02.03_PH-SUMMER SCHOOL

THE PASSIVE HOUSE STANDARD

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Language support: William GALLAGHER, Rob McLEOD, Michael WILLIAMS
Date: 2009-07-11

What is the Passivhouse - standard?

Which buildings can be Passivhouses ?

Where can Passivhouses be built ?

What is important for the design ?

What is important for the construction ?

Source:

PASSIVE HOUSE STANDARD

WHAT IS THE MAIN IDEA ?

Source:

The objectives are:

- optimal thermal comfort and
- hygienic required air change with
- highest energy efficiency
- and greatest economy

Source:

1st main strategy

Deficit – competition

Deficit – minimizing

Source: nach H. Krapmeier

Deficit - minimizing

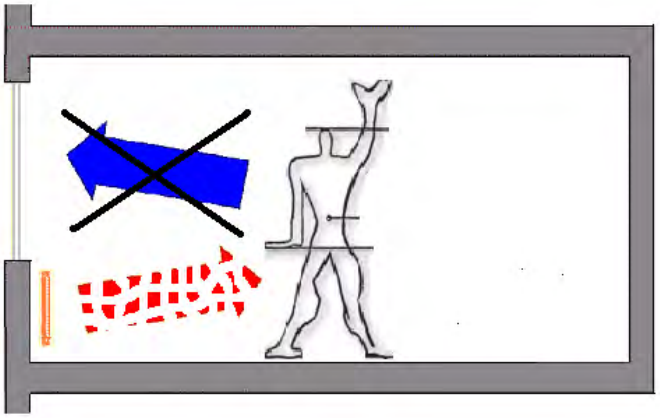
- of the transmission heat loses
  (heat loses through the outer shell of the building)

- of the ventilation heat loses
  (heat loses through ventilation leakages)

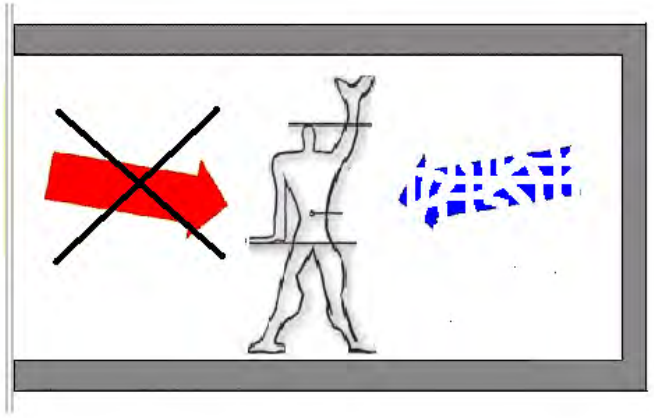
Source:

Deficit - minimizing instead of deficit - competition !

Winter



Summer



=> Energy efficiency !

Source:

2nd main strategy

active **passive**

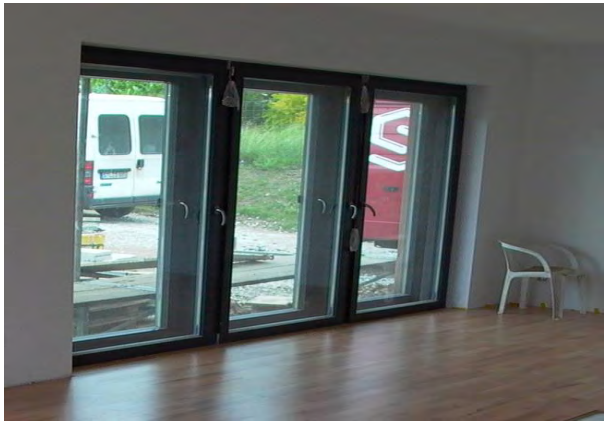
(Solar) – Energy use

Source: PH Institut Darmstadt

The passive house principle is:

1.

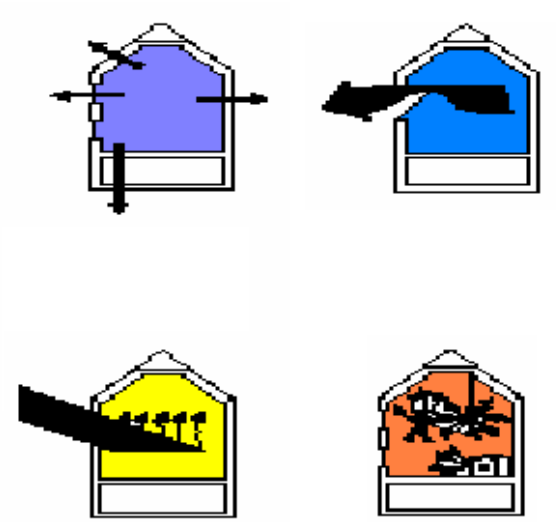
2.



Avoiding heat losses and optimising the free heat gains!

Source:

The heat balance calculation



losses

transmission losses	Q_{trans}
ventilation losses	$+ Q_{vent}$
summary losses	$= Q_{loses}$

gains

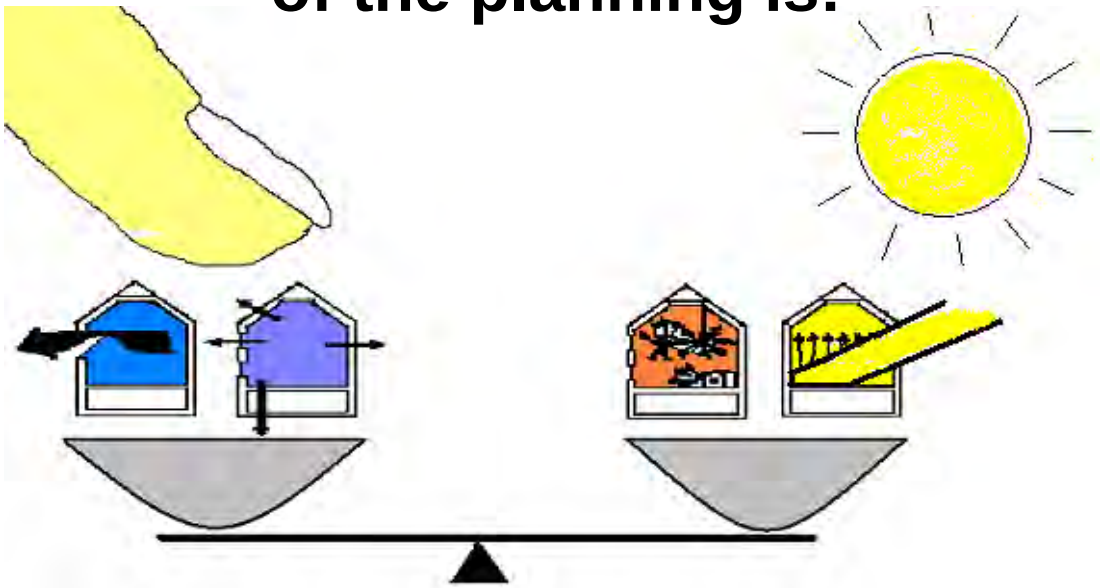
passive solar gains	Q_{Solar}
internal gains	$+ Q_{internal}$
summary gains	$= Q_{gains}$
x degree of efficiency	$x \eta$
useable gains	$= Q_{use.\ gains}$

heating load

summary losses	Q_{loses}
useable gains	$- Q_{use.\ gainsd}$
	$= Q_{heat.}$

Source:

The most substantial criterion of the planning is:



Bring heat losses and optimized free heat gains in a balance!

Source: Ernst Heiduk

PH - is low tech

No „Solar“ machines“ are necessary

Source: http://www.agsn.de/kerto/index.html

Origins of the Passive House Standard – Idea:

Prof. Bo Adamson,
co-originator of the concept ,
Lund University, Sweden

Prof. Wolfgang Feist,
co-originator of the concept and
founder of the
Passivhaus Institut Darmstadt
Innsbruck University, Austria

Source: http://en.wikipedia.org/wiki/Passive_house

The calculation to derive the “Condition for Passive Houses" is

From experience (and DIN 1946) we know, that **30 m³/h** is a minimum air rate **per person** to maintain a reasonable indoor air quality

Air has a specific heat capacity of **0.33Wh/(m³K)** (at 21°C). It is allowed to increase the fresh air temperature by 30 K (50 -20°C), not more, to avoid pyrolysis of dust. You get:

30m³/h/Pers*0,33Wh/(m³K)*30K = 300W/Pers

Source: www.passivhaustagung.de/Passive_House_E/passivehouse_definition.html

The calculation to derive the “Condition for Passive Houses" is

That shows: **300 Watts per person** can be delivered by a fresh air heating system. If you have e.g. **30 m² living space per person**, you get **10 W per m² living space**.

300W/Pers. / 30m² living space /Person = 10W /m² living space

Source: www.passivhaustagung.de/Passive_House_E/passivehouse_definition.html

This value (**10W /m² living space**)is independent of the climate. So far all values are peak load values, that is the maximum heat capacity needed at design conditions.

Depending on the external climate, Passive Houses will have to be insulated at different levels: More insulation in Stockholm, less in Rome.

Source: www.passivhaustagung.de/Passive_House_E/passivehouse_definition.html

PH-criteria No. 1

- A comfortable interior climate can be maintained without active heating and cooling systems!
- The necessity of the annual heating requirement (in central Europe) is less than **15 kWh/(m²a)** (calculated with PHPP)

Source: PH Institute - Darmstadt

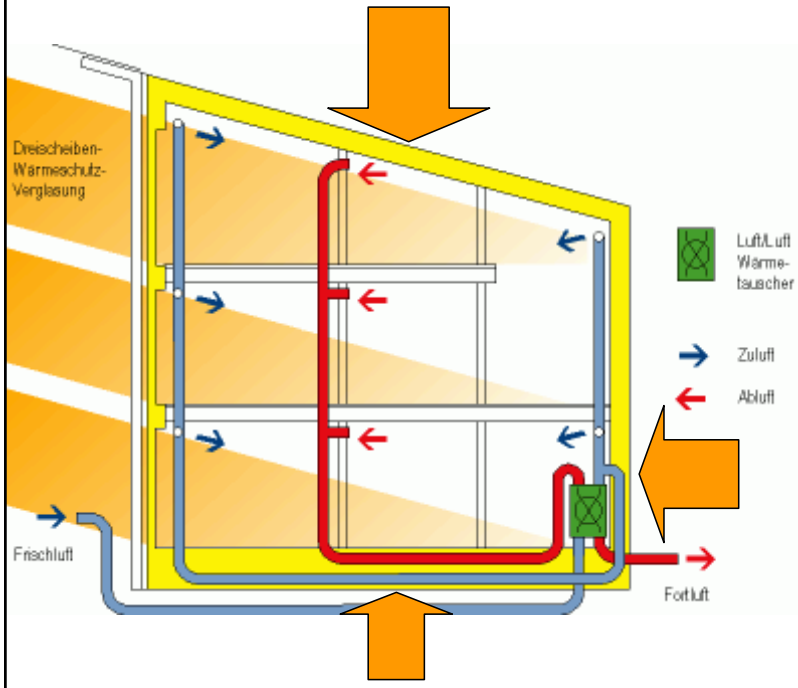
PH-criteria No. 2

- The criteria of thermal comfort must be fulfilled in each room for summer and winter.

  This gives the following requirements:

Source: PH Institute - Darmstadt

Optimised heat insulation means:



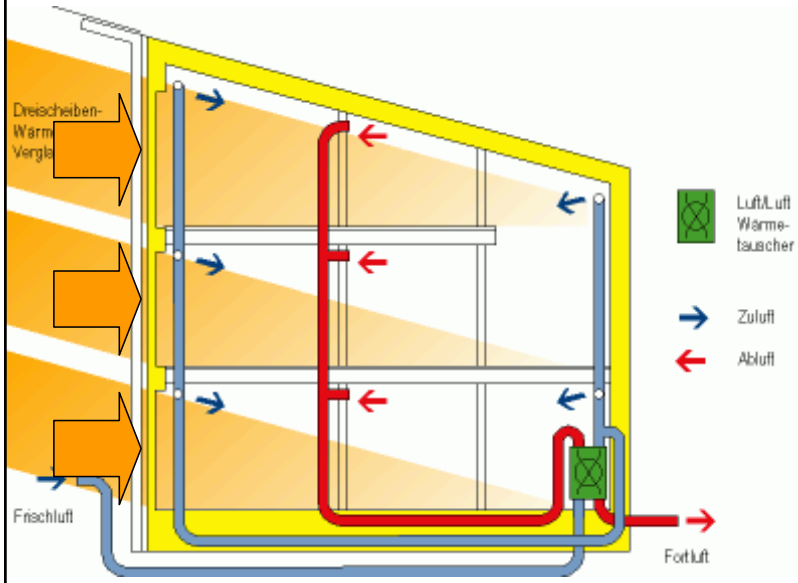
- **u-value < 0.15 W/m²K** for floor, wall and roof

  and a heat bridge free construction with
- **Ψ < 0.01 W/m2K**.

This is a heat insulation from 15(new) to 40 cm in thickness !

Source: PH Institute - Darmstadt

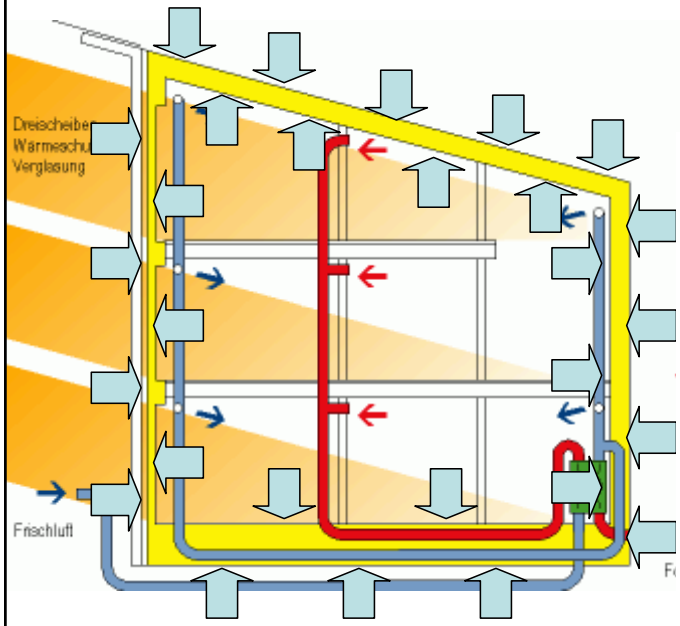
That means for the windows:



- a 3-layer low - E glazing with
- **u_w-value < 0.8 W/m²K** for glass and frame with a
- **g-value > 50 %** solar heat-gain coefficient

Source: PH Institute - Darmstadt

That means for the air-tightness:



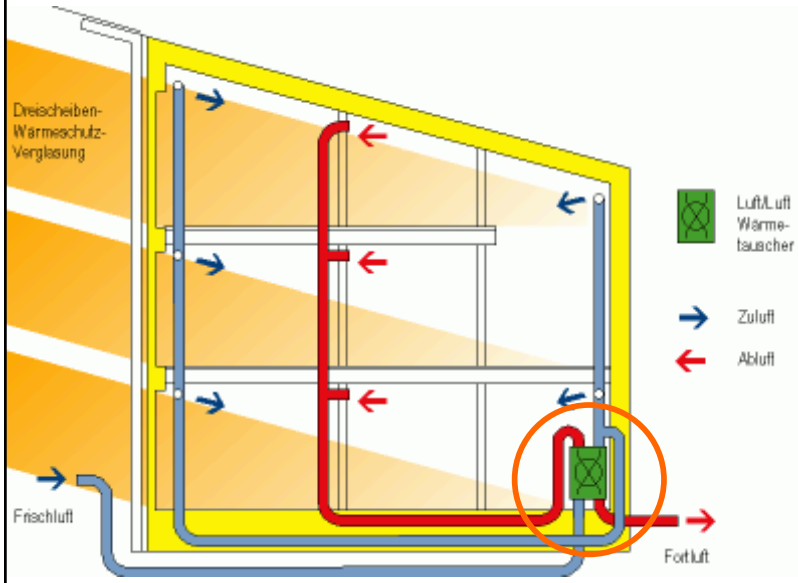
Air leakage through unsealed joints must be less than

- **n_{50} < 0.6 house volume/h**

Blower door test with a +/- pressure of 50 Pascal.

Source: PH Institute - Darmstadt

The comfort ventilation system effects:



1. A good indoor air quality

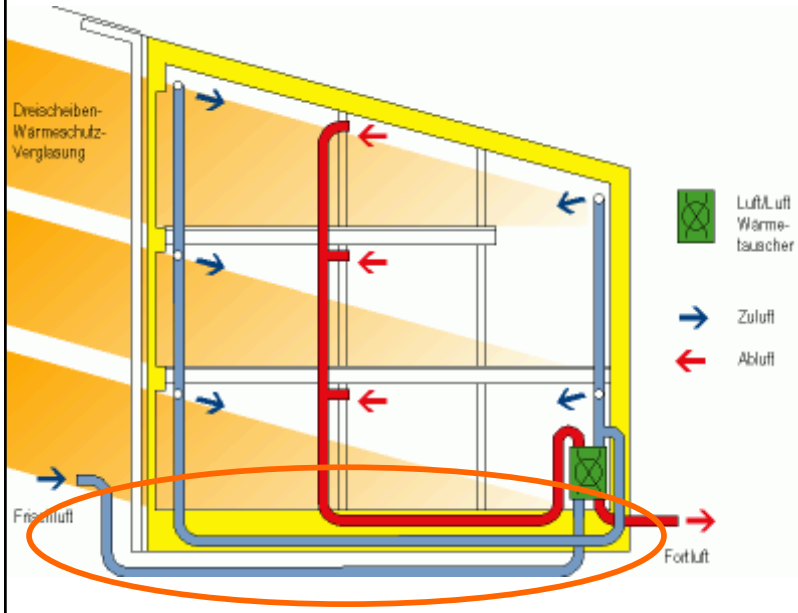
2. Energy -saving

> 75% heat recovery rate

Most of the perceptible heat in the exhaust air is transferred to the incoming fresh air

Source: PH Institute - Darmstadt

A passive warming of fresh air makes sense:



Fresh air may be brought into the house through underground ducts that **exchange heat with the soil**.

This preheats fresh air to a temperature above 5°C even on cold winter days.

Source: PH Institute - Darmstadt

PH-criteria No. 3

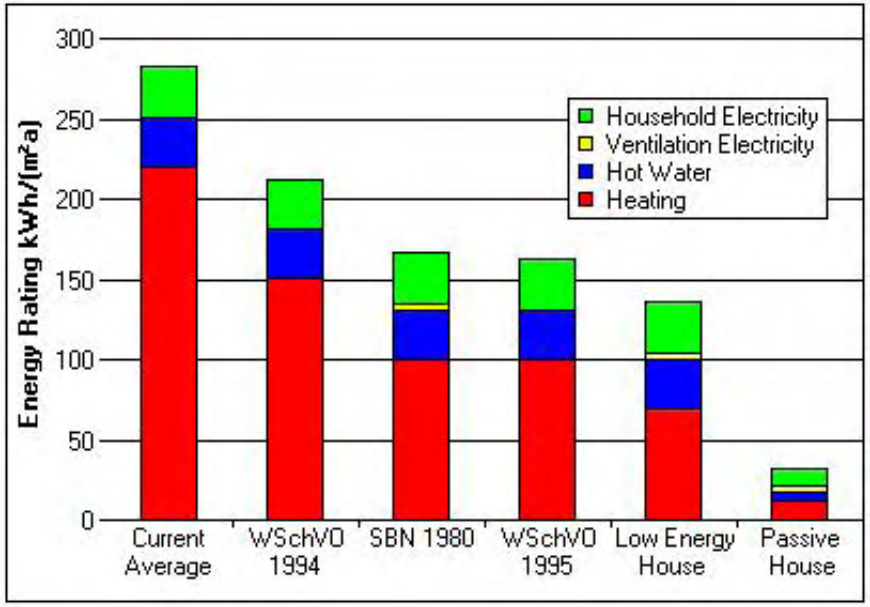
- The specific primary energy use for all household applications

  (heating, warm water and household electricity) together must not be higher than **120 kWh/(m²a)**.

  (for a central European energy mix)

Source: PH Institute - Darmstadt

That guarantees a maximum of thermal comfort and air hygiene with high economic efficiency and less energy consumption.

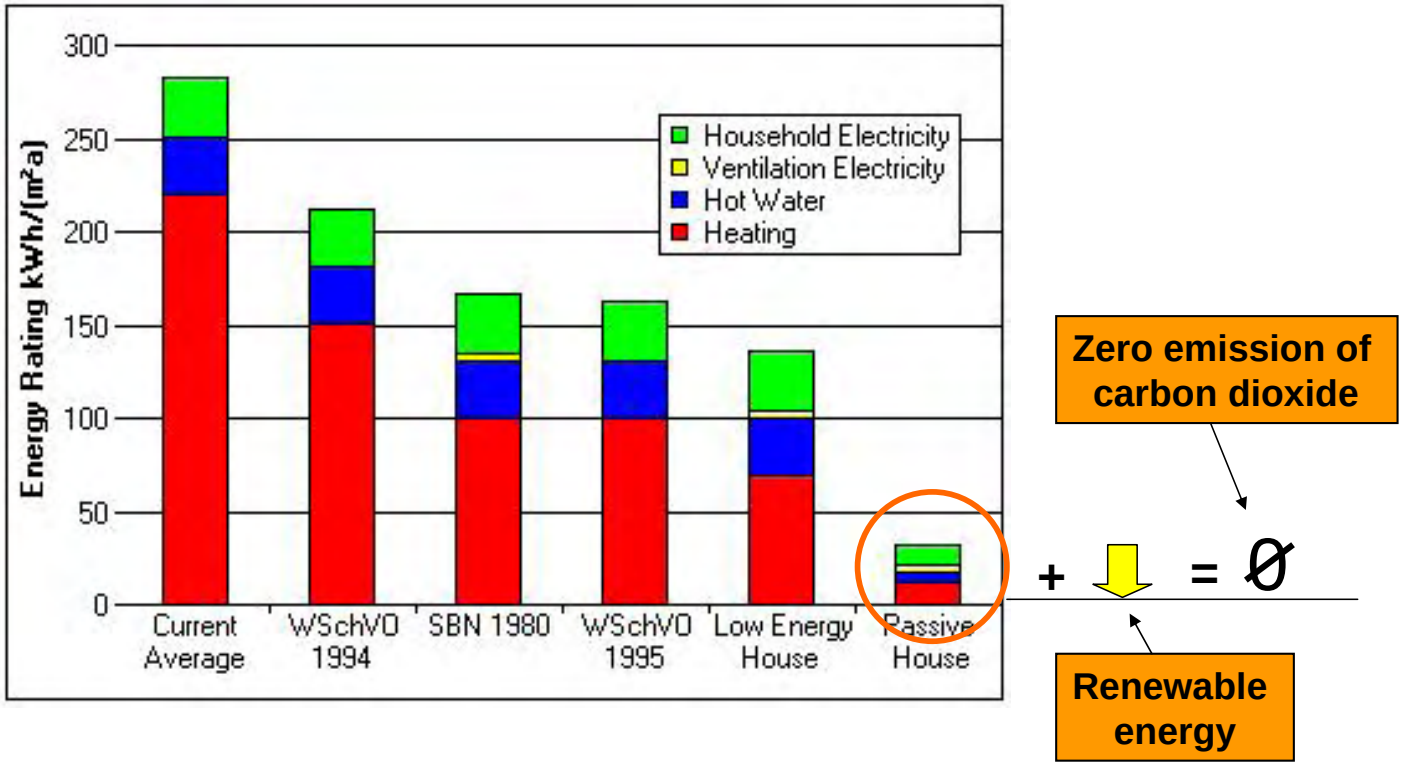


Comparison of Energy Ratings of Homes

WSchVO = German Heat Protection Regulation SBN = Swedish Construction Standard

Source: PH Institute - Darmstadt

And the final target must be:



Source: PH Institute / Darmstadt + additions

What is the Passive House - standard ?

Which buildings can be Passive Houses ?

Where can Passive Houses be built ?

What is important for the design ?

What is important for the construction ?

Source:

Aspects of typology

- The larger the volume and the bigger the internal heat gains are, the more easily the PH-concept can work in the cold regions.
- The larger the volume and the smaller the internal heat gains are, the more easily the PH-concept can work in the hot regions.

Source:

Aspects of typology

- The easiest typology: a restaurant with a kitchen
- Less easy: Office buildings and big apartment buildings
- ……
- ……
- Difficult: Very small houses
- The most difficult typology: a Kindergarten

Source:

What is the Passive Houses standard ?

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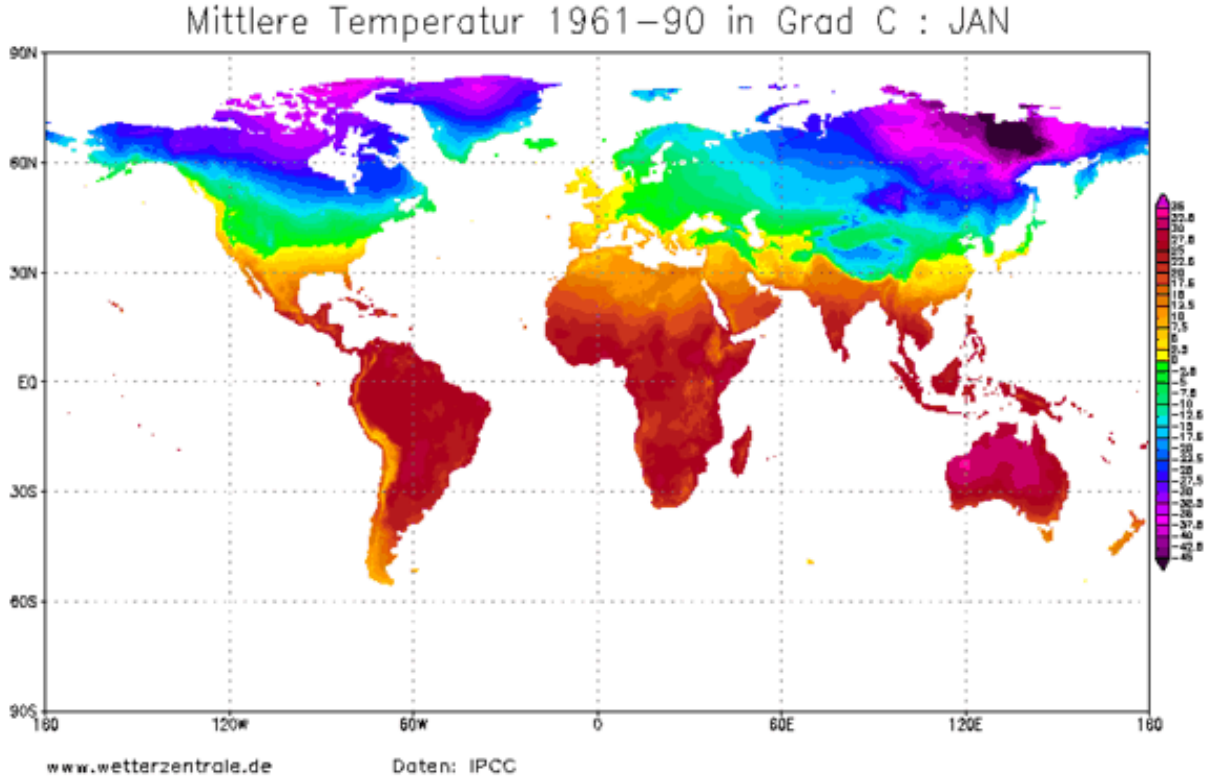
Source:

Aspects of location

In principle a Passive House can be built everywhere



Source: IPCC, www.wetterzentrale.de

Aspects of location

It is important to distinguish heat load values (power in W (Watts)) from annual consumption values (heat or energy in kWh).

In a Central European climate we know from experience and simulation that typical heating energy consumption of Passive Houses is some 15 kWh/(m²a) - but these are only approximate figures.

In Stockholm it could be up to 20, in Rome more like 10 kWh/(m²a).

Source: www.passivhaustagung.de/Passive_House_E/passivehouse_definition.html

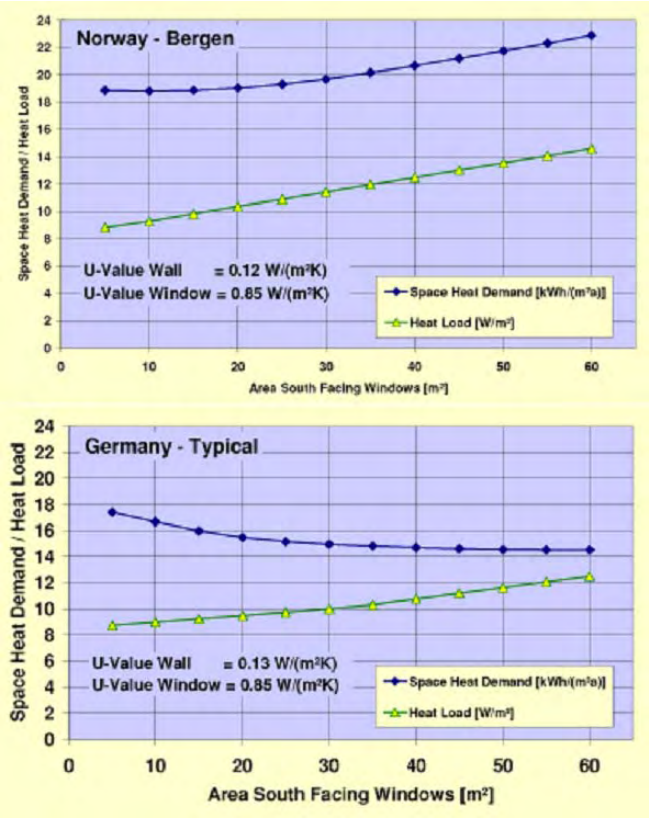
Aspects of location

In the cold, northern regions (Scandinavia…) there is not enough sun for needed solar gains in the winter time.
The criteria 10 W/m² heating load requires more heat insulation.
But there will still be a higher specific heating demand.

There must be a higher input of renewable energy.

Source:

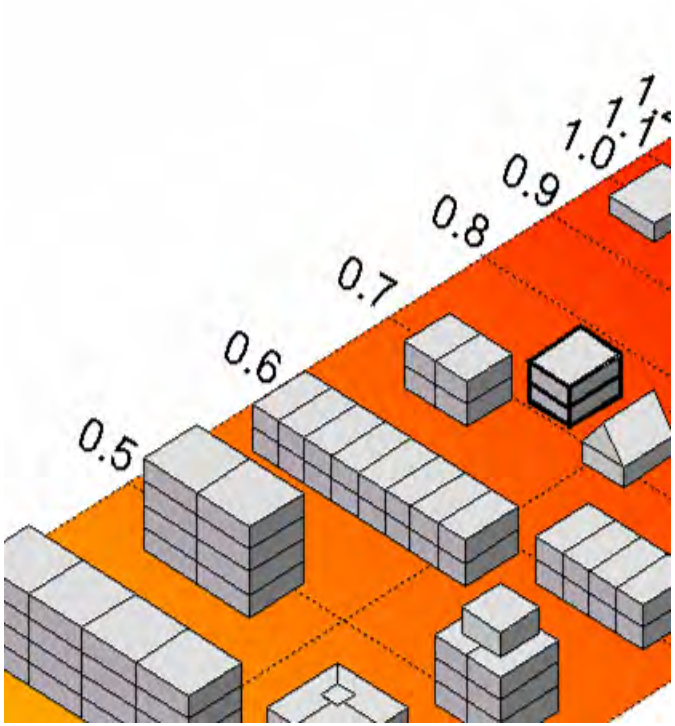
Aspects of location



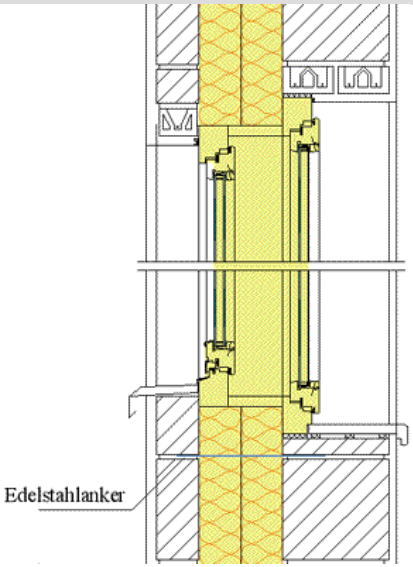
This figure of the PHI-Darmstadt shows the situation of Bergen in Norway.
The outcome of larger south facing windows is a higher required heat load and a higher heat demand.
A south facing window in northern regions has a negative energy balance - too few solar gains!!!

Source: http://erg.ucd.ie/pep/images/4_1_3_b.jpg

Aspects of location



In these regions a better thermal quality of the windows is very important. A double window can give better values.



Source: V.Ö.Z. Broschüre “Zweischalen-Mauerwerk für Niedrigenergie- und Passivhäuser”

What is the Passive House - standard ?

Which buildings can be Passive Houses ?

Where can Passive Houses be built ?

What is important for the design ?

What is important for the construction ?

Source:

Aspects of design

Design and planning a good and functional building is not only

– a question of art.

It also requires

– knowledge and expertise in construction

– knowledge and expertise in physical criteria

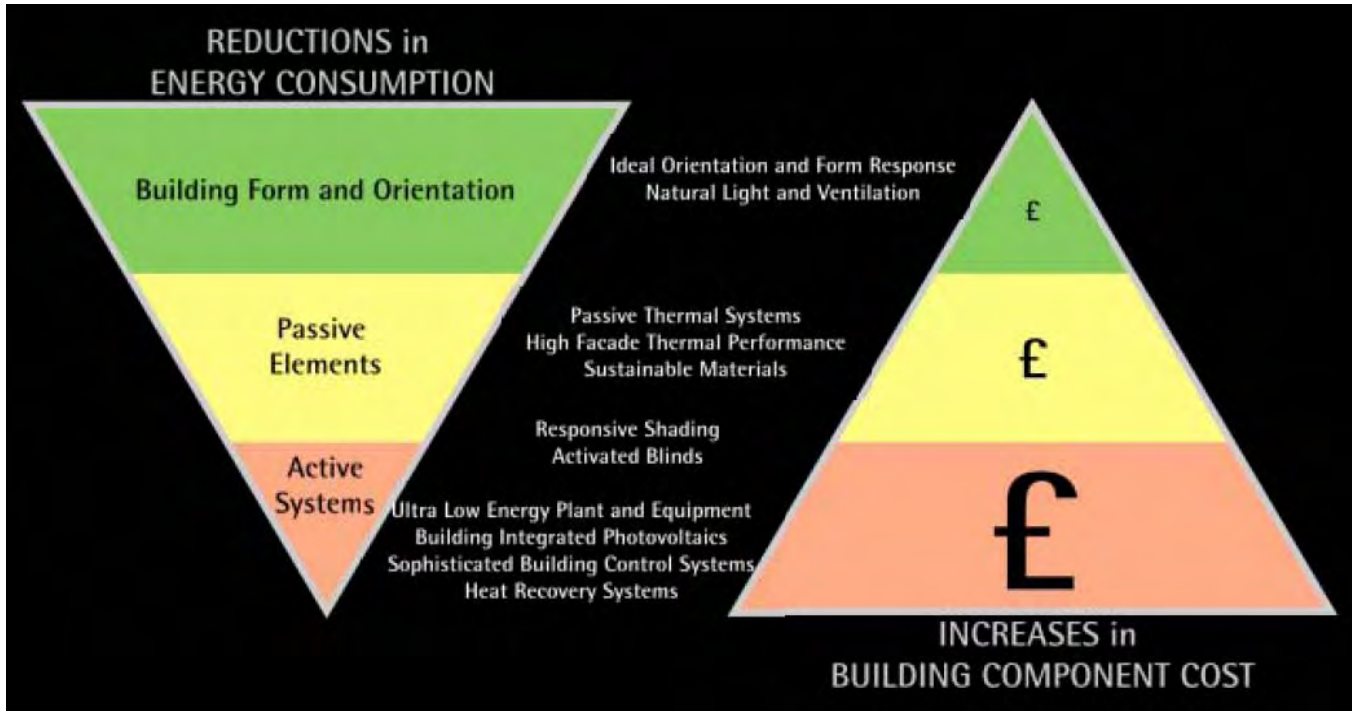
– and long-term (future) prospects!

Source:

Aspects of design

Ranking of the priorities of buildings

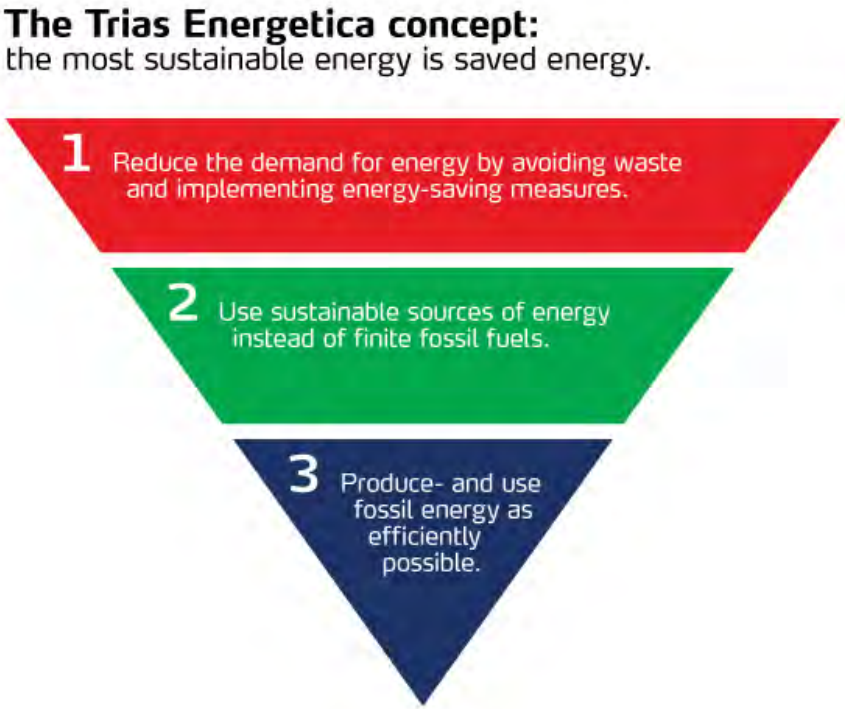
Procedural options / Cost options (€, $, ...)



Source: Lecture, Sir Norman Foster

Aspects of design

Ranking of the priorities of energy efficiency



Source: http://www.rockwool.com/energy+efficiency/the+role+of+insulation

Aspects of design

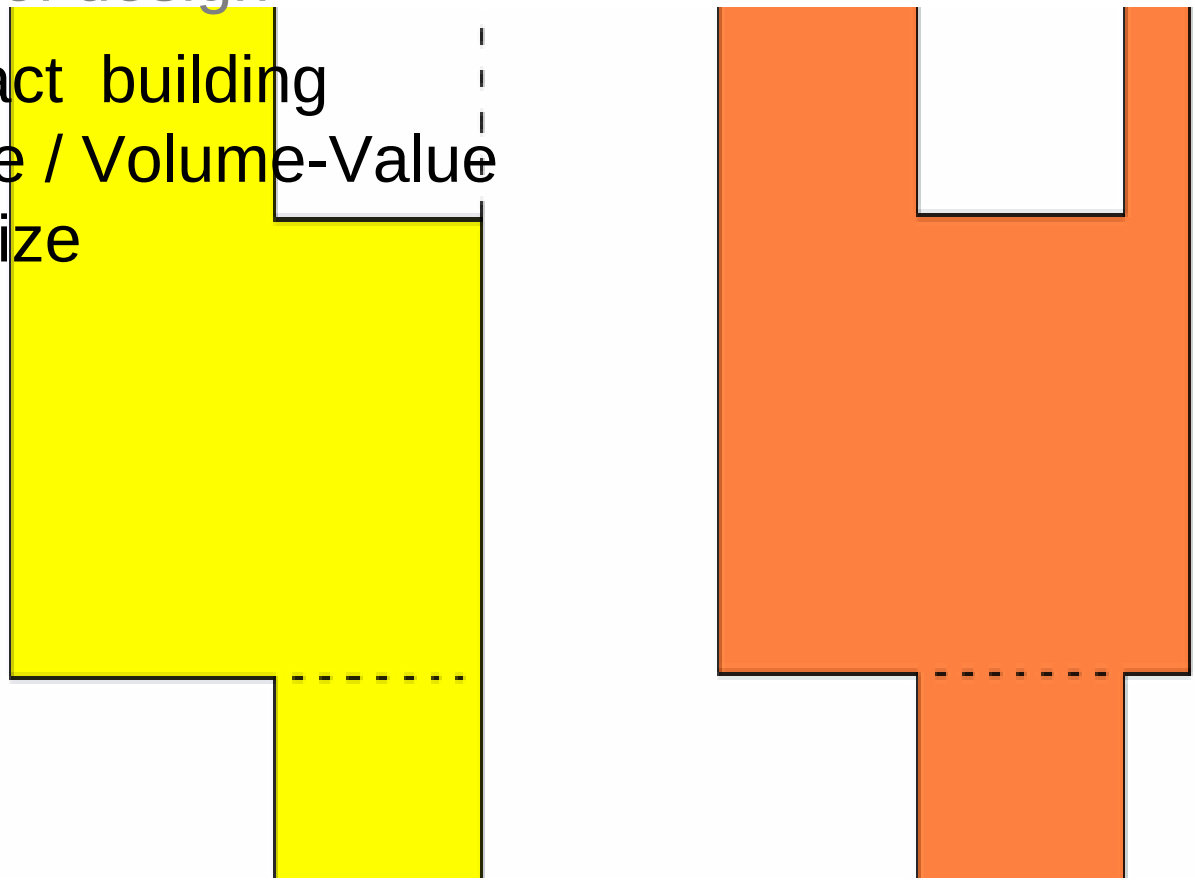
Priorities of the design

- The Surface / Volume value
- Clear warm and cold zones – „Warm box“
- High quality envelope and air-tightness
- Free of or reduced thermal bridges
- Windows for optimizing the solar gains in the winter
- Solar protection for the glazing in the summer

Source:

Aspects of design

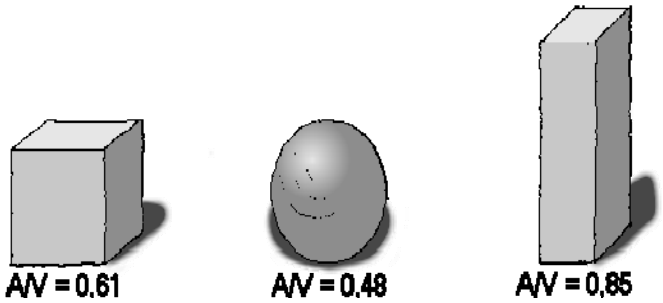
-Compact building
-Surface / Volume-Value
-Total size

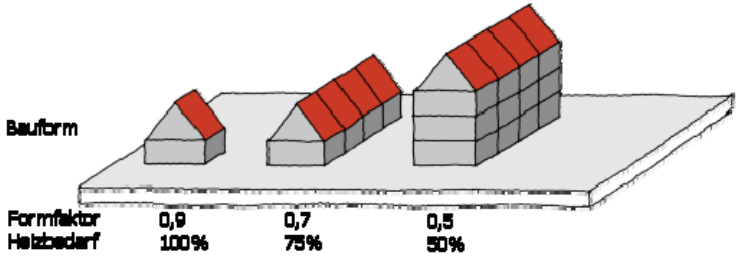


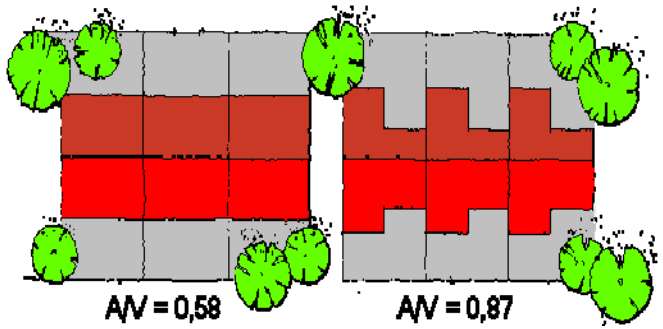
Source: http://home.arcor.de/gosol/grundl.htm#Kenngr%F6%DFen%20der%20Heizw%E4rmebilanz

Aspects of design

The Surface / Volume Value





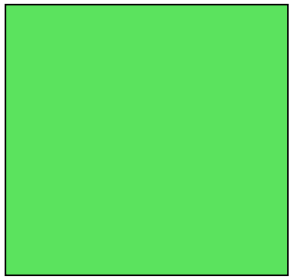


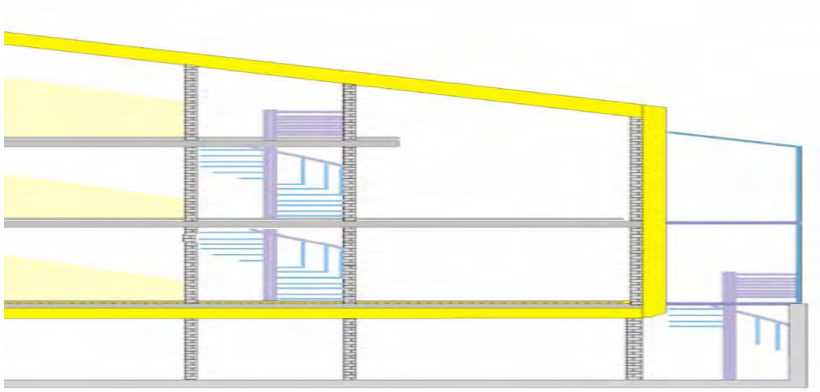
⇒The „Worst Case“
is the
Single Family House

Source:

Aspects of design

Influence of the envelope enlargement at the same area to required heat insulation





Basic size

Enlargement 10 %
= Heat insulation + 2 cm

Enlargement 20 %
= Heat insulation + 4 cm

Source: R. Borsch-Laaks

Aspects of design

Optimized building envelope	Solar optimized building envelope	Efficient energy technique
(compact) building volume	Orientation, size of windows, angle	Controlled ventilation and heat recovery
(Thermal) optimized building envelope	Light optimized glazing	Efficient small heat + warm water production
Air tightness	Energy optimized glazing	Optimized regulation / hydraulics / storage
	Energy optimized shading	Efficient lighting systems
	Solar active surfaces	Solar electricity
		Thermal solar collectors
		(Solar cooling)

Attention to the Priorities !!

Source: Ernst Heiduk

Aspects of design

Ranking of the priorities

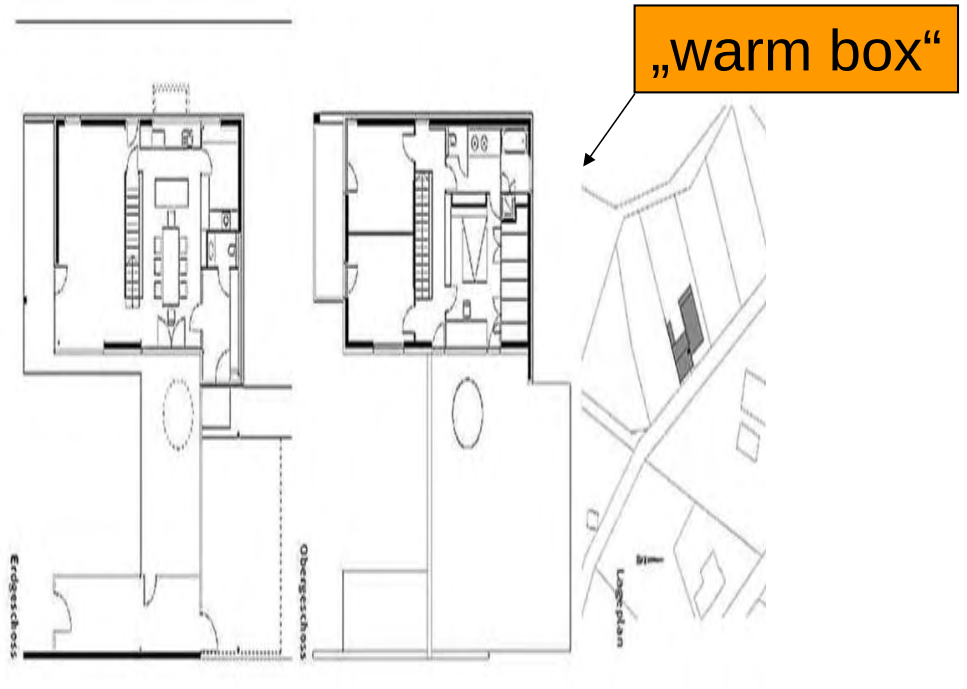
1. **External envelope**
2. **Load carrying structure**

(Form follows function!!!)

Source:

Aspects of design

Clear decisions between warm and cold zones!!!



Source: PH Institute - Darmstadt

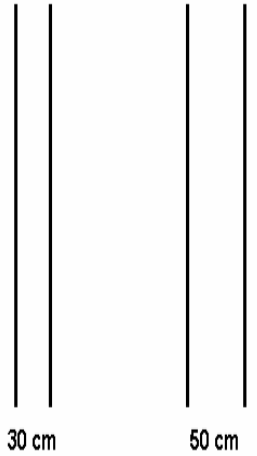
Aspects of design

„warm box“

PH - Neuhofen (A)
12,6 kWh/m²a

Architect Heinz Plöderl

Warm box

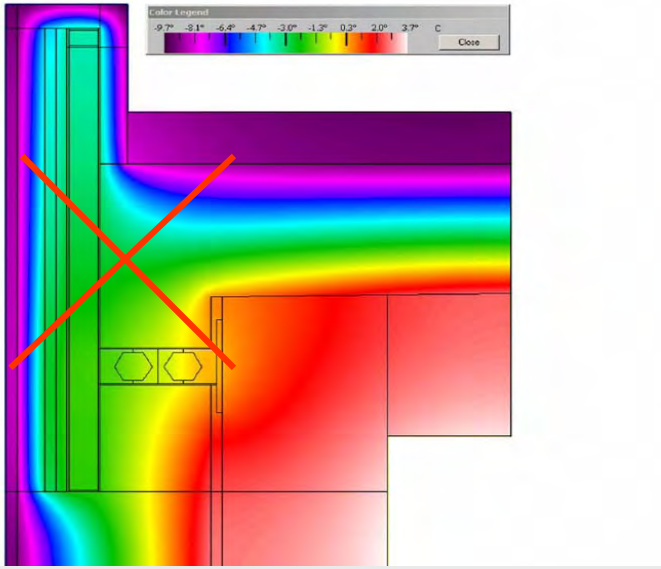


Source: Architekt Heinz Plöderl

Aspects of design

Take for your design sketches an outside wall with 50 cm thickness

- It's not possible to make a good and economic wall construction with 30 cm



Source:

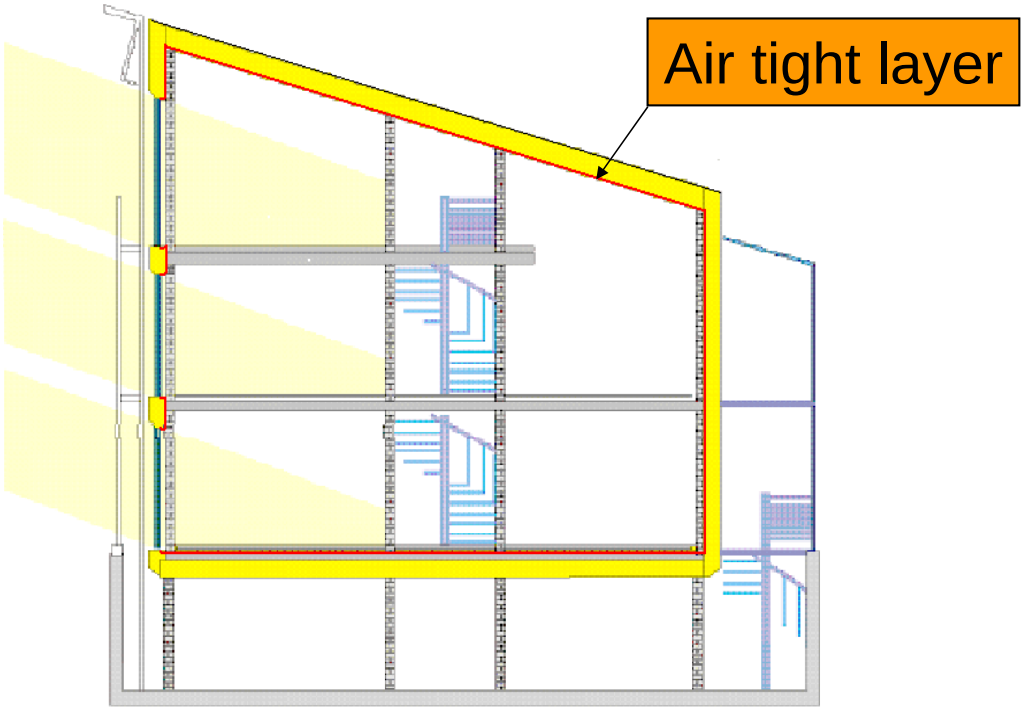
Aspects of design

Constructions free of or with reduced thermal bridges

Source: Arch. Michael Tribus

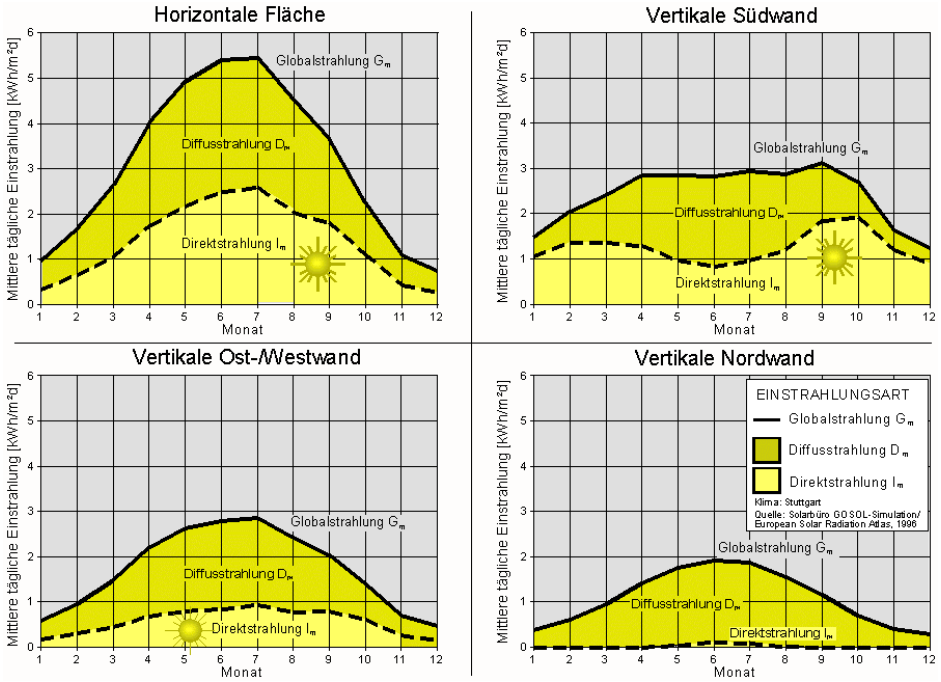
Aspects of design

Air tightness for the „warm box“



Source: PH Institute - Darmstadt

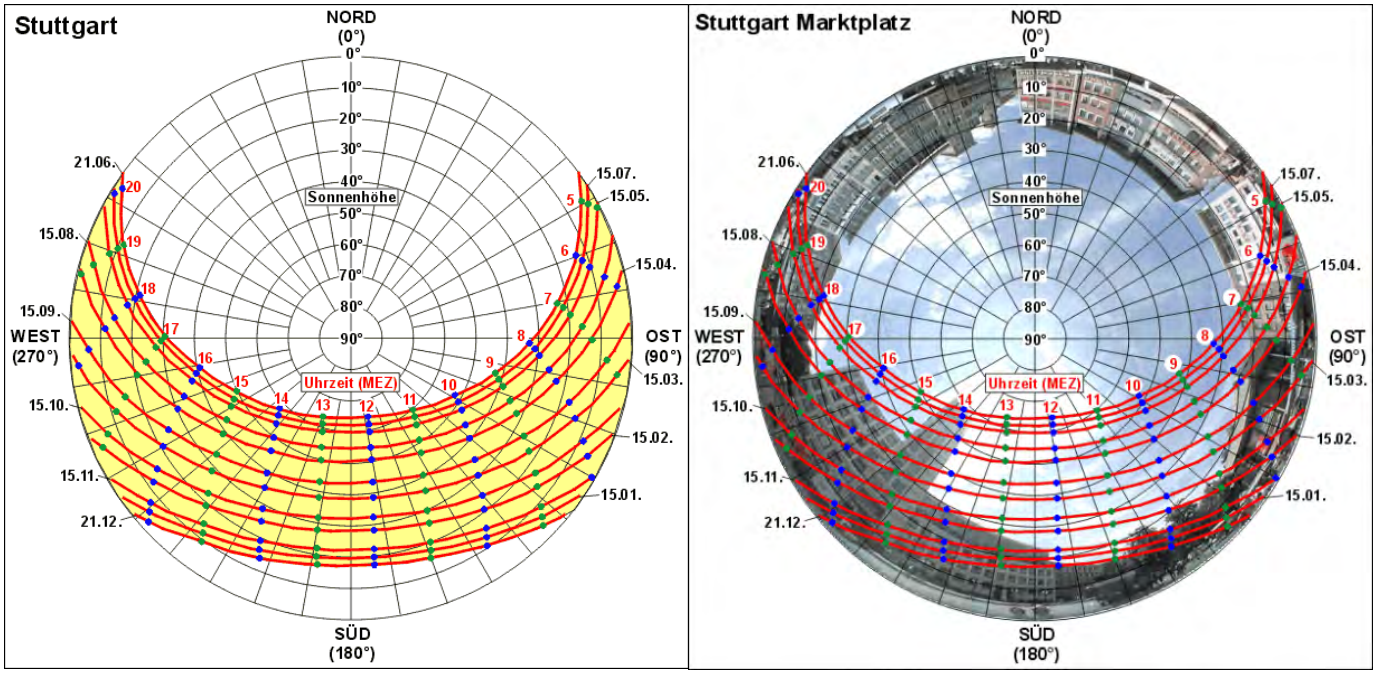
Aspects of design
Orientation to the sun



Source: http://home.arcor.de/gosol/grundl.htm#Kenngr%F6%DFen%20der%20Heizw%E4rmebilanz

Aspects of design

Solar radiation – shading of horizon



Source: http://www.stadtklima-stuttgart.de/index.php?klima_sonnenstand

Aspects of design

Sun protection for the glazing in the summer

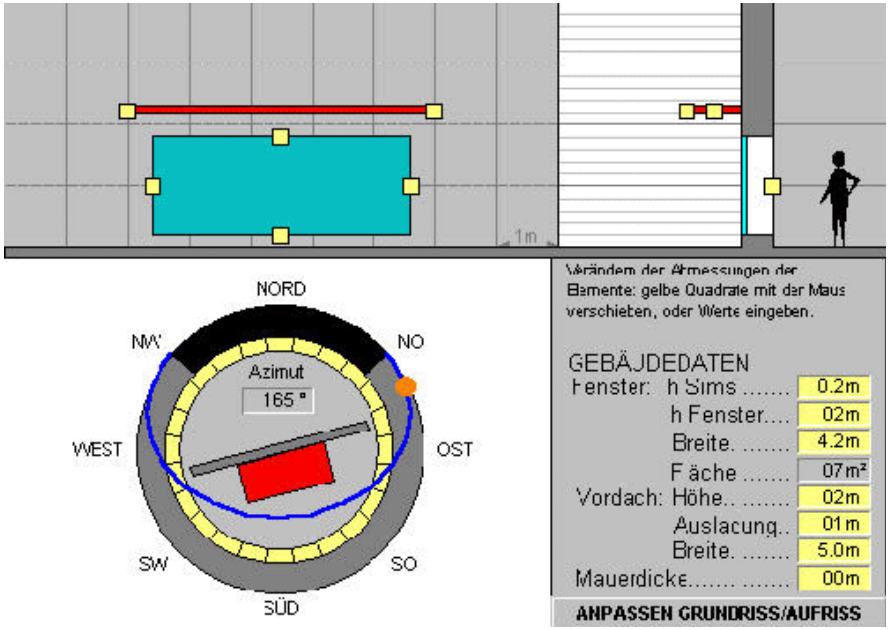
or „the building gets ill and gets spots“

For good summer comfort you need shading elements for the windows – in our climate air-conditioning is not necessary and a sign of a building with bad summer conditions

Source: Ernst Heiduk

Aspects of design

On the south side a permanent shade is useful



Source: Prof. Heid, Unversity of Siegen

Aspects of design

On the other sides a movable shade is useful

Lohbach West/Tirol Bild: E. Schwarzmüller

Source: Baumschlager & Eberle

Aspects of design

On the top sides a movable shade is important

Source:

Aspects of design

Size of the windows:

This is a balance between

- Daylight
- Passive solar gains in the winter
- Energy loss in the winter
- Sun protection in summer

- and the architectural intention

Source:

What is the Passive House - standard ?

Which buildings can be Passive Houses ?

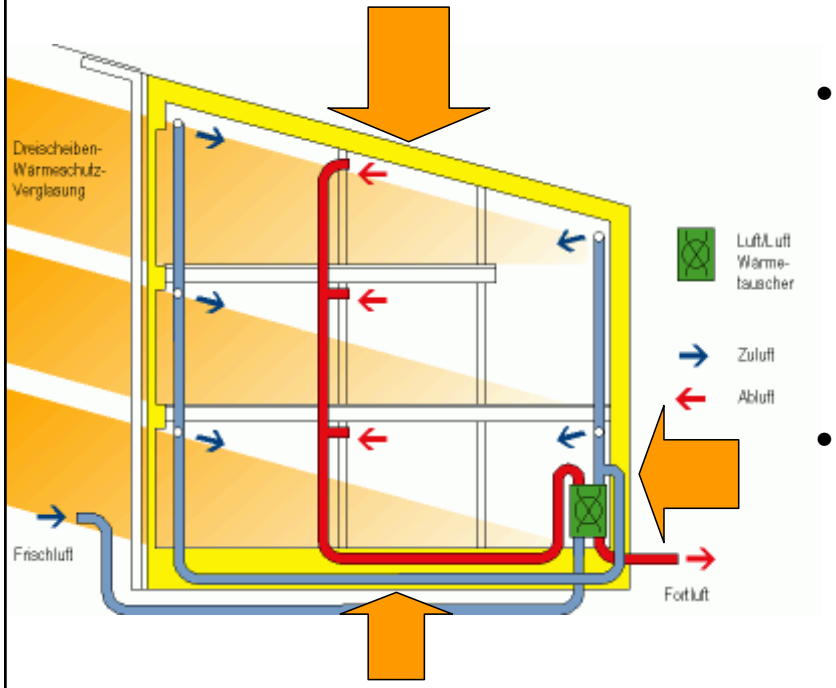
Where can Passive Houses be built ?

What is important for the design ?

What is important for the construction ?

Source:

Aspects of construction



- **U-value < 0.15 W/m²K**
  for floor, wall and roof

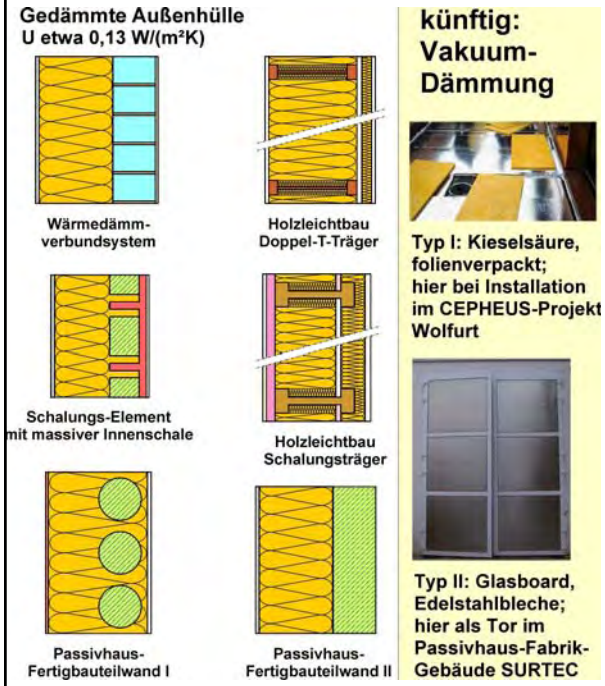
  and a thermal-bridge free construction with
- **Ψ < 0,01 W/m2K**.

This is a heat insulation from 15(new) – 40 cm !

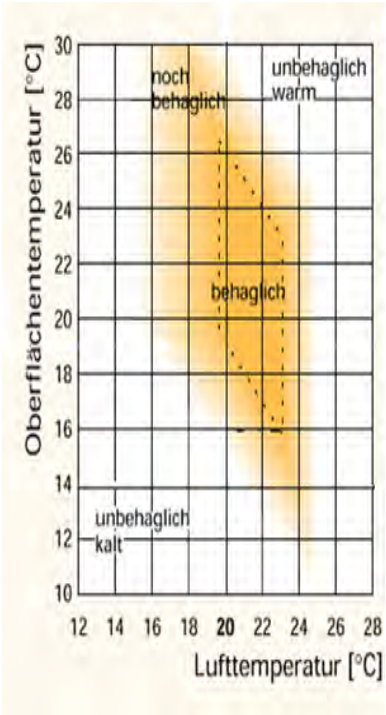
Source: PH Institute - Darmstadt

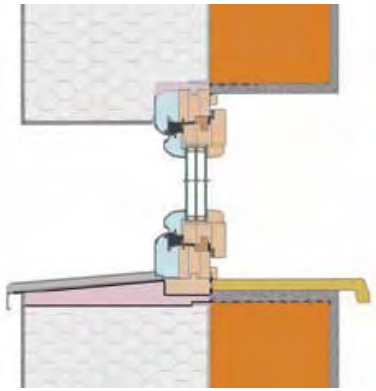
Optimized building envelope for a passive house

heat insulation



windows and connections



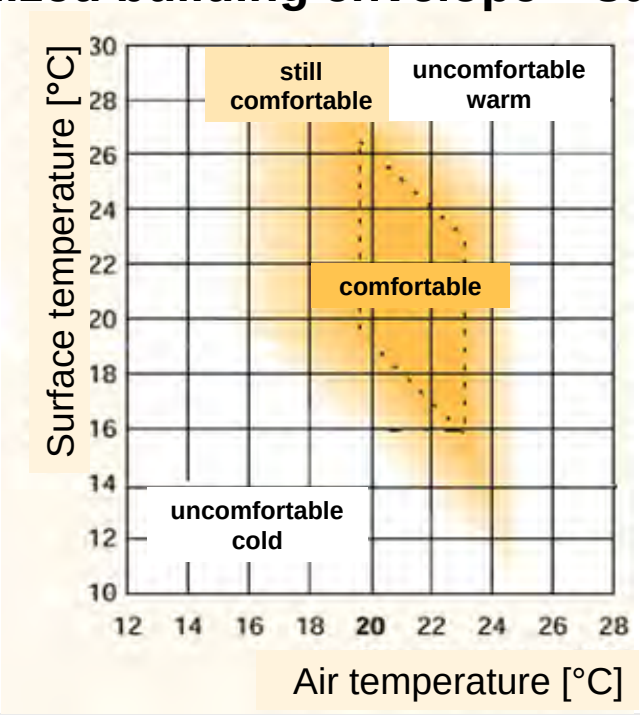


Source: PH Institute - Darmstadt

Optimized building envelope – surface temperatures

The first base must be the thermal comfort and the relevant temperature boundaries

Optimized building envelope – surface temperatures



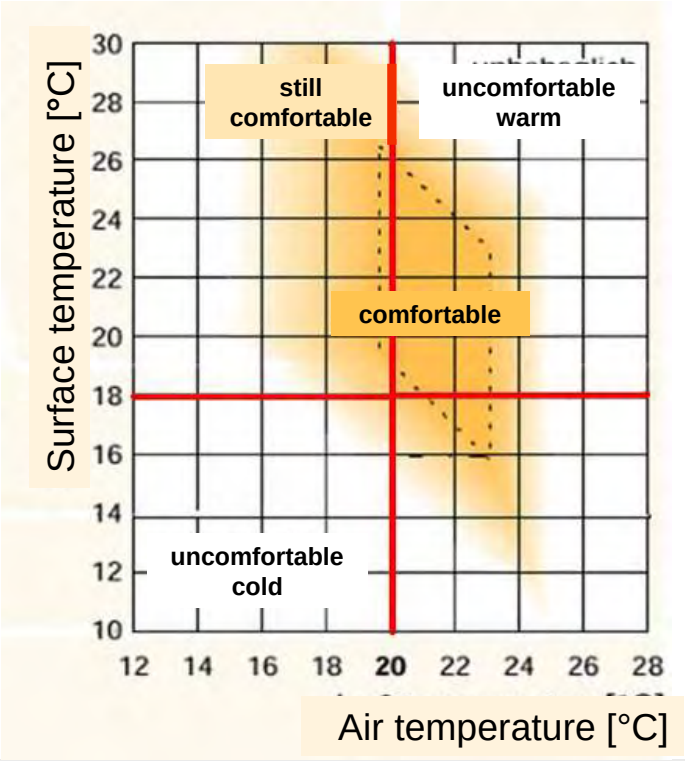
Surface - temperature: ?

Air- temperature: ?

Source:

Optimized building envelope – surface temperatures

For winter time comfort:



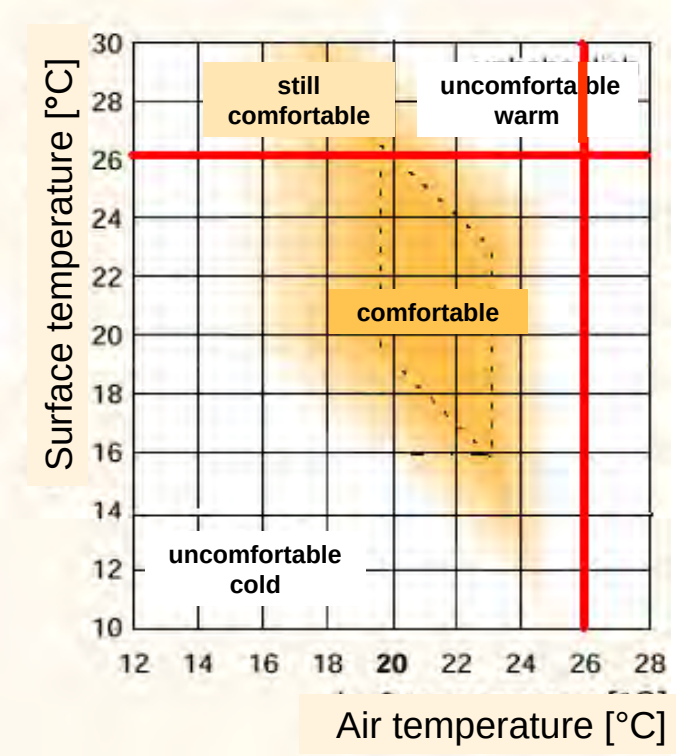
Surface - temperature: >18°C

Air-temperature: >20°C

Source:

Optimized building envelope – surface temperatures

For summer time comfort:



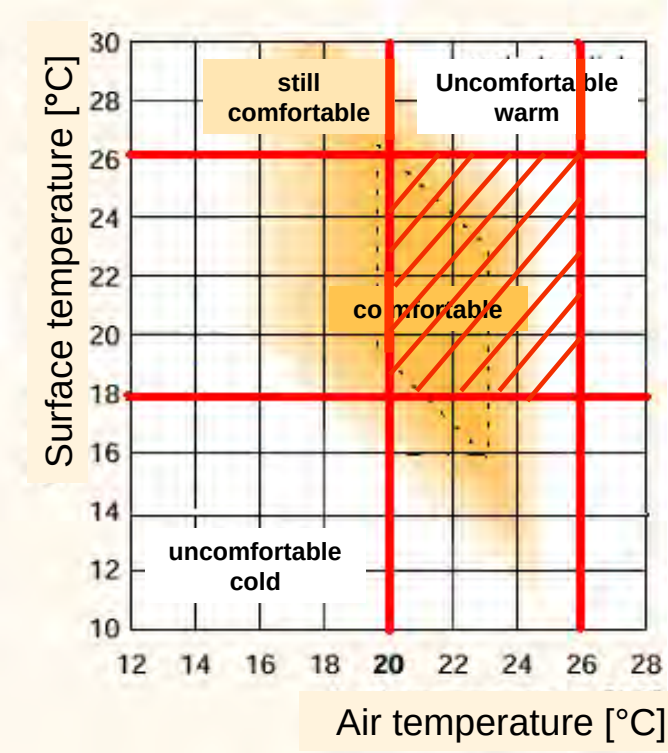
Surface - temperature: <26°C

Air-temperature: <25°C(night) < 27°C (day)

Source:

Optimized building envelope – surface temperatures

The „window“ of optimal comfort:



Surface - temperature: 18 - 26°C

Air- temperature: 20 - 26°C

Source:

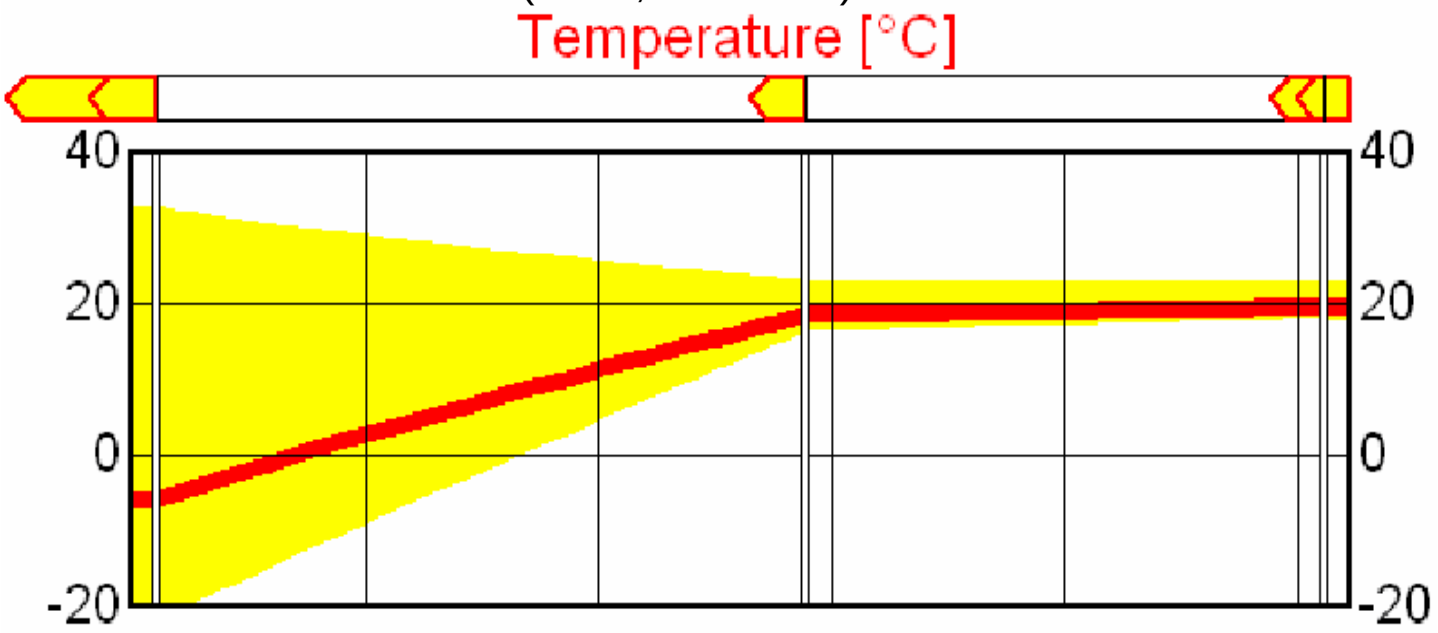
Opaque elements - Wall constructions

Source:

Aspects of the building envelope

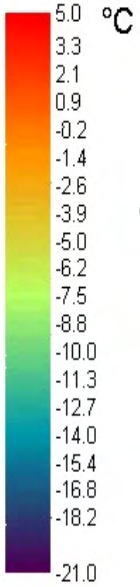
An optimised wall construction holds the temperature of the internal wall surface in the area of optimal comfort all the year

(U = 0,13 W/m2K)



Source: xxx

Aspects of the building envelope

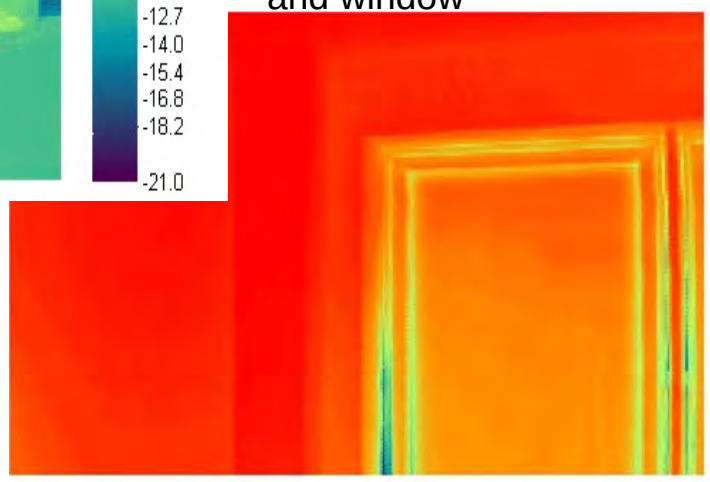


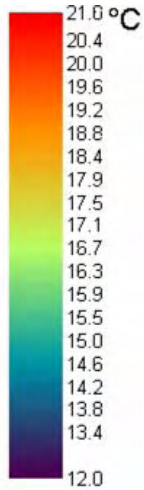
Optimised building envelope

outside cold

inside warm

IR- inside view of outside wall and window





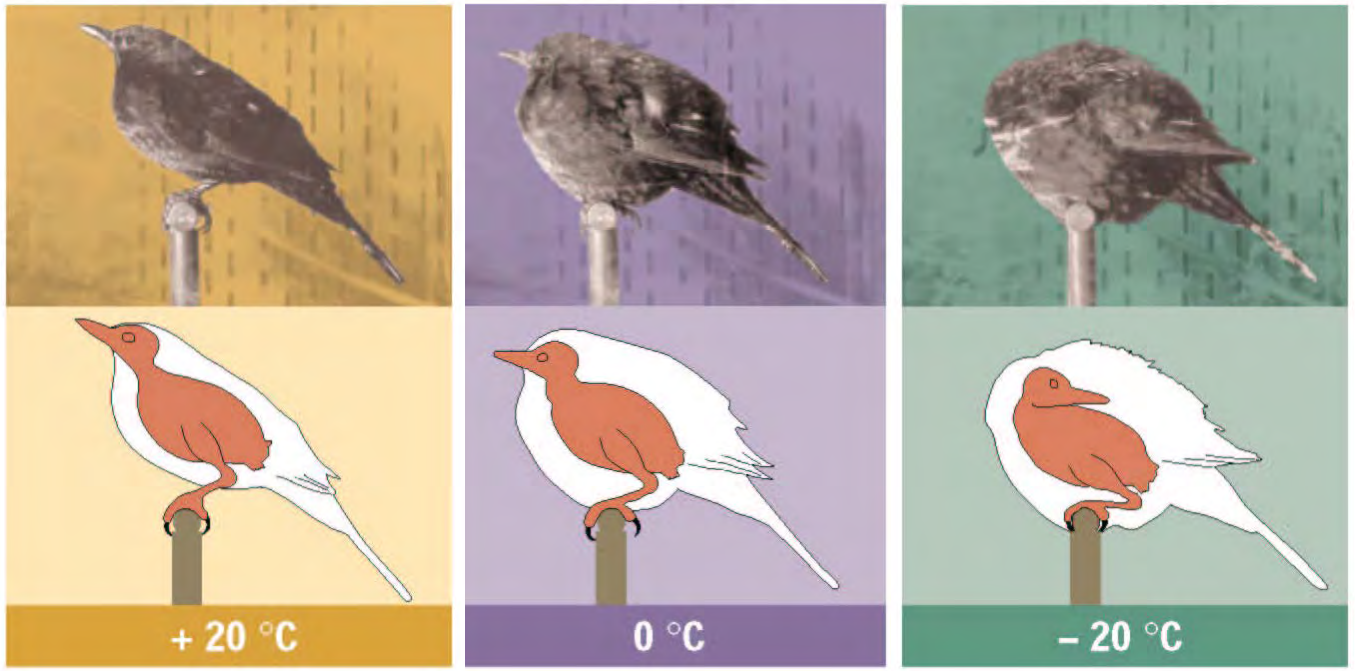
Kassel Marbachhöhe /
Fotos PHI – Wolfgang Feist

Source: PH Institut Darmstadt

Opaque elements - Thermal or Heat bridges

Source:

Aspects of thermal bridges

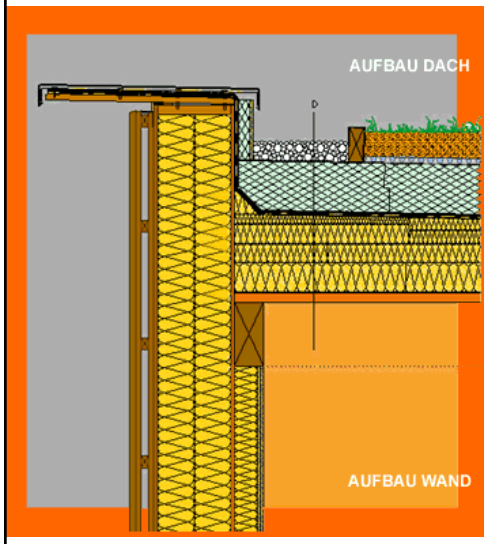


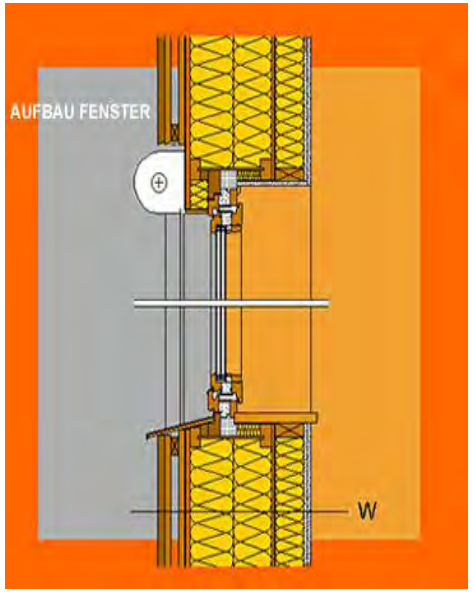
Heat insulation and thermal bridges of a bird

Source:

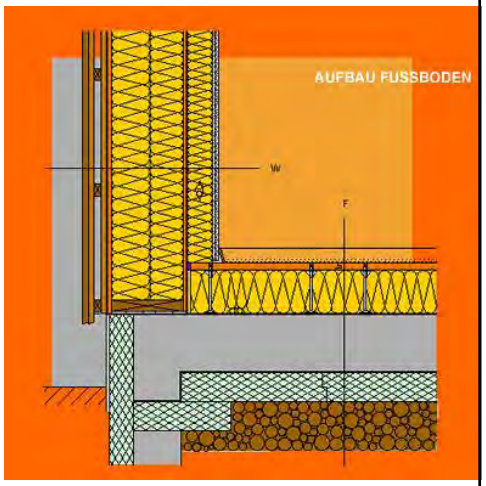
Aspects of thermal bridges

Thermal bridge free constructions all around





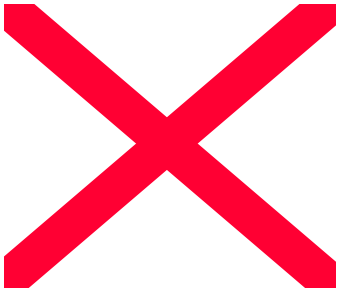
All around good connections in detail



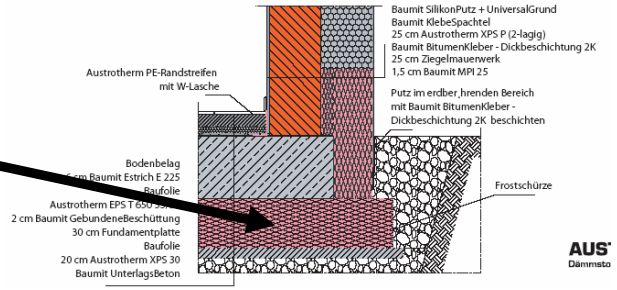
Source: Günter Lang, Lang consulting

Aspects of thermal bridges

Thermal bridge free constructions all around

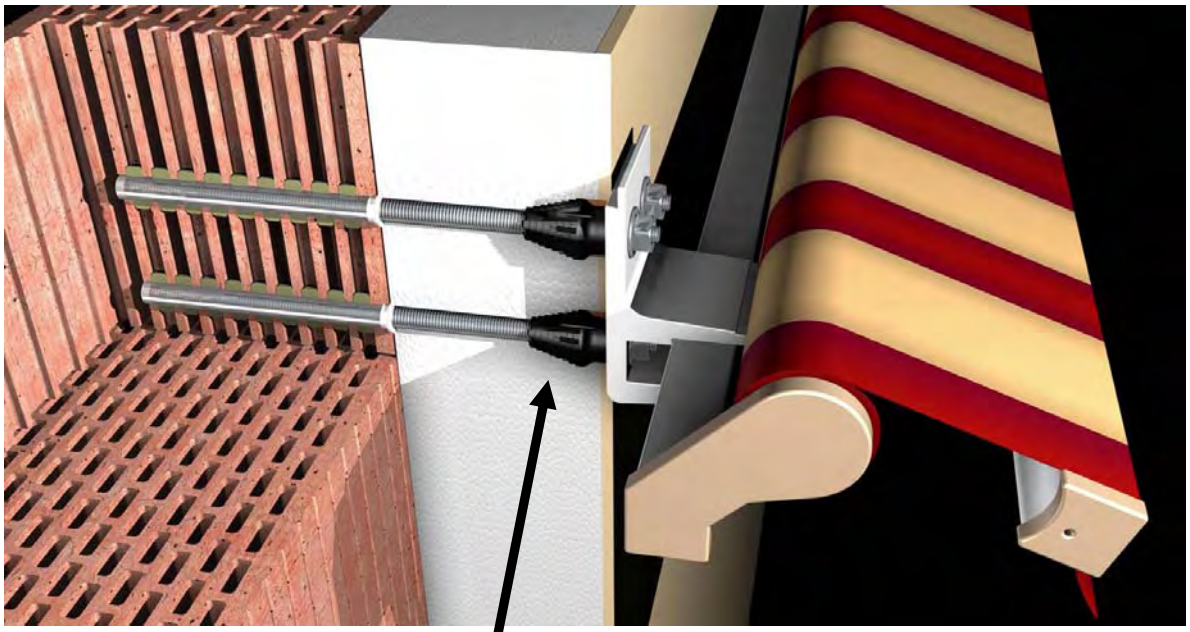


Extruded polystyrene



Source: http://www.austrotherm.com/imperia/md/content/baumitat2/deutsch/ratundtatgeber/neh_folder.pdf

Aspects of thermal bridges

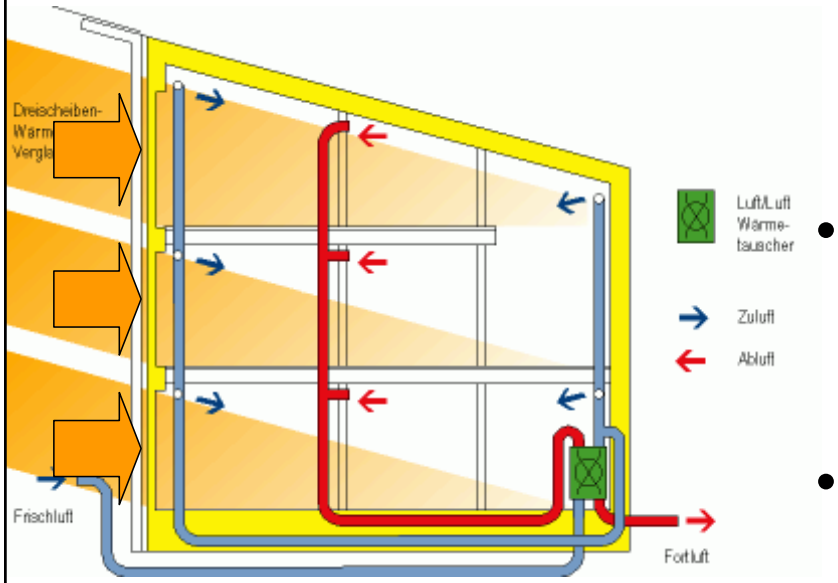


Thermal bridge reduction of metal connections with decoupling elements

Source: Fischer Systems www2.basf.de/basf2/html/plastics/images/presse/06_356_2_gross.jpg

Aspects of glazing

PH – Values for the transparent parts of the envelope:



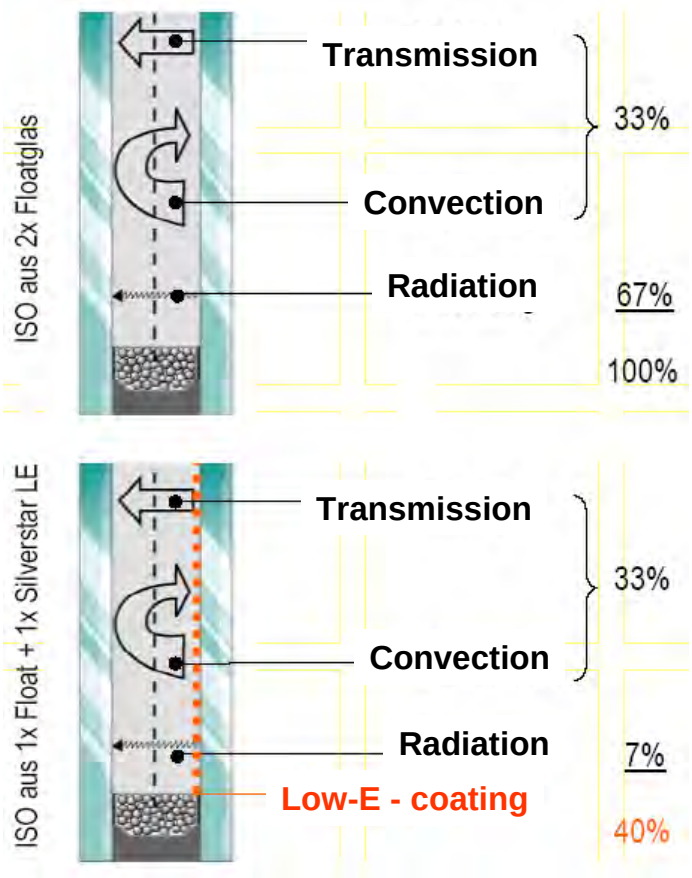
a 3-layer low - E glazing with

- **U_w-value < 0.8 W/m²K** for glass and frame with a
- **g-value > 50 %** solar heat-gain coefficient

Source: PH Institut Darmstadt

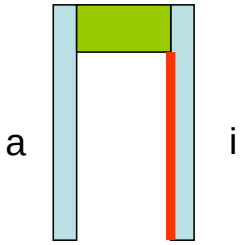
Aspects of glazing

Influence of Low-E - coating „low emissivity“

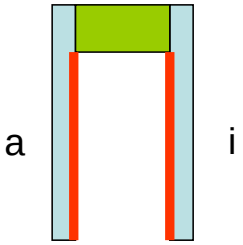


Source: http://www.satw.ch/D/V4_JK05_Troesch.pdf

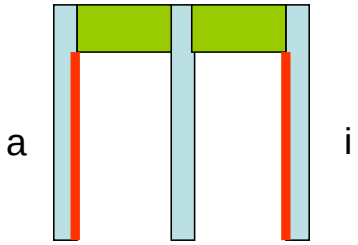
Aspects of glazing



U_g > 1,2 W/m²K
Gas:
-Air
-Argon



U_g: >1,0 W/m²K
Gas:
-Argon
-Krypton

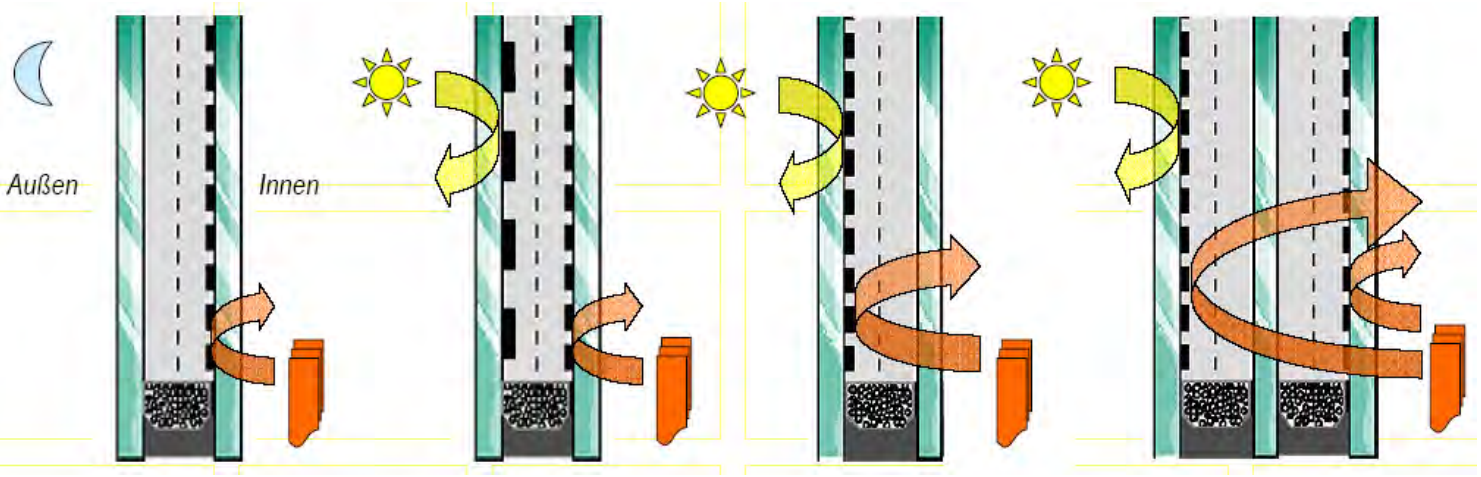


U_g: > 0,4 W/m²K
Gas:
-Argon
-Krypton
-Xenon

Source: nach A. Greml – FH Kufstein

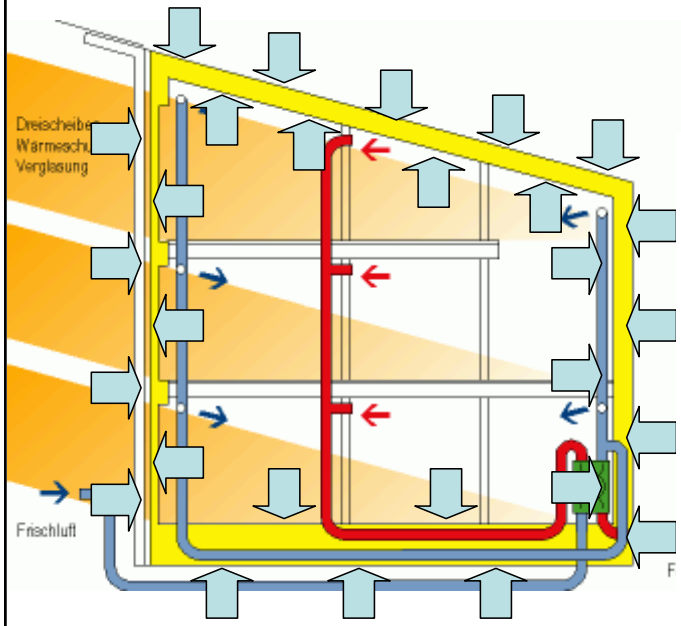
Aspects of glazing

Coating for glazing



Source: www.satw.ch/D/V4_JK05_Troesch.pdf

Aspects of air tightness



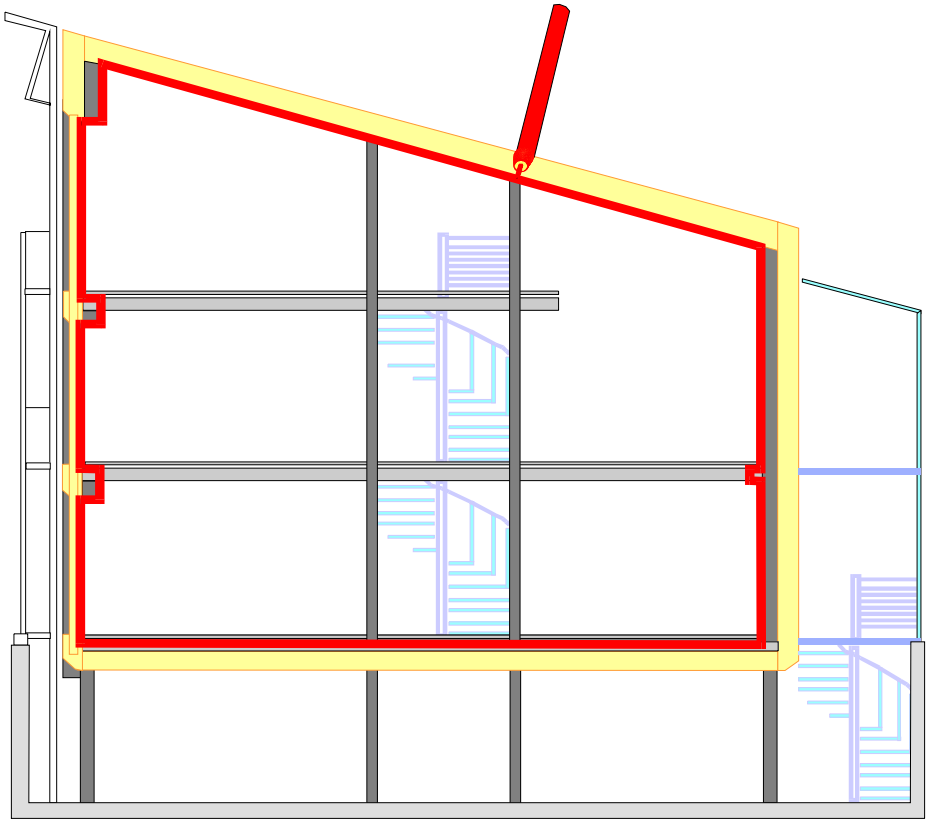
Air leakage through unsealed joints must be less than

- **n_{50} < 0.6 house volume/h**

Blower door test with a +/- pressure of 50 Pascal.

Source: PH Institut Darmstadt

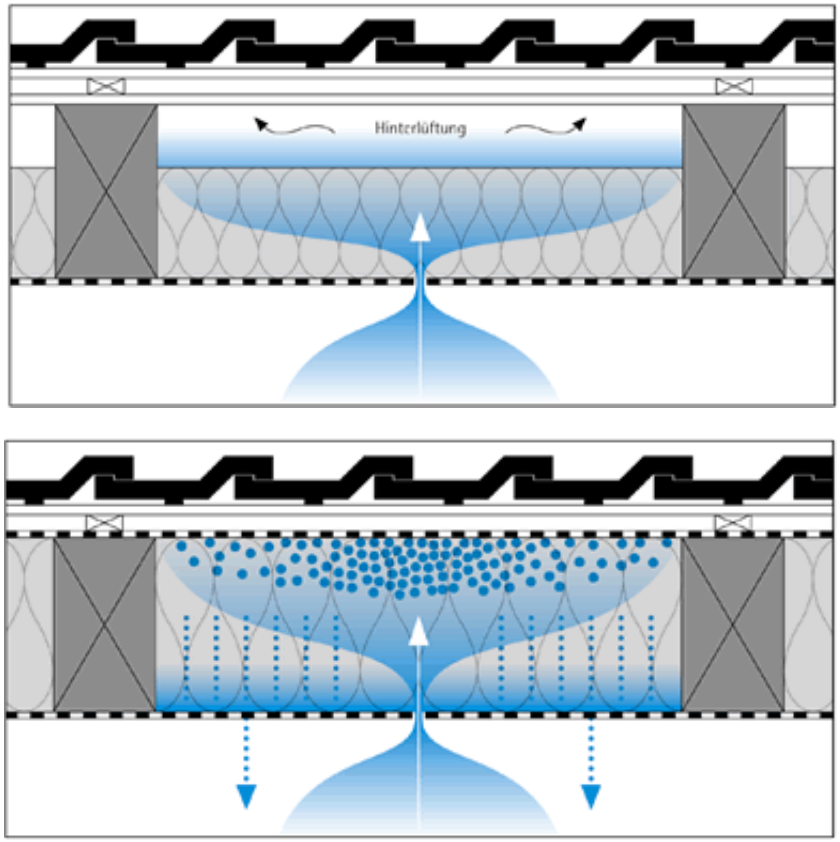
Aspects of air tightness



The air-tight layer contains the complete heated volume.

Source: PH Institut Darmstadt

Aspects of air tightness

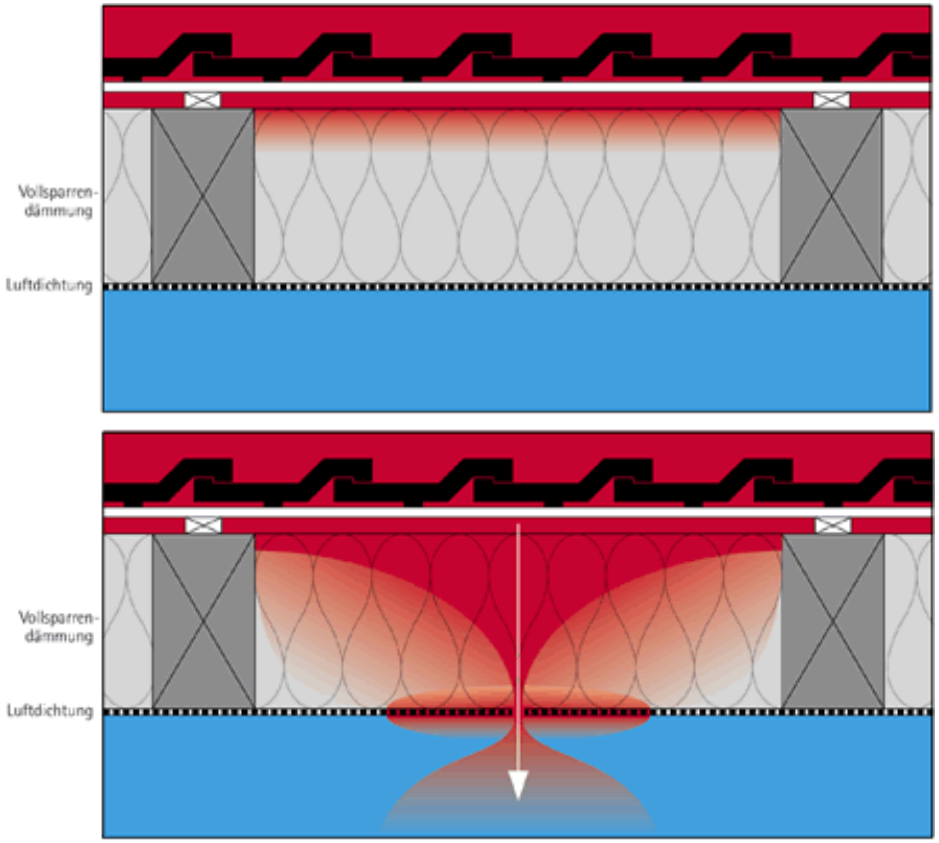


Humidity transport
through a vapour barrier:
0.5 g/m2 x 24h
through 1 mm gap:
800 g/m2 x 24h

Rising factor: 1,600

Source: www.proclima.de/htmlpc_D_2_0_warum-luftdichtung.html

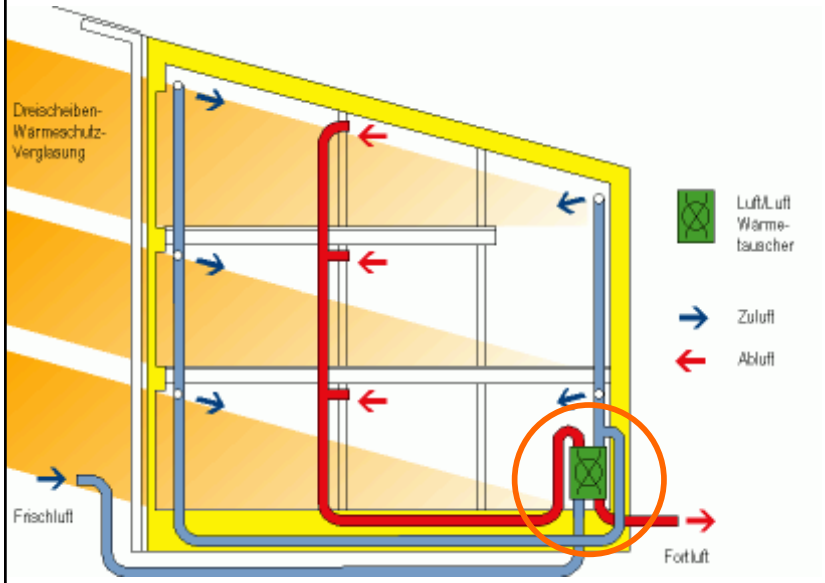
Aspects of air tightness



Infiltration of hot summer air into the inside rooms

Source: www.proclima.de/germany/04/04-4/04-4.htm

Aspects of air ventilation



For the design:
Give enough space for the domestic engineering (ventilation pipes /ducts)

Source: PH Institut Darmstadt

Aspects of air ventilation

What does that mean for the ventilation element window ?

un-tight windows

-

- draught phenomena
- uncomfortable temperatures
- high heating need
- dust and noise

+

- good air quality
- good humidity exhaust

tight windows

+

- no draught phenomena
- comfortable temperatures
- less heating need

-

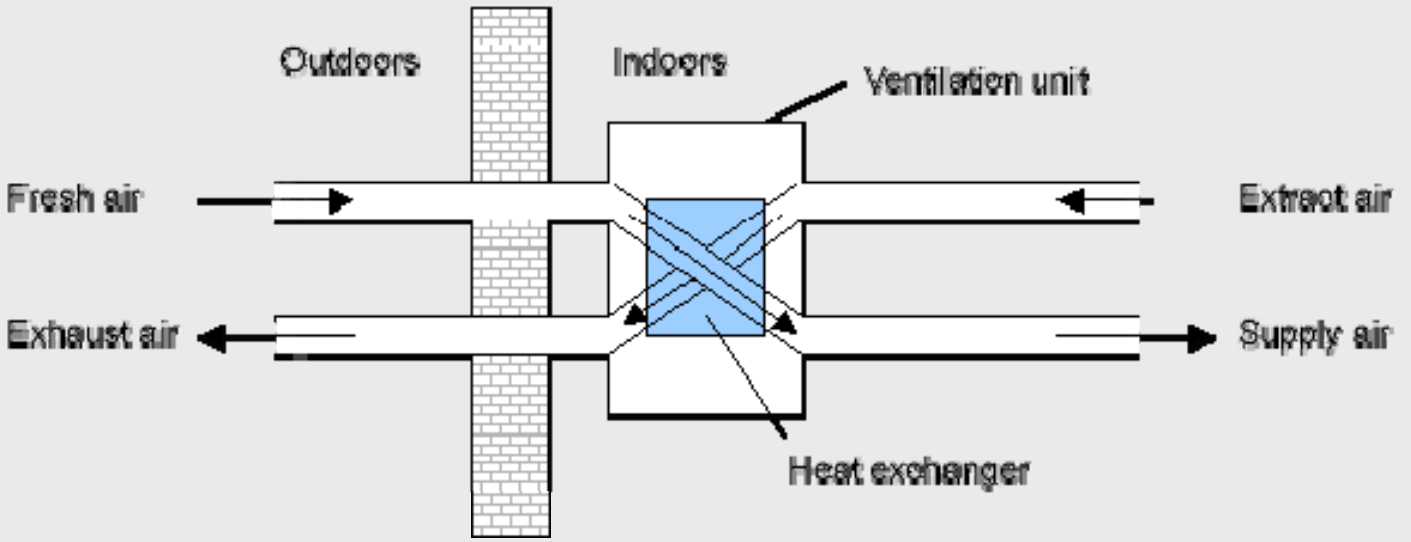
- bad air quality
- high humidity
- mould danger

Source:

Aspects of air ventilation

The solution to this problem -

Controlled / mechanical ventilation with heat exchange

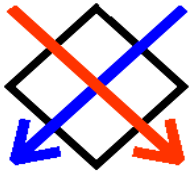


Source:

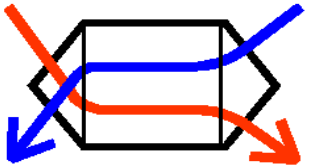
Aspects of air ventilation

Controlled or mechanical ventilation
with heat exchange
(heat recovery)

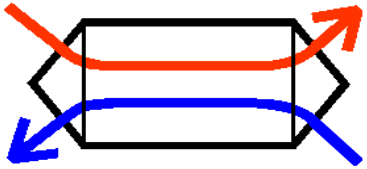
= **Comfort ventilation**



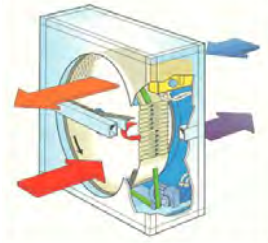
**Cross flow-
heat exchanger**



**Cross counter
flow-
heat exchanger**



**Counter flow-
heat exchanger**

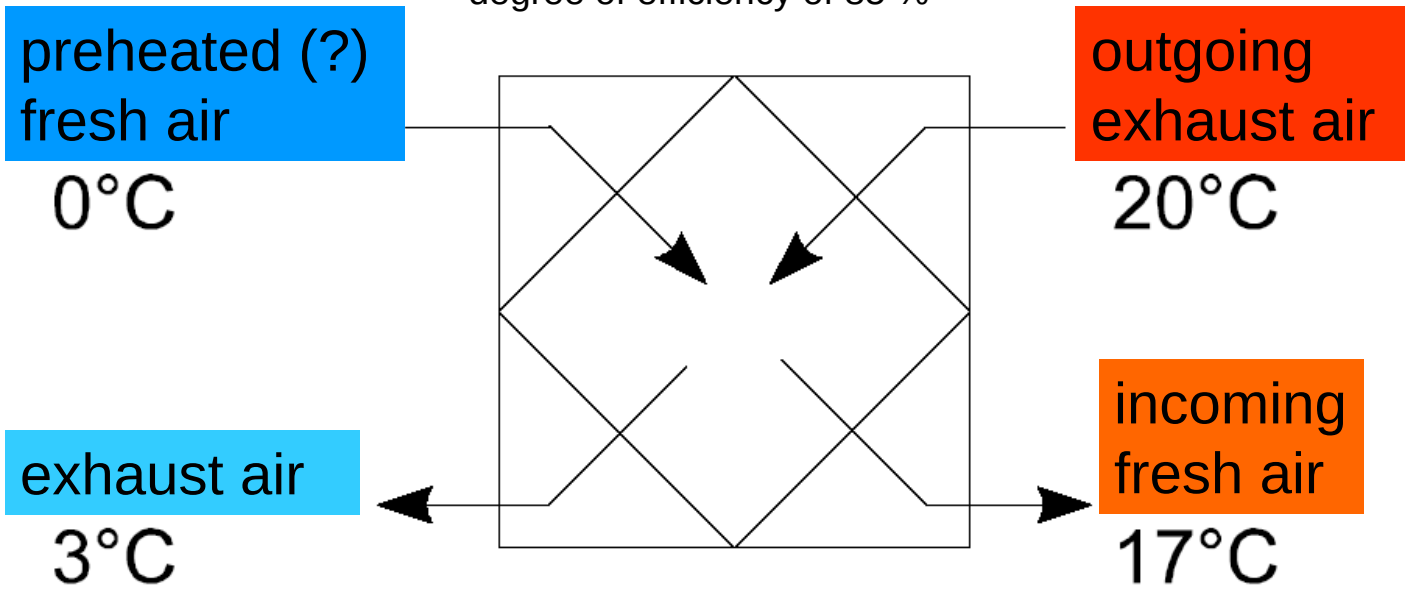


**Rotation-
heat exchanger**

Source:

Aspects of air ventilation

Schematic plate heat exchanger with an incoming temperature – degree of efficiency of 85 %

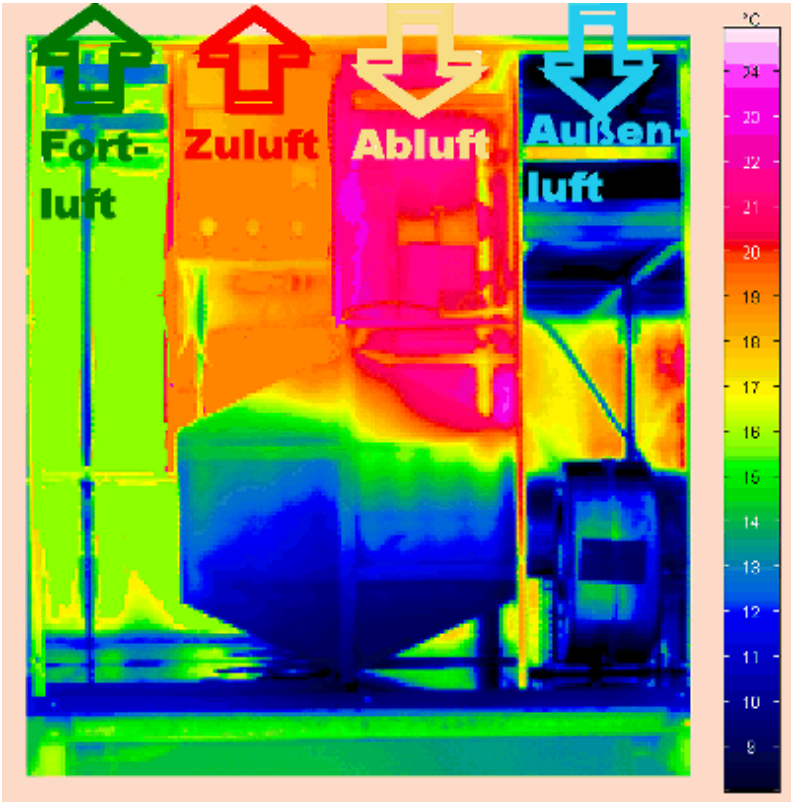


temperature - degree of efficiency $\eta_{\upsilon 2} = \frac{\upsilon_{Zuluft} - \upsilon_{Aussenluft}}{\upsilon_{Abluft} - \upsilon_{Aussenluft}}$

Source:

Aspects of air ventilation

Heat exchanger – thermography



Source: PHI, B. Schulze-Darup

Aspects of air ventilation

Heat exchanger

Source: E. Heiduk