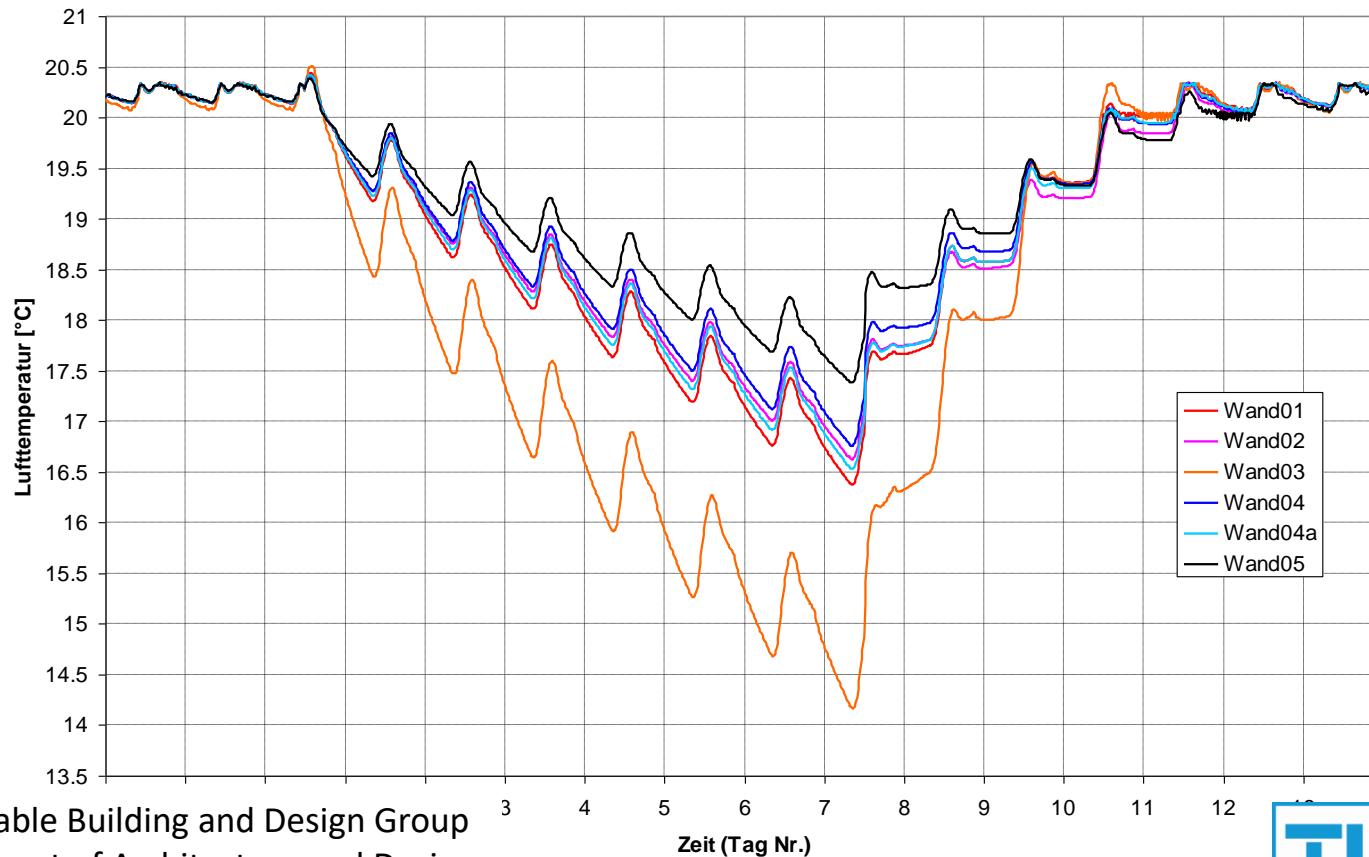
Long-term potential (in total)

Total RES (2030 to 2050): 31,802 TWh

From 3400 TWh to 31 000 TWh in 2050!

Thermal Building Simulation

Karin Stieldorf & Klaus Kreč



Sustainable Building and Design Group
Department of Architecture and Design

Vienna university of technology

Thermal building behaviour → Central questions



Passivhaus Proyer in Steyr, OÖ
Proyer & Proyer Architects

Heating load

Heating demand

Energy demand

Thermal comfort

Summer behaviour



***Thermal and energetical
Building performance***

Basis of estimating the Thermal Building behaviour:

Constant heat balance equation

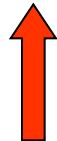
With constant (i. e. time independent) view :

Heat losses = Heat gains

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$

(Mathematical representation)

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$



Transmission



Ventilation

Heat losses

→ $L_T \cdot (\Theta_i - \Theta_e)$ Transmission heat losses

→ $L_V \cdot (\Theta_i - \Theta_e)$ Ventilation heat losses

Unit: **W**

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$

Transmission Ventilation

Factors of proportionality

→ L_T thermal (Transmission-) **Conductance** of building envelope

→ L_V **Ventilation conductance** Unit: WK^{-1}

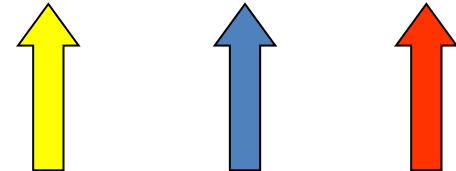
Boundary conditions

→ Θ_i Internal air temperature

Θ_e Ambient air temperature

Unit: K

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$



Heat gains

- Φ_s Solar heat gains
- Φ_i Heat gains caused by building use
- Φ_h Heat gains caused by heating devices

Unit: *W*

Constant heat balance equation

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$

Applicabilities

- Heating load calculation
- Calculation of heating demand
- Calculation of summer behaviour

Climatic boundary conditions

Significant influences on the thermal building behaviour:

- ambient air temperature
- solar radiation

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$


The diagram consists of three downward-pointing arrows. The first arrow is red and points to the term $L_T \cdot (\Theta_i - \Theta_e)$. The second arrow is brown and points to the term $L_V \cdot (\Theta_i - \Theta_e)$. The third arrow is red and points to the right side of the equation, where it points to the terms $\Phi_s + \Phi_i + \Phi_h$.

Ambient air temperature

A) Instantaneous values

Designated use

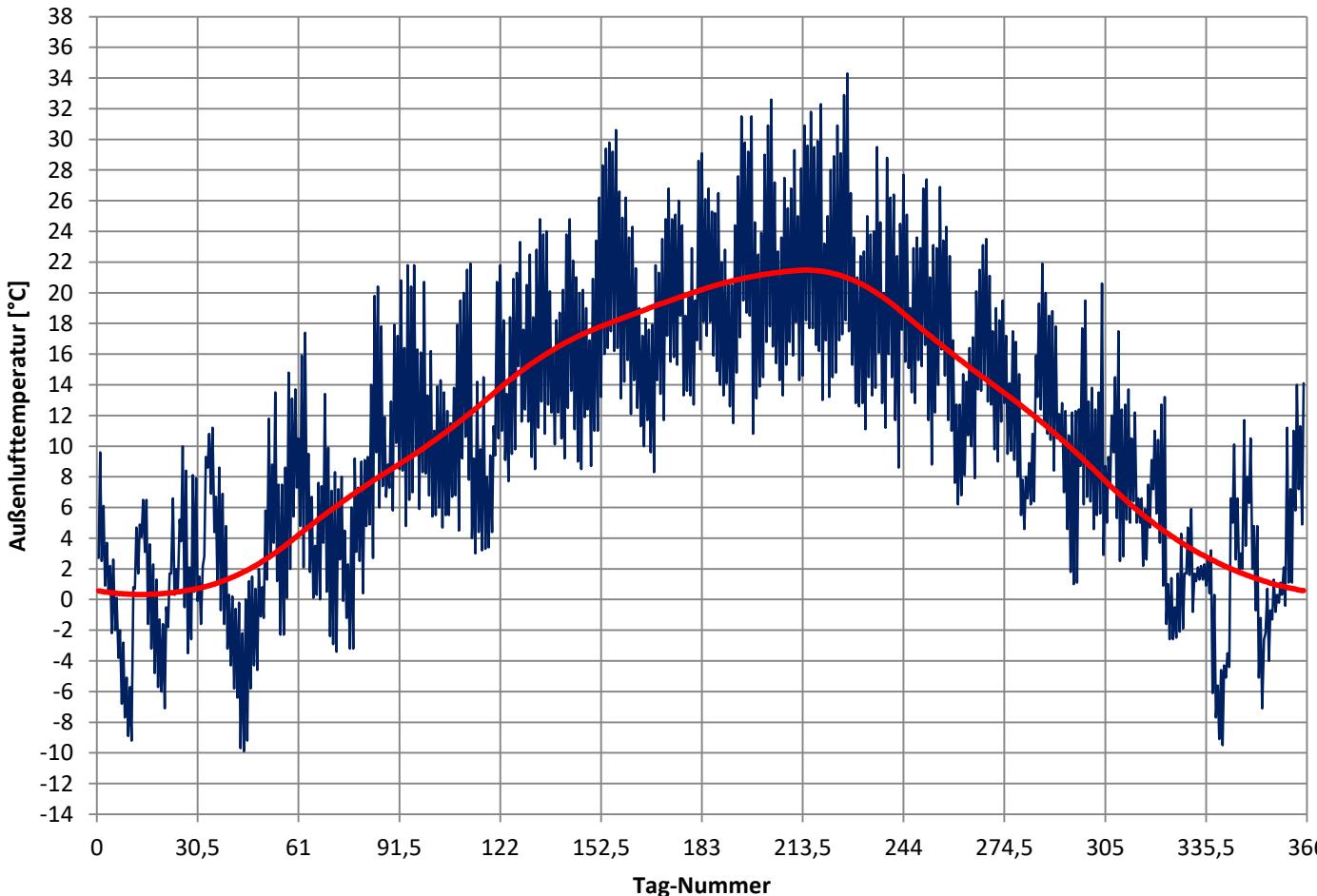
Input values for the simulation of the thermal behaviour of buildings and building constructions

Most commonly

used:

- hourly data over the year (8760 values)
 - long-time monthly mean values should be guaranteed by the test reference year
- ***half-synthetic climate data (HSKD)***

Half-synthetic climate data (HSKD) Wien, Hohe Warte



	Monthly mean values [°C]		$\Delta\theta [K]$
	actual	nominal	
January	0.44	0.45	0.01
February	2.01	2.01	0.00
March	6.35	6.36	0.01
April	10.89	10.89	0.00
May	15.82	15.82	0.00
June	18.9	18.90	0.00
July	20.91	20.91	0.00
August	20.67	20.67	0.00
September	16.19	16.19	0.00
October	10.98	10.98	0.00
November	5.2	5.20	0.00
December	1.56	1.56	0.00
year	10.83	10.83	0.00

Long-time monthly mean values
Wien, Hohe Warte
Source: Program package OEKLIM

Referenced time period 1978 - 2007

Ambient air temperature

B) Mean values

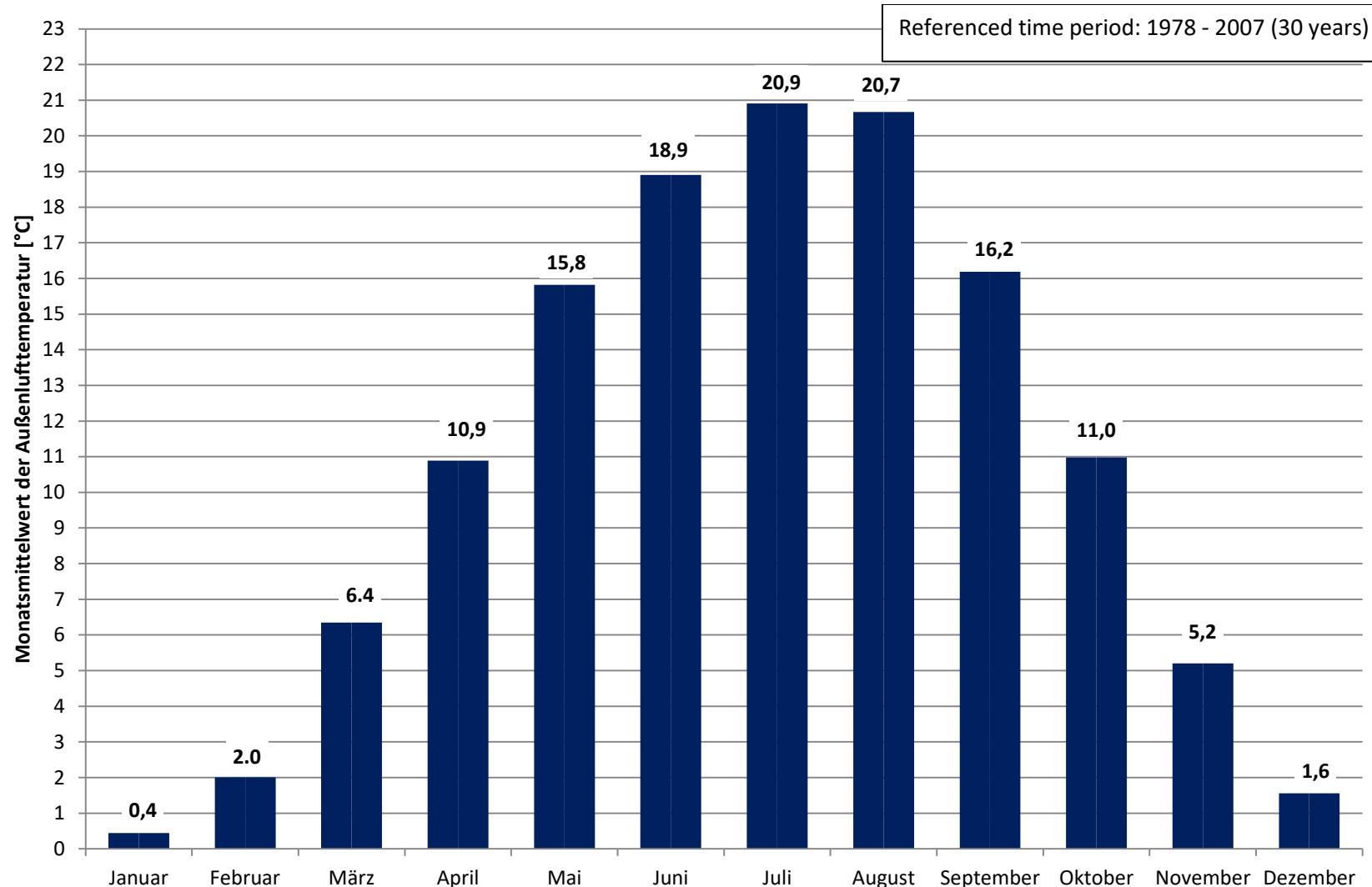
Designed use

Input values for simplified calculation approaches
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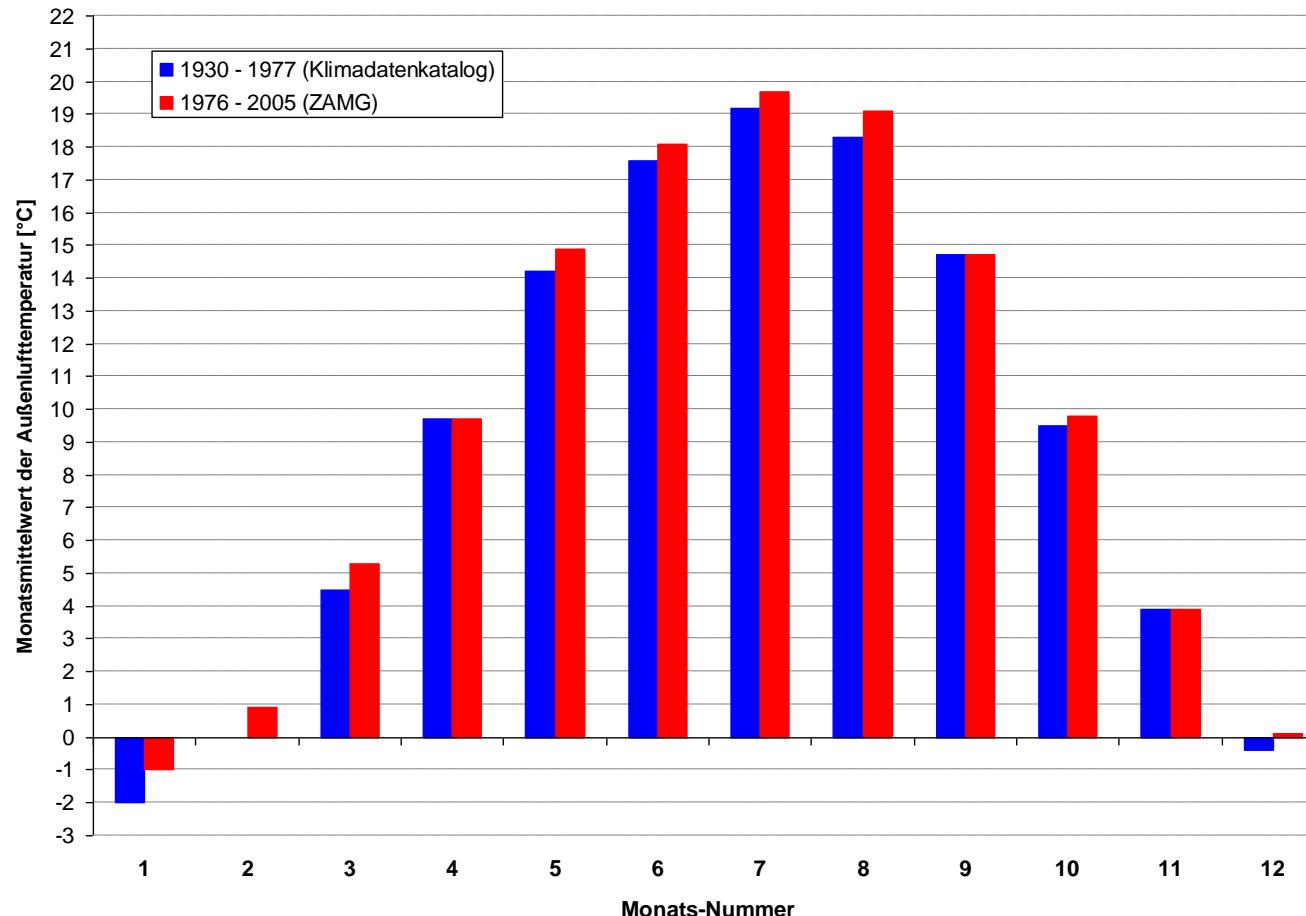
Most commonly

- used:
- long-time monthly means (12 values)
 - means are to built at least over 10 years
(EN ISO 15927-4) ; default: 30 years (WMO)

**Long-time monthly mean values of ambient air temperature
Wien, Hohe Warte**

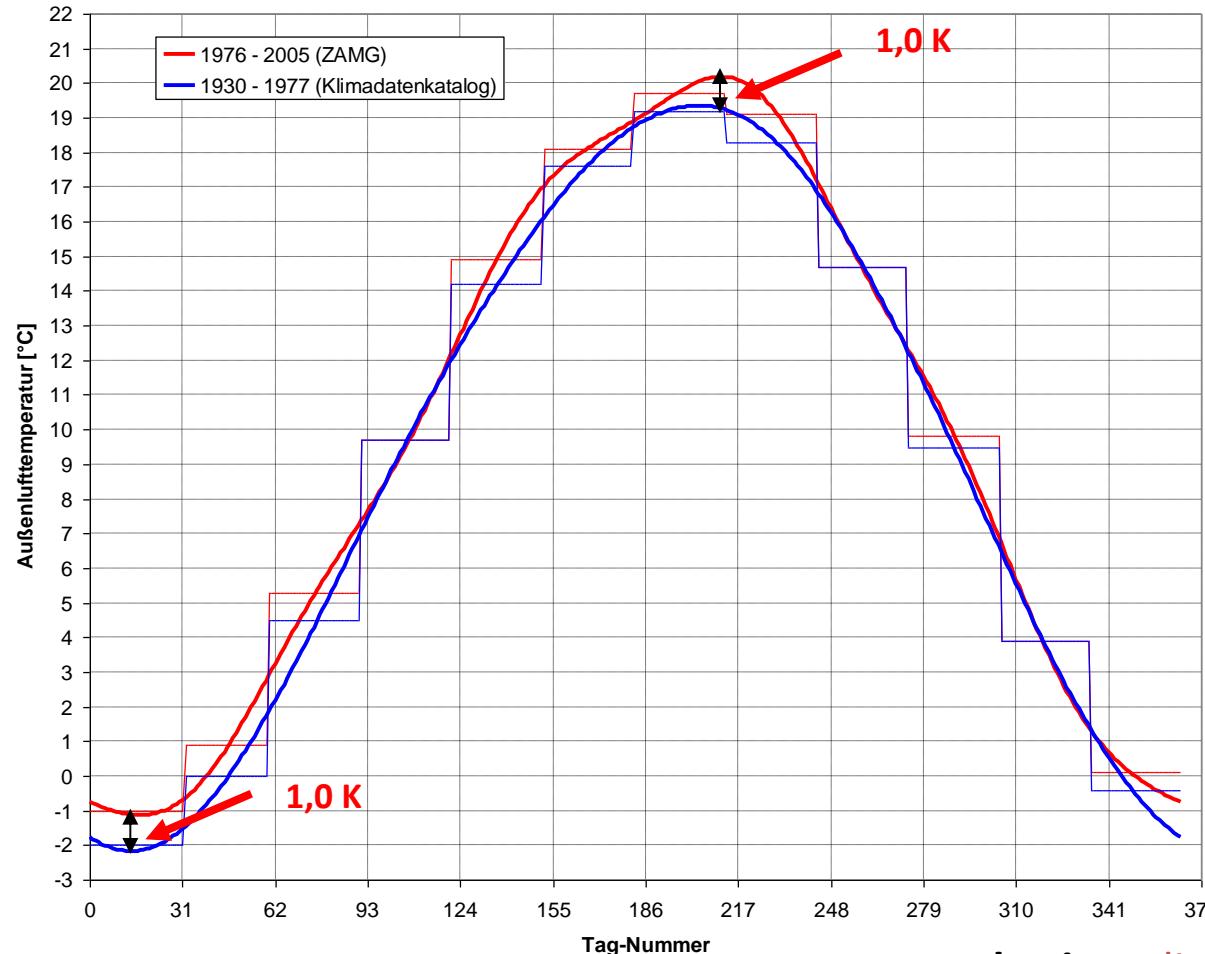


Long-time monthly mean-values of ambient air temperature
Graz - Universität



Data basis: Klimadatenkatalog 1930 – 1977
ZAMG 1976 - 2005

**Long-time course of the year of ambient air temperature
Graz - Universität**



Data basis: Klimadatenkatalog 1930 – 1977
ZAMG 1976 - 2005

**Effect of climate
Change!**

Solar radiation

Solar radiation consists of:

- direct (beam) radiation
 - diffuse sky radiation
 - (ground-)reflected solar radiation
- } **diffuse solar radiation**

Direct radiation + Diffuse solar radiation

=> global (solar) radiation

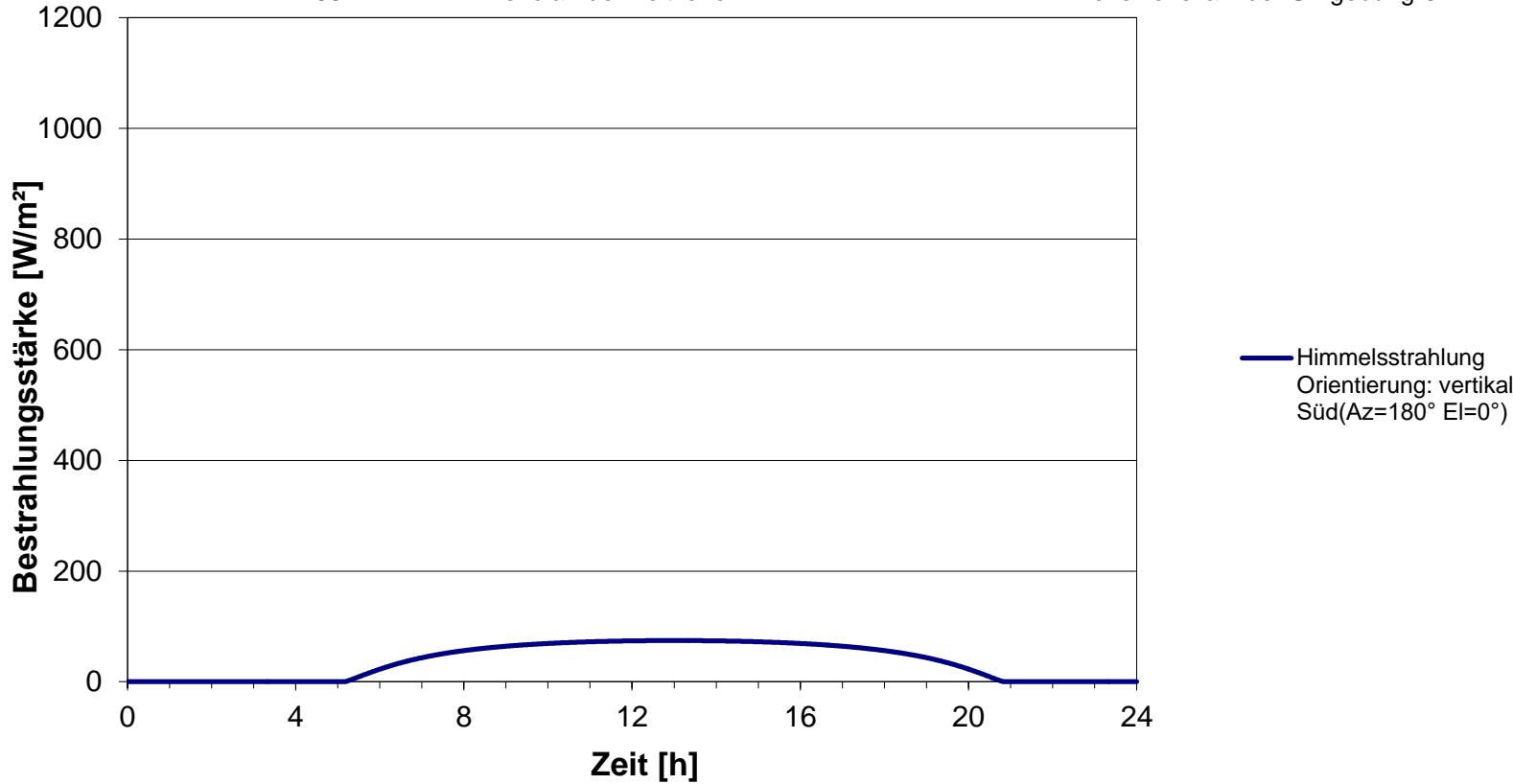
Solar flux of July 15

Feststehendes Flächenelement

Geogr. Länge: $16^{\circ} 21' O$
Geogr. Breite: $48^{\circ} 15' N$
Seehöhe: 198 m

Standort: Wien - Hohe Warte
Meridian der Zeitzone: $30^{\circ} 0' O$

Trübungsfaktor nach Linke: 4.5
Diffusstrahlungsfaktor nach Reitz: 0.333
Reflexionszahl der Umgebung 0.2



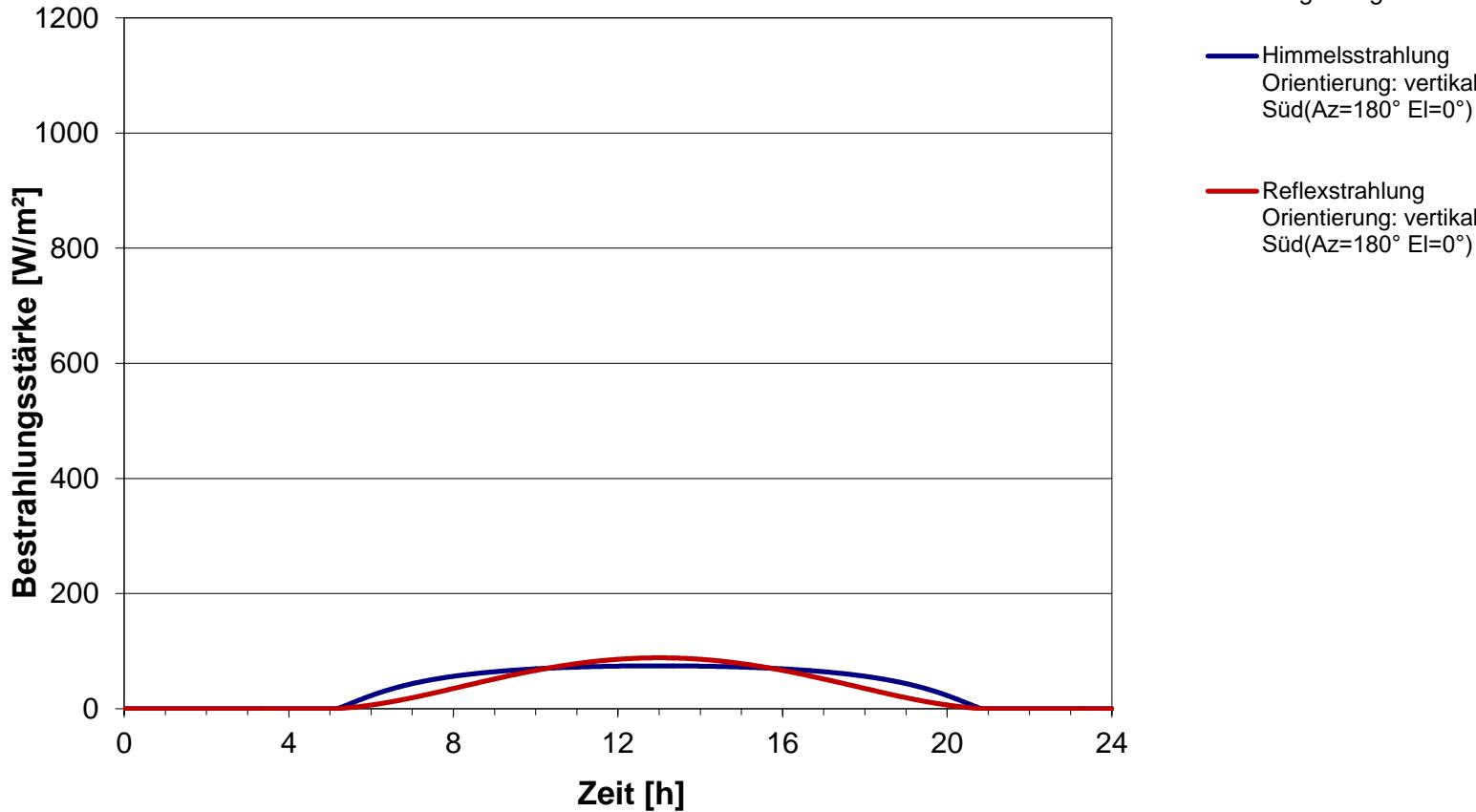
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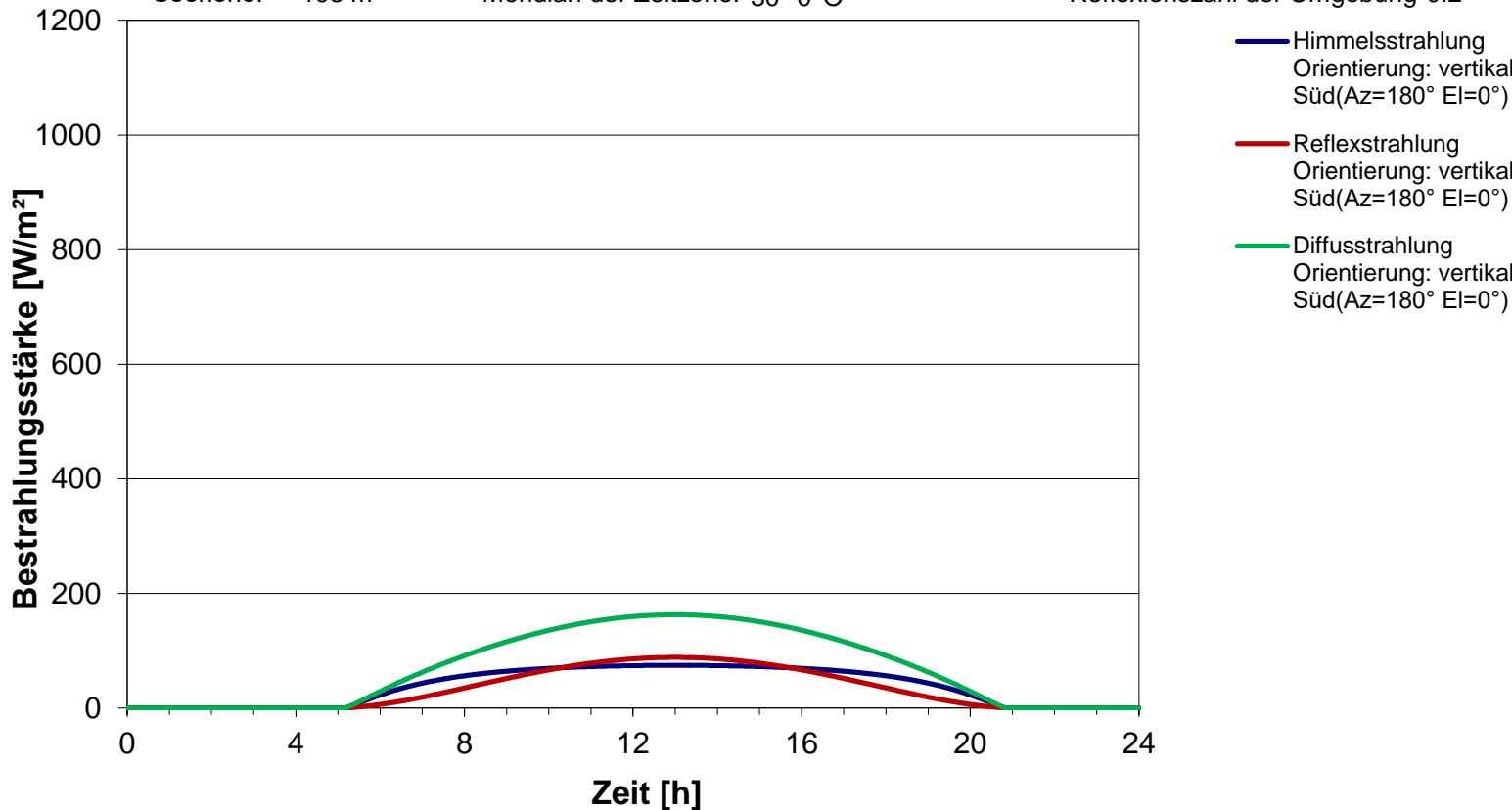
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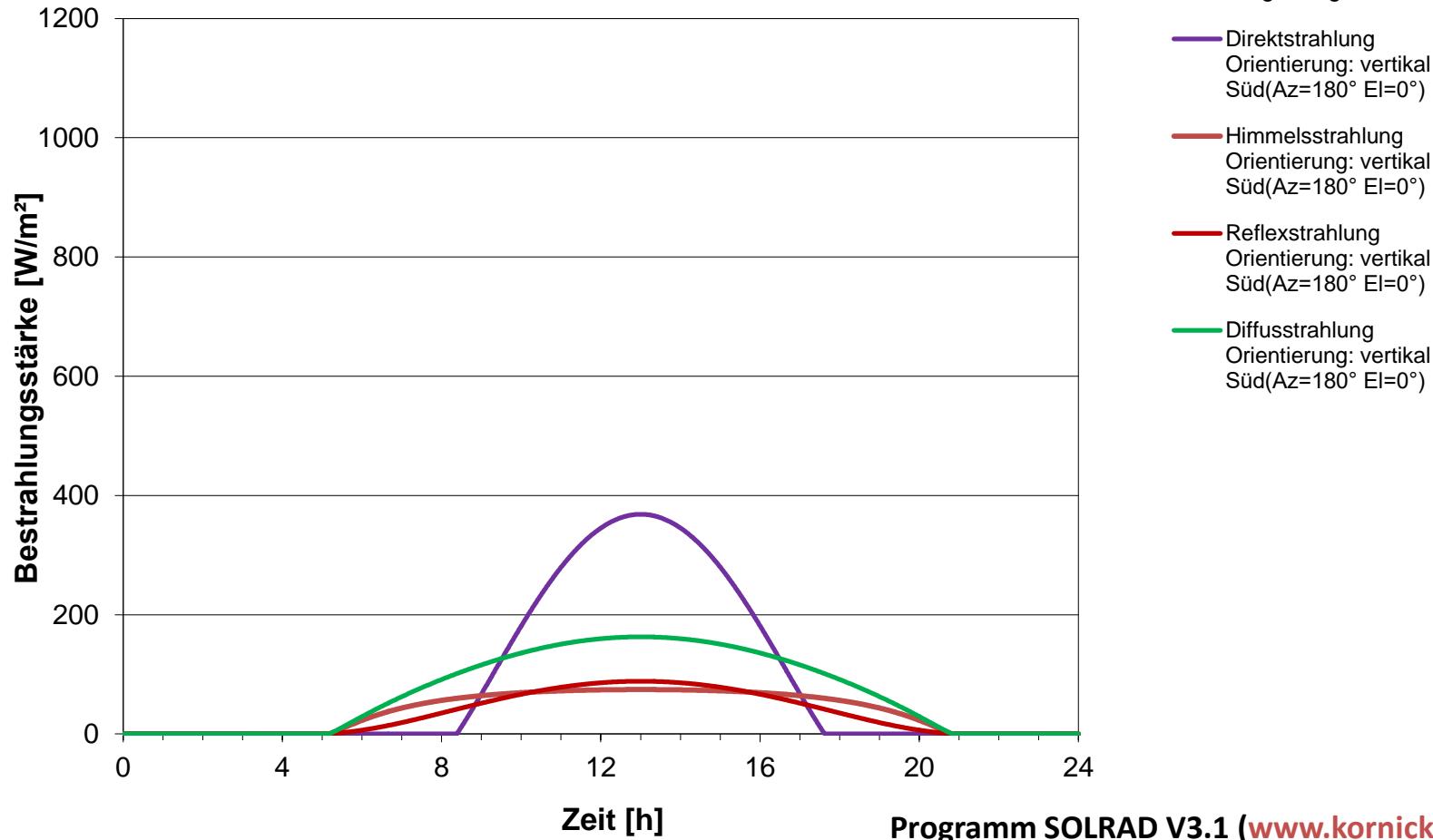
Standort: Wien - Hohe Warte

Meridian der Zeitzone: 30° 0' O

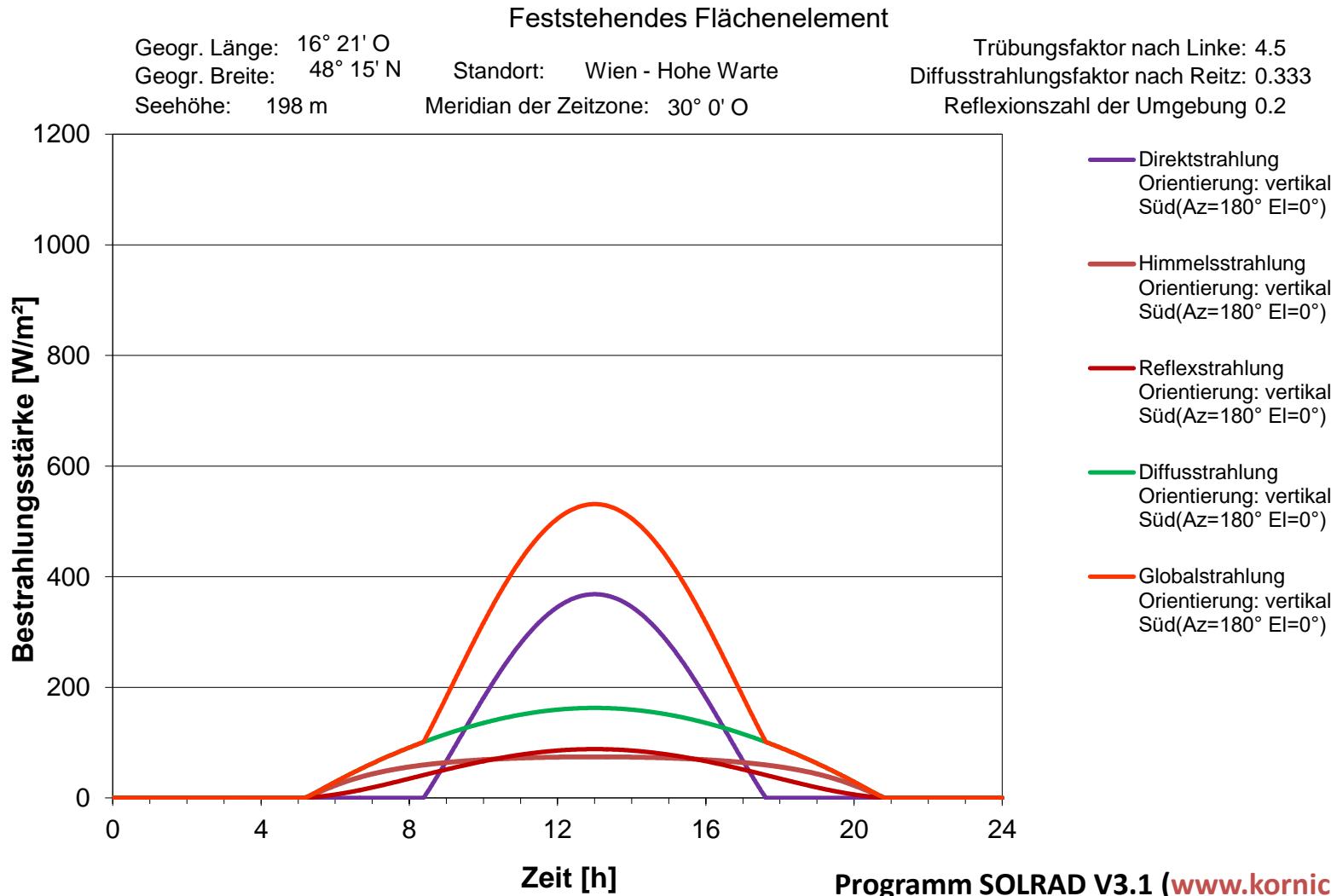
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Diffusstrahlungsfaktor nach Reitz: 0.333

Reflexionszahl der Umgebung 0.2

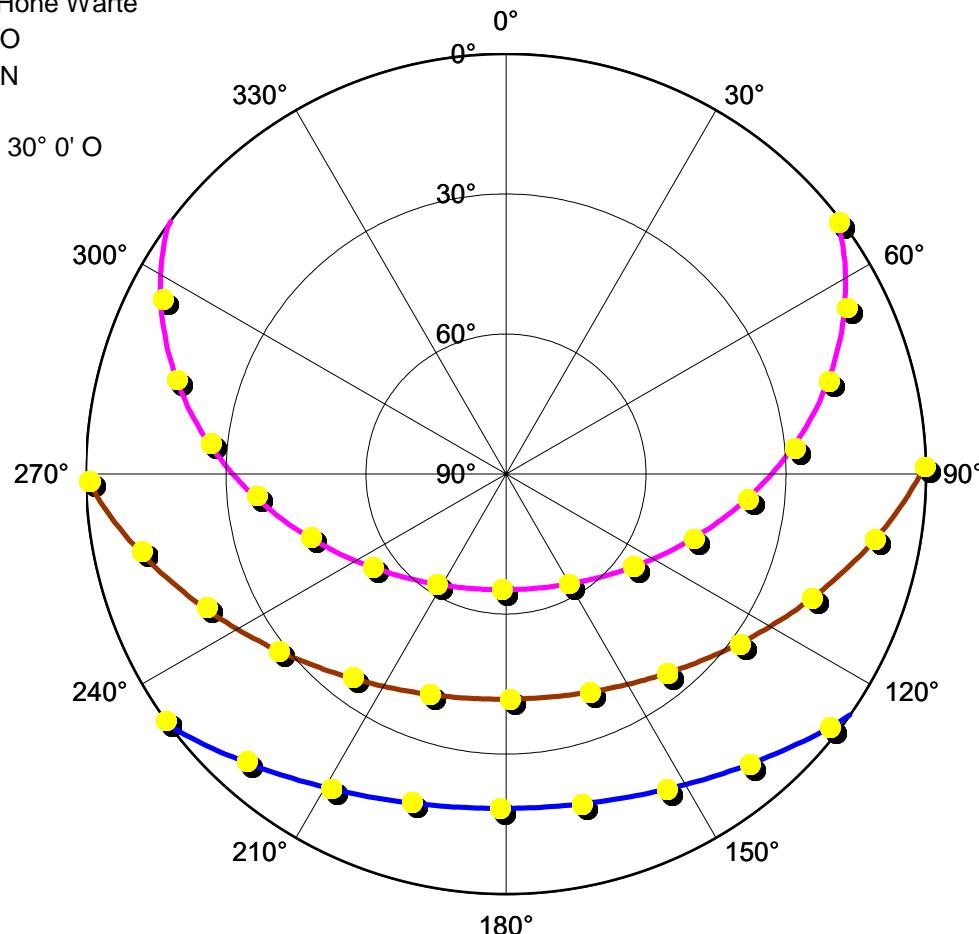


Solar flux of July 15



Solar path diagram

Standort: Wien - Hohe Warte
 Geogr. Länge: $16^{\circ} 21' \text{ O}$
 Geogr. Breite: $48^{\circ} 15' \text{ N}$
 Seehöhe: 198 m
 Meridian der Zeitzone: $30^{\circ} 0' \text{ O}$



- Horizont
- Freier Himmel
- 21. März (Tag- u. Nachtgleiche)
Sonnenaufgang : 6h 59'
Sonnenuntergang: 19h 6'
- 21. Juni (Sommersonnenwende)
Sonnenaufgang : 4h 55'
Sonnenuntergang: 20h 57'
- 21. Dezember (Wintersonnenwende)
Sonnenaufgang : 8h 44'
Sonnenuntergang: 17h 1'
- Tageslänge: 12h 7'
Sonnendeklination: $-0^{\circ} 0'$
- Tageslänge: 16h 1'
Sonnendeklination: $23^{\circ} 27'$
- Tageslänge: 8h 16'
Sonnendeklination: $-23^{\circ} 27'$

Solar radiation

A) Instantaneous values

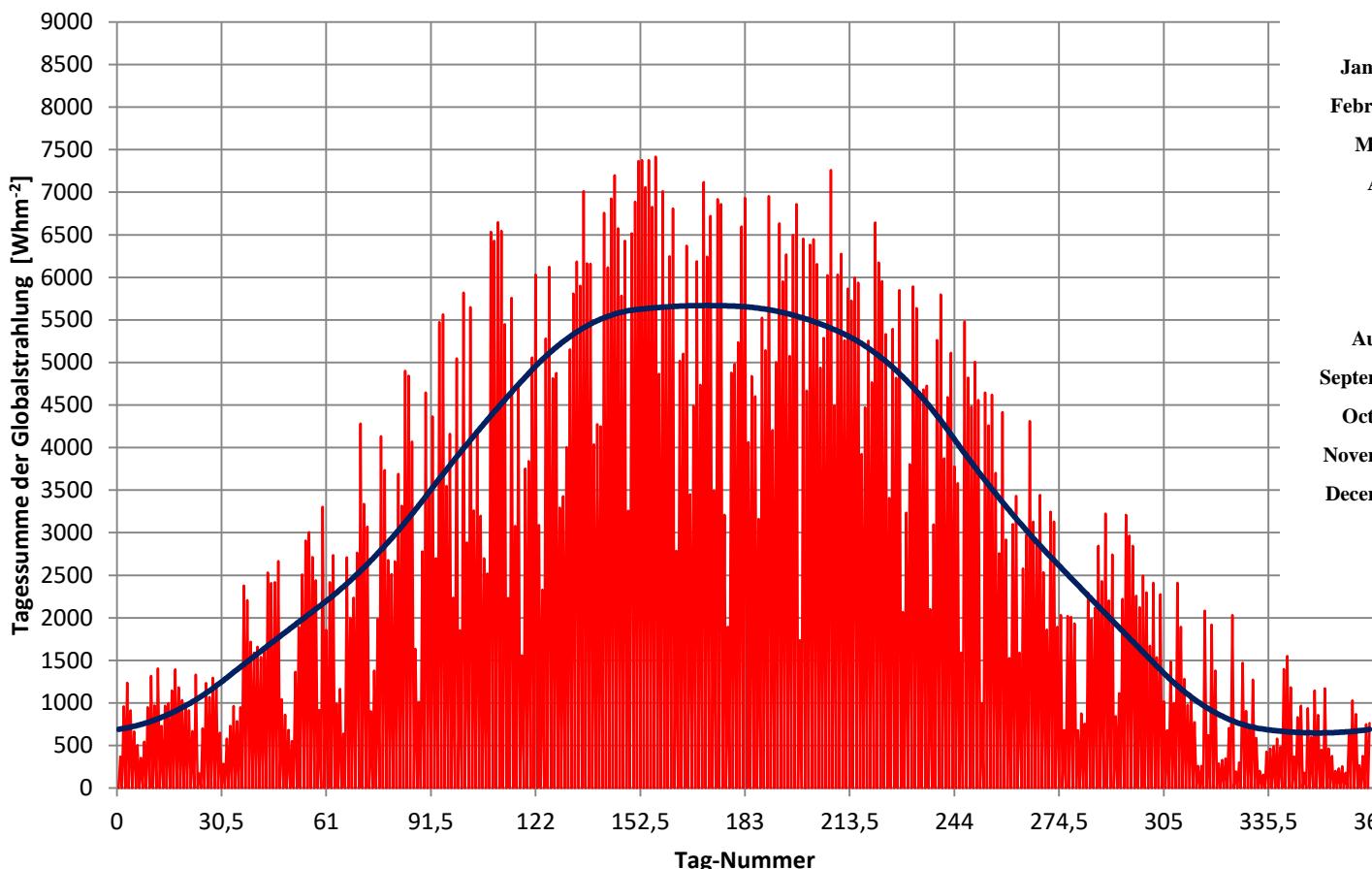
Designated use

Input values for the simulation of the thermal behaviour of buildings and building constructions

Most commonly

- used:
- hourly data over the year (8760 values)
 - long-time monthly mean values should be guaranteed by the test reference year
- ***half-synthetic climate data (HSKD)***

Half-synthetic climate data (HSKD) Wien, Hohe Warte



	Monthly sum [kWhm^{-2}]	actual	nominal	$\Delta\theta$ [kWhm^{-2}]
January	28.2	28.2	28.2	0.0
February	47.7	47.7	47.7	0.0
March	84.4	84.4	84.4	0.0
April	125.2	125.2	125.2	0.0
May	165.7	165.7	165.7	0.0
June	169.7	169.7	169.6	-0.1
July	171.7	171.7	171.7	0.0
August	150.1	150.1	150.1	0.0
September	101.4	101.4	101.4	0.0
October	63.0	63.0	63.0	0.0
November	28.6	28.6	28.6	0.0
December	20.5	20.5	20.5	0.0
year	1156.1	1156.1	1156.1	0.0

Long-time monthly sums
Wien, Hohe Warte
Quelle: ZAMG

Referenced time period: 1978 - 2007

Solar radiation

B) Mean values

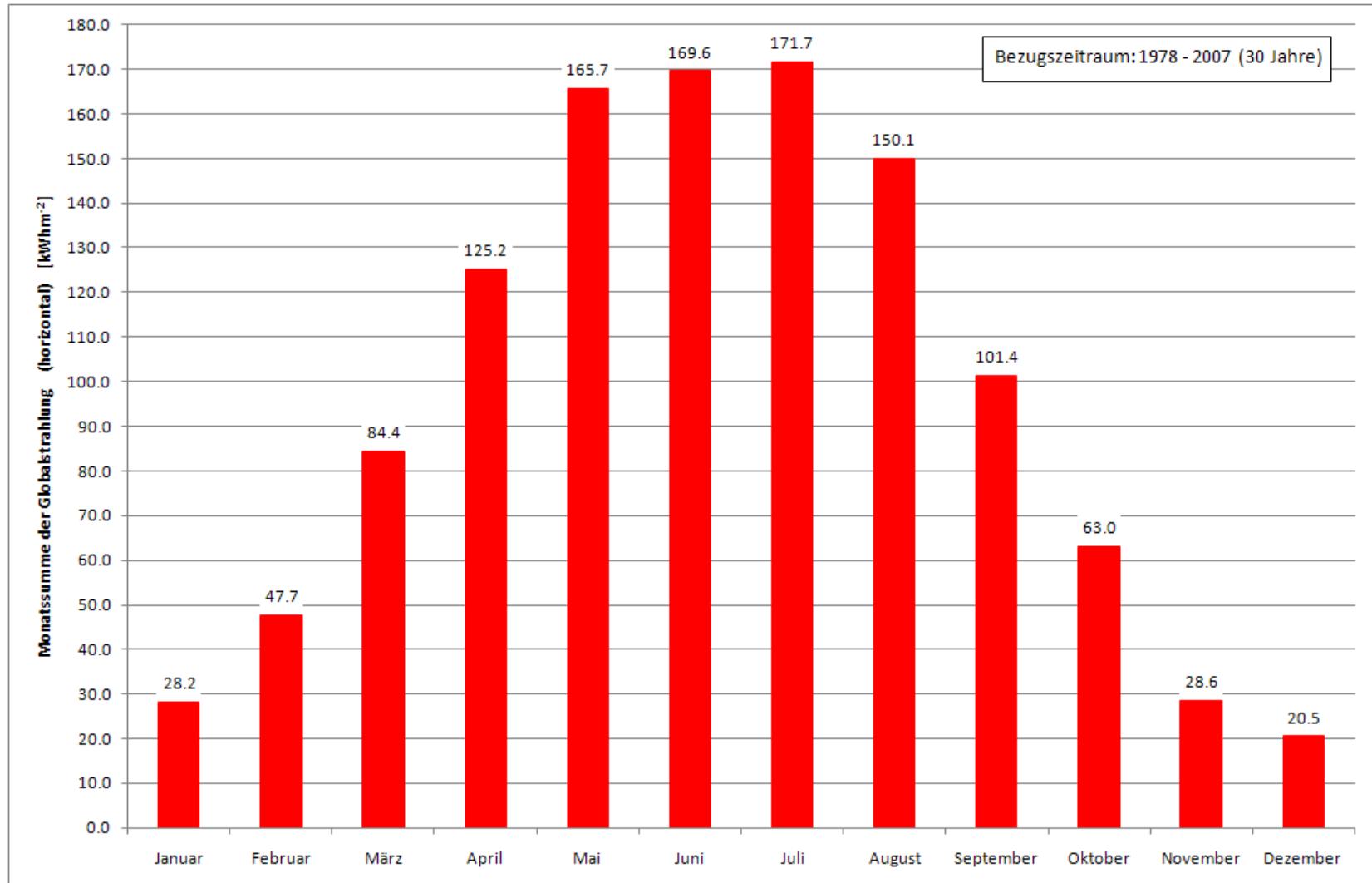
Designed use

Input values for simplified calculation approaches
(heat and energy demand)

Most commonly

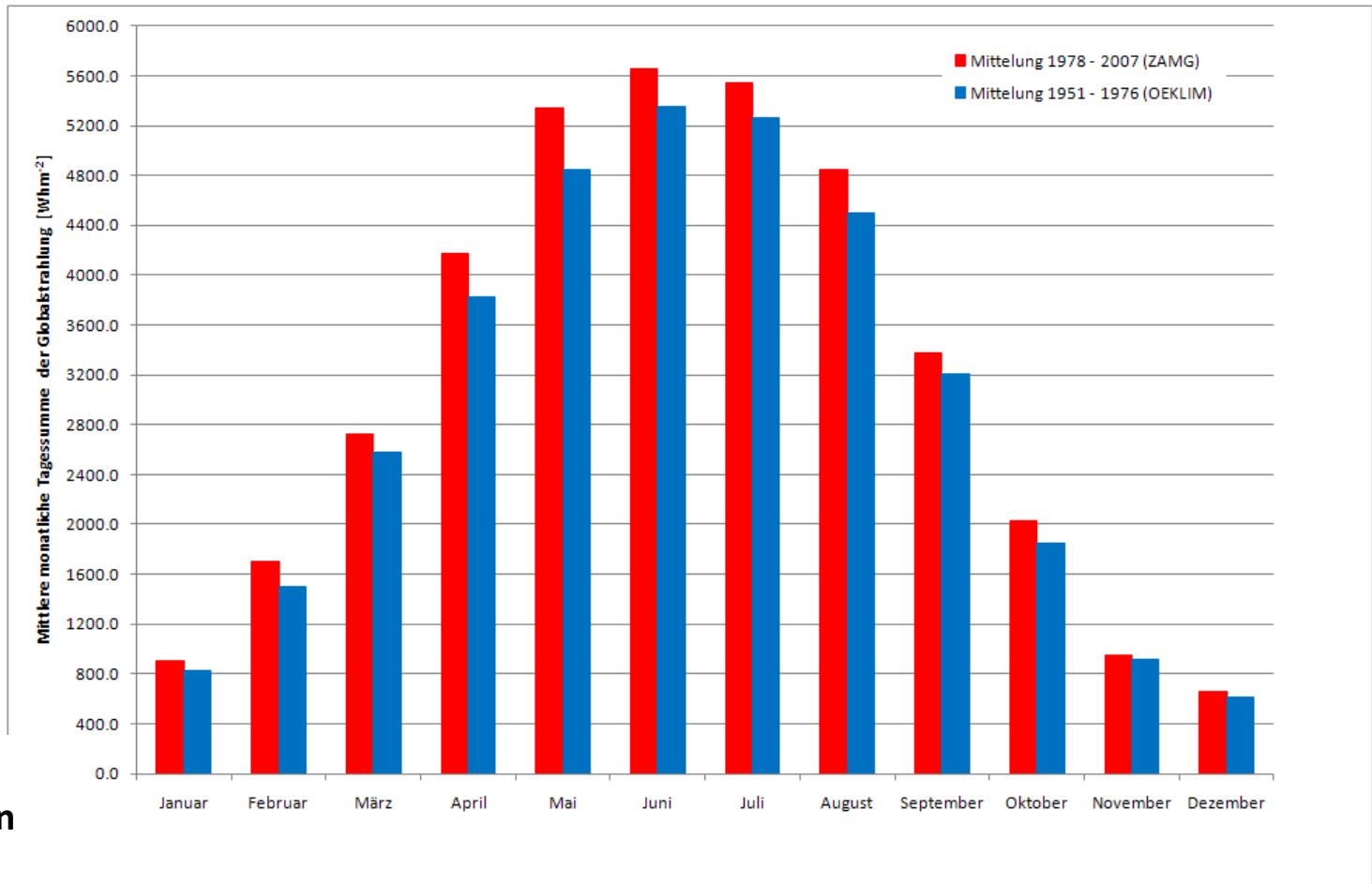
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 - means are to built at least over 10 years
(EN ISO 15927-4) ; default: 30 years (WMO)

Long-time monthly sums of global radiation for Wien, Hohe Warte



Long-time monthly sums of global radiation for Wien, Hohe Warte

Time development



Increase of
Global solar radiation
by approx. 10%!

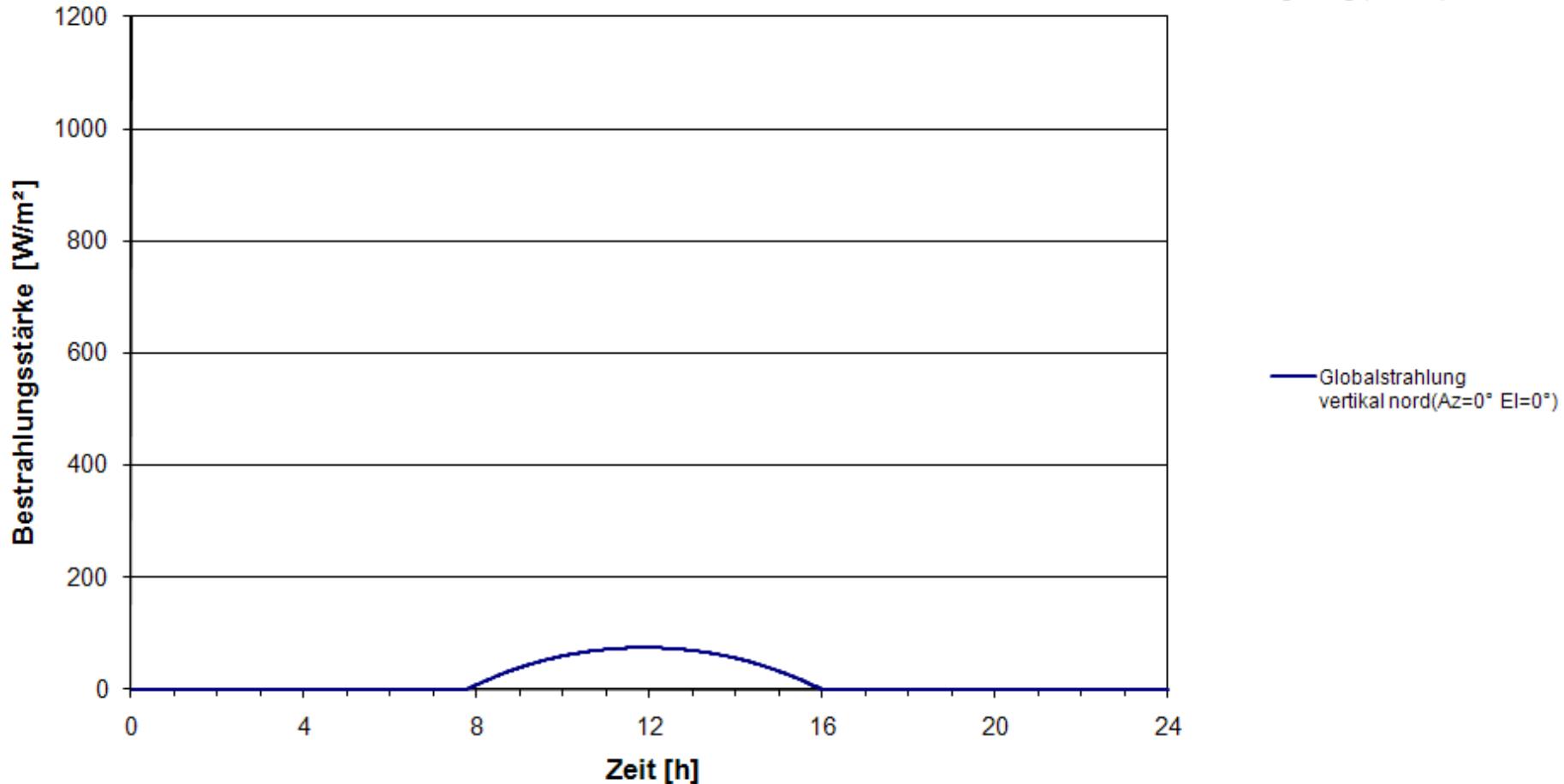
Strahlungsflüsse am 21. Dezember (Wintersonnenwende)

Feststehendes Flächenelement

Geogr. Länge: $16^{\circ} 23' O$
Geogr. Breite: $48^{\circ} 13' N$
Seehöhe: 170 m

Standort: Wien - Innere Stadt
Meridian der Zeitzone: $15^{\circ} 0' O$

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Reflexionszahl der Umgebung (Albedo): 0.2



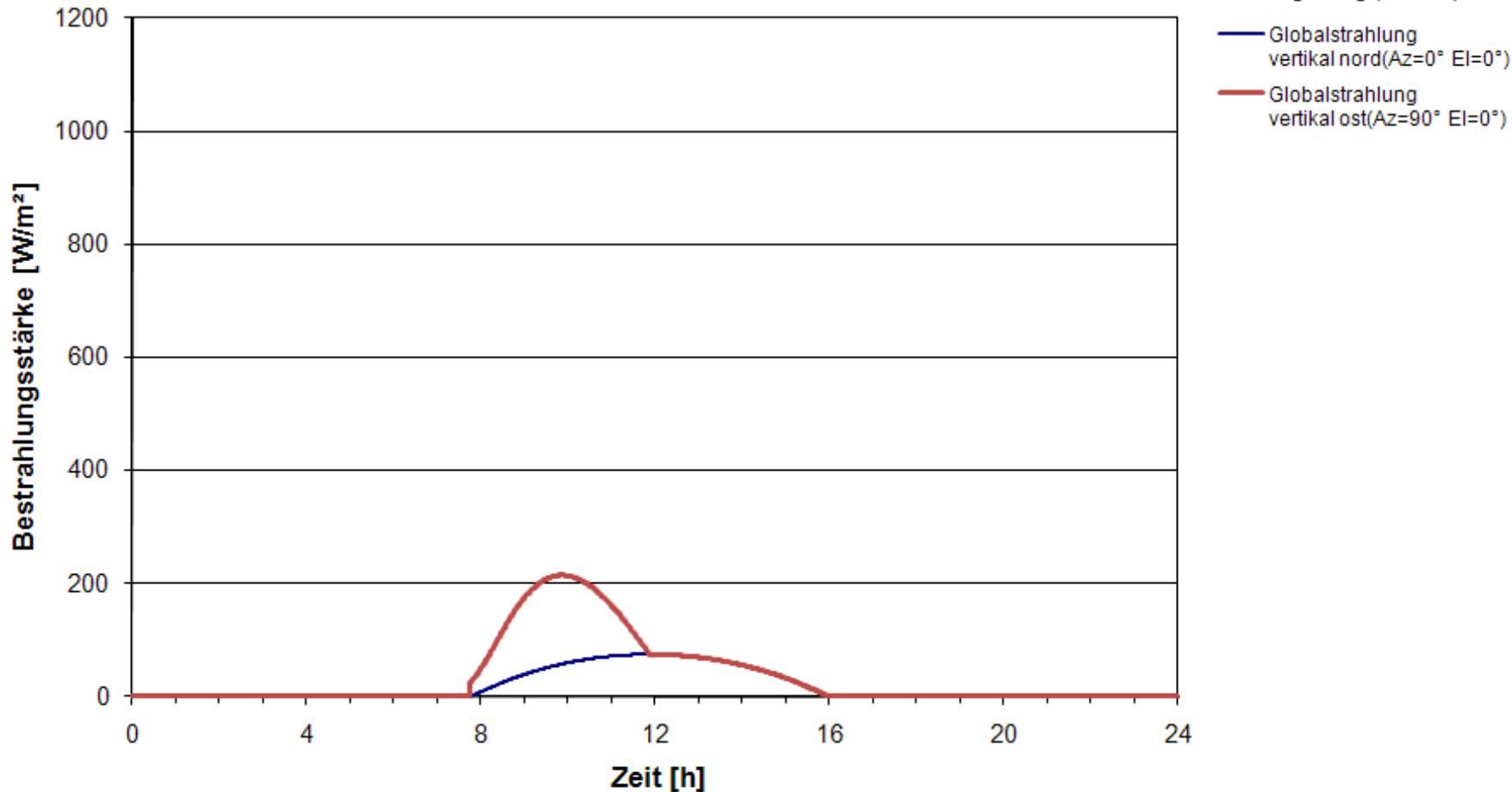
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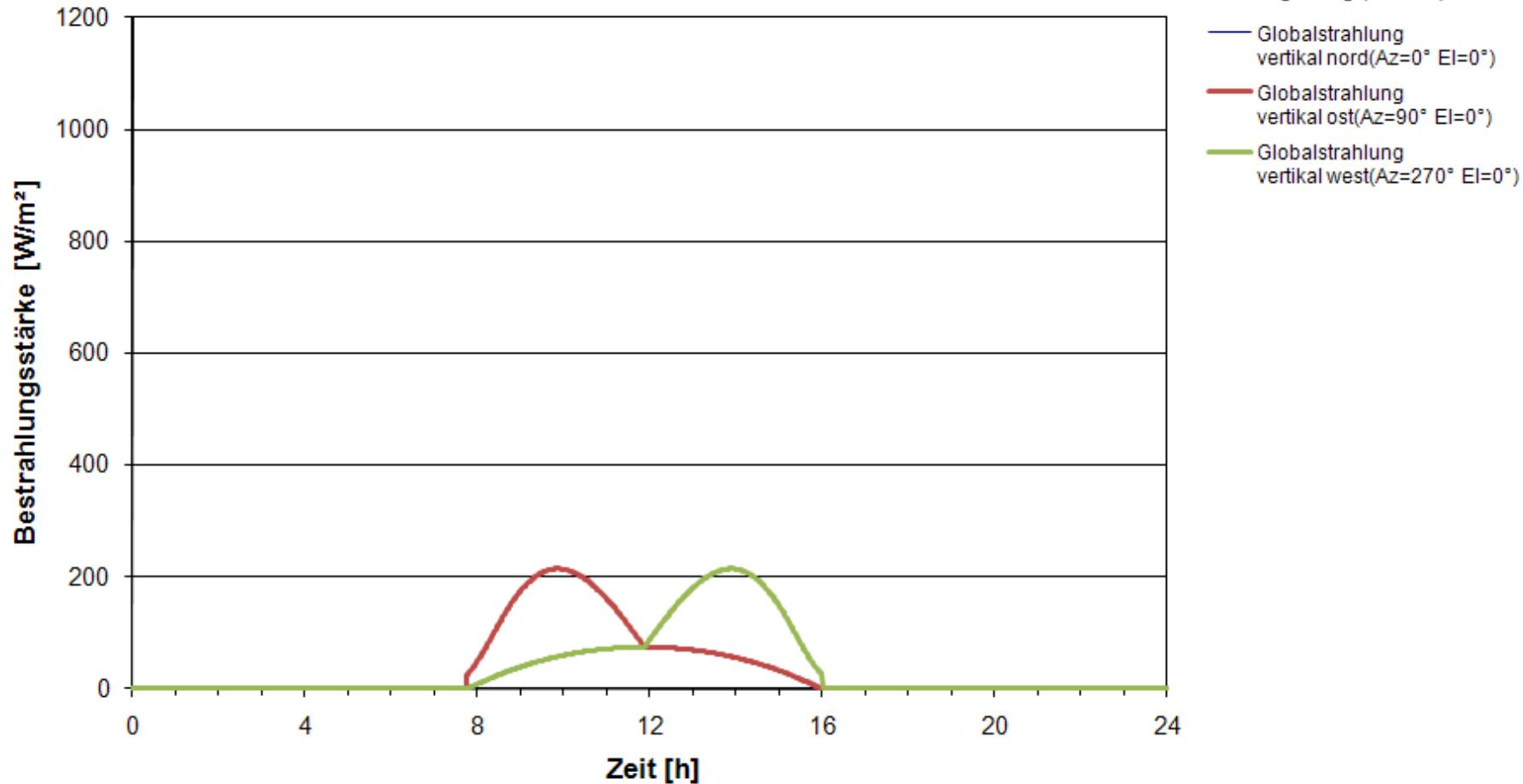
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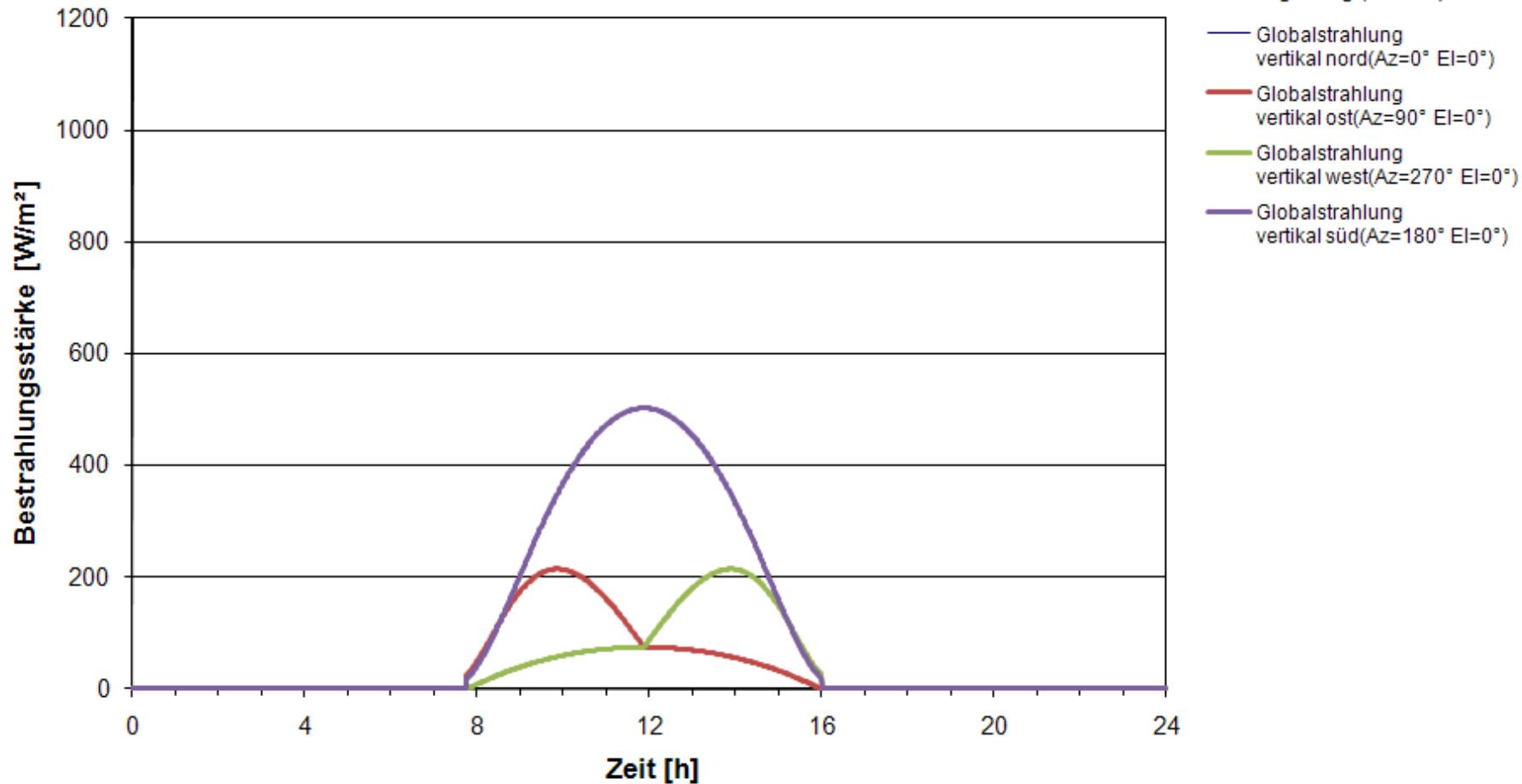
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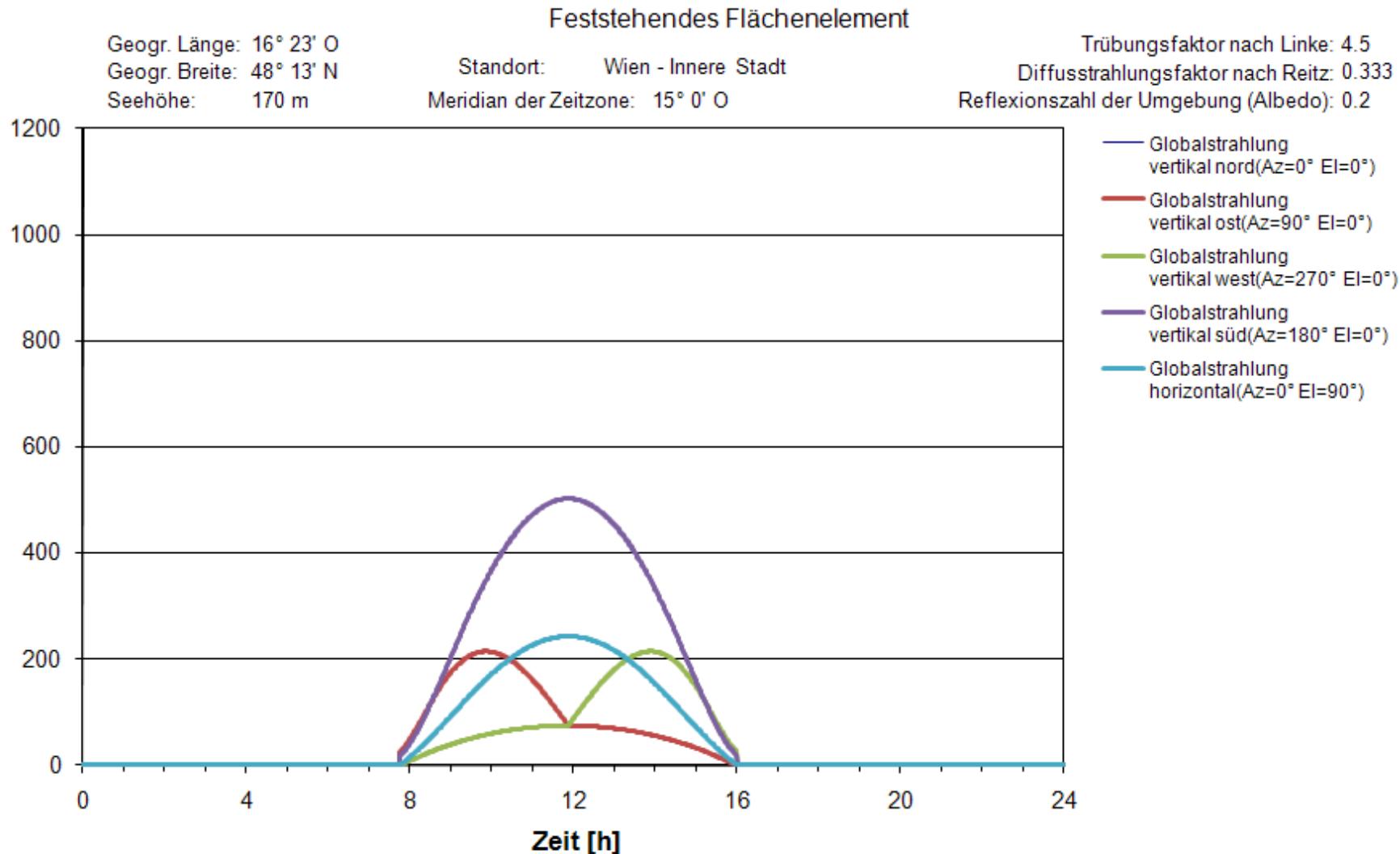
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Strahlungsflüsse am 21. Dezember (Wintersonnenwende)



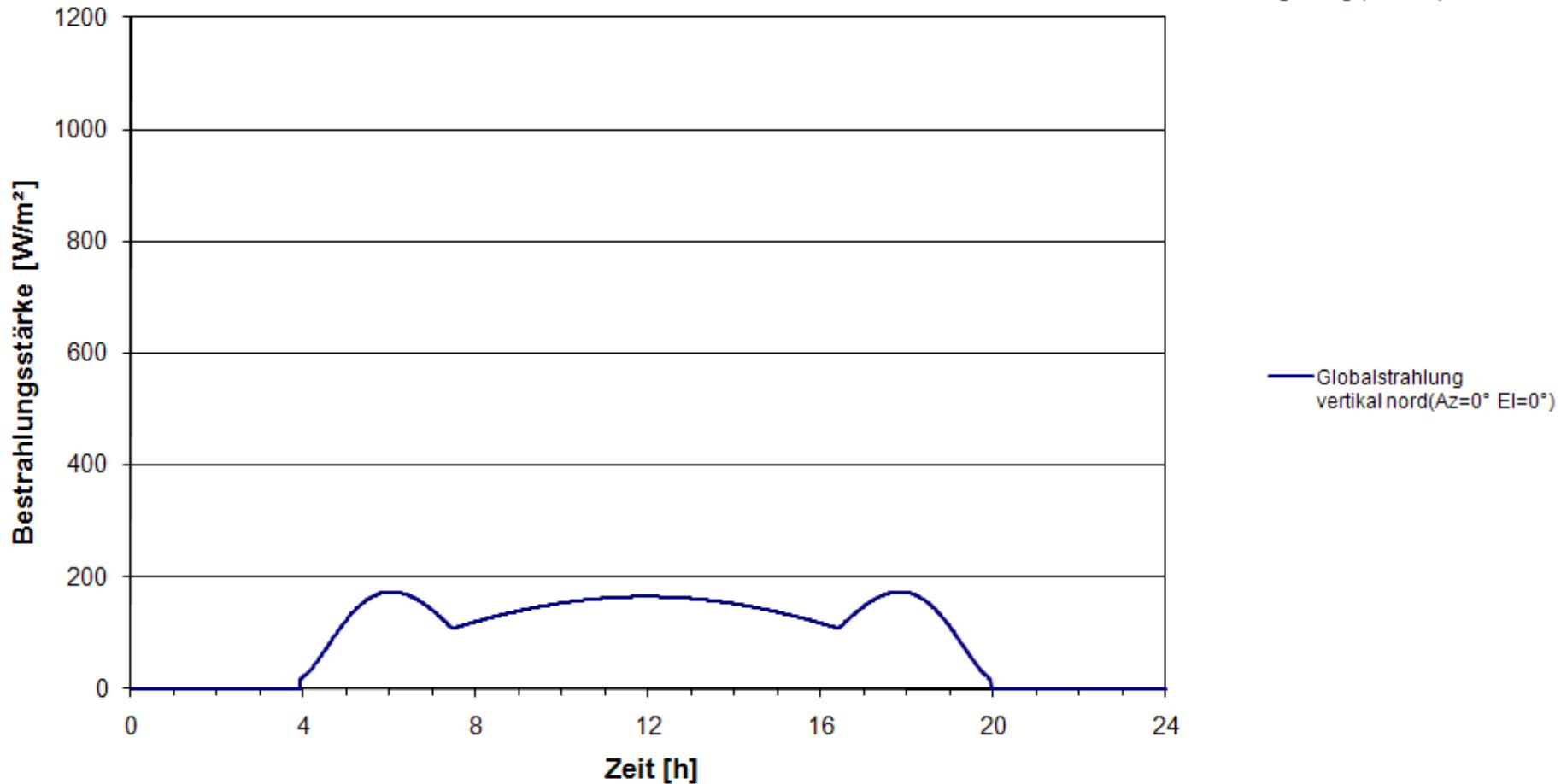
Strahlungsflüsse am 21. Juni (Sommersonnenwende)

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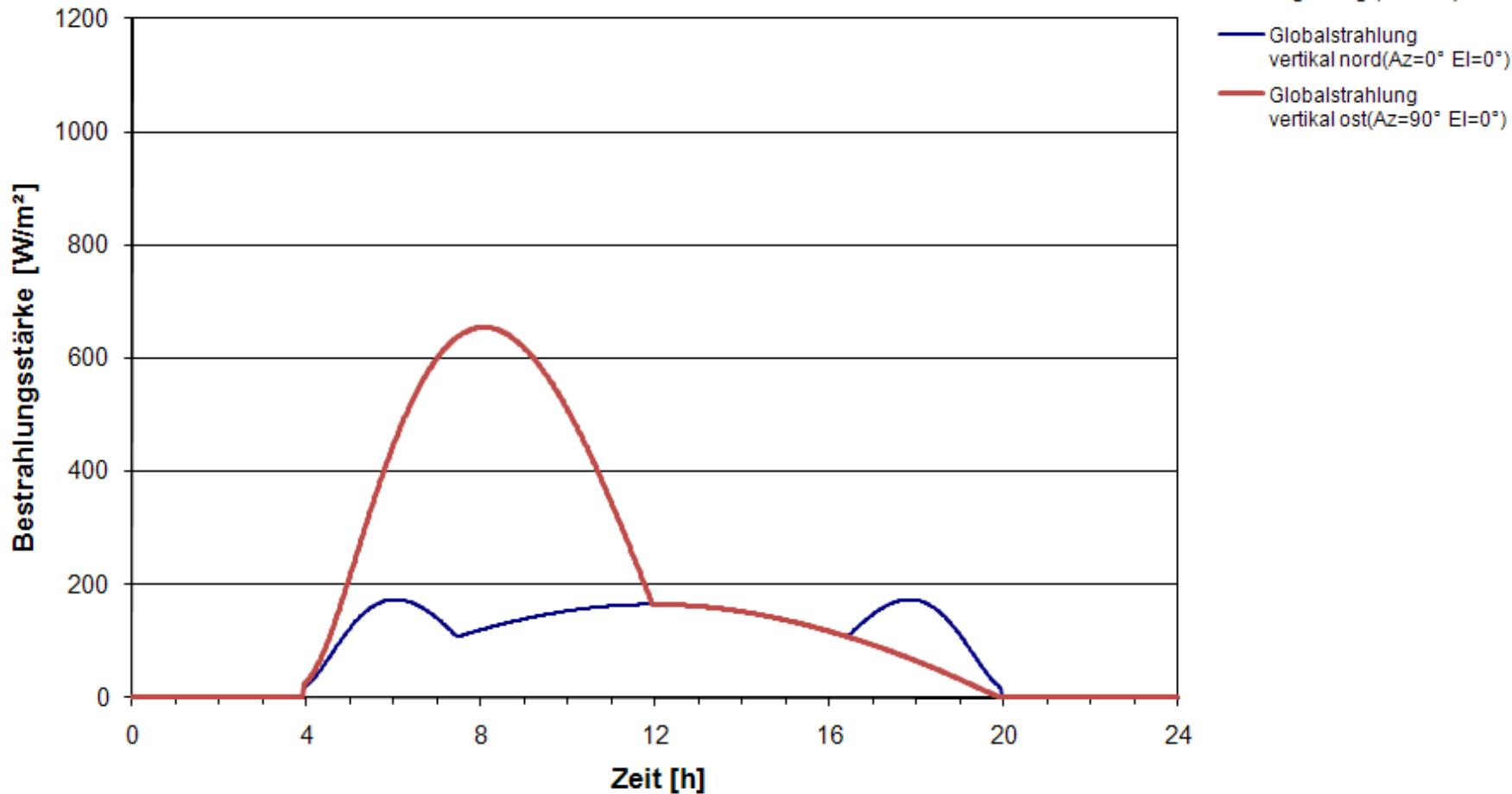
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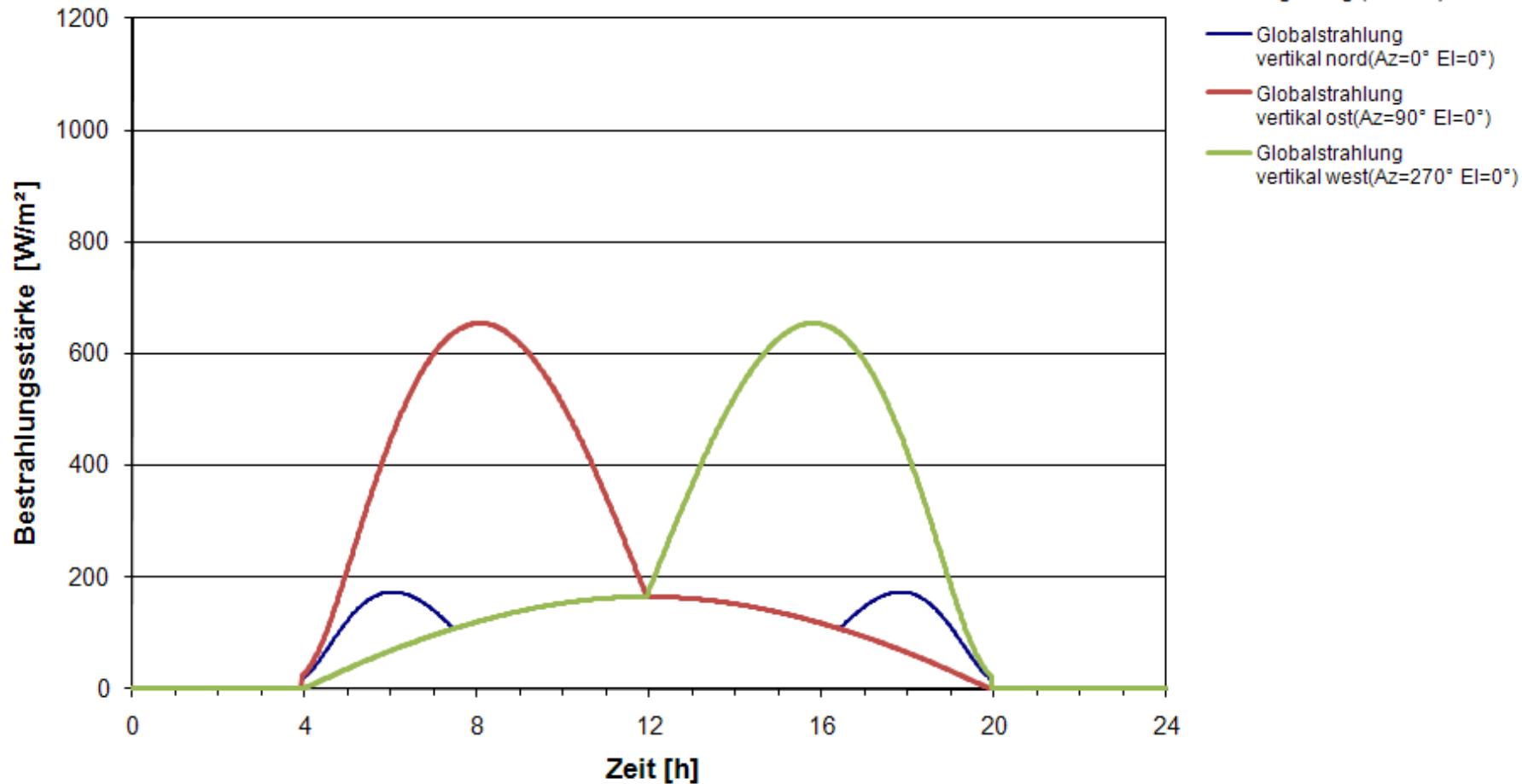
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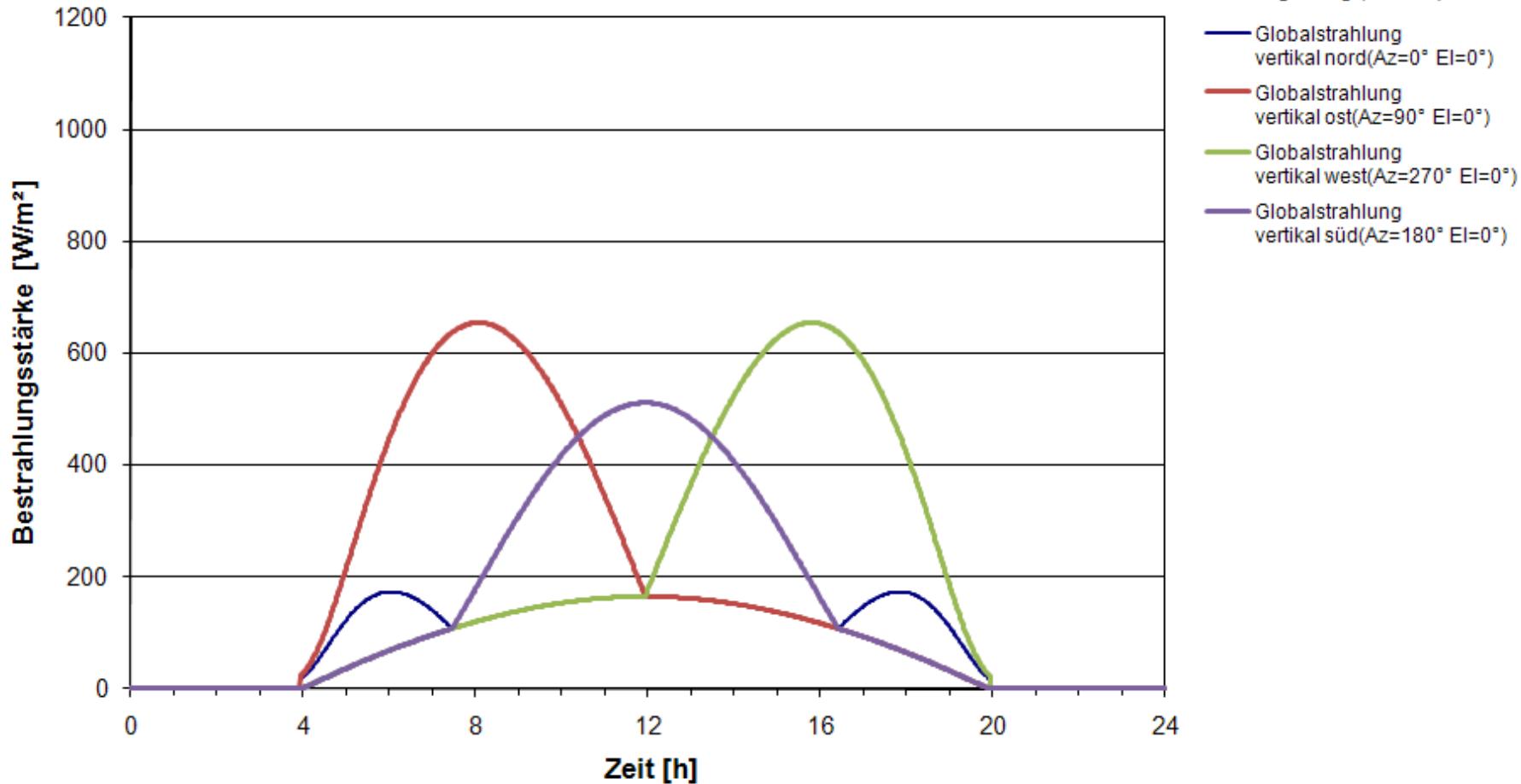
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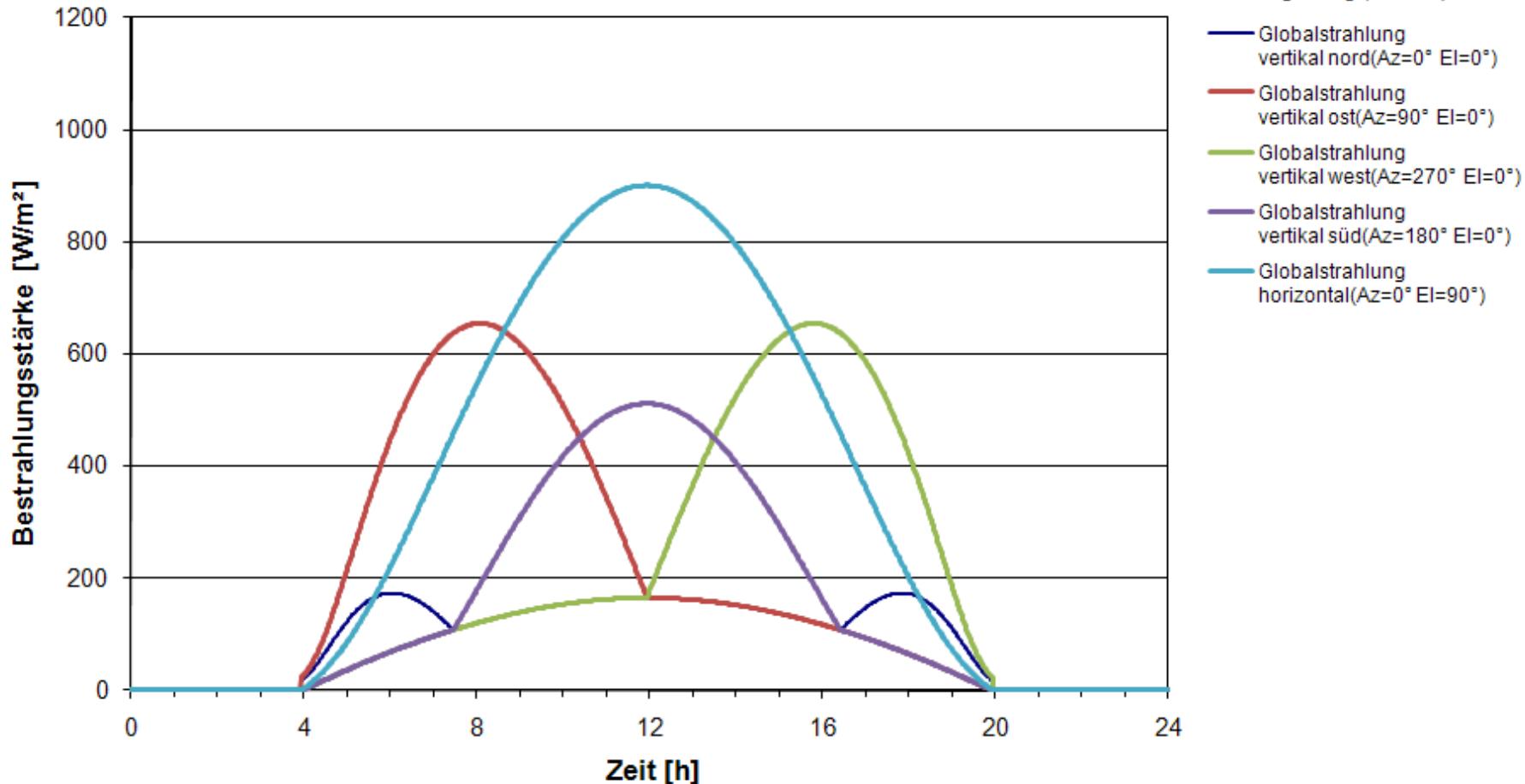
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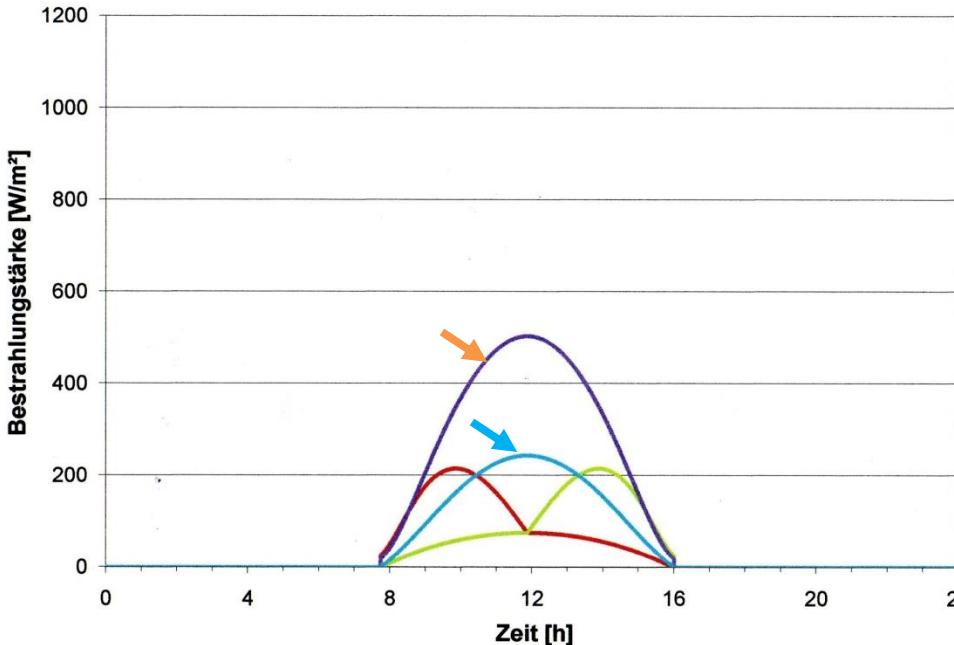
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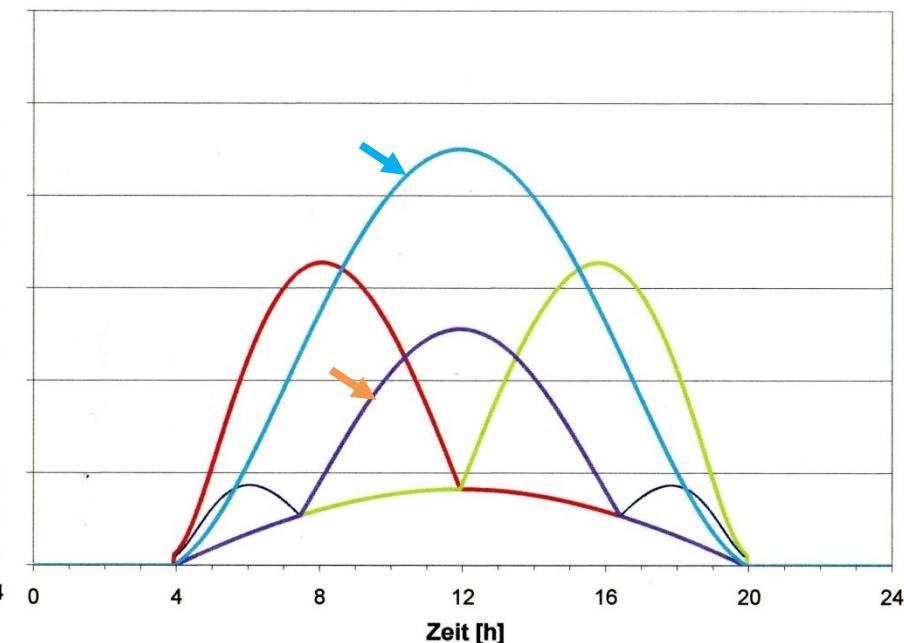


Solar flux at vertical walls and flat roof

Winter solstice



Summer solstice



Design recommendations:

- ➡ Take advantage of benefits of south oriented windows!
- ➡ Avoid the disadvantages of roof windows!



South facade



North facade

Design strategy: Minimizing heat losses

goal: Reduction of heat power by reduction of heat losses

$$\Phi_h = \underline{L_T \cdot (\Theta_i - \Theta_e)} + \underline{L_V \cdot (\Theta_i - \Theta_e)} - \Phi_s - \Phi_i$$

Transmissions heat losses

and / or

Ventilation heat losses

Design strategy: Minimizing heat losses

Reduction of transmission heat losses

$$L_T \cdot (\Theta_i - \Theta_e)$$

$(\Theta_i - \Theta_e)$ depend on building use and climate

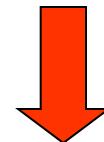


therefore **hardly alterable!**

L_T depends on U-values, areas, thermal bridges



substantial suggestible by the designer!



Reduction of transmission heat losses necessitates design measures
for **minimizing the transmission conductance !**

Design strategy: Minimizing heat losses

Reduction of the Transmission Conductance

$$L_T = \sum_i U_i \cdot A_i + \sum_j \psi_j \cdot l_j + \sum_k \chi_k$$

Design measures:

- Reduction of the U-values – improved insulation
- Reduction of areas – Minimizing the area of the building envelope
- Increasing the compactness of the building
- Reduction of correction factors in view of thermal bridges –
pain-taking design of building details!

Design strategy: Minimizing heat losses

Reduction of Ventilation heat losses $L_v \cdot (\Theta_i - \Theta_e)$

L_v

Depends on the required hygienic ventilation rate and on ventilation requirements caused by the prevention of mould growth



therefore (for present-day buildings) **hardly alterable!**

$(\Theta_i - \Theta_e)$

Depends on the temperature of the incoming air



suggestible by the designer !



Reduction of ventilation heat losses necessitates design measures for **increasing the temperature of the incoming air!**

Design strategy: Minimizing heat losses

Increasing the temperature of the incoming air:

$$(\Theta_i - \Theta_e) \rightarrow (\Theta_i - \Theta_z)$$

Design measures:



**Include ventilation heat recovery system!
(outgoing air warms up incoming air)**



**Incoming air is warmed up by soil-heat exchanger
[heat is detracter from the soil (winter) / heat is absorbed by the soil (summer)]**



Reduction of ventilation heat losses necessitates **controlled ventilation** (ventilation system) and an **air-tight building envelope!**

Design strategy: Maximizing heat gains

goal: Reduction of the heat demand by increasing heat gains

$$\Phi_h = L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) - \underline{\Phi}_s - \underline{\Phi}_i$$

Solar heat gains

and / or

Heat gains caused by building use

Design strategy: Maximizing heat gains

Increase of heat gains

$$\Phi_i = \Phi_P + \Phi_G \quad \text{Dependant on the building use}$$

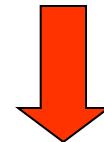


therefore hardly alterable!

$$\Phi_S \quad \text{Dependant on kind, size and position of the windows}$$



substantial suggestible by the designer!



Enlarging internal heat gains necessitates design measures
for increasing solar heat gains!

Design strategy: Maximizing heat gains

Calculation of heat gains caused by solar radiation:

Heat power caused by solar radiation incoming through the transparent part of the window:

$$\Phi_s = B \cdot A_g \cdot g \cdot r \cdot z$$

Φ_s ... Heat gain inside the room [W]

B ... Solar irradiation [Wm^{-2}]

A_g ... Area of the glass [m^2]

g ... g-value

r ... Reduction factor for g

(angle of incidence, soiling)

z ... Shading factor

Design strategy: Maximizing heat gains

Total solar energy transmittance

The total solar energy transmittance of a glass is that part of the solar irradiance inclining on the external surface of the glass, which takes effect as solar heat gain inside the room.

The g-value is comprised by the radiation transmission factor τ_s and the secundary heat emission factor q_i :

$$g = \tau_s + q_i$$

The total solar energy transmittance is defined for solar radiation **impinging perpendicular** upon the glass.

Design strategy: Maximizing heat gains

Total solar energy transmittance for several glasses



Bezeichnung	U_g	τ_s	g
Einfach-Glas 6 mm	5.8	0.80	0.83
Zweifach-Isolierglas Klarglas 6-8-6	3.2	0.65	0.71
Zweifach-Isolierglas Klarglas 6-12-6	2.9	0.65	0.71
Zweifach-Isolierglas Klarglas 6-16-6	2.7	0.65	0.72
Zweifach-Verbundfenster Klarglas 6-30-6	2.7	0.65	0.72
Dreifach-Isolierglas Klarglas 6-12-6-12-6	1.9	0.53	0.63
Zweifach-Wärmeschutzglas beschichtet 4-16-4 (Luft) $\varepsilon \leq 0.05$	1.5	0.48	0.61
Zweifach-Wärmeschutzglas beschichtet 4-15-6 (Ar) $\varepsilon \leq 0.1$	1.3	0.47	0.61
Zweifach-Wärmeschutzglas beschichtet 4-12-4 (Kr) $\varepsilon \leq 0.05$	1.1	0.49	0.62
Zweifach-Wärmeschutzglas beschichtet 4-12-4 (Xe)	0.9	0.49	0.62
Dreifach-Wärmeschutzglas beschichtet 4-8-4-8-4 (Kr) $\varepsilon \leq 0.05$	0.7	0.29	0.48
Dreifach-Wärmeschutzglas beschichtet 4-8-4-8-4 (Xe)	0.5	0.29	0.48

Source: ÖNorm B8110-1

Design strategy: Maximizing heat gains

Reference values for the reduction factor

The reduction factor r lies in the range of **0,8 and 0,9** in winter time.

During **summertime** the reduction factor is dependant on the orientation of the glasses:

Orientierung	r
Süd	0,65
Ost /West	0,80
Nord	0,70

Design strategy: Maximizing heat gains

The shading factor z

Shadowing can strongly affect the heat gains caused by solar radiation:

Shadowing by

- skyline
- adjacent buildings
- shape of the building
- design of the facade
- blinds

Shading factor z: Reduction factor for irradiation

Design strategy: Maximizing heat gains

Shading devices: Venetian blinds, Screens, outside awning blinds, sun sails,

Shading factor z: Reduction factor for the **g-value**

Abschattungsvorrichtung	Abminderungsfaktor <i>z</i>
keine Abschattungsvorrichtung	1,00
Außenjalousie, Fensterläden mit Jalousiefüllung (beweglich, unterlüftet, Belichtung ohne künstliche Beleuchtung möglich)	0,27
Zwischenjalousie	0,53
Innenjalousie (je nach Farbe und Material)	0,75
beschattungswirksame Vordächer, Balkone und horizontale Lamellenblenden	0,32
Markisen (seitlicher Lichteinfall möglich)	0,43
Rolläden, Fensterläden mit voller Füllung	0,32
helle Innenvorhänge, Reflexionsvorhänge und Innenmarkisen	0,75
Bepflanzung	0,50 bis 1,00

Source: ÖNorm B8110-3

Design strategy: Maximizing heat gains

Enlargement of the solar heat gains

$$\Phi_s = B \cdot A_g \cdot g \cdot r \cdot z$$



Design measures:

- Enlarge the solar input by appropriate orientation of the windows (optimum for europe: south orientation)
- Appropriate dimensioning of the window areas
- Applicate glasses with high g-values
- Avoid shadowing during winter season /
Enable shadowing in summer (design of facades / use of blinds)

Summer behaviour of rooms

Standards:

Guide lines with regard to calculation parameters:

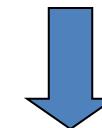


International standards (EN and/or ISO)

Definition of acceptable summer temperatures:



National standards

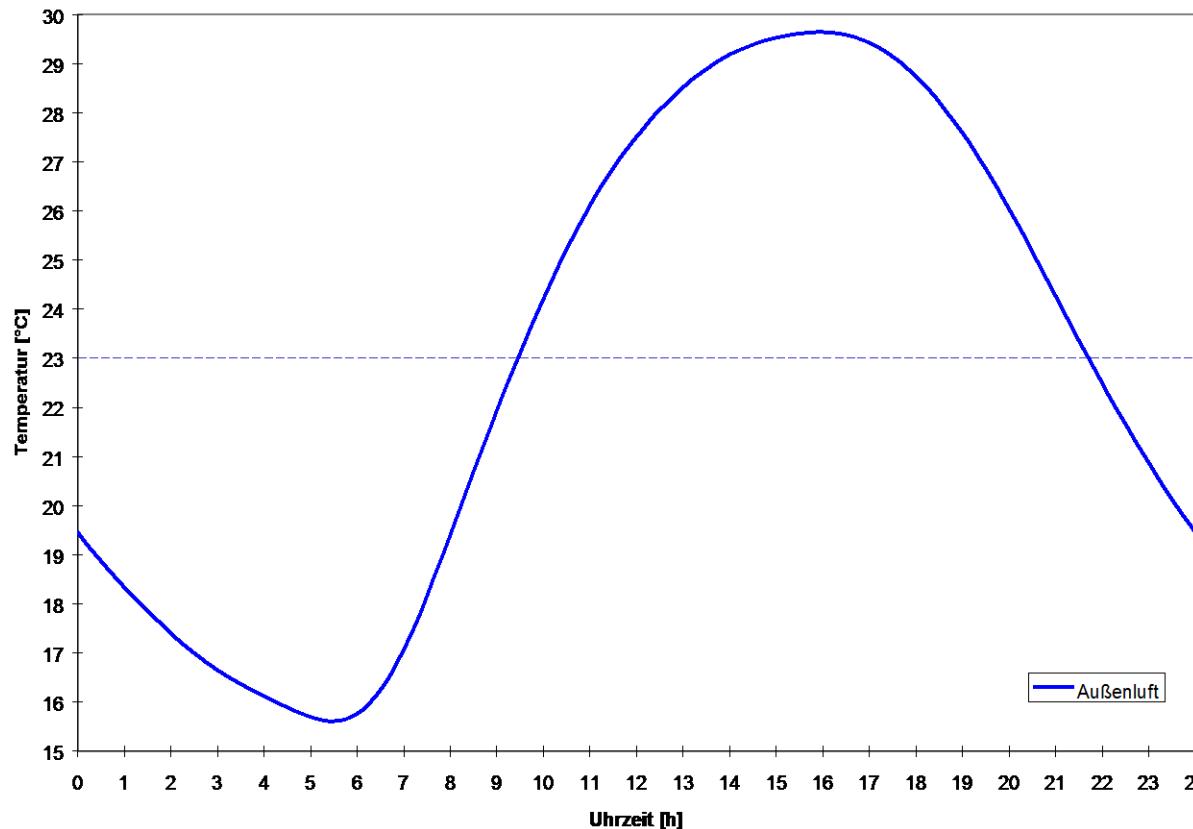


Austria: ÖNorm B8110-3:1999

Definition of summer climate (Austria)

Standardized climate:

$$\text{Ambient air temperature: } \Theta_e \Rightarrow 23,0^\circ C \pm 7,0K$$



Definition of summer climate (Austria)

Standardized climate:

Solar radiation:



Haziness factors:

Linke: 4,5

Reitz: 0,333

Albedo: 0,2



Date: July 15



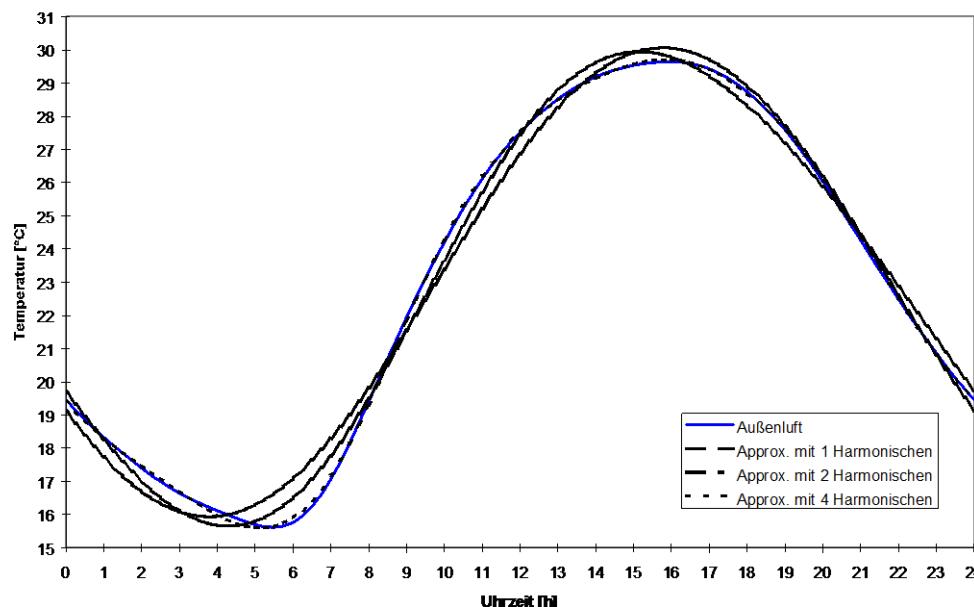
location: building site or Vienna (Hohe Warte)

Definition of summer building -behaviour (Austria)

Calculation method: **periodic calculation**

→ **Period length: 1 day (24 h)**

→ **Calculation model: Fourier-analysis**



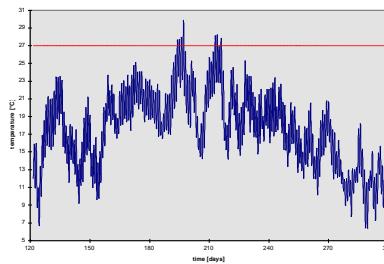
Calculation method: Time analysis

Sommertauglichkeitsberechnung

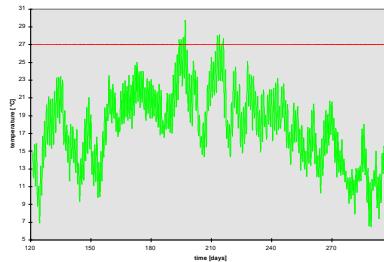
Variantenrechnung mittels Zeitschrittverfahren

Berechnungsergebnis:

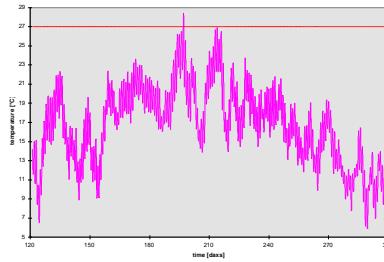
Lufttemperaturverlauf



Variante 1:
Isolierverglasung 6-12-6
 $U=3.1 \text{ [W/m}^2\text{K]}$; $g=0.71$

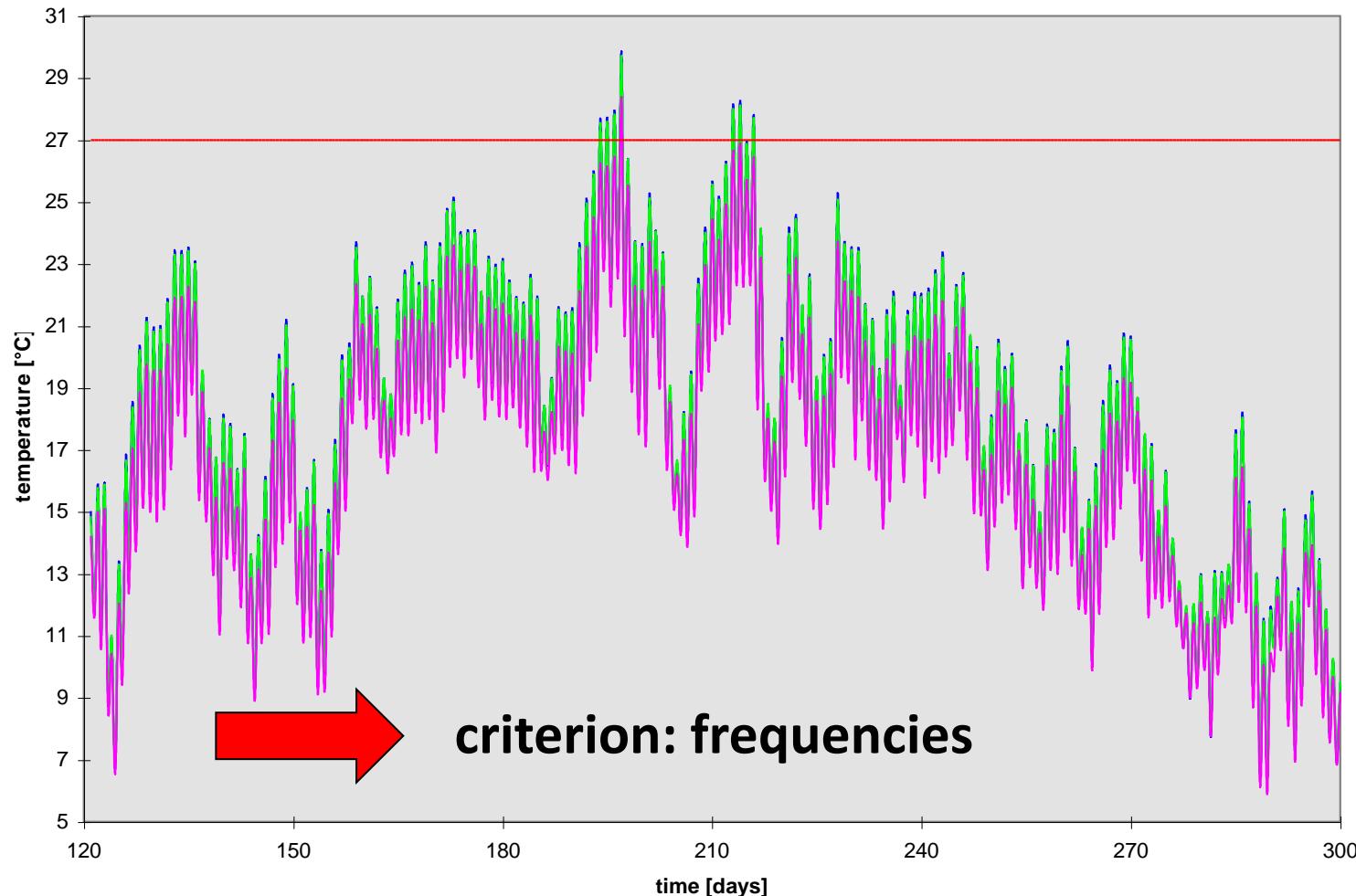


Variante 2:
WS-Verglasung 4-12-4
 $U=1.3 \text{ [W/m}^2\text{K]}$; $g=0.61$

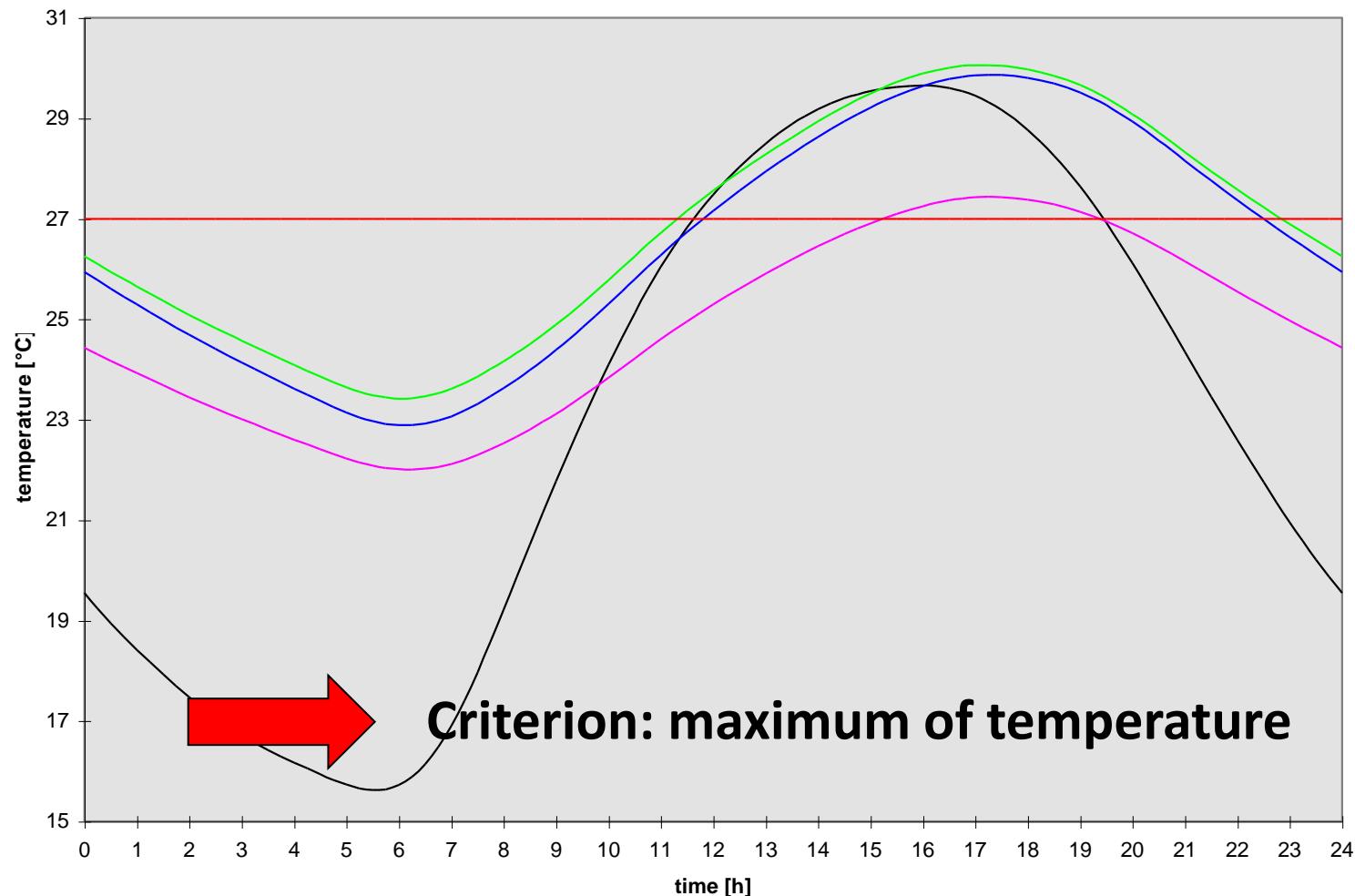


Variante 3:
SS-Verglasung 6-15-6
 $U=1.3 \text{ [W/m}^2\text{K]}$; $g=0.25$

Calculation method:
Time analysis



Calculation method:
Periodic calculation



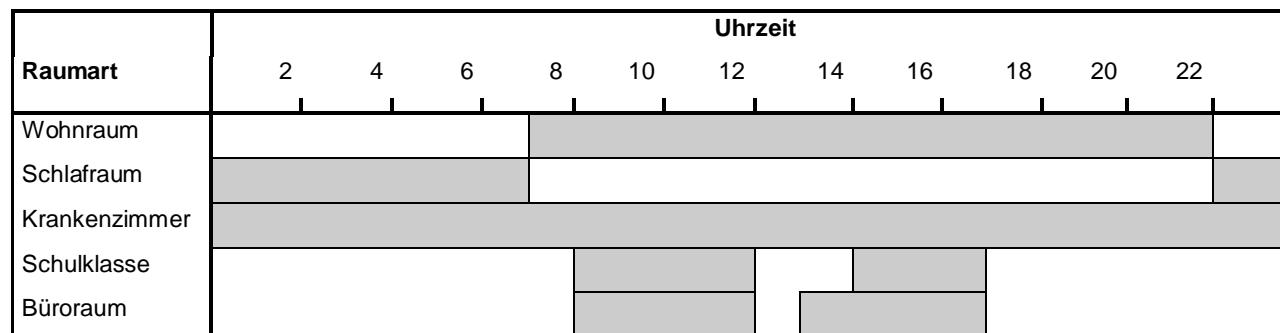
Definition of acceptable summer temperatures (Austria)

Standardized indoor climate:

A room fulfills the demands of standards with regard to its thermal summer behaviour, if the ***operative temperature*** does not exceed

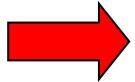
→ **27 °C for rooms used during day**

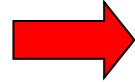
→ **25 °C for rooms used during night**



Source: ÖNorm B8110-3

Methods of calculation summer behaviour

1. Hand calculation  Daily **mean** of internal air temperature

2. Standardized calculation
according to ÖNorm B8110-3 (Austria)  Yes/no – decision
(rough estimate)

3. periodic simulation



- daily course of internal air temperature
- daily courses of surface temperatures
- daily courses of operating temperature
- depending on building building site, climate,
Shading measures, ventilation strategies, ...

- suitable for proof of summer behaviour **and**
- optimization of internal summer climate

Rough estimation of summer behaviour (hand-calculation):

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$



Constant calculation leads to the **dayly mean of the internal air temperature**:

$$\Theta_i = \Theta_e + \frac{\Phi_s + \Phi_i}{L_T + L_V} + \frac{\Phi_h}{L_T + L_V} \quad [^\circ\text{C}]$$



$$\Delta\Theta$$

Rough estimation of summer behaviour (hand-calculation):

$$L_T \cdot (\Theta_i - \Theta_e) + L_V \cdot (\Theta_i - \Theta_e) = \Phi_s + \Phi_i + \Phi_h$$



Constant calculation leads to the **dayly mean of the internal air temperature**:

$$\Theta_i = \Theta_e + \frac{\Phi_s + \Phi_i}{L_T + L_V} - \frac{\Phi_k}{L_T + L_V} \quad [^\circ\text{C}]$$



$$\Delta\Theta$$

Rough estimation of summer behaviour (hand-calculation):

$$\Theta_i = \Theta_e + \frac{\Phi_s + \Phi_i}{L_T + L_V} - \frac{\cancel{\Phi_k}}{\cancel{L_T + L_V}}$$

Conclusions:

- Without cooling power the daily mean of indoor temperature is higher than the daily mean of ambient air temperature
- Increasing the internal heat leads to a higher daily mean of indoor temp.
- Reducing the transmission conductance – by means of better insulation – leads to a higher daily mean of indoor temperature
- Enlarging the ventilation conductance – by means of increase of the Ventilation rate – leads to lower daily mean of indoor temperature

research project: Assessment of summer behaviour of rooms

K. Kreč, 2006

Parameters study – Geometrie Room 1

Living space at standard-floor

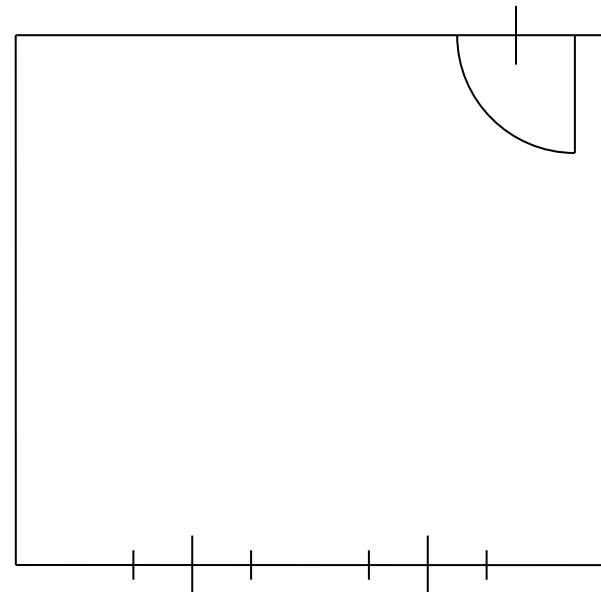
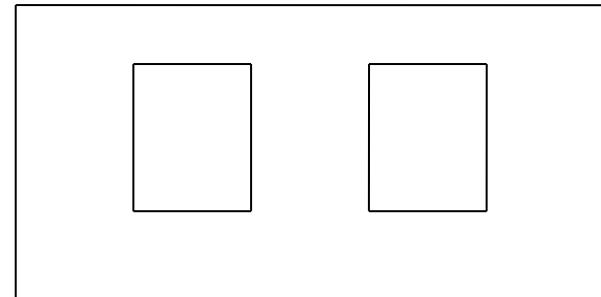
Ground plan: 5,0 x 5,0 m

Room height: 2,5 m

Similar rooms above and below
the room under consideration

Variants:

1 or 2 external walls

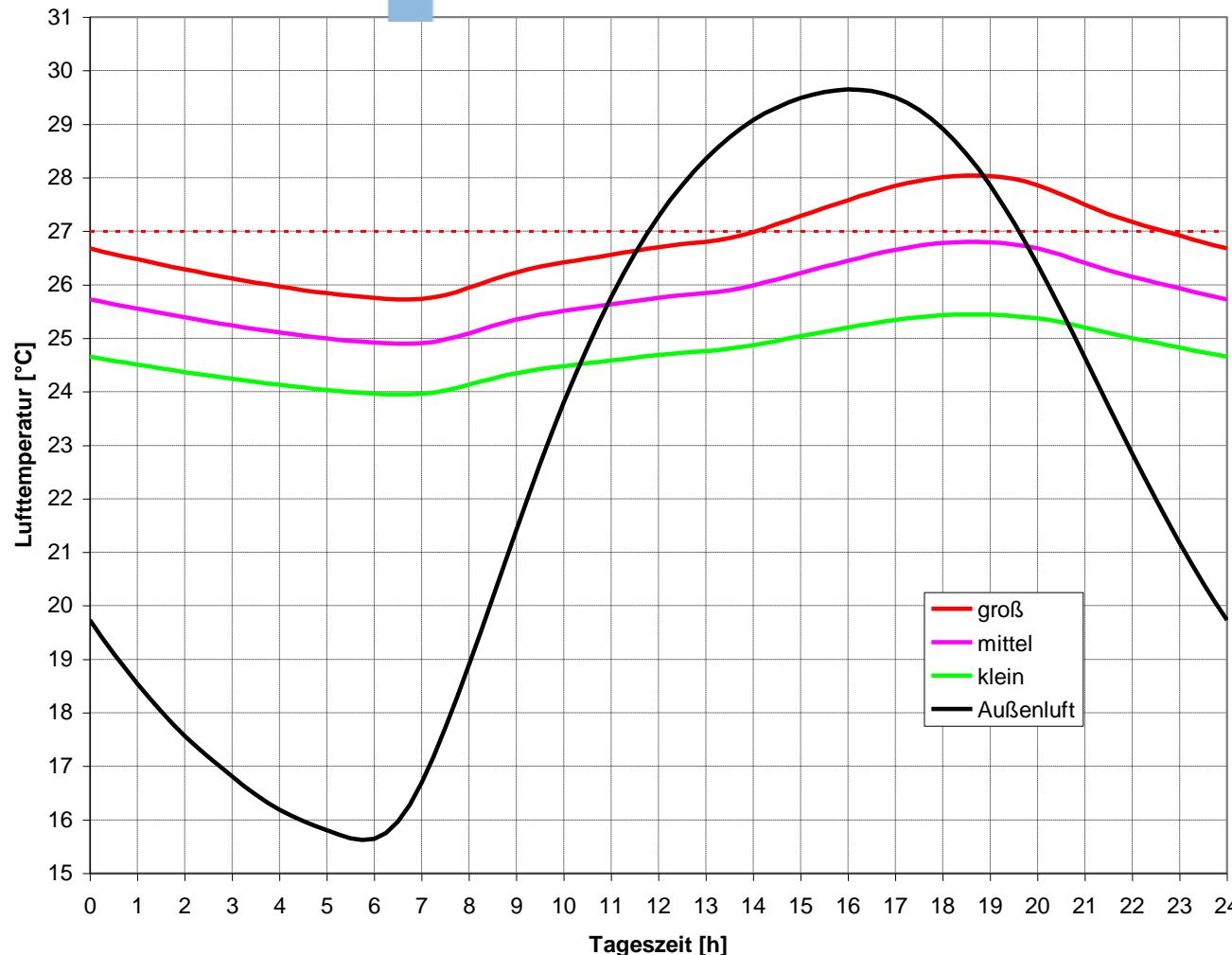


research project: Assessment of summer behaviour of rooms

K. Kreč, 2006

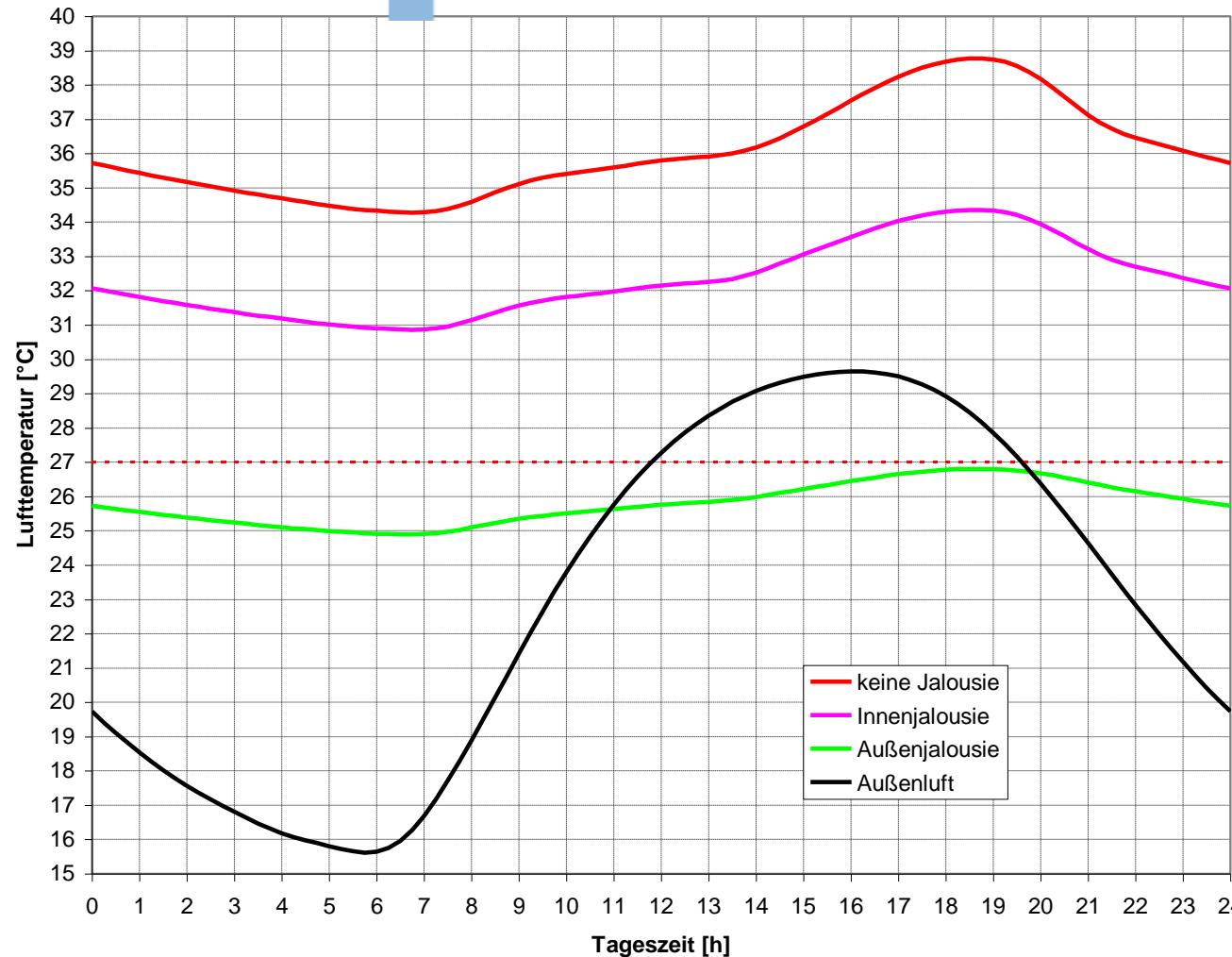
Paramets varied:

- | | |
|--------------------------------|---|
| Construction method: | heavy – light weight |
| Way of insulation: | Standard – NEH - PH |
| Area of windows: | small – medium - big |
| Shading: | without – internal / external blinds |
| Orientation of windows: | Room 1: 1 facade
north – east – south – west
Raum 1: 2 facades
north + east – south + west |

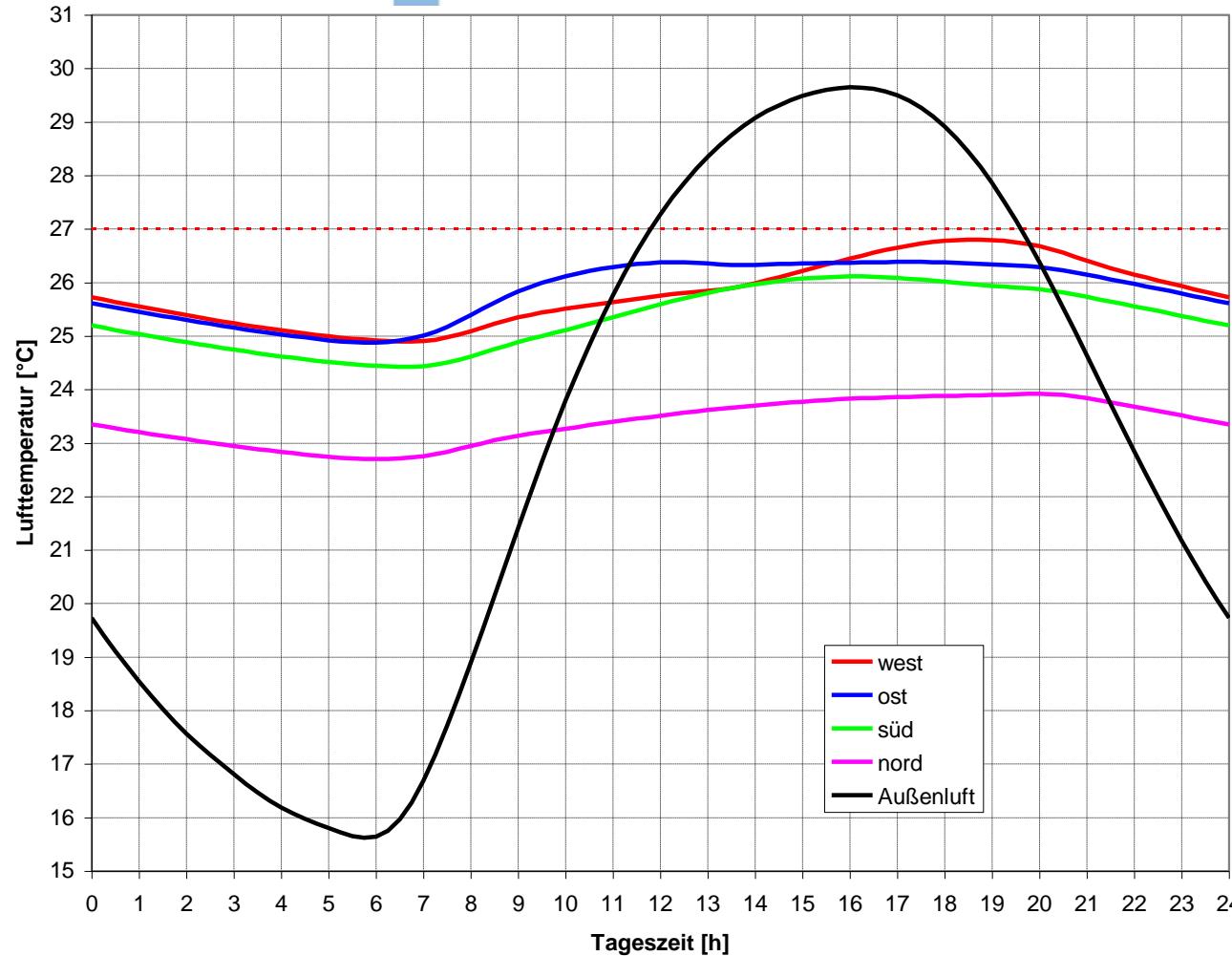


big 24%
medium 18%
small 12%
(referred to
net floor area)

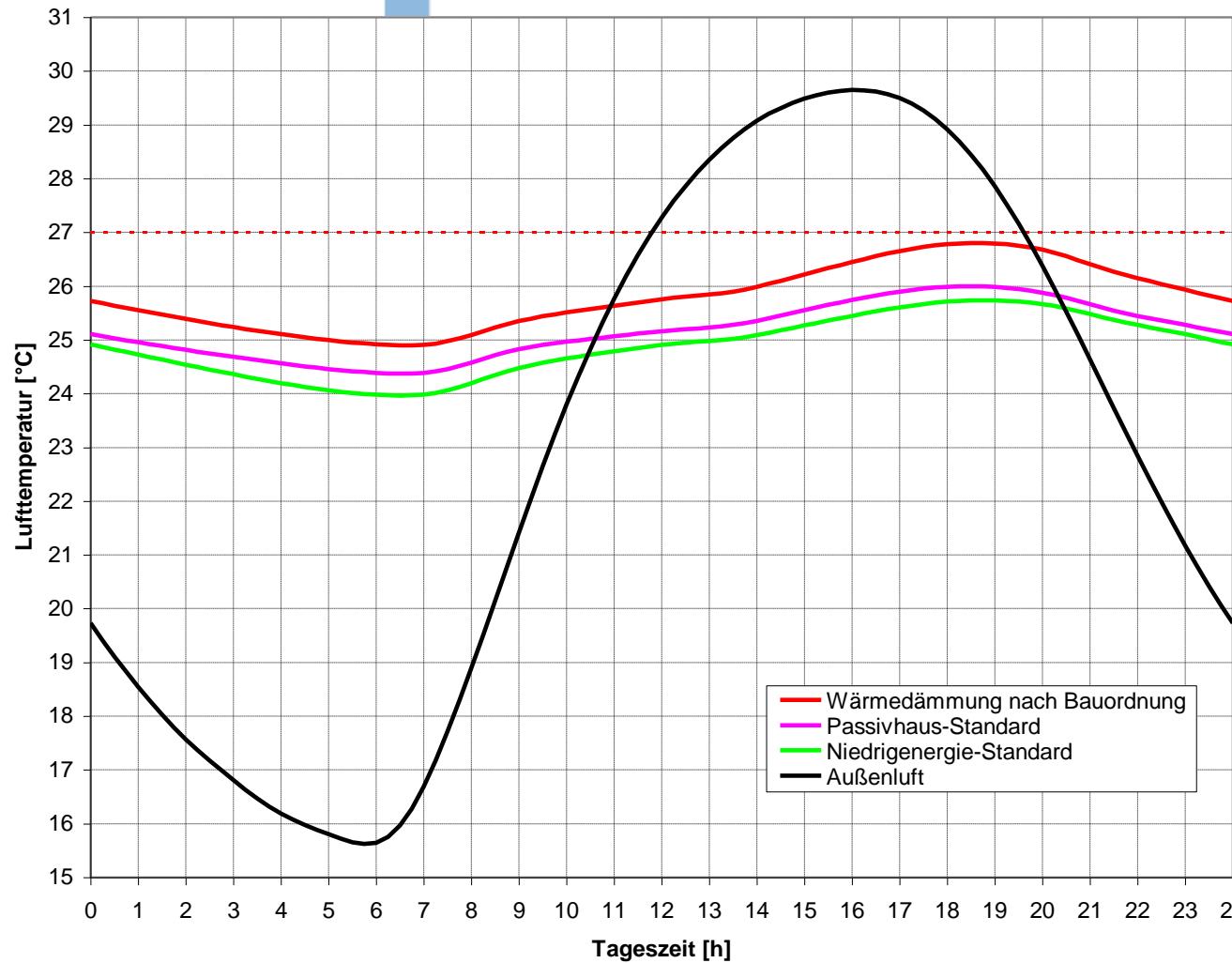
Window west oriented/ external blind – calculation parameter: **window area**



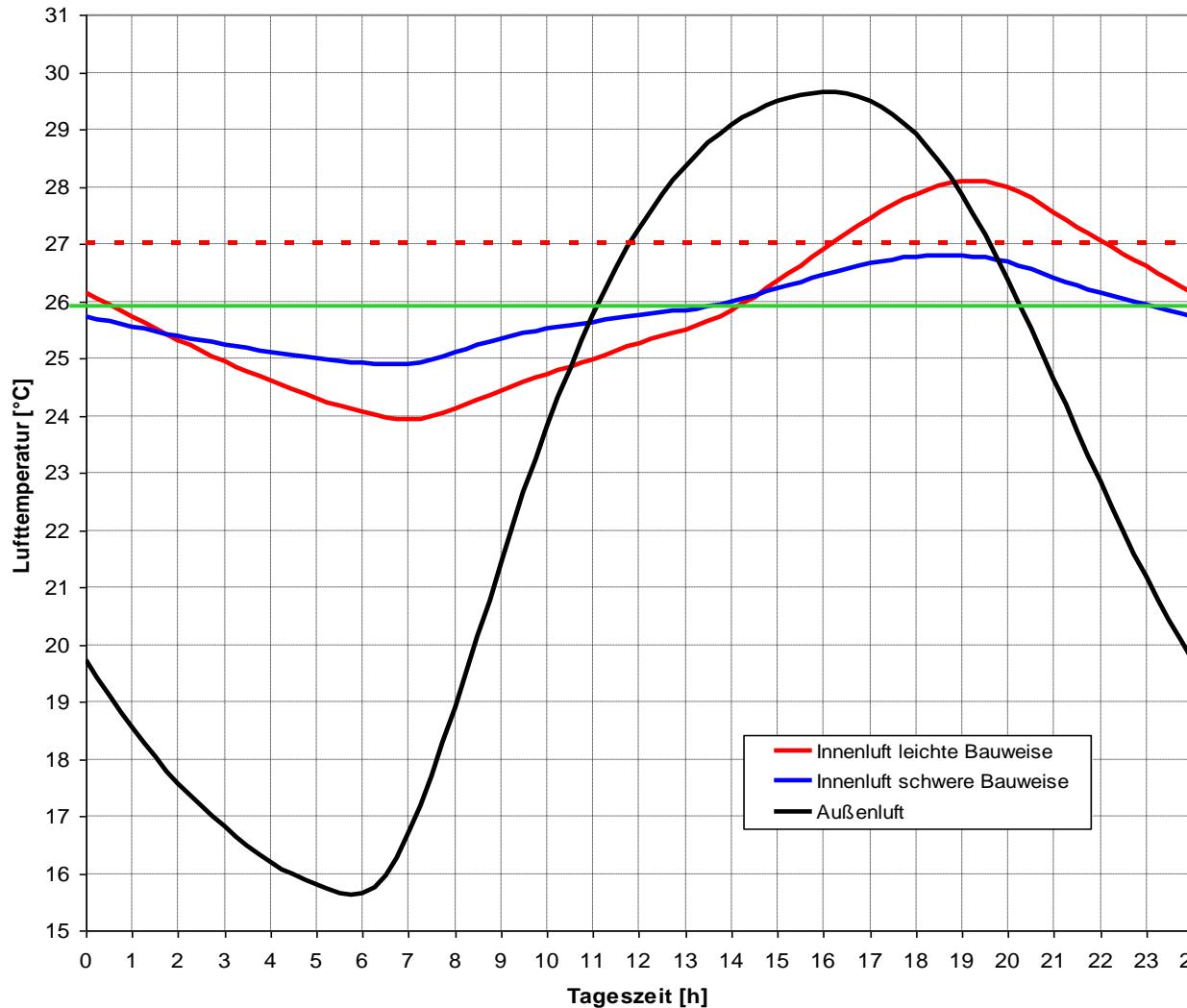
Window west-oriented / medium size – Calculation parameter: **venetian blinds**



Window west-oriented / medium size – Calculation parameter: **window orientation**



Window west-oriented / medium size – Calculation parameter: **way of insulation**



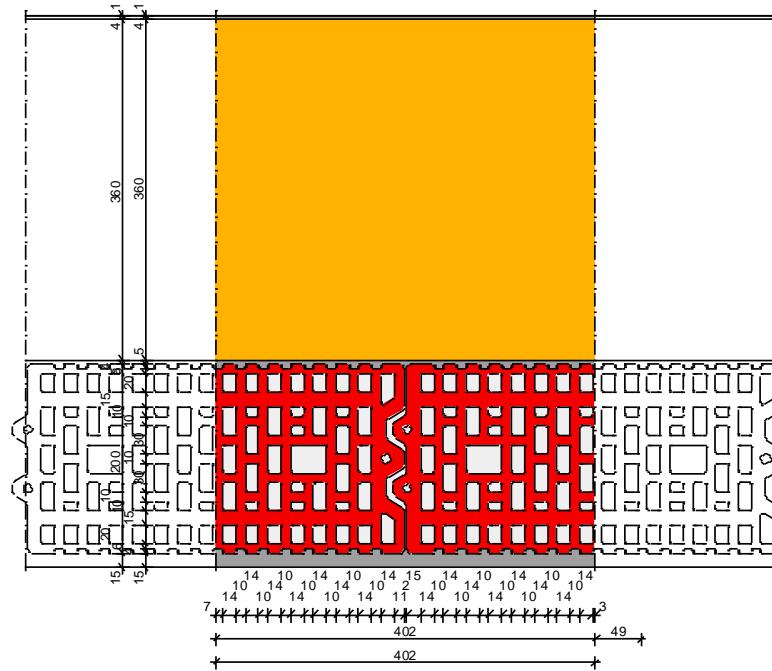
Light weight constr.:
Timber light constr.
Heavy weight constr.:
Clay brick building

Window west-oriented / medium size – Calculation parameter: **construction method**

*Parameter study about the effect on the **heat storage**
of external walls suited for passiv houses*

WAND 01

36,0 cm Vollwärmeschutzfassade
20,0 cm Porotherm 20-40 Objekt Plan
1,5 cm Gipsinnenputz



Outline from:

Master – Thesis
Johannes Stockinger
Danube-University Krems
2003

$$U=0,104 \text{ Wm}^{-2}\text{K}^{-1}$$

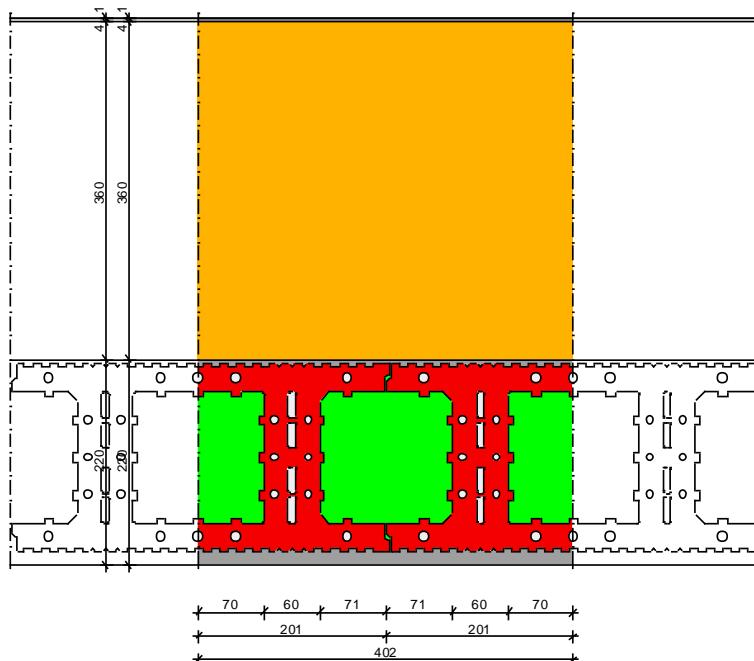
*Parameter study about the effect on the heat storage
of external walls suited for passiv houses*

WAND 02

36,0 cm Vollwärmeschutzfassade

20,0 cm Porotherm 20-40 SBZ Plan

1,5 cm Gipsinnenputz

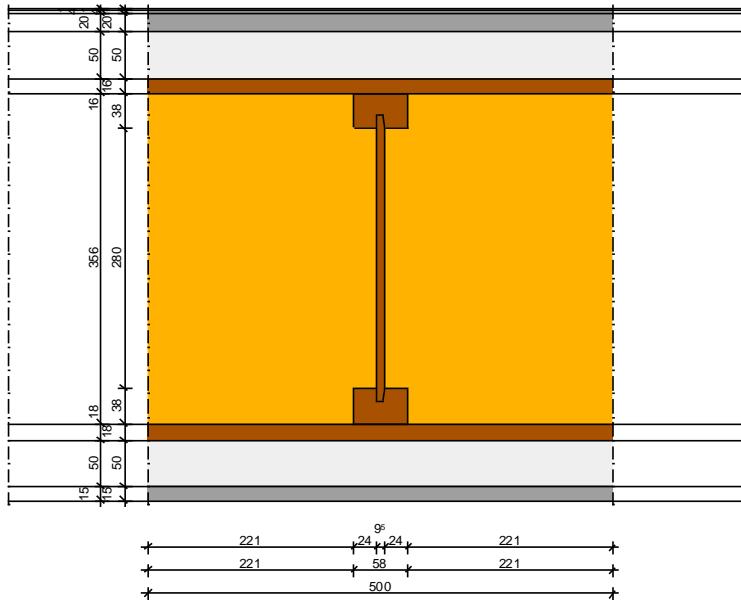


$$U=0,106 \text{ Wm}^{-2}\text{K}^{-1}$$

**Parameter study about the effect on the heat storage
of external walls suited for passiv houses**

WAND 03

2,0 cm Putzträgerplatte, Heraklith
 5,0 cm Hinterlüftung bzw. Holzquerlatten 5/5
 1,6 cm OSB-Platte
 35,6 cm TJI/PRO-350-Stiele / Zellulosedämmung
 1,8 cm DWD-Platte diffusionsoffen
 5,0 cm Installationsebene bzw. Holzquerlatten 5/5
 1,5 cm Gipsfaserplatte



$$U=0,111 \text{ Wm}^{-2}\text{K}^{-1}$$

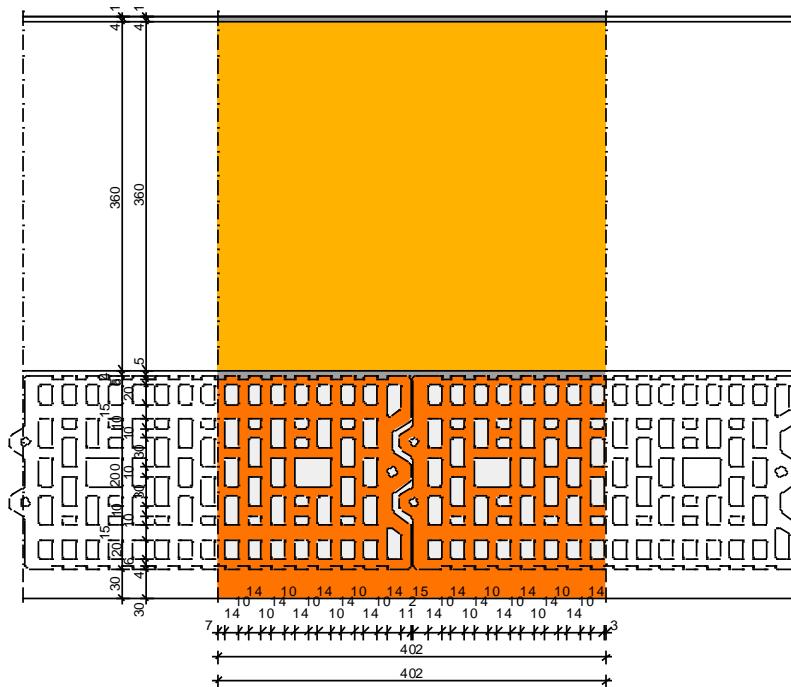
***Parameter study about the effect on the heat storage
of external walls suited for passiv houses***

WAND 04

36,0 cm Vollwärmeschutzfassade

20,0 cm Porotherm 20-40 Objekt Plan Lehmziegel

3,0 cm Lehminnenputz



$$U=0,104 \text{ Wm}^{-2}\text{K}^{-1}$$

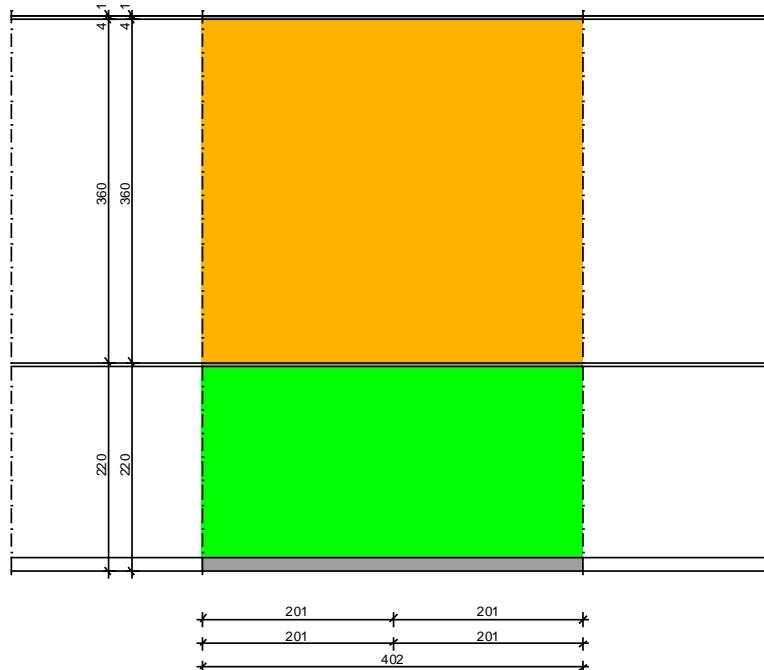
***Parameter study about the effect on the heat storage
of external walls suited for passiv houses***

WAND 05

36,0 cm Vollwärmeschutzfassade

20,0 cm STB-Beton-Wand

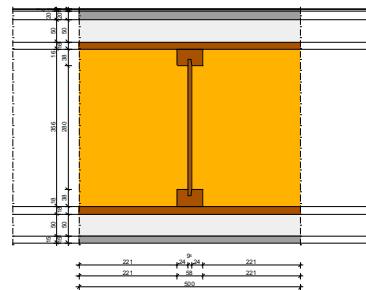
1,5 cm Gipsinnenputz



$$U=0,108 \text{ Wm}^{-2}\text{K}^{-1}$$

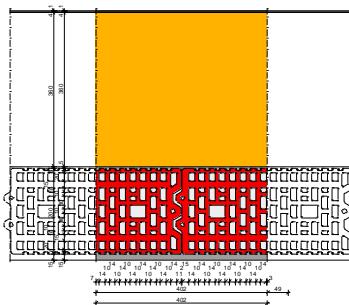
WAND 03

2,0 cm Putzträgerplatte, Heraklith
5,0 cm Hinterlüftung bzw. Holzquerlatten 5/5
1,6 cm OSB-Platte
35,6 cm TJI/PRO-350-Stiele / Zellulosedämmung
1,8 cm DWD-Platte diffusionsoffen
5,0 cm Installationsebene bzw. Holzquerlatten 5/5
1,5 cm Gipsfaserplatte



WAND 01

36,0 cm Vollwärmeschutzfassade
20,0 cm Porotherm 20-40 Objekt Plan
1,5 cm Gipsinnenputz



34,0

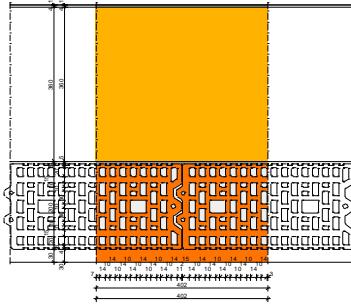
14,5%

90,8

38,8%

WAND 04

36,0 cm Vollwärmeschutzfassade
20,0 cm Porotherm 20-40 Objekt Plan Lehmziegel
3,0 cm Lehminnenputz

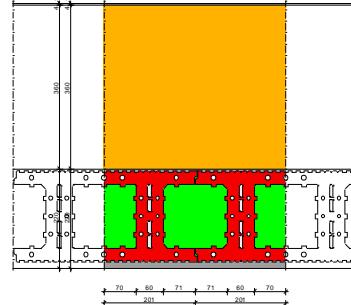


118,1

50,5%

WAND 02

36,0 cm Vollwärmeschutzfassade
20,0 cm Porotherm 20-40 SBZ Plan
1,5 cm Gipsinnenputz

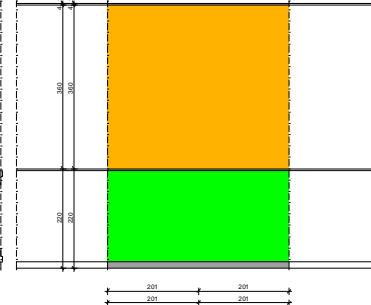


145,0

62,0%

WAND 05

36,0 cm Vollwärmeschutzfassade
20,0 cm STB-Beton-Wand
1,5 cm Gipsinnenputz



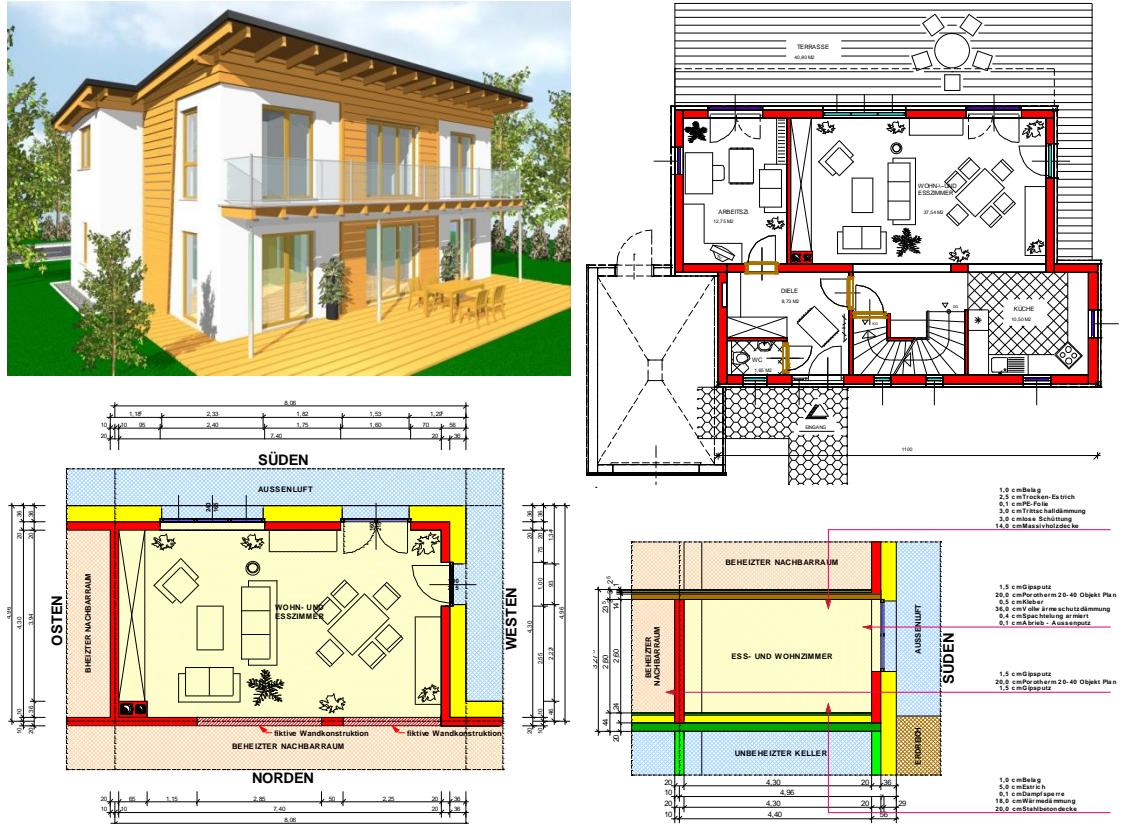
233,9

100,0%

Effective heat capacities [kJm⁻²K⁻¹] (acc. to EN ISO 13786)

Parameter study about the effect on the heat storage of external walls suited for passiv houses

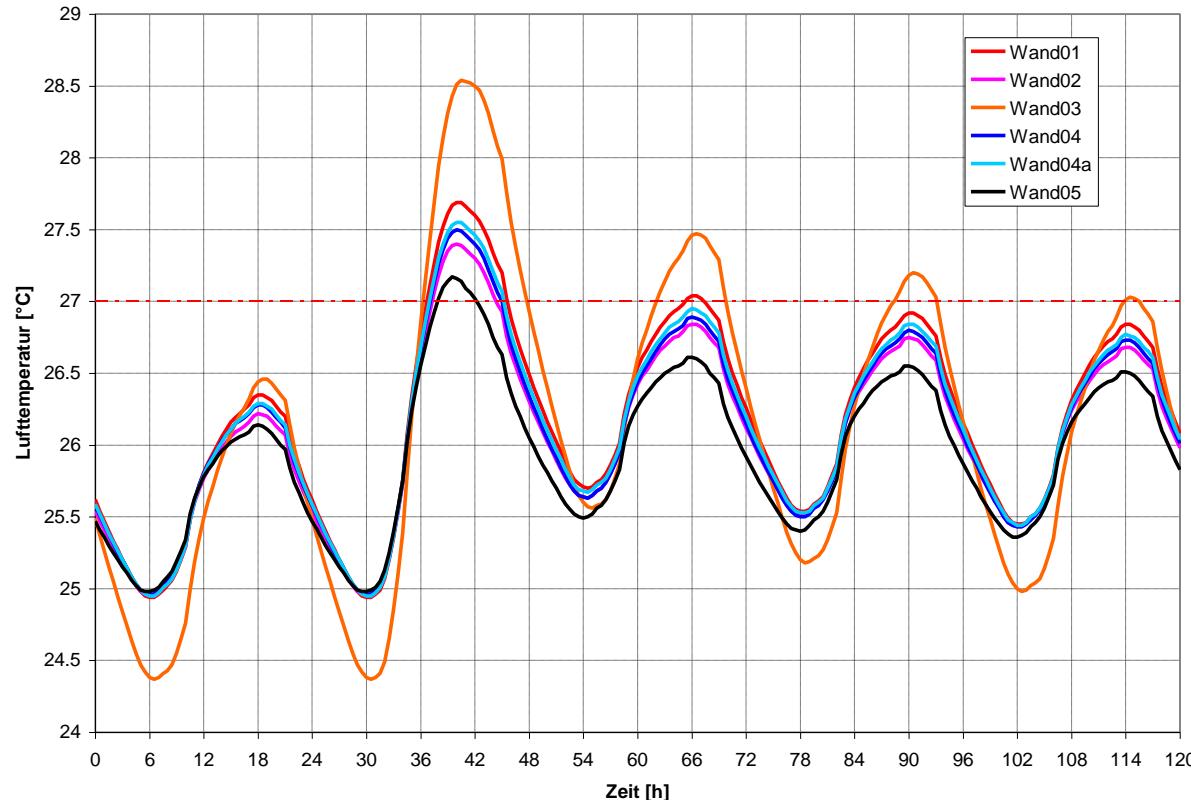
Simulation of the thermal behaviour of a living room in a passive house



**Parameter study about the effect on the heat storage
of external walls suited for passiv houses**

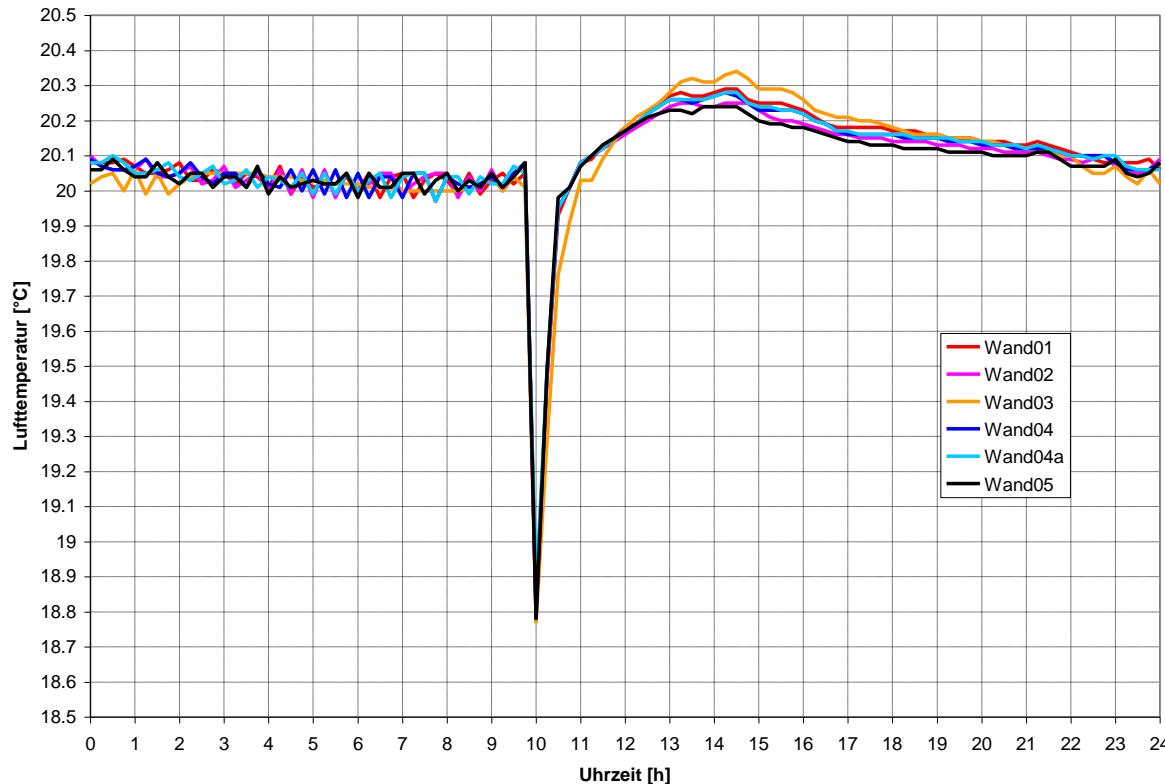
Simulation of the thermal behaviour of a living room

summer case: failure of the blind during one day



**Parameter study about the effect on the heat storage
of external walls suited for passiv houses**

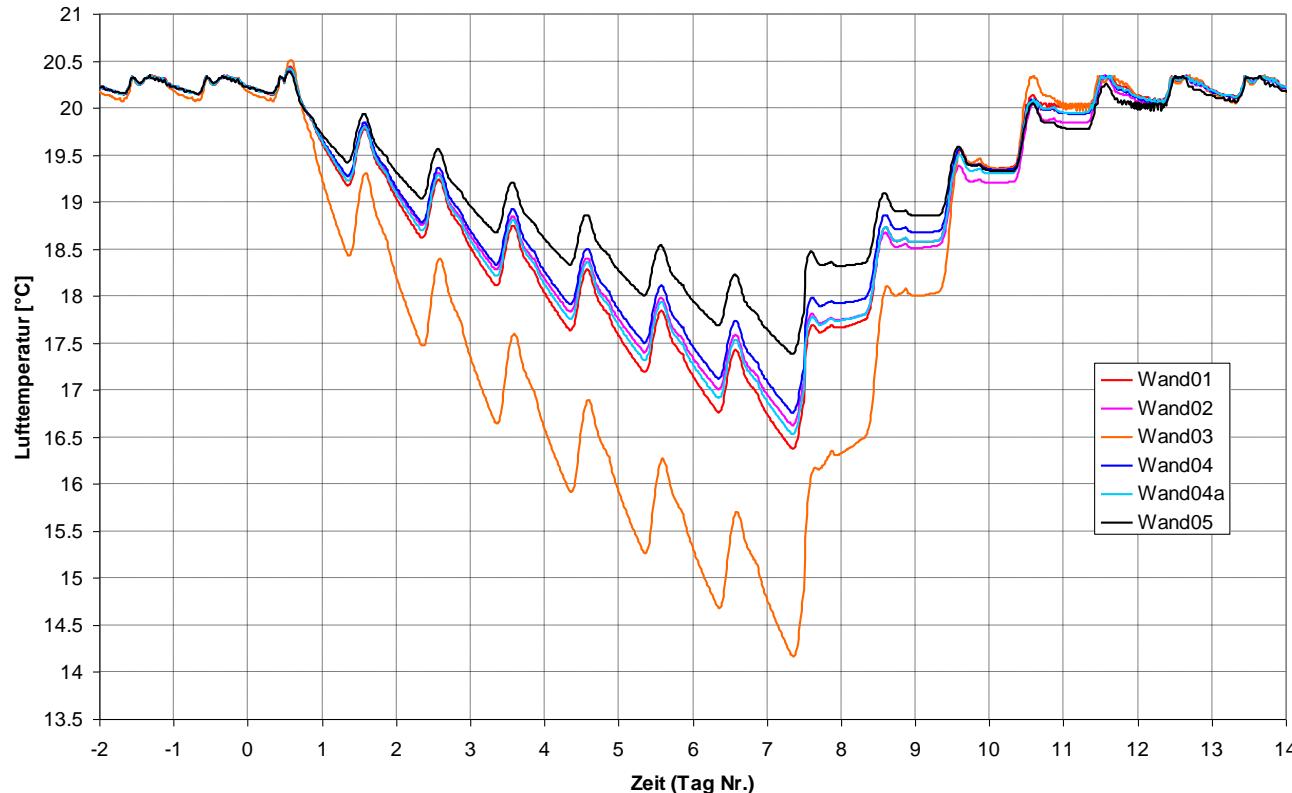
Simulation of the thermal behaviour of a living room
winter case 1: momentary ventilation



Parameter study about the effect on the heat storage of external walls suited for passiv houses

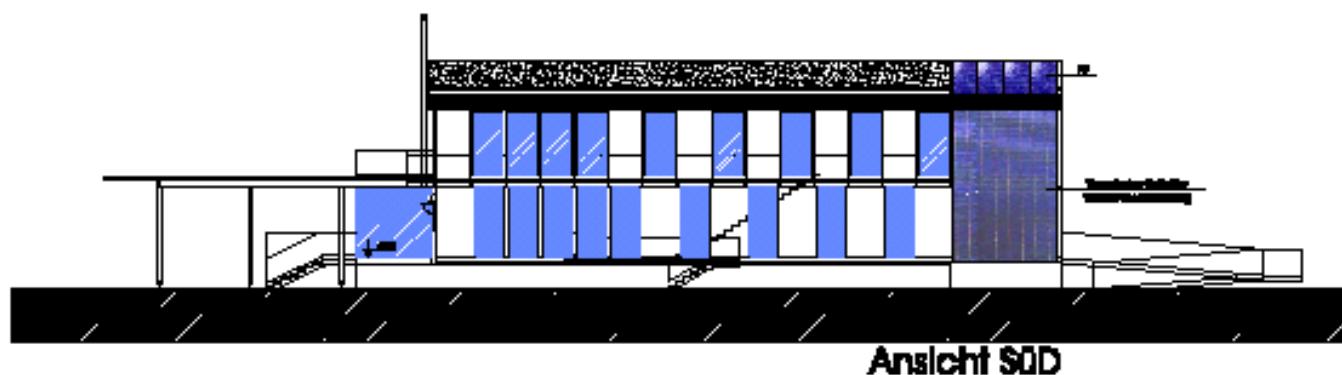
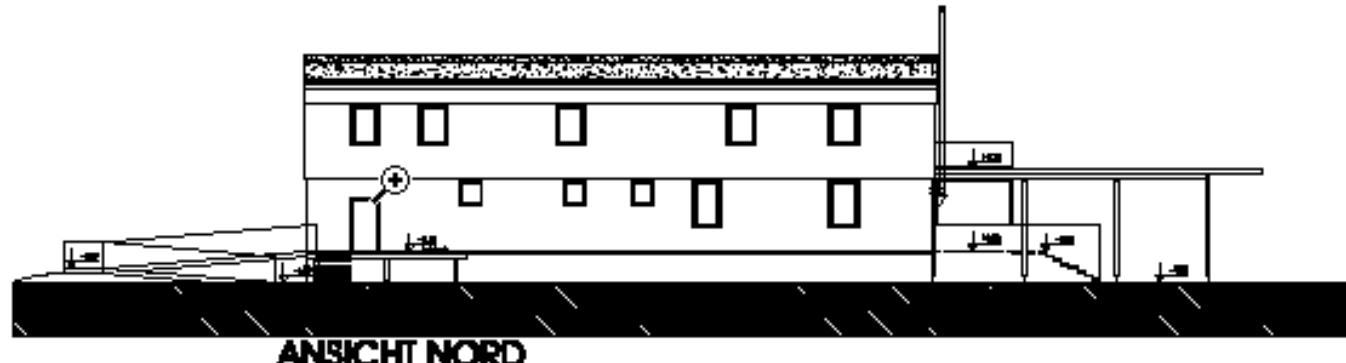
Simulation of the thermal behaviour of a living room

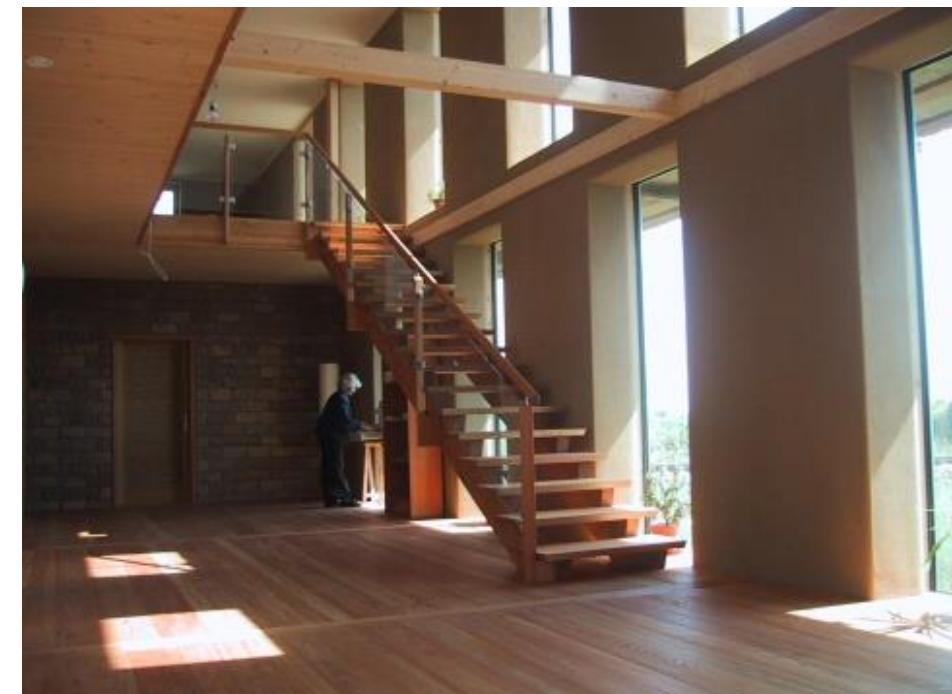
winter case 2: failure of heating system during one week



Office Building in clay/loam construction, Tattendorf

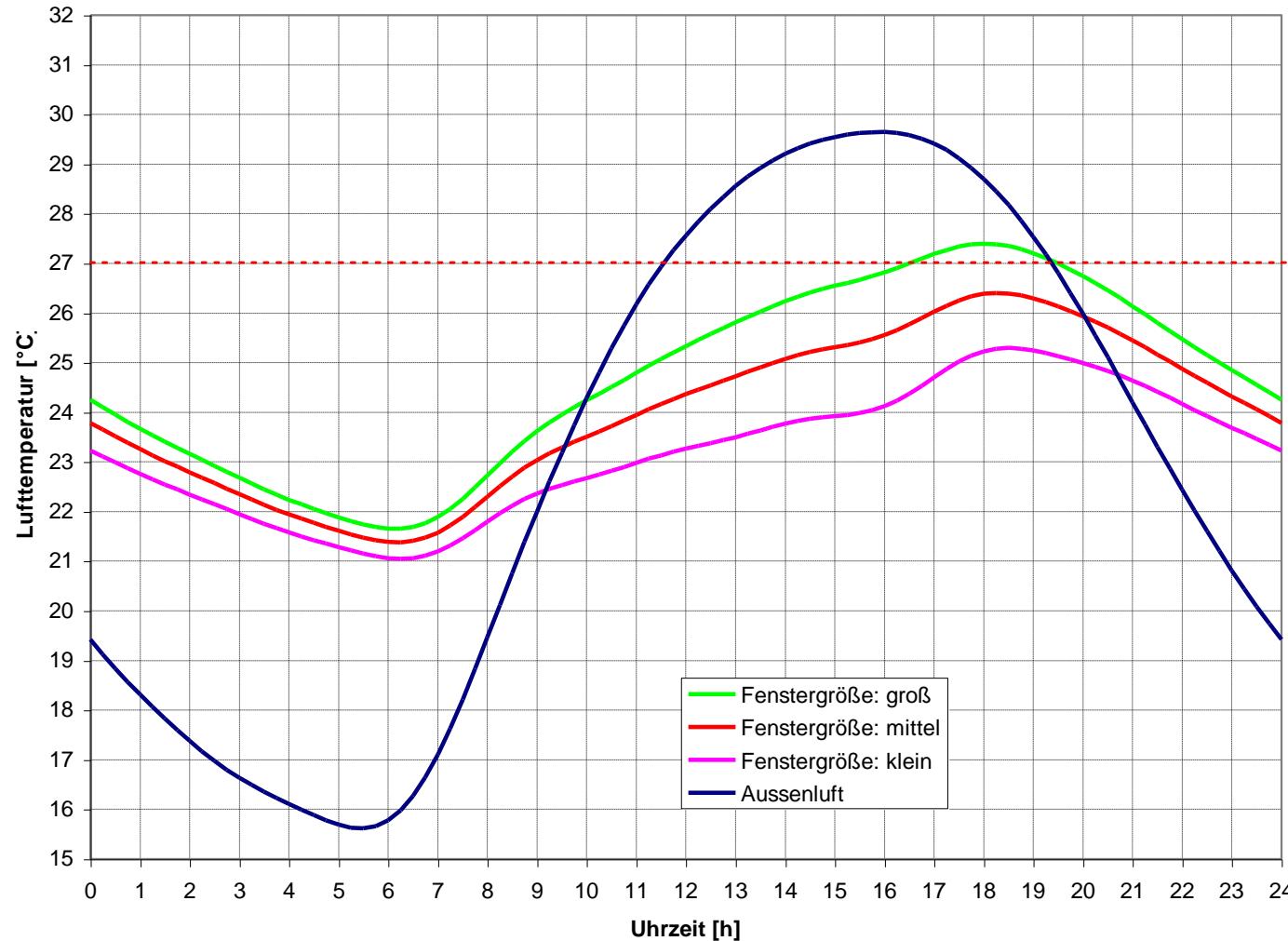
(Arch. Reinberg für Bauen und Lehm)





Parameterstudie:

Glasgrößen Südfassade – Sommerfall; Raum Aula EG



Visit us on the internet ...

www.ic-ces.at

**We are looking forward
to the future.
Wherever!
Whenever!
With you.**



CES clean energy solutions GmbH
Schönbrunner Str. 297
1120 Vienna, Austria
T +43 1 521 69 – 0
www.ic-ces.at; office@ic-ces.at
UID: ATU 64715133, FN 320442p