PASSIVE HOUSE THEORY

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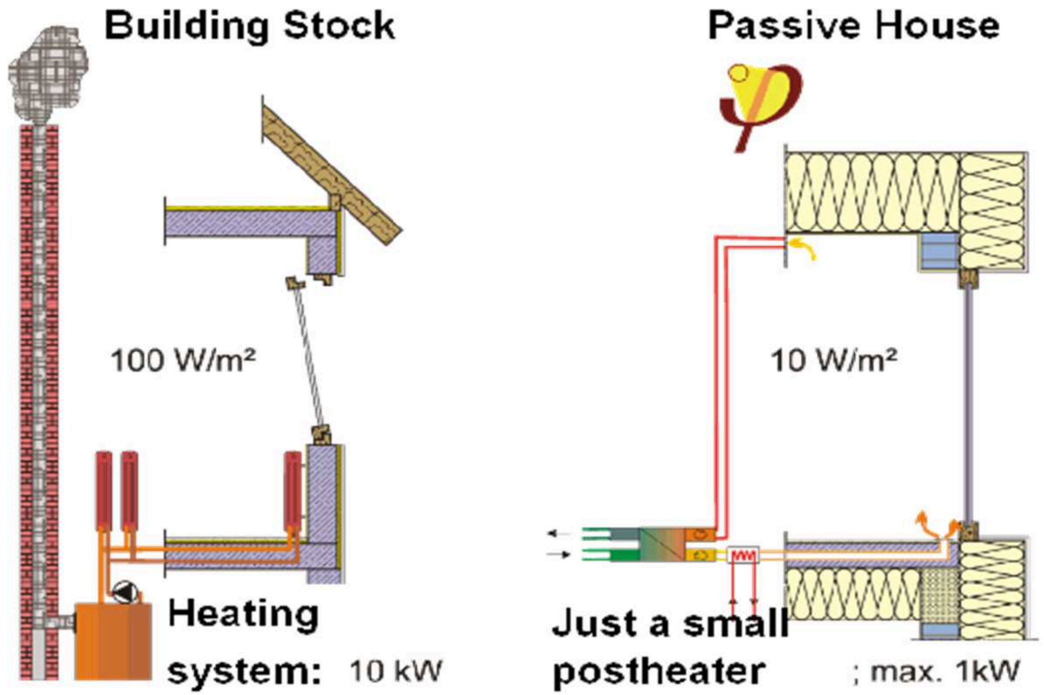
The basic principle or question of a Passive House:
Isn´t it possible to use **just the ventilating** air to heat (and cool) the house?



Yes, in principle this is possible, but the maximum **heat load** which can be dealed with by this concept is **very low**.

Definition of Passive Houses

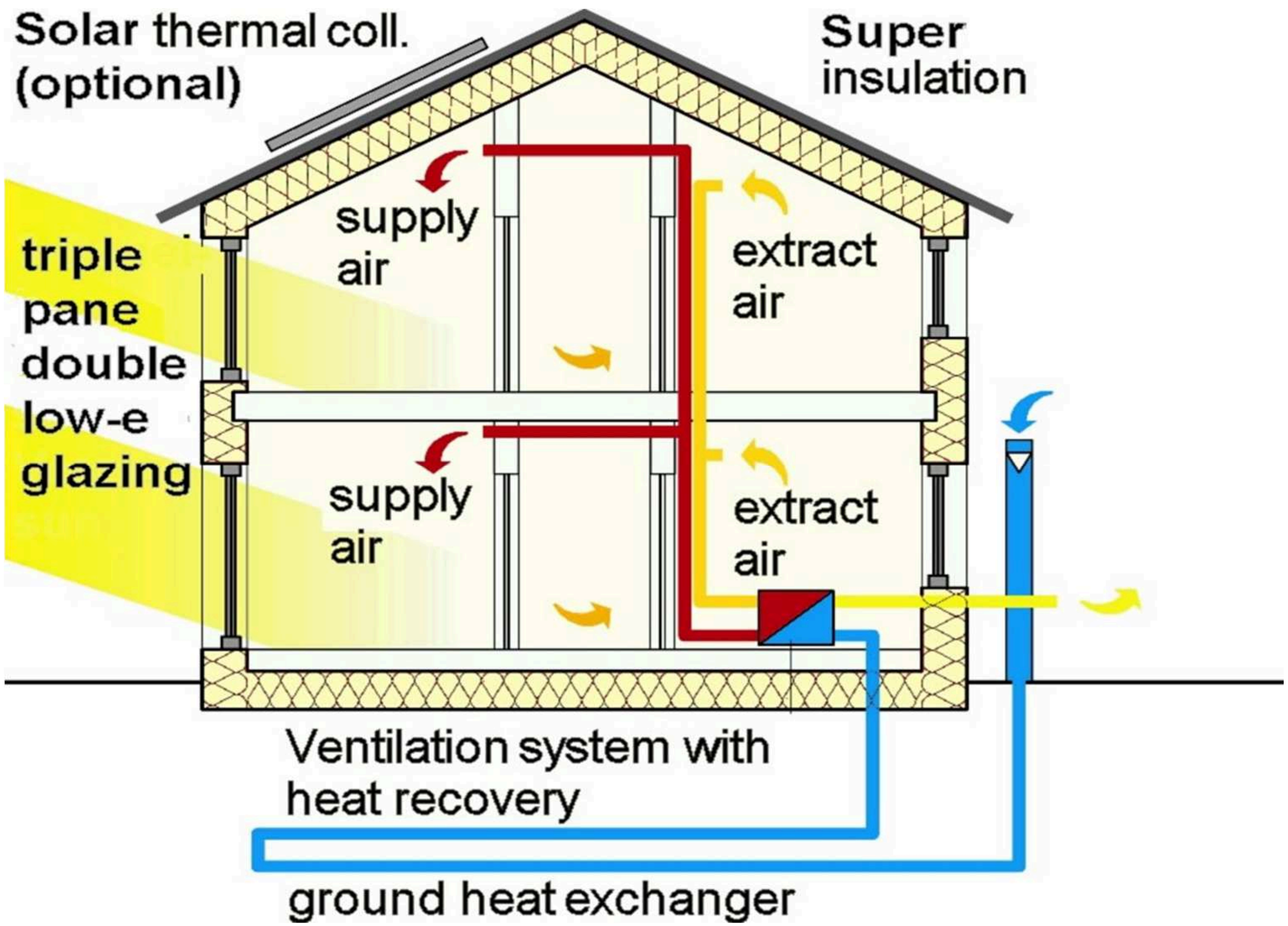
"A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved **solely** by postheating or postcooling of the fresh air mass, which is required to fulfil sufficient indoor air quality conditions (DIN 1946) - **without** a need for recirculated air.„

Dr. Wolfgang Feist

Passive Houses require superior design and components with respect to:

- high quality thermal insulation
- design without thermal bridges
- high quality air tightness
- ventilation with heat recovery
- comfort windows
- innovative heating technology
- compact form of the building
- exact and conscious design

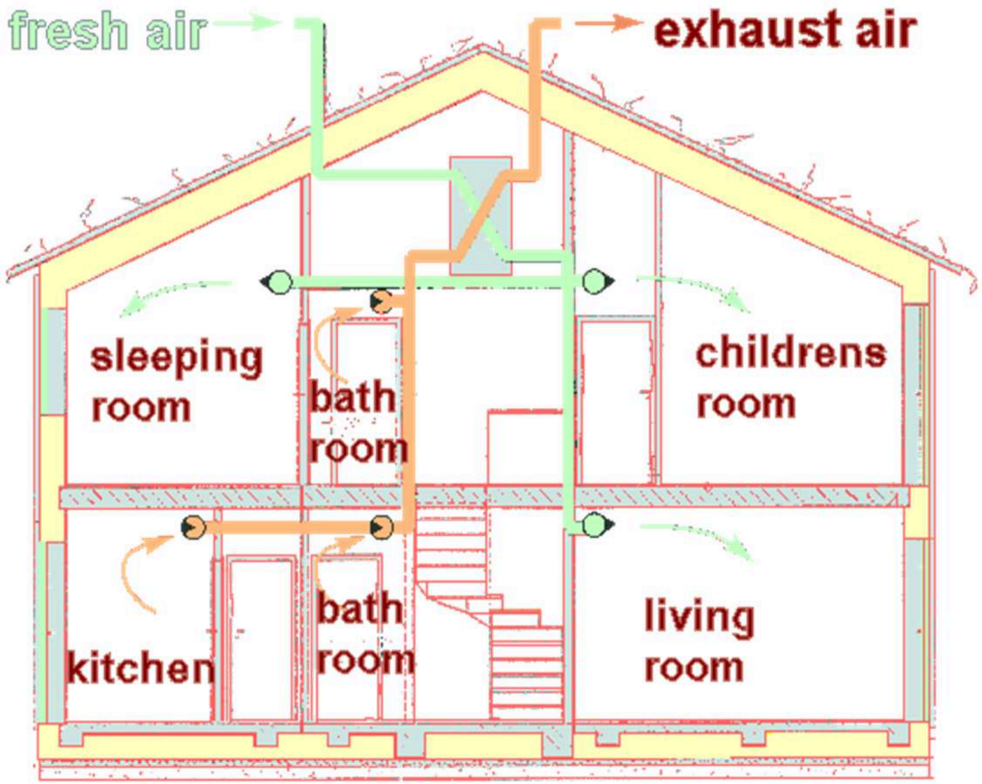
What is a Passive House?



What is a Passive House?

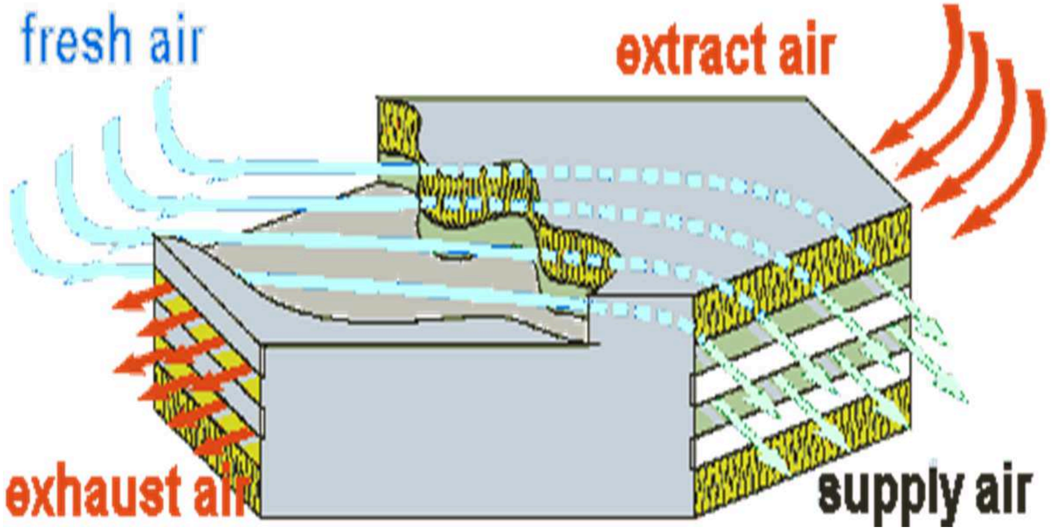
- In a Passive House the consumption for **space heating is reduced by 90 percent.**
- In a Central European climate the typical heating energy consumptions of Passive Houses are not more than **15 kWh/(m²year)**.
- In Stockholm it could be up to **20**, in Roma more like **10 kWh/(m²year).**
- The whole energy consumptions of Passive Houses are not more than **120 kWh/(m²year)** (ventilation, heating, cooling, hot water, washing machine, tv, radio…)
- In contrast to ordinary buildings – which in European climates – have to be heated actively, a Passive House uses the free heat sources inside of the building envelope - **e.g. the heat from the persons in the house and from solar energy incidenting through windows**.

COMFORTABLE VENTILATION SYSTEM



The scheme of a comfortable ventilation system. Stale air (brown) is removed permanently from the rooms with the highest air pollution. Fresh air (green) is supplied to the living rooms.

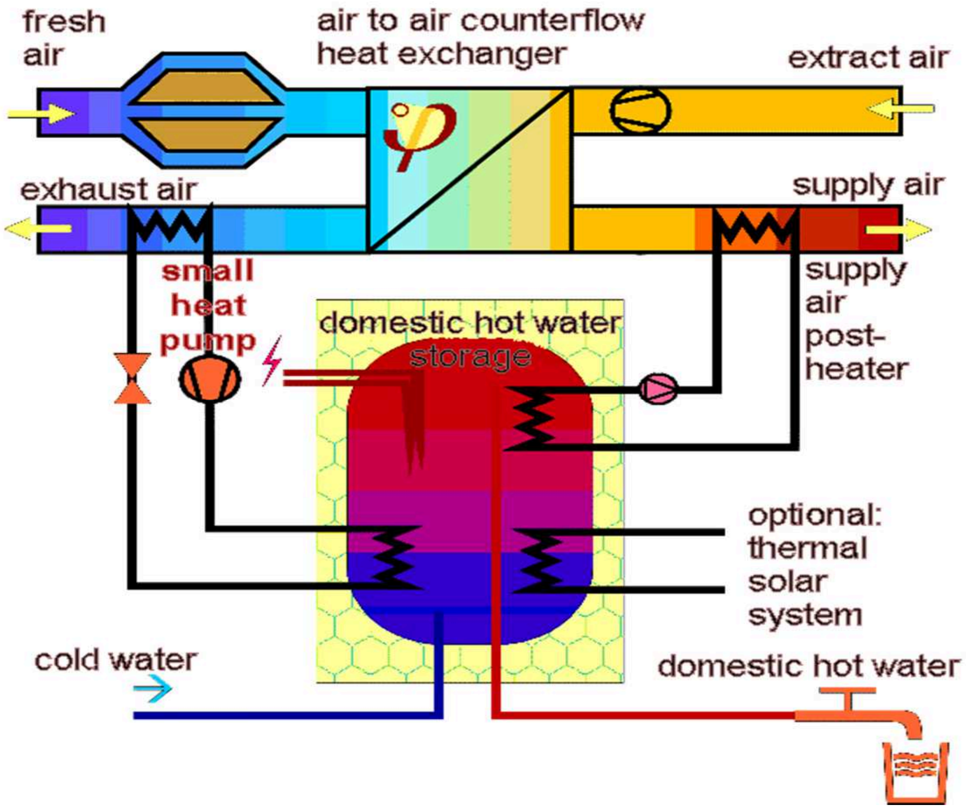
Why a mechanical ventilation system is recommended in Passive Houses



This is how a **counterflow heat exchanger** works: The warm air (red, extract air) flows through a channel and **delivers heat to the plates**. This air will leave the exchanger cooled (orange, then called exhaust air). On the opposite side of the exchanger plates the fresh air (blue) flows in **separate channels**. This air will absorb the heat and it will leave the exchanger with a higher temperature (but still unpolluted), then called supply air (green).

This will only work in a Passive House:

Heating with nothing other than fresh air

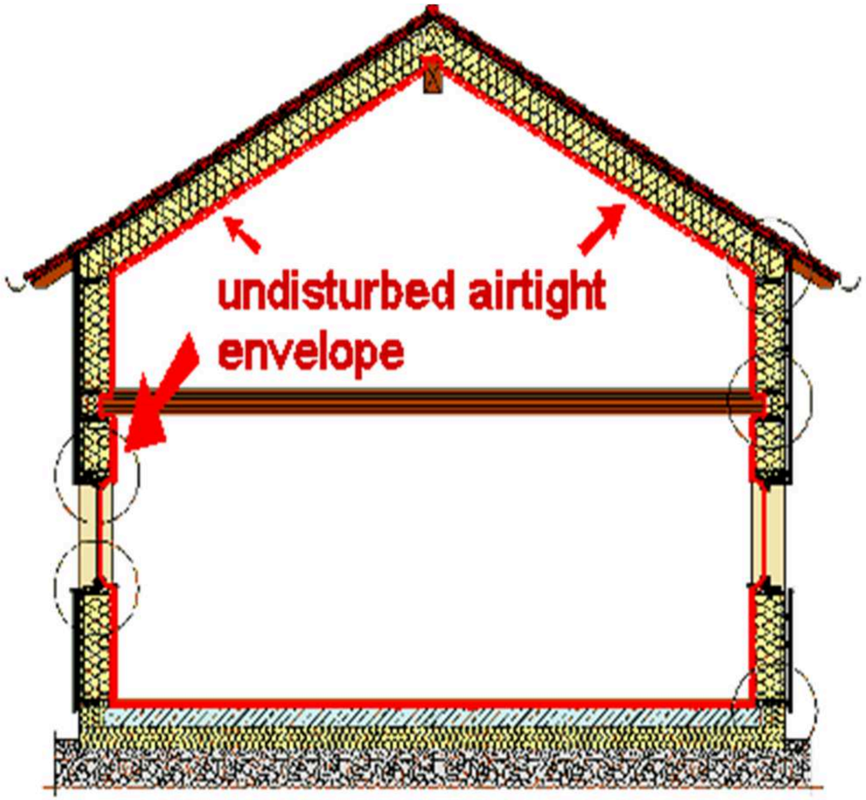


This is the know "classical" **compact** unit: all building services are realised **in one** handy appliance:

- heating,
- ventilation and
- domestic hot water.

Use the fresh air required for indoor air quality also for heating the building

Insulation and airtight



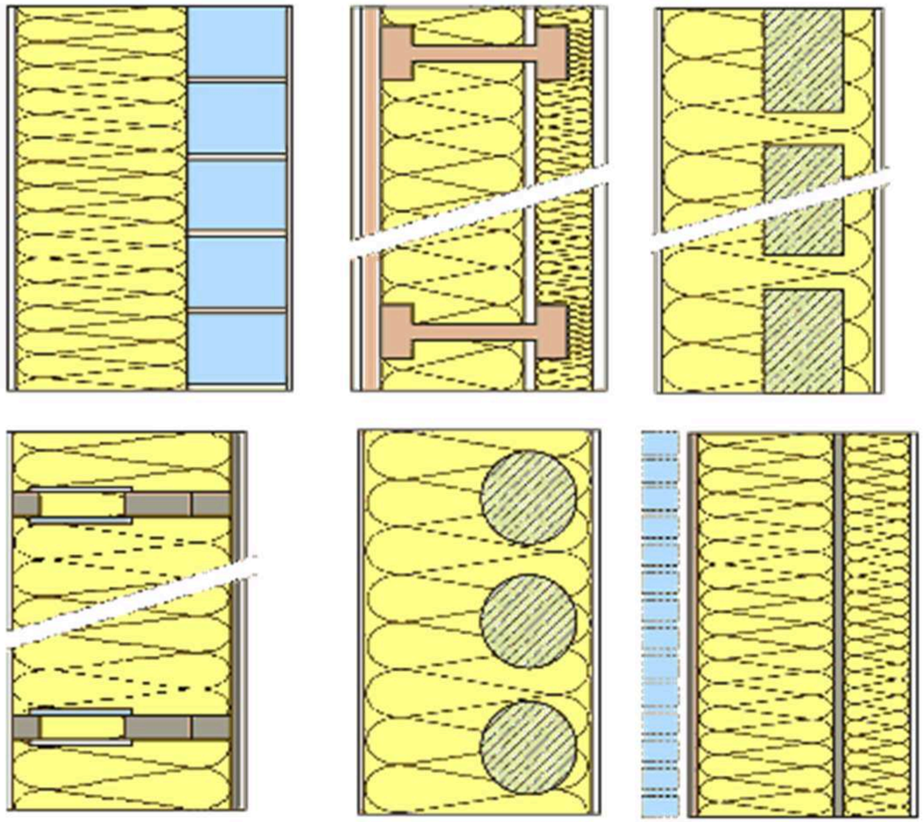
The most important principle of a Passive House:

- insulation (yellow), applied **continuously** around the building **envelope**
- without thermal bridging
- this reduces the heat losses like a **warm coat**.
- Most **insulation materials are not airtight**, however.
- Therefore the envelope has to be **undisturbed** airtight, too.

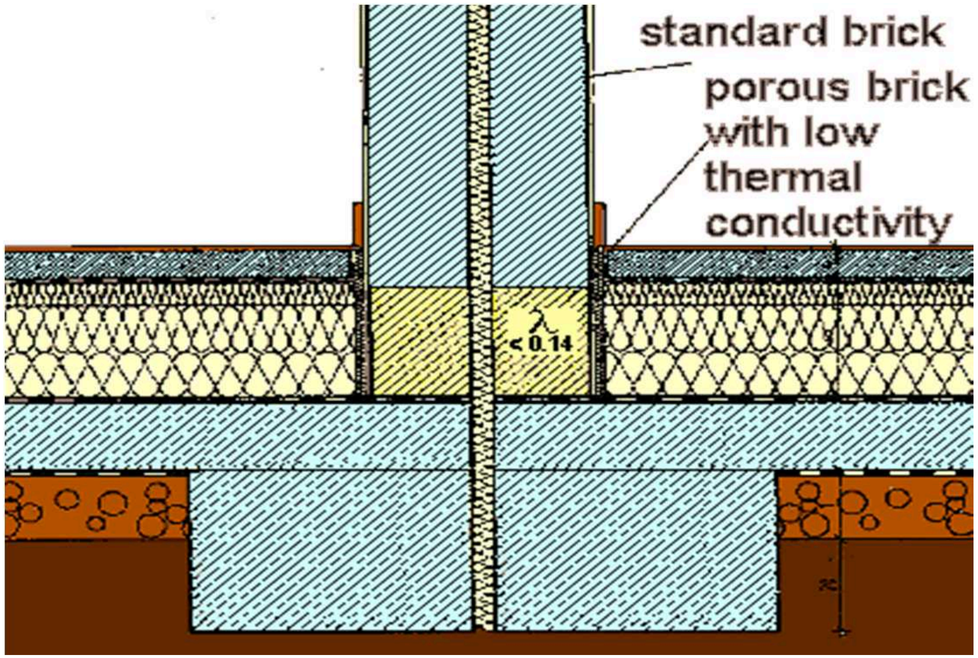
Thermal insulation

Examples of constructions suitable for passive houses with an excellent thermal insulation
WALLS

($U \leq 0{,}10\text{-}0{,}15\ W/m^2K$)

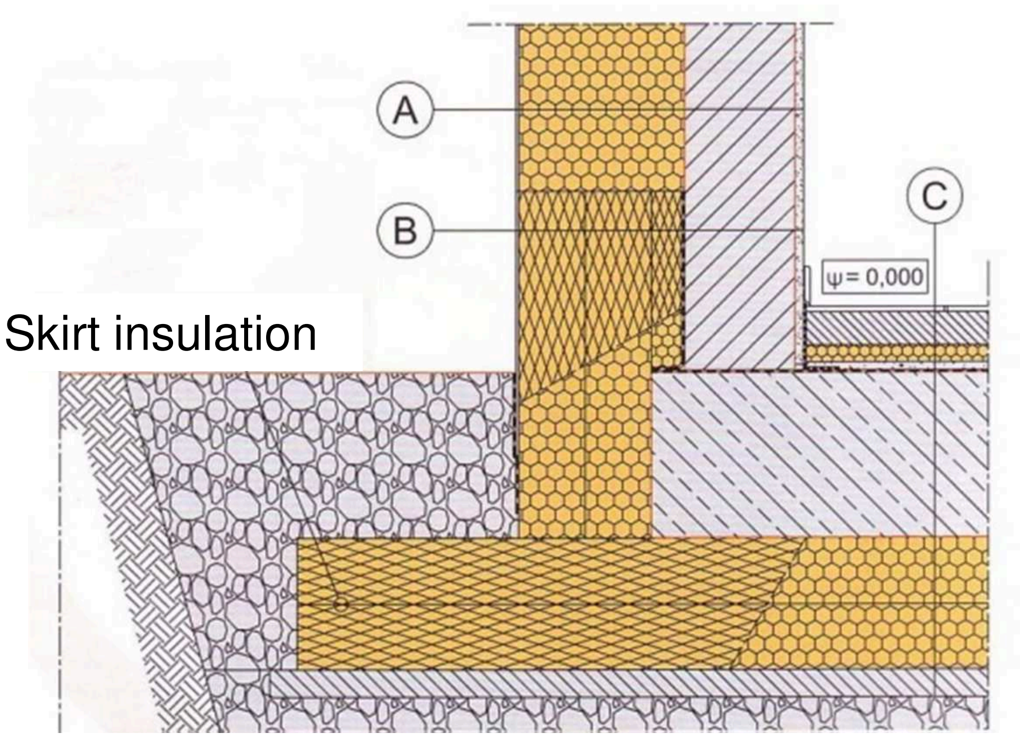


Design avoiding thermal bridges - preferable not only for Passive Houses

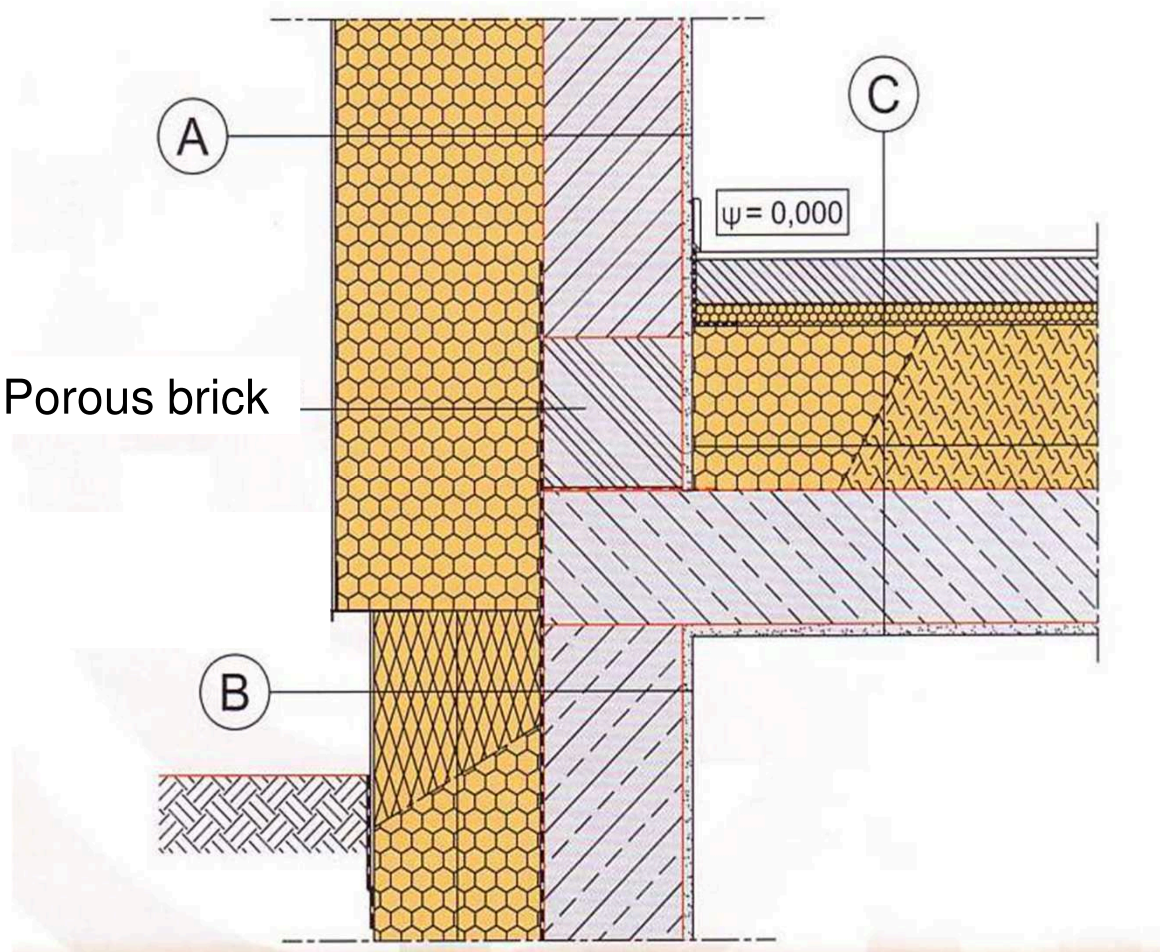


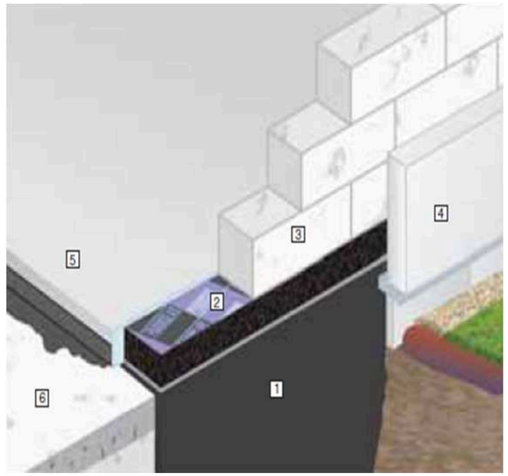
An example: The thermal bridge at the joint of the interior masonry wall with the slab-on-grade can be avoided almost completely if a **porous concrete** block (yellow) is used for **the first row of bricks**.

Examples of constructions suitable for passive houses with excellent thermal insulation FOUNDATIONS

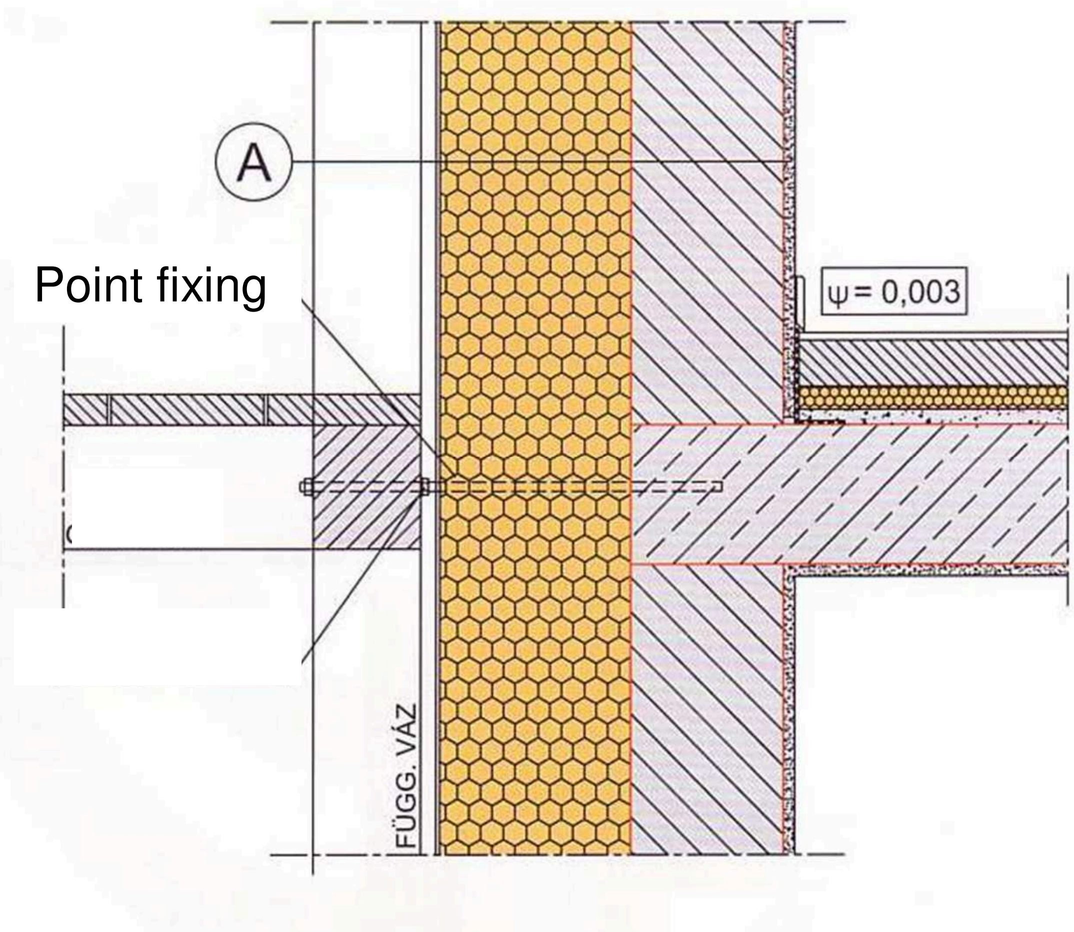


Examples of constructions suitable for passive houses with an excellent thermal insulation
A wall and a ceiling

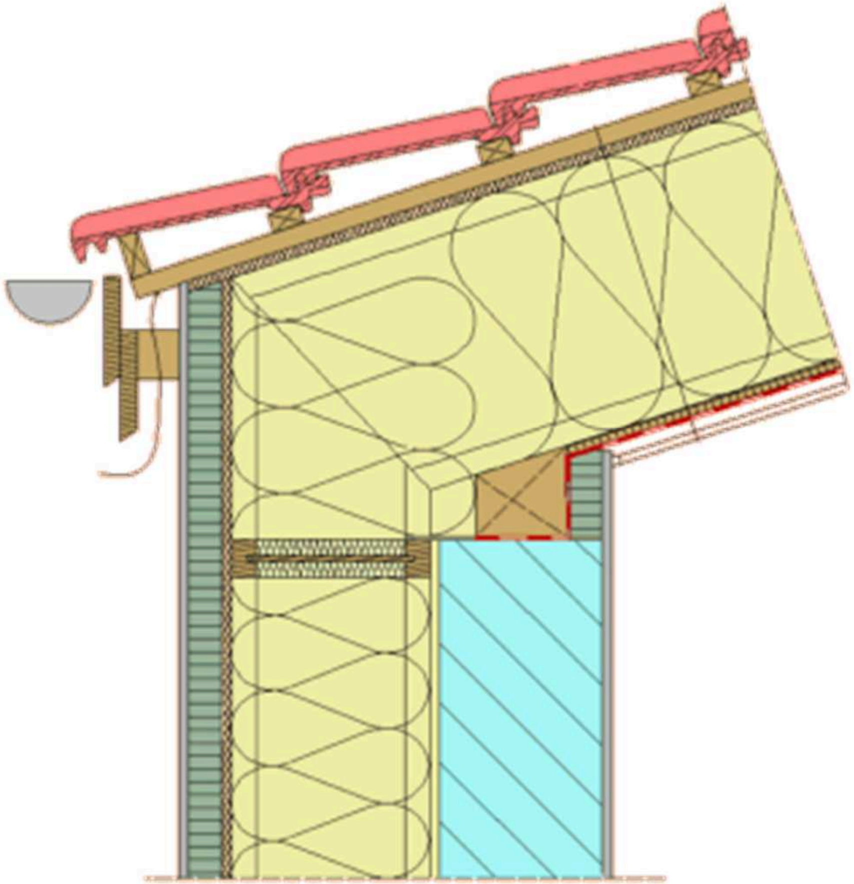




Examples of constructions suitable for passive houses with an excellent thermal insulation
BALCONY



Examples of constructions suitable for passive houses with an excellent thermal insulation
ROOF



Examples of constructions suitable for passive houses with an excellent thermal insulation
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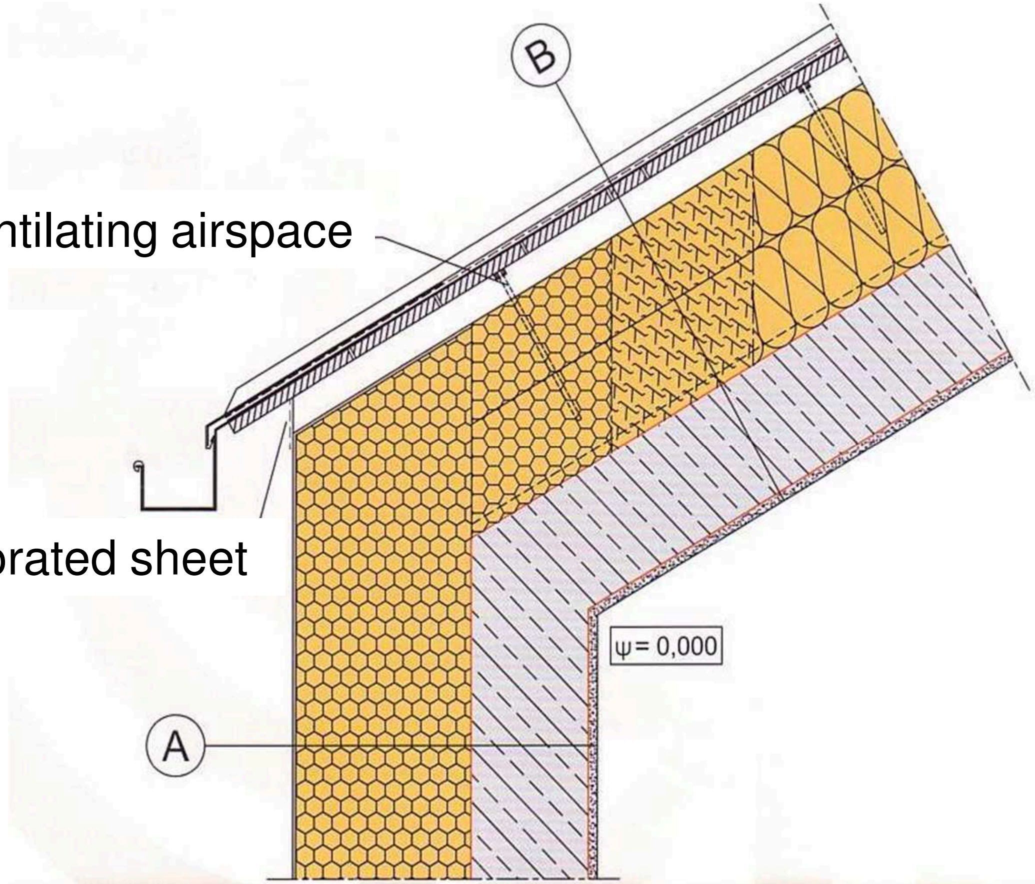
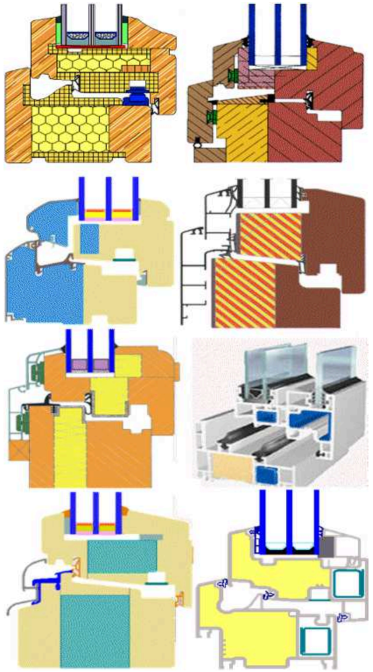
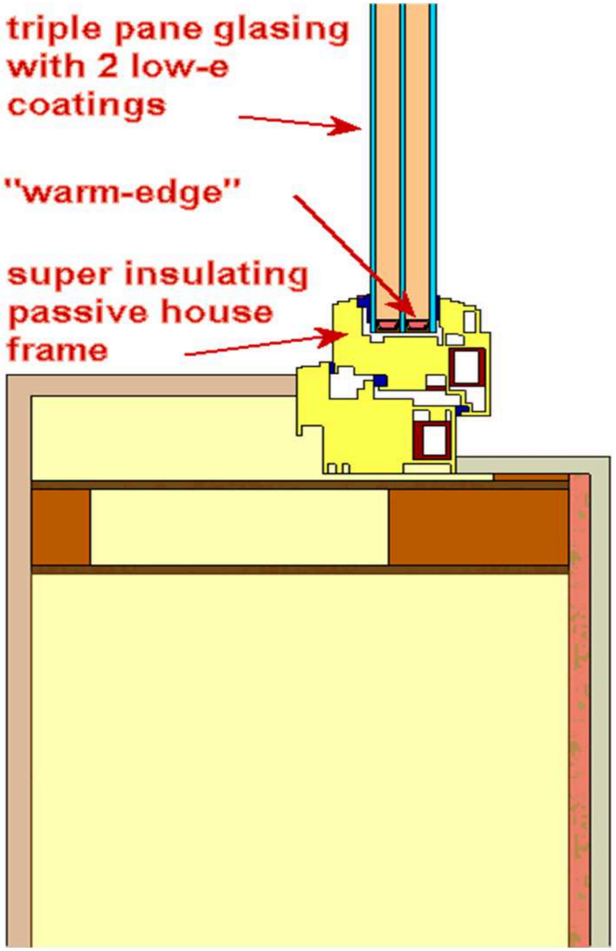


Ridge-pole lifting

Windows for Passive Houses

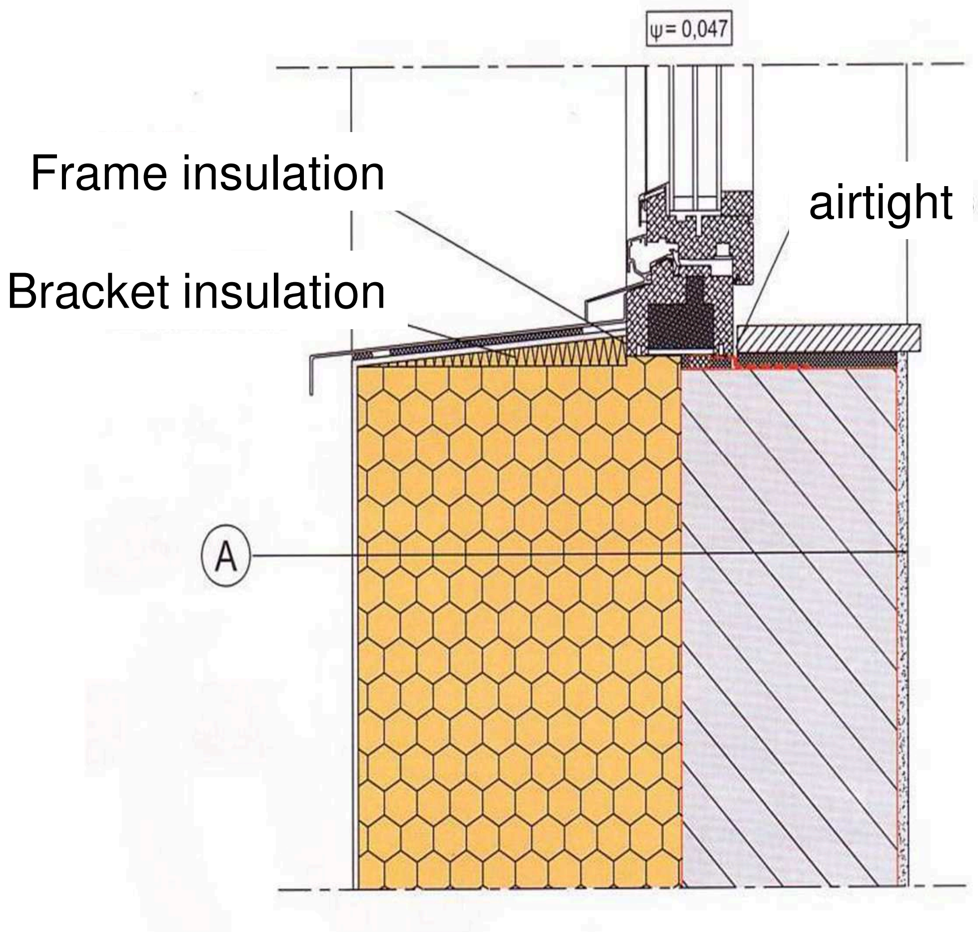
$U_w \leq 0{,}8\ W/m^2K$

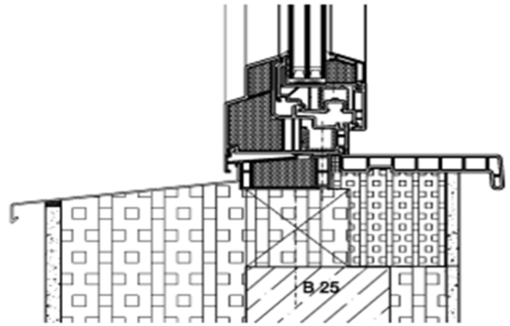


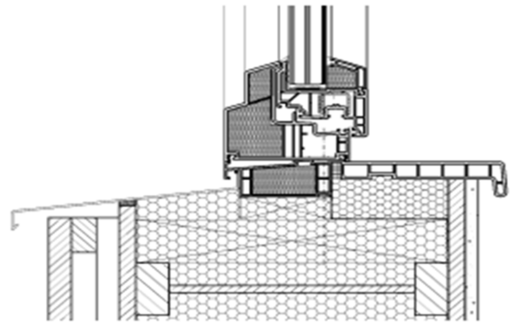


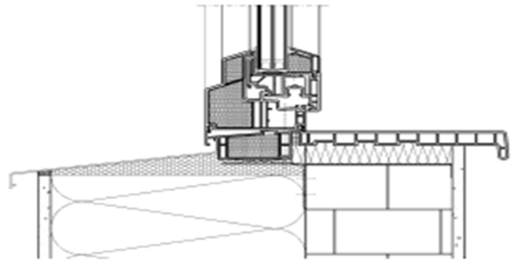
- To build Passive Houses, highly efficient windows have to be used.
- The type of glazing and frames will depend on climate.
- In the Central European climate there are three essentials:
  - *Triple glazing* with two low-e-coatings,
  - *"Warm Edge" - spacers*,
  - *Super-insulated frames*.

Examples of constructions suitable for passive houses with an excellent thermal insulation
WINDOWS









AIR TIGHTNESS

- Further, achieving air tightness should not be mistaken with the function of a "**vapour barrier**".
- The latter is a diffusion tight layer: An oiled paper is **airtight, but it allows moisture vapour to pass through**.
- **Conventional room plastering** (gypsum or lime plaster, cement plaster or reinforced clay plaster) **is sufficiently airtight**, but allows vapour diffusion.

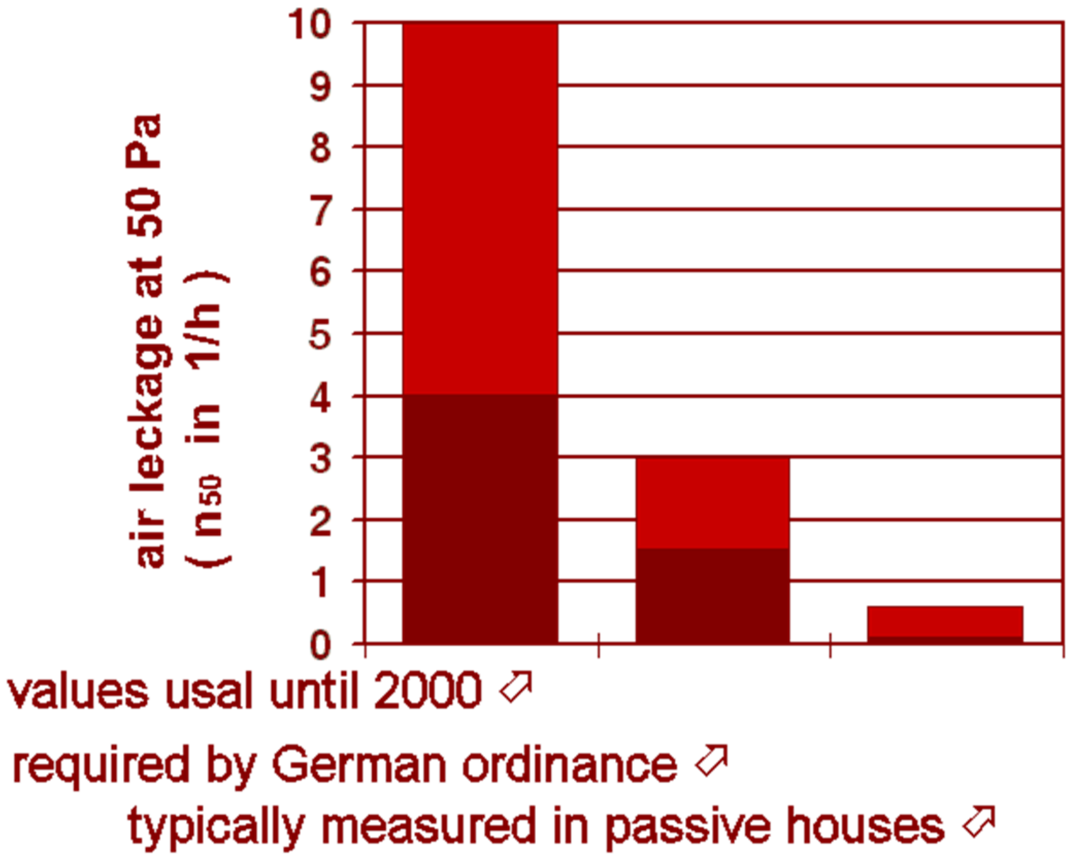
Air Tightness to Avoid Structural Damages

- The external envelope of a building should be **as airtight as possible** - this is true for conventional as well as for passive houses. It is the only means to **avoid damage caused by condensation of moisture**, room warm air penetrating the construction.

- The new German building code addresses the air tightness of new constructions. Without a ventilation system the n_{50}-airchange-values have to be less than 3 l/h, with ventilation systems 1.5 l/h. From the experience in low energy houses **recommended tighter construction** (lower n_{50}) **leakages**.

- In passive houses far better n_{50} leakage rates are frequently achieved. The requirement is n_{50} **not greater than 0.6 l/h**.

The diagram compares the air tightness of passive houses to that of existing and typical new construction.

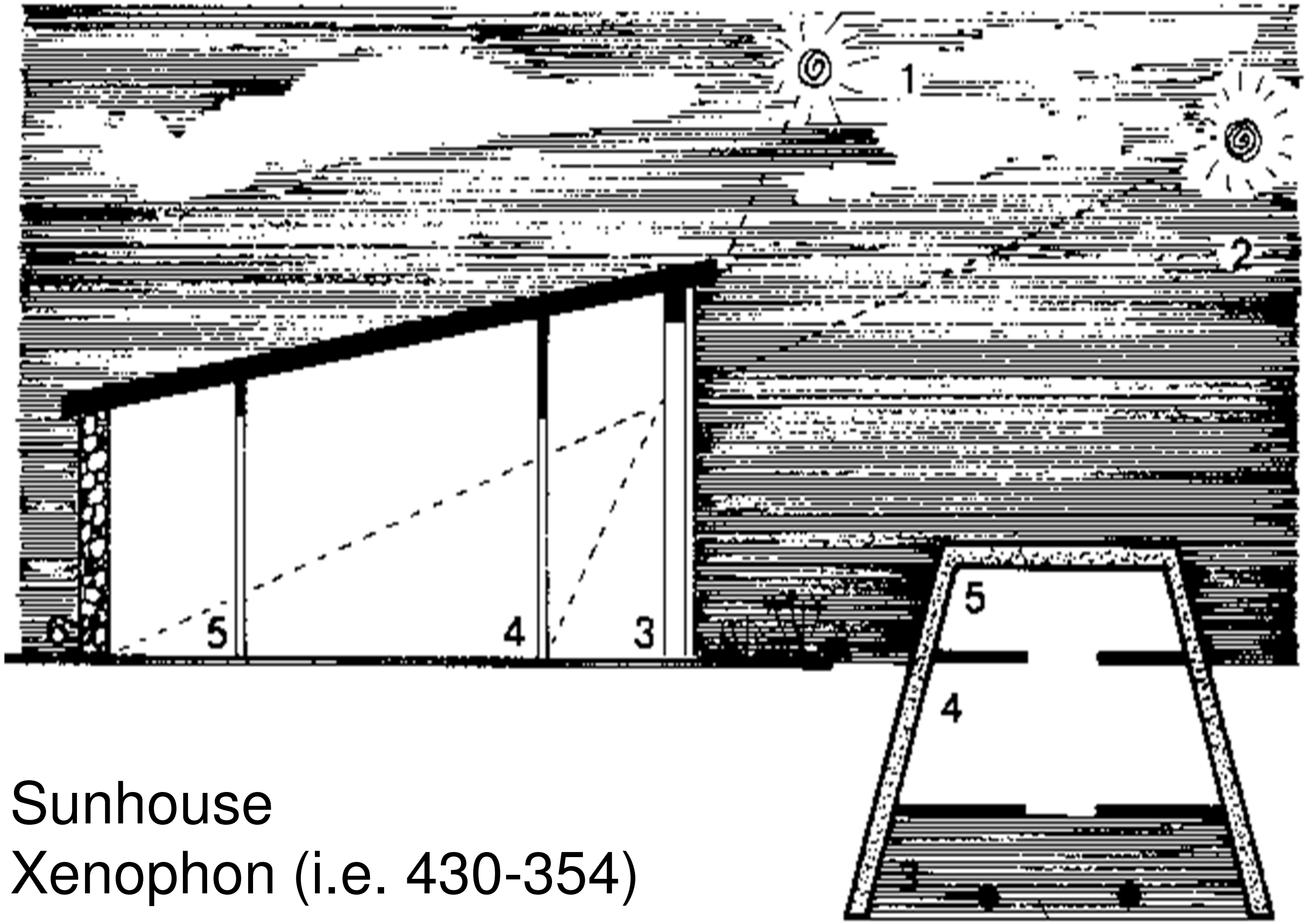


PHPP: Far More Than Just An Energy Calculation Tool

The Passive House Planning (Design) Package (PHPP) includes:

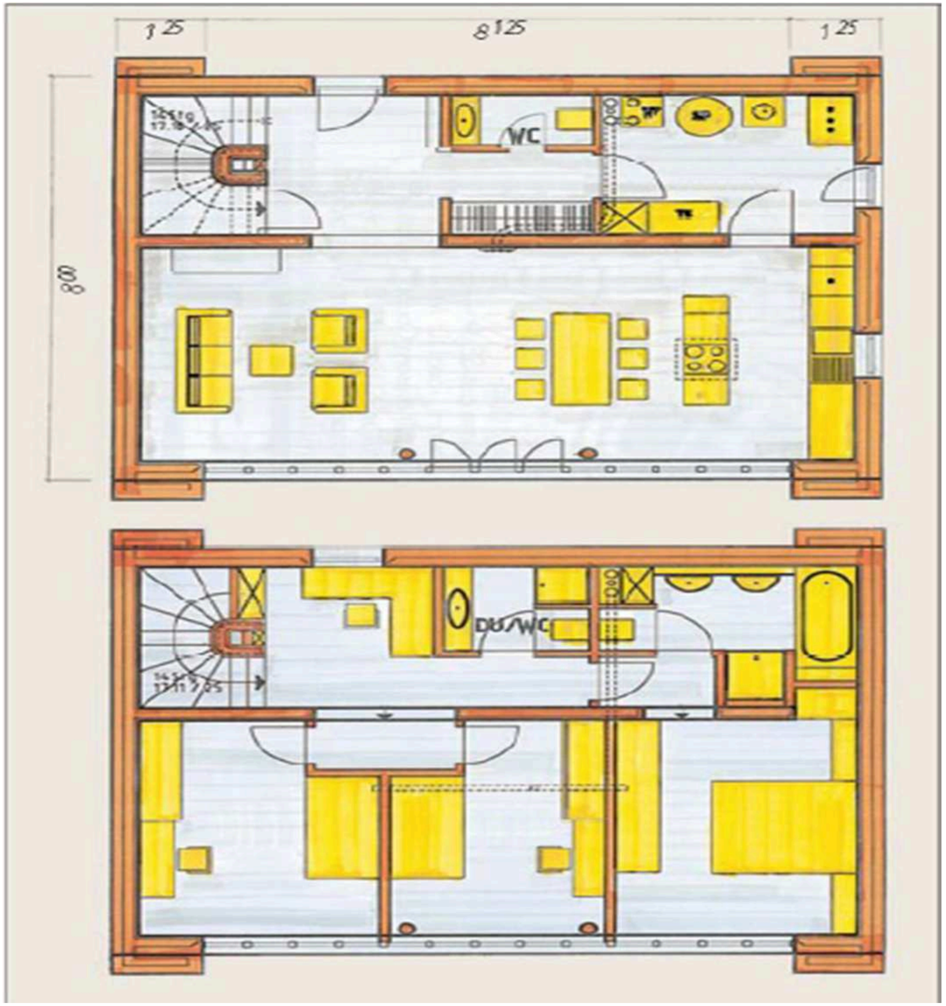
- **energy calculations** (incl. U-values)
- design of **window specifications**
- design of the indoor air quality **ventilation system**
- sizing of the **heating** load
- sizing of the **cooling** load
- forecasting for **summer comfort**
- sizing of the heating and **domestic hot water systems**
- calculations of electricity, primary energy requirements of such as well as projection of CO_2 emissions
- Climate Data Sheet: Climate regions may be selected from over **200 locations in Europe and North America.** User-defined data can also be used.

EXACT AND CONSCIOUS DESIGN
ORIENTATION

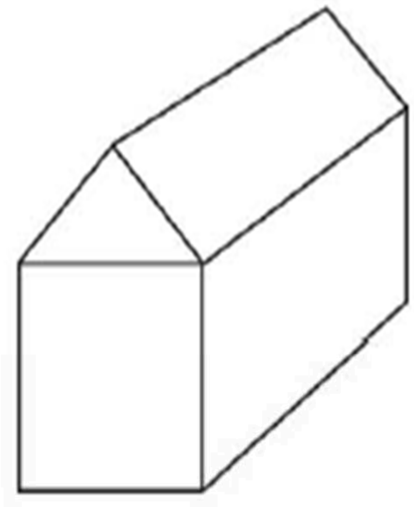


Sunhouse
Xenophon (i.e. 430-354)

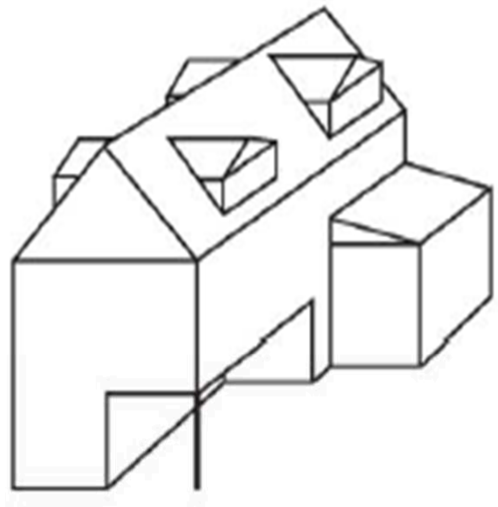
Horizontal plan of a TIPICAL passive house



Compact form of the building

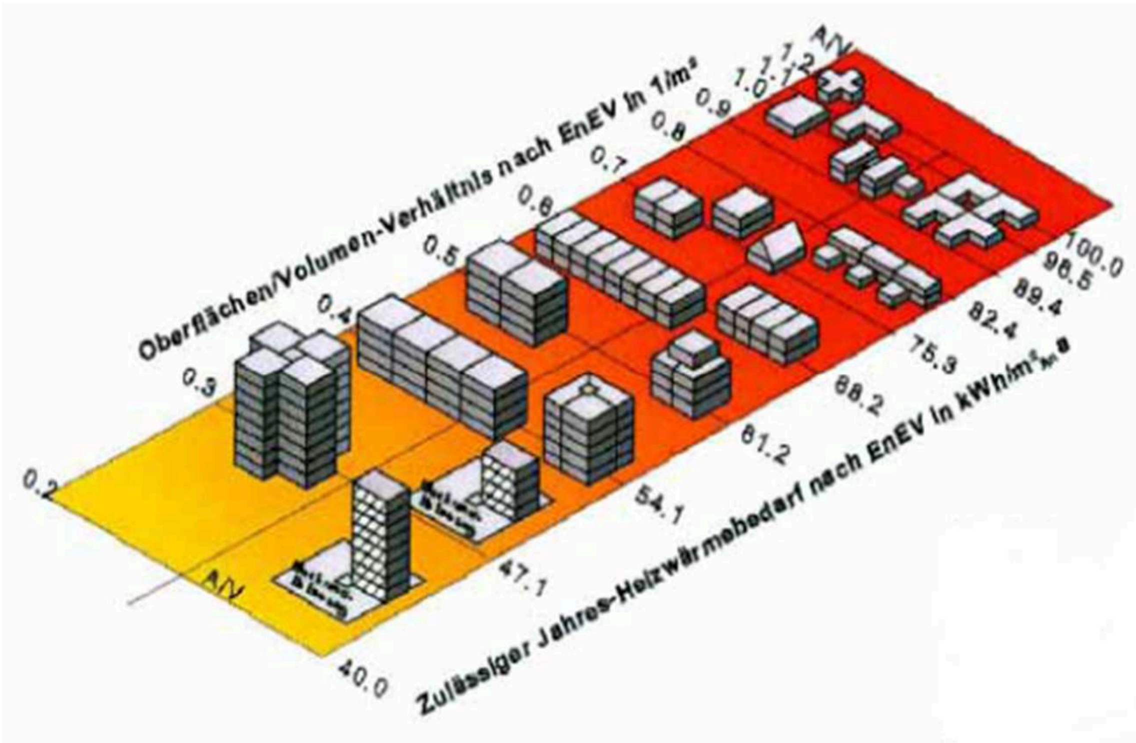


$$\frac{A}{V} = \frac{325{,}7\ m^2}{400\ m^3} = 0{,}81$$



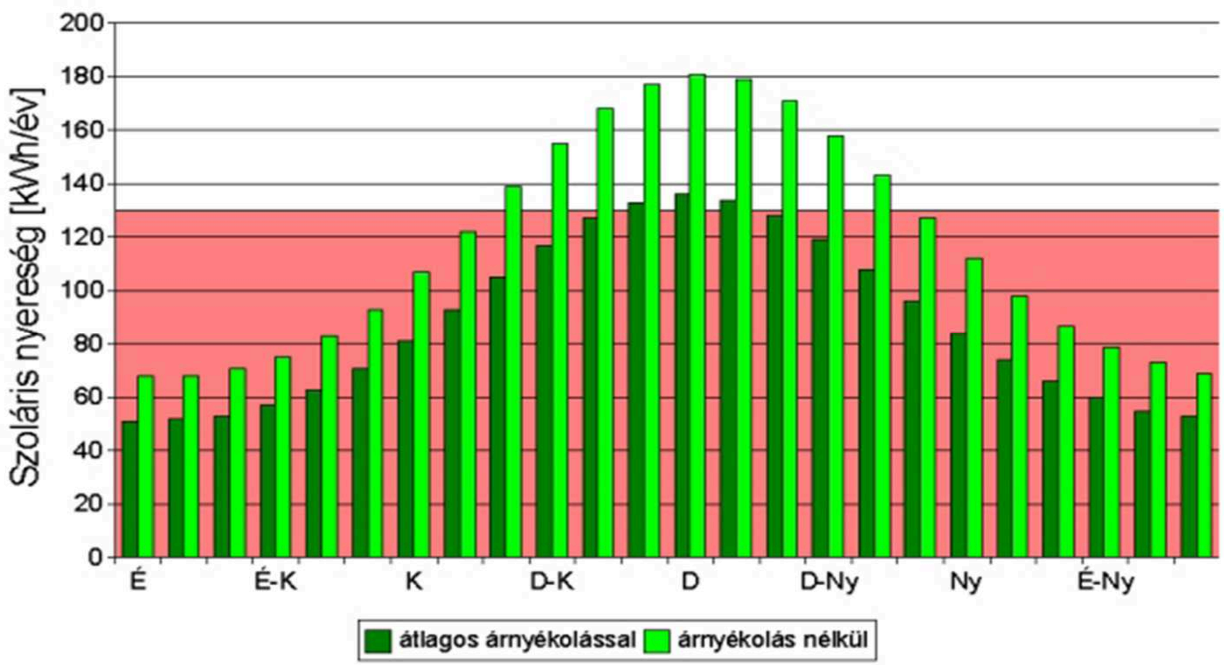
$$\frac{A}{V} = \frac{376{,}3\ m^2}{400\ m^3} = 0{,}94$$

Compact form of the building



A/V and the heatig energy consumptions

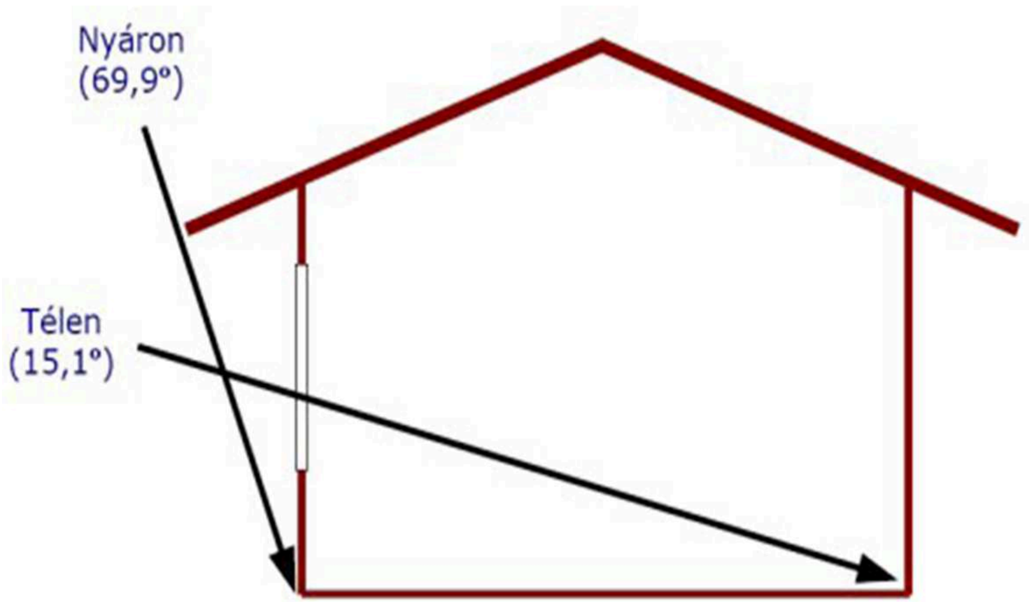
Solar proceeds and orientation of windows (with and without screening)



The scale of windows in compare to area ground space is not more than 30-40%.

70% of the windows are on the south side of the building (+/- 30°).

PASSIVE SCREENING
IN THE SUMMER AND IN THE WINTER

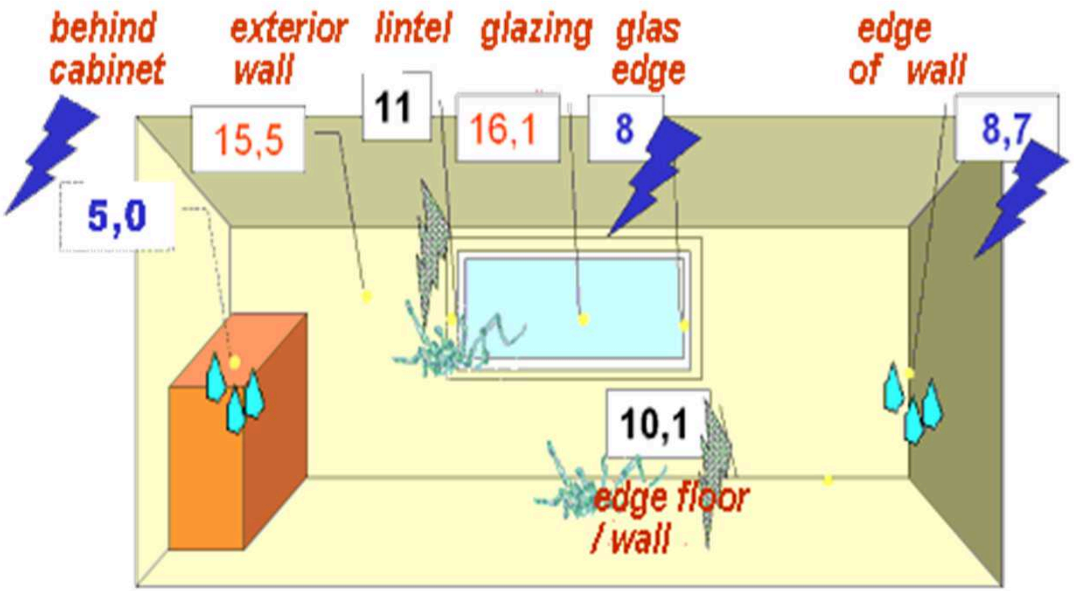


- **deciduous trees,**
- **fix screening,**
- **moving screening,**
- **balcony,**
- **other buildings**

Modernization of Old Buildings:
High Energy Efficiency is Better

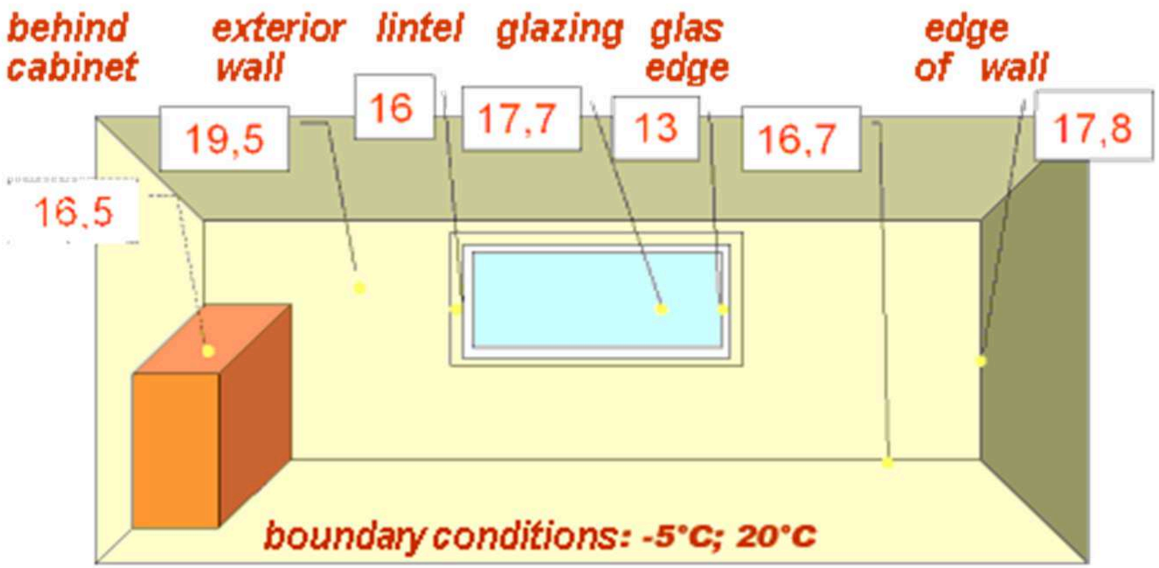
- Rennovated buildings usually have an **existing heat distribution** system
- and there is no reason not to **use the very same system** after renovation
- With the renovation the **heat requirement is reduced**, then the system temperatures can also be reduced.
- Therefor, **high efficiency** boilers and heat pumps can then be used.
- Good thermal insulation and high efficency mechanical equipment go hand in hand.

Modernization of Old Buildings



Old building – situation without insulation
*Example of conditions one usually finds in a **partially** modernized building: New windows were installed, but **no insulation was added** to the exterior walls. Under winter boundary conditions (outside -5℃; inside 20℃).*
In the uninsulated old building mould damage is caused by the increased humidity.

Modernization of Old Buildings



Well insulated (200 mm) building after renovation

*The concept that **better insulation reduces the danger of mold** growth is not limited to the case shown here. By increasing the insulation of the wall, interior surface temperatures rise. Systematic investigations show that adequate insulation all critical connection points raises surface temperatures high enough so that the relative humidity remains under 80% everywhere and therefore **problems with humidity are eliminated**.*

Comfort in the passive house - why better thermal insulation always leads to better comfort

- the air is **not too humid**,
- **air speeds** remain within the **acceptable** limits
- the difference between **radiant and air temperature** remains small,
- the difference of the radiant **temperature in different directions** remains small
- the room air temperature stratification is less than 2 °C **between head and feet** of a sitting person
- The **temperature varies less than 0.8 °C** within the living area

Examples of Passive Houses

Passive House Darmstadt Kranichstein – the first Passive House, built in 1990. Four terraced houses in solid building, first use of insulated window frames. Architects: Prof. Bott /Ridder /Westermeyer.

Examples of Passive Houses

The **first multi-storied Passive House** in a social housing scheme – built from GWG Kassel and planned by the architects Prof. Dr. Schneider, Hegger (HHS) and Nolte (ASP).

Examples of Passive Houses

In the year 1999, architect Prof. Hermann Kaufmann realized his **architectural office** Kaufmann-Lenz-Gmeiner in the city of Schwarzbach/Voralberg according to Passive House standards.

Examples of Passive Houses

Single-family Passive House in Lindlar near Cologne. Architect: Manfred Brausem, built in 1998

Examples of Passive Houses

Single-family Passive House in Ardagger, designed by the architects Prehal and Poppe.

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