Multi-Comfort House

Live comfortably – Save natural resources.

Built for the future: The ISOVER Multi-Comfort House.

ISOVER

Our comfort must be Nature's comfort.

Dear house owners, planners and architects, *"My home is my castle" will be topped in the future by "My home is my ISOVER Multi-Comfort House". For this reason, we have created this brochure. Needless to say that you will find here all those many arguments which speak in favour of building according to the passive house standard: ecological, economical and quite comfortable reasons. For the ISOVER Multi-Comfort House compromises on nothing, least of all energy waste.*

But our brochure offers much more than just arguments. It can be a source of information and help you with the planning and realization of any kind of building project. And should you need further support: we will be glad to help you – any time.

Good luck and have a good life!
Your Saint-Gobain ISOVER Team

The Kyoto Protocol is a climate protection initiative. The Passive House is active climate protection.

Everybody talks about increasingly extreme weather events, but only some take action. With their signature under the Kyoto Protocol, a Climate Protection Agreement, more than 140 industrial nations committed themselves to drastically reduce their CO_2 emissions. This means: highest priority for economizing on our natural resources and for using energy-saving technologies on a worldwide scale. Against this background it seems obvious that each and every one of us should contribute to more economical housekeeping – for example by building and living while making most efficient use of energy.

Make your decision for the ISOVER Multi-Comfort House – Combine comfort & environmental protection under one roof.

Live comfortably. Make no sacrifices. But go easy on the environment all the same. A fantastic vision? Much more than that. The ISOVER Multi-Comfort House can make this vision come true. No matter what you have in mind: the passive house standard allows you to realize all your building dreams. Quite simple. Economical. Energy-efficient **... and it pays off – cash!**

State-of-the-art knowledge for an excellent energy balance.

It is the details in the ISOVER Multi-Comfort House that play such an important role. Because quality is the most essential precondition for an excellent energy balance. That's why we have created this brochure. It contains all you would and should like to know as a house owner, planner or architect. Clearly arranged in five chapters.

Pettenbach, Upper Austria: Refurbishment of an old building acc. to passive house standard. G. Lang Consulting.

The planning CD with construction examples.

List of Contents

For a good life. For every one. For

Simply move in and feel at home.

Life in an ISOVER Multi-Comfort House does not need time for settling in. For the simple reason that you won't miss anything. Except maybe a couple of annoyances. But honestly: who will seriously long for cold feet, draughty corners and musty or overheated rooms? In the passive house, however, everyone can enjoy their own patch of paradise.

No freezing and no sweating.
You will enjoy agreeable room temperatures between 20 and 23 °C – all year round. Scientifically this has been proven to be the ideal temperature range for relaxed living and efficient working. And most of the year without any heating at all.

Draw a deep breath – day and night.
Even allergy sufferers never run out of good air in an ISOVER Multi-Comfort House. Thanks to the Comfort Ventilation System which is part of a passive house's basic equipment. It works similar to the human lung. A permanent flow of filtered fresh air constantly ensures best air quality, free of dust, pollen and aerosols, while at the same time removing stale air. And in the same breath, heat distribution and heat recovery take place in the entire house.

Built-in safety to ensure long life.
Last but not least, this also applies to the building fabric. Thanks to its ideal humidity, the good air in the ISOVER Multi-Comfort House prevents the formation of mould and thus structural damage into the distant future. And this ensures the building's high resale value – just in case.

Build with all comfort. And gain energy at the same time.

The most inexpensive energy is the one that is not consumed in the first place. It does not need to be generated, imported, or paid for. Naturally, this also doesn't have any harmful effects, neither on human beings nor the environment. This is the basic concept of the passive house. Since a sufficient amount of warmth remains in the house, any active heat supplied by traditional space heating is usually superfluous. This saves energy and costs. The more so in view of further increasing world market prices for limited resources such as oil and gas. Thanks to its uncomplicated technical equipment, the ISOVER Multi-Comfort House requires very little maintenance.

ever.

The passive house standard gives you all the freedom you want.

A passive house does not define itself by outer appearance but by its inner values. Therefore any type and size of building can be realized. Every year, a growing number of examples testify to that. Whether one-family house or industrial estate. Whether school or church or mountain shelter. And it is no longer only the new buildings which comply with this future-oriented building standard. There is an increasing number of existing, old and even historical buildings where the refurbishment is based on passive house principles. By using well-selected passive house components it is possible to achieve ecologically and economically sensible results.

Office and residential building in Mosnang. Insulated with Flora natural hemp by ISOVER. Architect: Monika Mutti-Schaltegger.

Snugly warm with 10 tea lights.

Count on energy savings of up to 75 %.

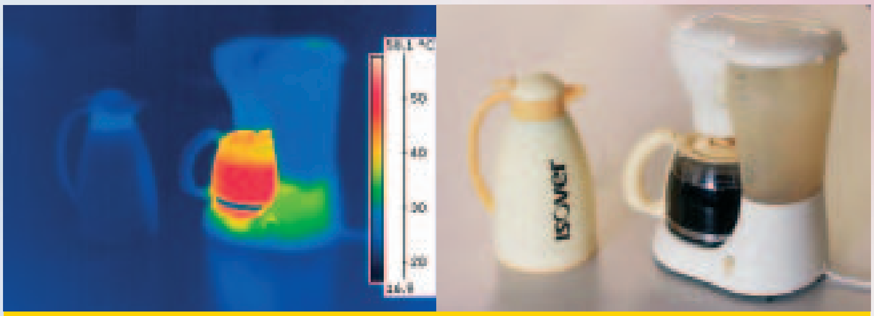
College of Physical Education Albstadt, Architect Prof. Schempp, Tübingen, Germany

Compared to conventionally built new houses, the space heating requirement of a passive house is lower by about 75 %. And in contrast to old buildings, savings amount to as much as 90 %. In cold winters, a room of 20 m^2 can be heated with just 10 tea lights or two bulbs of 100 watts each to keep it snugly warm. In terms of fuel consumption, a passive house needs less than 1.5 l heating oil or 1.5 m^3 natural gas per square meter and year.

WeberHaus, Rheinau-Linx

The motto for all rooms: Keep the warmth inside!

Based on the thermos flask principle, the ISOVER Multi-Comfort House retains its comfortable temperature. As in the thermos flask, the interior is well protected against loss of heat. Active heat from outside is supplied in a controlled way. The passive house really lives up to its name by making extensive use of "passive" components. These include heat-insulating windows, heat distribution systems in the heated space and, above all, efficient thermal insulation to ensure that the warmth is kept inside.

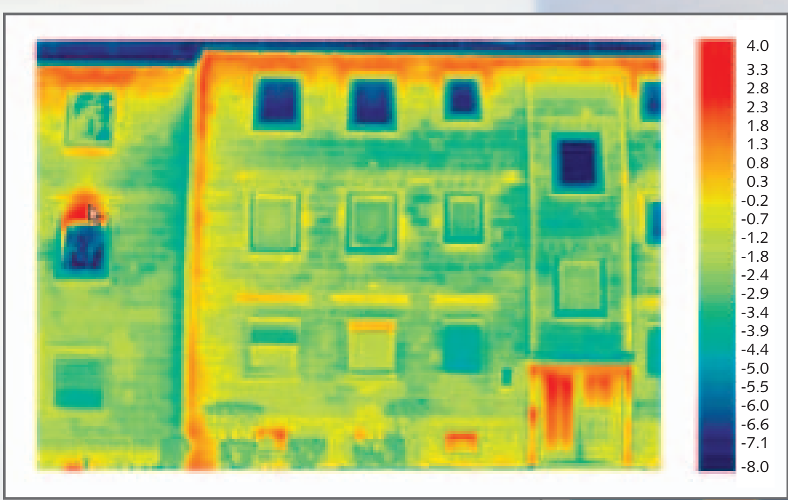


Modern comfort: keeping warm without consuming energy.

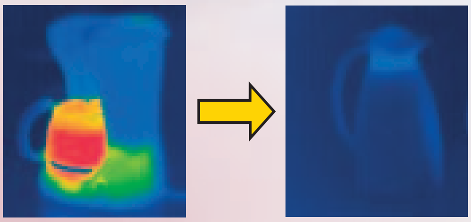
Every occupant is a heat source.

Unlike conventional buildings that suffer high losses of heat to the outside, the thermal discharge of humans, animals and household appliances is quite important for covering the required amount of heating energy. Every person contributes by a calorific value of approx. 80 watts to heating up the interior. Considerable heat gains are realized through the windows which in winter allow higher amounts of sun energy to enter the house than those lost to the outside. Add to this the heating energy recovered from the exit air and you can normally save yourself the expense incurred by a conventional heating system.

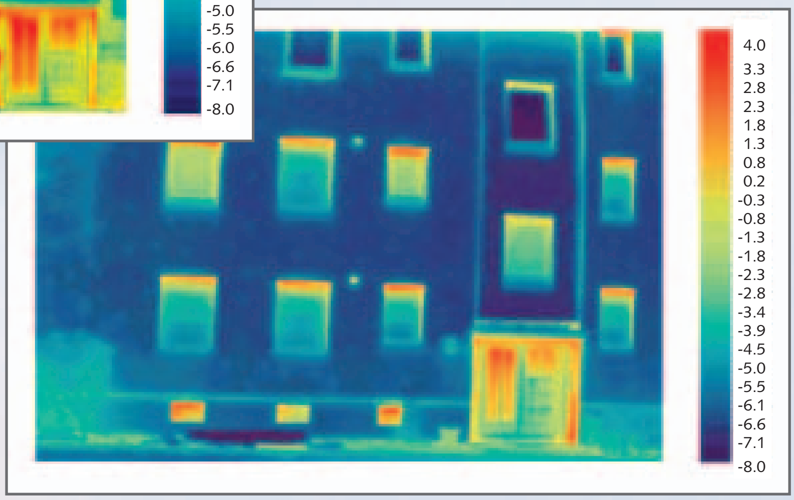
Multi-family house after energetic refurbishment



Thermographic picture – before refurbishment: The entire house is a thermal bridge.



From active to passive!



Thermographic picture – after refurbishment: The external wall is thermally insulated, but heat still leaks through windows and doors.

Everything well-insulated and airtight.

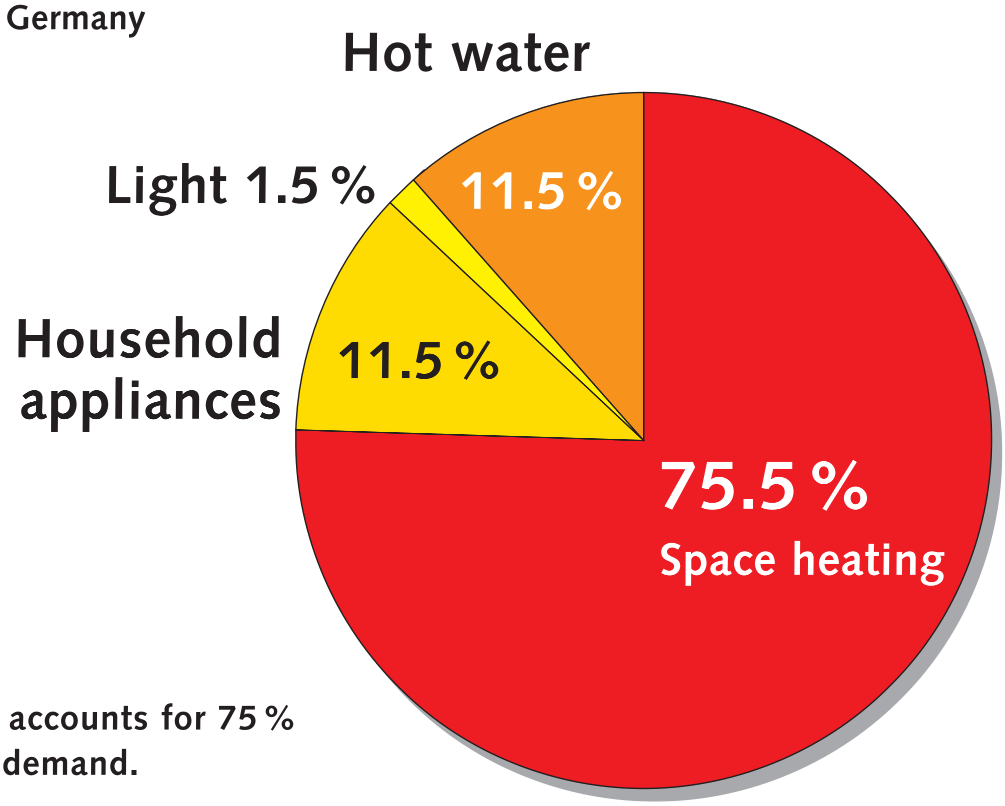
From the roof down to the foundation slab: a jointlessly sealed and airtight building envelope ensures thermal and acoustic insulation. And the ventilation system – complete with heat recovery – takes care of fresh air supply and heat distribution.

Always ahead – simply unrivalled.

Indicators: A car's fuel consumption is a house's U-value.

The energy coefficient or U-value of the ISOVER Multi-Comfort House is the best indicator of its economy. Houses with ideal southern exposure can even remain under the maximum annual heating demand of 15 kWh per square meter and year. This value makes other newly built houses look like veritable energy wasters.

Final energy consumption* of private households in Germany

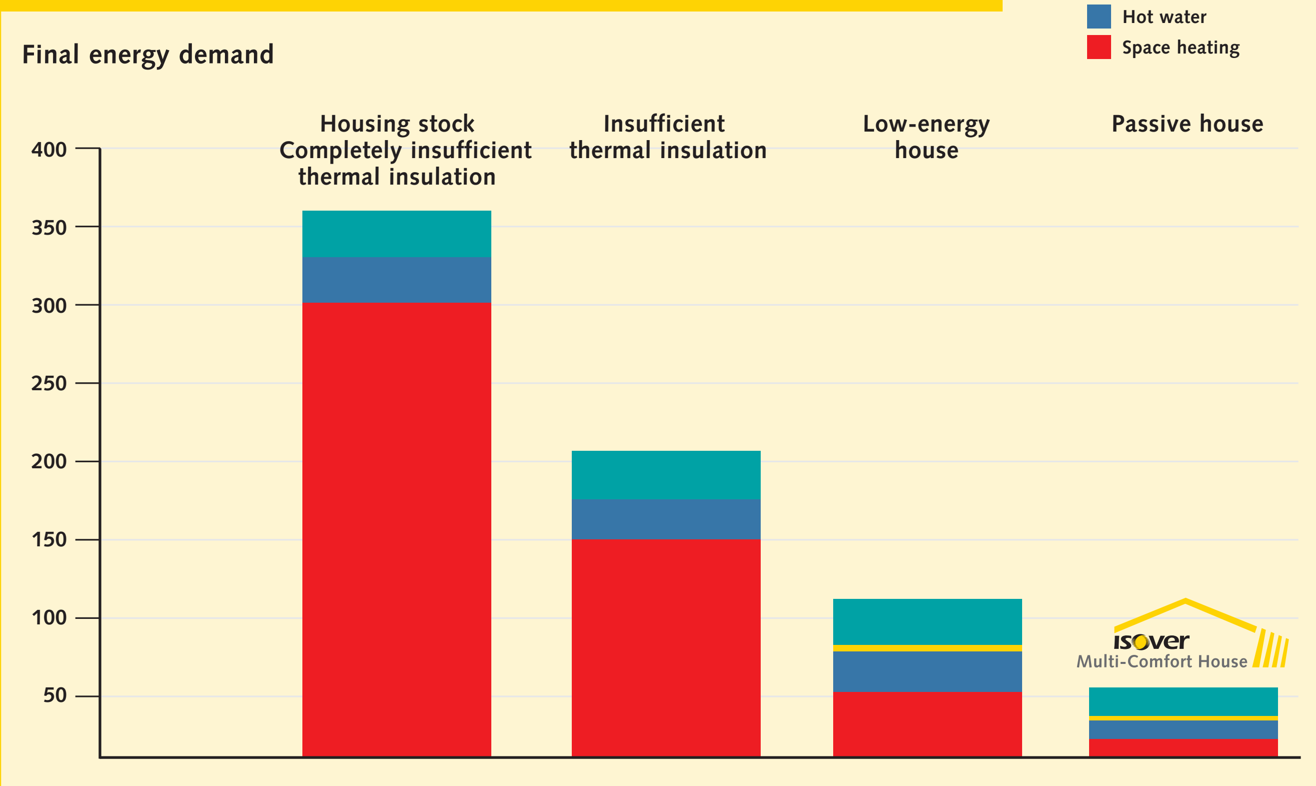


* Electricity, gas, oil, petrol etc. Source: VDEW, issued in 2002

Space heating accounts for 75 % of our energy demand.

Building and living is regarded to be that sector of life which is most harmful to our climate. For instance, an approximate 3000 kg oil equivalents per capita still vanish into thin air every year for providing hot water and space heating (example: Western Europe). However, 90 % of this energy can be saved today. Without high investment cost. Even state-sponsored in many cases. Always comfortable in the ISOVER Multi-Comfort House.

Energy demand in kWh per m² useful living space and year



Heating energy demand of a typical one-family house	kWh/m²a 300-250	kWh/m²a 150-100	kWh/m²a 50-40	kWh/m²a ≤ 15
BUILDING STANDARD	**Completely insufficient thermal insulation** Structurally questionable, cost of heating no longer economical (typical of rural buildings, non-modernized old buildings).	**Insufficient thermal insulation** Thermal renovation is clearly worth the trouble (typical of residential houses built in the 50s to 70s of the last century).	**Low-energy houses**	**Very low energy houses** (passive houses need to meet this parameter as part of the requirement profile)
BUILDING ELEMENT	**Typical U-values and insulation thicknesses**			
External walls (massive wall of 25 cm) Insulation thickness	1.30 W/(m²K) 0 cm	0.40 W/(m²K) 6 cm	0.20 W/(m²K) 16 cm	0.13 W/(m²K) approx. 30 cm
Roof Insulation thickness	0.90 W/(m²K) 4 cm	0.22 W/(m²K) 22 cm	0.15 W/(m²K) 30 cm	0.10 W/(m²K) 40 cm
Floors to ground Insulation thickness	1.0 W/(m²K) 0 cm	0.40 W/(m²K) 6 cm	0.25 W/(m²K) 10 cm	0.15 W/(m²K) 26 cm
Windows	5.10 W/(m²K) Single glazing	2.80 W/(m²K) Double glazing, insulation glass (air-filled)	1.10 W/(m²K) Double glazing, thermal insulation glazing	0.80 W/(m²K) Triple glazing, thermal insulation glass, special frame
Ventilation	Leaky joints	Open the windows	Exhaust air unit	Comfort ventilation with heat recovery
CO_2 emission	60 kg/m²a	30 kg/m²a	10 kg/m²a	2 kg/m²a
Energy consumption in liters heating oil per m² living space and year	30-25 liters	15-10 liters	4-5 liters	1.5 liters

Live comfortably – and make high

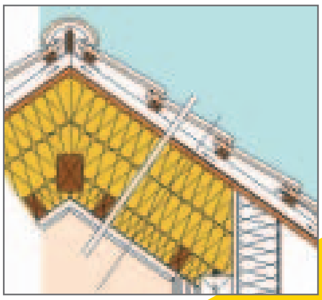
Air temperature 20-23 °C, relative air humidity 30-50 %.

In order to enjoy such agreeable living conditions, you have to dig deep into your pockets with conventionally built houses. Not with the ISOVER Multi-Comfort House where highest living comfort in all rooms helps you save a lot of cash. Even if the construction of such a house may incur extra cost, the total financial burden will be significantly lower compared to a conventionally built new house – thanks to extremely low energy costs over its useful life.

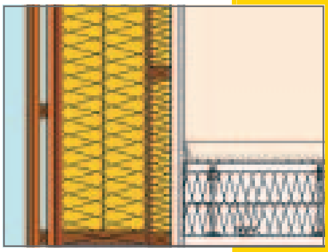
Point by point a profitable system.

- *Heat-insulating roof structure*
- *Heat-insulating wall structures*
- *Heat-insulating floor structures*
- *Airtight building envelope*
- *Triple-glazed windows*
- *Heat-insulating window frames*
- *Comfort Ventilation System*
- *Optimum installation*

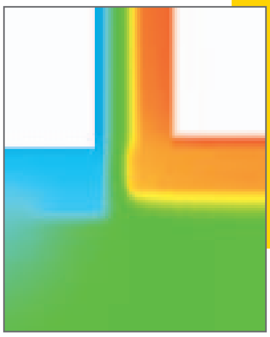
U-value 0.1 W/m^2K



Airtightness



U-value 0.1 W/m^2K



Largely reduced thermal bridges

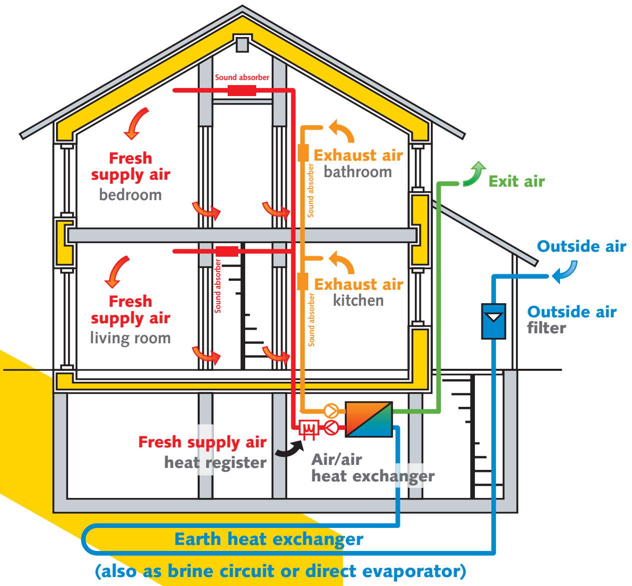
Heating energy demand: < 15 kWh/m^2a

Max. 10	W/m^2	Heating load calculated according to the Passive House Planning Package
Max. 15	**$kWh/(m^2a)$**	**Specific heating energy demand**
40-60	$kWh/(m^2a)$	Specific total[1] final energy demand
100-120	$kWh/(m^2a)$	Specific total[1] primary energy demand

Reference area (m^2) is the heated useful living space.

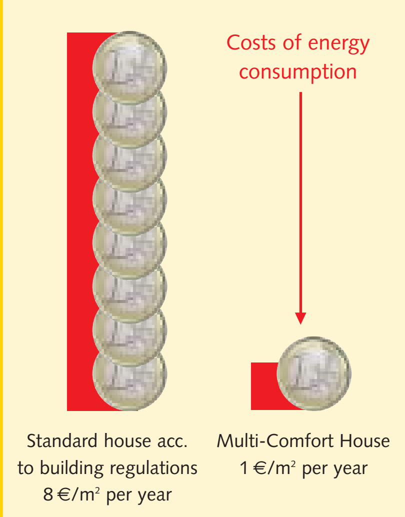
[1]total = including all of the household's energy consumers (heating, hot water, ventilation, pumps, lighting, cooking and household appliances)

savings.



Improvement by 8:1 compared to building regulations. That's life in an ISOVER Multi-Comfort House.

Compared to the passive house standard, not only conventionally built new houses but even more progressive types such as the low-energy house are comparatively expensive. Whenever possible, choose the passive house standard right from the start. After all, how often do you build a house? Just once in a lifetime.

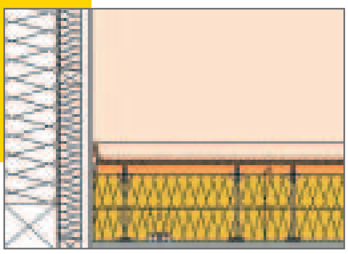


U-value 0.7 W/m²K

Planning with maximum precision and responsibility.

Optimum house location, correct positioning of windows and doors, proper dimensioning of the ventilation system, very high insulation standard, tight building envelope – all these factors are considered before building an ISOVER Multi-Comfort House. Special attention must be paid to avoiding thermal bridges. Thermal bridges and leaks have serious consequences for every type of building. Technically as well as energetically.

U-value 0.12 W/m²K



Cosiness.

When living in a passive house, the enclosing areas such as walls, floors and windows have very pleasant inner surface temperatures, even at very low outdoor temperatures. External walls as well as floors above the cellar are only by 0.5 to 1 degree cooler than the room air temperature. Passive house windows are by 2 to 3 degrees cooler than the room air temperature. In houses that do not comply with the energy standard of a passive house, such a high degree of cosiness can only be reached with considerably higher heating costs.

A lifetime investment which pays off

Profitable also under financial aspects. An example of subsidized housing in Lower Austria.

True, if you want to enjoy the benefits of a Multi-Comfort House, you'll first have to dig a bit deeper into your pockets. Due to the high quality of the single components, construction costs are currently around 5-8 % higher than for standard houses. But there are signs that the cost difference will gradually diminish in the course of realization. Some passive houses have already been built at prices typical of conventional housing.
The reason? Well, increasing demand, of course. The higher the number of passive houses built, the cheaper the production of high-quality building components and the lower the total price of the building. A look at total profitability will finally convince you. As soon as you include the current expenses for operation, maintenance and repair, the ISOVER Multi-Comfort House shows itself at its best. Thanks to the minimum annual demand for heating and water of currently 100 to 160 EUR, the extra costs pay off after only a few years. One example for illustration: In a standard house built according to the latest Austrian Building Regulations, energy costs account for 4.23 % of the monthly total burden – compared to a mere 0.35 % in a passive house. Should energy prices continue to rise or even double over the next few years, their share of total costs will inevitably rise to 8 % and more in conventionally built homes – making cost savings for passive house owners grow even further. If you also consider that household net incomes in Europe decrease by an average 1-2 % p.a., the passive house is the low-cost alternative of the future.

Cost benefits today

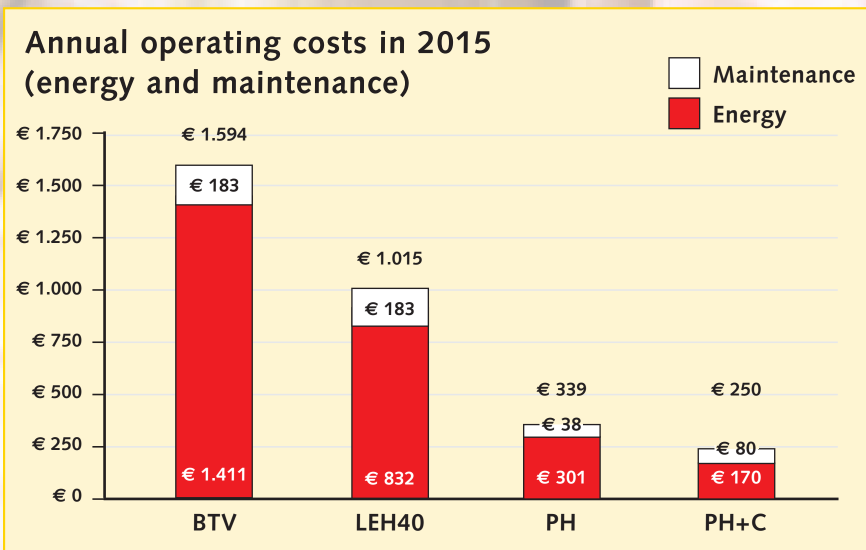
Energy costs	Standard	LEH	PH	PH+C
per year in EUR	788 100 %	465 59 %	169 21 %	95 12 %
Operating costs sum total in EUR	934 100 %	611 65 %	199 21 %	159 17 %

Source: E. M. Jordan, "Über die Wirtschaftlichkeit von Niedrigenergie- und Passivhäusern unter besonderer Berücksichtigung der Bedingungen in Niederösterreich." (About the profitability of low-energy and passive houses with special consideration of the conditions in Lower Austria)

Standard: house acc. to the Building Regulations of 1985
LEH: low-energy house
PH: passive house
PH+C: passive house with collector

daily.

Cost benefits in 2015



Source: E. M. Jordan, "Wirtschaftlichkeit des Passivhauses – Architektur zum Wohlfühlen als Preisschlager unter besonderer Berücksichtigung der Bedingungen in Niederösterreich." (Profitability of the passive house – "Feel-good" architecture at bargain prices under special consideration of the conditions in Lower Austria)

With a current price increase of 6 % per year, heating costs will have doubled in ten years!

BVT A house complying with the NÖ Bauordnung (Lower Austrian building regulations) resp. the NÖ Bautechnikverordnung (Lower Austrian building code).

NEH40 A house achieving an annual heating demand of requirements of 40 kWh/m²a (according to EN 832).

PH A passive house – this example house was actually built!

PH-K A passive house with a solar collector for domestic hot water preparation.

Go easy on energy – get high subsidies.

The higher construction costs incurred by passive houses are offset right from the start if you can benefit from state subsidies. Building a Multi-Comfort House entitles you to maximum financial support, thus making it a profitable project for all parties involved. And rightly so! If people actively support better building quality, this does not merely reflect an idealistic concern for our environment, but a turn towards sustainable profitability – both for the individual and society as a whole.

Point by point:

The ISOVER Multi-Comfort House can score many points in a cost/benefit analysis:

- *Energy-saving construction pays off from the very first day*
- *Safe investment into the future*
- *Added value every year through decreasing operation costs*
- *Comfortable living in all seasons*
- *Longer useful life thanks to highest quality standard*
- *Valuable contribution to sustainable climate protection*

Multi-Comfort House

The Planning.

Circumspect & meticulous.

- A heating energy demand of 15 kWh/m²a.
- Always based on a holistic concept.
- The planning steps: from idea to realization.

A heating energy demand

Where a heating energy demand of 15 kWh per square meter and year is achieved, economy, building physics and design are are in perfect harmony.

Judging from its outer appearance alone, an ISOVER Multi-Comfort House may resemble conventional design patterns. But when it comes to interior design, meticulous planning is indispensable. This is more demanding and more cost-intensive – at least at the start. Eventually, however, the new concept will facilitate realization and help achieve the decisive energy balance: low heat losses on the one, solar and internal heat gains on the other hand. The occupants benefit from low heating costs while enjoying high living comfort and the long-term appreciation of their homes.

These are the values you can expect from your ISOVER Multi-Comfort House:

Max. 10 W/m²	Heating load calculated according to the Passive House Planning Package (PHPP)
Max. 15 kWh/(m²a)	**Specific heating energy demand acc. to the PHPP**
40-60 kWh/(m²a)	Specific total* final energy demand
100-120 kWh/(m²a)	Specific total* primary energy demand

Reference area (m²) is the heated useful living space.

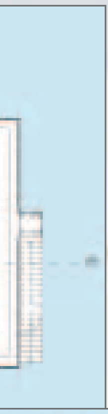
* total = including all of the household's energy consumers (heating, hot water, ventilation, pumps, lighting, cooking and household appliances)

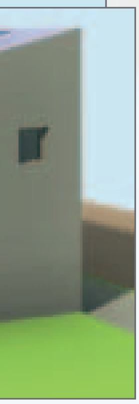
One team. One plan. One house.

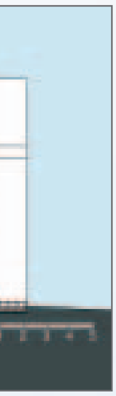
Careful planning is one thing, excellent workmanship another. Why? Because a passive house has only a limited "energy budget". Its energy performance must therefore be guaranteed for many decades. In the long run, the quality of workmanship is even more important for the building's energy efficiency than the U-values calculated for the individual structural components. By the way: in an ISOVER Multi-Comfort House you will never find the structural damage frequently caused by condensation and moisture.

Draft of an ISOVER Multi-Comfort House in Bougival near Paris. Architect: Vincent Benhamou.

# of 15 kWh/m^2a: that's the benchmark.







Quality assurance right from the start.

Specialist companies normally guarantee that the predefined values are achieved. Nevertheless, it is highly advisable to incorporate quality assurance measures in the invitation to tender. These include above all:

- Energy demand calculation which is made independently of the client
- Measurement of airtightness (the so-called "Blower Door Test")

Meticulous planning facilitates the craftsmen's work.

While the planning of passive houses is a highly demanding job that requires both elaborate design and the consideration of high efficiency standards plus controlling, the craftsman's job is comparatively easy. One example: Roofs are planned to be free of penetrations as far as possible. Easier to build, faster to realize.

Point by point: Success factors for the passive house standard.

Primary factors

- *Maximum thermal insulation, structural compactness and freeness of thermal bridges: All components of the building envelope are insulated at a U-value below 0.15 $W/(m^2K)$, achieved by insulating thicknesses between 25 and 40 cm.*
- *The windows must have triple glazing and insulated frames. Aim: a U-value of < 0.80 $W/(m^2K)$, including the frame, and a g-value of 0.5 (total solar energy transmittance) for the glazing.*
- *Airtightness of the building: The result of the Blower Door Test must be < 0.6 air changes per hour.*
- *Heat recovery from the exhaust air: Over a counterflow heat exchanger, the major part of the warmth from the exhaust air is fed again to the fresh air supply – heat recovery rate above 80 %.*

Secondary factors

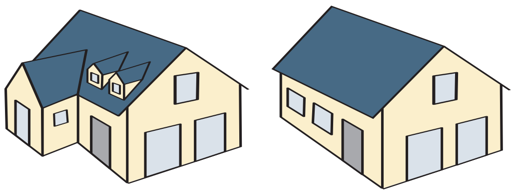
- *Pretreatment of fresh air: Fresh air can be pre-heated in winter and pre-cooled in summer via a geothermal heat exchanger (energy well).*
- *South orientation and freedom from shadows in winter: Passive use of solar energy saves heating energy.*
- *Domestic hot water generation: The required energy can be produced with solar collectors (energy demand for the circulating pump 40/90 watts per liter) or by air-to-water heat pumps (average coefficient of performance 4). In summer, the heat pump can also be used for energy-efficient cooling. Dishwashers and washing machines should be hot-water connected to save the energy needed for the heating process.*
- *Energy-saving household appliances: Fridge, oven, deep-freezer, lamps, washing machine etc. as efficient power savers are yet another useful constituent of the passive house concept. But this is something the occupants must take care of themselves.*

A concept that allows no

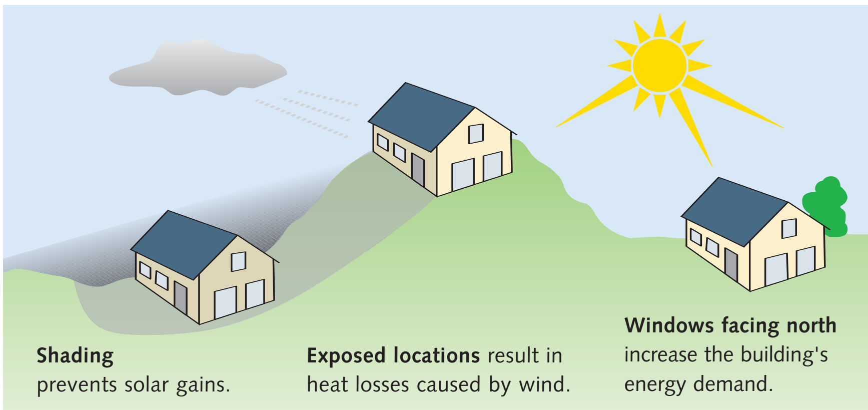
Compact design is most favourable.

In order to keep the costs of building an ISOVER Multi-Comfort House as low as possible, it is recommendable to choose a simple, compact design. Every exposed or projecting part of the building increases the energy demand. As far as the building's geometry is concerned, a favourable relation between envelope and volume definitely helps (minimization of the envelope enclosing the heated volume). Less building envelope area reduces the heat loss and the cost of construction.

House in Skaerbaek, Denmark, with favourable north/south orientation.



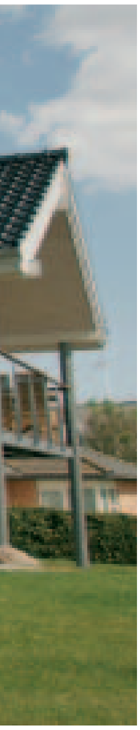
Complicated designs increase the energy demand compared to plain, compact building styles.



Plan with the sun.

In addition to the shape of a building, also location-related factors have a positive impact on the building's energy balance. If there is a choice, the ISOVER Multi-Comfort House should ideally face south. Without shade provided by mountains, surrounding trees or other buildings so that maximum solar gains can be achieved, especially in the cold winter months. It is therefore recommended that the window areas face south.

gaps.



Thermal bridge free construction down to the very last corner.

Thermal bridges are weak points of the building envelope and cause unwanted loss of energy. To build a thermal bridge free envelope therefore takes top priority in energy-efficient construction. In fact, the building envelope must be planned in such a way that every blueprint – whether floor plan or sectional drawing – can be circled with a pen "in a single breath".

The critical areas for potential thermal bridges are where the pen needs to stop. Here, it is necessary to work out detailed solutions – preferably in close cooperation with the craftsmen.

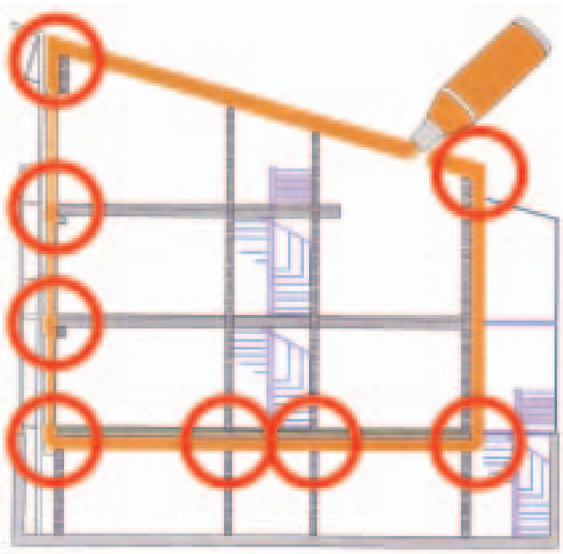


Fig. Passivhaus Institut Dr. Wolfgang Feist

Control is a must.

Just as essential as meticulous planning down to the very last detail is the execution of the Blower Door Test in the construction phase. This test checks the building's airtightness and is able to pinpoint secret energy wasters such as joints, cracks, thermal bridges or other leaky spots. This type of quality control assures long-term security – for the building as well as for all parties involved. The best time for carrying out the Blower Door Test is definitely after completion of the building envelope and airtight barrier and before installation of the interior insulation. This makes the detection of leaks and their sealing easier.

Point by point: These are the criteria to be fulfilled by a passive house.

- *High airtightness of the building envelope. The recommended value of 0.6 air changes at a 50 Pascal pressure difference should be observed and checked before completion.*
- *0.8 W/(m²K) is the benchmark for windows including frame, above all in rooms with large glass areas and little extraneous heat, produced e.g. by human beings or electrical appliances. To reach this aim it is absolutely necessary to install specially insulated windows and frames: even at glazing values below 0.6 W/(m²K).*
- *Continuous insulation and avoidance of thermal bridges/penetrations of the insulating envelope caused by cellar stairs, attic stairs, emergency chimneys.*
- *Ideally south orientation of the windows.*
- *Shading of east, south and west windows in summer.*
- *Compactness of the building envelope: V/A (volume to surface area ratio) should be between 1-4, A/V (surface area to volume ratio) should be between 1-0.2.*

Peace and quiet don't co
even in

Location is crucial.

How loud or quiet a building is depends first and foremost on the proper dimensioning of sound insulation with respect to the authoritative outdoor noise level. In the approach corridors of airports, along main roads and next to schools or swimming baths, a high level of external noise is inevitable. Here, more extensive soundproofing measures are necessary to ensure that the residents can live quietly. In these extreme conditions, the passive house shows itself off to best advantage: the windows need not be opened as fresh air is supplied via a ventilation system.

Meticulous planning.

If the building site is affected by excessive noise, the passive house can be located as far as possible away from the noise source. The windows of living and sleeping rooms should then be installed on the front facing away from the noise source. Depending on the dimensions of the house and its surrounding buildings, the sound level can be expected to be 5-10 dB lower. But since it is necessary to make passive use of solar radiation for heating, this might be feasible only to a limited extent.

Indoor and outdoor sound insulation.

Sound is a phenomenon that occurs both outside and inside the building, caused by talking, walking, music, sanitary installations, and outside. It is therefore requisite to provide adequate sound insulation – from the roof all the way down to the cellar. When planning the building's facade, window areas play an important role: they determine the acoustic insulation of the external wall. As they are transparent, their sound absorption capacity is much lower. To offset this shortcoming, the acoustic insulation of the light-proof components must be increased. Usually, a construction sound reduction index R'w of approx. 53 dB is required by law. When designing quietness into the interior, structural engineers differ between airborne and structure-

Multi-Comfort House

me easy – passive houses.

borne (resp. impact) sound. The sound reduction index indoors is determined by walls, doors and flanking components. In Europe, the recommended values are 40 to 48 dB. Impact acoustic insulation refers to the acoustic insulation of floors and stairs. If possible, an impact acoustic insulation L'nT,w+CI,50-2500 of 40 dB should be achieved for neighbouring flats and of 45 dB within a flat or one-family house. The recommended value for comfortable airborne sound insulation between individual flats is in the range of 58 to 63 dB (D'nT,w+C). On the whole, all building styles used in the construction of passive houses are able to ensure excellent acoustic quality.

Good acoustics, good marks.

Good acoustics also help in non-residential buildings such as offices, hospitals and schools. The things that children learn or don't learn at school often determine their future path of life. Since pupils spend most of their lesson time listening, good classroom acoustics are an important criterion. A low noise level and a short reverberation time in the classroom improve concentration, promote communication and make learning easier. Today, we have the necessary knowhow and technologies for designing perfect acoustic environments. The surface condition of ceilings and walls plays an essential role in this process. Soundproof wall and ceiling panels are able to reduce disturbing background noise. By absorbing sound, they prevent undesired reflections of sound. Thus, disturbing echoes and reverberant noise are suppressed and the background noise level is decreased. As a result, pupils can better hear and grasp what is being said: with less effort – also for the teaching staff – better learning results are achieved. The same applies to offices, event locations and factory halls. By providing optimum acoustic conditions, it is possible to improve people's performance and well-being. We should take advantage of these positive effects: by making use of high-quality mineral fibre boards with fleece backing. They guarantee optimum sound absorption and excellent acoustic quality in all rooms.

Live and let live in peace

Only "enhanced" or even higher sound insulation is able to guarantee the residents' satisfaction. Hence, "comfort class" insulation should generally be installed. And, with musicians around, even a class higher.

Whether from inside or outside: noise is always disturbing.

Where more and more people live together on less and less space, noise becomes an increasingly disturbing factor. In their own four walls, residents often have to suffer from outdoor noise. As if that wasn't enough, indoor noise sources are also becoming increasingly important. Studies carried out in different European countries clearly show: the most important source of noise – besides road traffic – is your own neighbours! And it is the European sound insulation regulations that must be blamed for this negative trend in the first place. Fact is that in virtually all European countries the legally required sound insulation is not sufficient to allow comfortable living.

Every human being has a need for quietness.

We need quiet phases in our daily lives like we need food and drink. They allow us to refuel body and soul. And they maintain our health. On the other hand, every human being does also produce noise. By talking, walking, showering, cooking, playing, listening to music etc, we often cause a level of noise that is perceived as a nuisance by others.

and quiet.

Of course, this affects first and foremost our neighbours. But also our own family members may feel disturbed.

The troublemakers: airborne sound and impact sound.

Surveys carried out among tenants have shown that the minimum sound insulation stipulated by the European countries is sufficient only in rare living conditions. In particular the tenants of multi-family houses complain about noise nuisance caused by neighbours. But they also complain when they need to restrict their own activities to ensure their fellow tenants' peace and quiet. Based on these experiences, ISOVER has worked out recommendations and guide values which guarantee acoustic comfort even under unfavourable living conditions. In order to produce a quiet indoor climate, a distinction is made between airborne resp. structure-borne sound and impact sound. The quality of airborne sound insulation depends on walls and flanking components such as floors, doors etc. The level of impact sound is determined by floors and stairs. In a nutshell: If you want to ensure a satisfactory level of acoustic quality, better go for the ISOVER Comfort Class right from the start.

To the point: The acoustic comfort classes of ISOVER.

Class	Music	Comfort	Enhanced	Standard
Airborne sound insulation between living units $D_{nT,w} + C$ (dB)	≥ 68 ($C_{50\text{-}3150}$)	≥ 63	≥ 58	≥ 53
Impact sound insulation between living units $L'_{nT,w} + C_I$ (dB)	≤ 40	≤ 40	≤ 45	≤ 50

Between living units

Class	Music	Comfort	Enhanced	Standard
Airborne sound insulation of partitions (without doors) within a living unit $D_{nT,w} + C$ (dB)	≥ 48	≥ 48	≥ 45	≥ 40
Impact sound insulation within a living unit $L'_{nT,w} + C_I$ (dB)	≤ 45	≤ 45	≤ 50	≤ 55

Within living units

Always favourable and worthwhile in new builds, costlier in old ones.

Provided good planning according to EN 12354 (valid in most European countries) and workmanship, a comfortable level of sound insulation can be achieved in new buildings at relatively low costs. You just need to budget for 2-3 % extra costs compared with "noisy" solutions. Often, the thermal insulation provided by the passive house standard at the same time ensures comfortable sound insulation. In these cases, next to no extra costs are incurred for either new or old buildings. Instead, the quality of living rises as does the value of the house. When letting or selling the house, a higher price can be achieved if the house is equipped with comfort class sound insulation. The acoustic comfort classes set up by ISOVER can serve as a valuation basis here.

So that everything runns

Point by point: The most important planning steps.

1. Site plan

- *Freedom from shading in winter and structural shading in summer*
- *Best possible freedom from shading caused by buildings, mountains, coniferous forests*
- *Compact building styles are preferable*

2. Concept development

- *Minimize shade in winter. This means: if possible build without parapets, projections, non-transparent balcony enclosures, divider walls etc.*
- *Choose a compact building structure. Use opportunities to combine buildings. Glazed areas should face south and cover up to 40 % of the wall area. Keep east/west/north windows small and only as big as required for optimum ventilation.*
- *Use a simple shell form, without unnecessary recesses.*
- *Concentrate the utilities installation in one place, e.g. bathrooms above or adjacent to the kitchen.*
- *Leave space for the necessary ventilation ducts.*
- *Thermally separate the basement from the ground floor (including cellar staircase) – absolutely airtight and thermal bridge free.*
- *Get at first energy estimate based on a calculation of the expected energy demands.*
- *Check the possibility for state subsidies.*
- *Work out a cost estimate.*
- *First exploratory talk with the building authority.*
- *Contract agreement with architects, including a precise description of services to be rendered.*

3. Construction plan and building permit planning

- *Select the building style – light or solid. Work out a design concept, floor plan, energy concept for ventilation, heating and hot water.*
- *Plan the insulating thickness of the building envelope and avoid thermal bridges.*
- *Consider the space required for utilities (heating, ventilation etc.).*
- *Floor plan: short pipe runs for hot/cold water and sewage.*
- *Short ventilation ducts: cold air ducts outside, warm ducts inside the insulated building envelope.*
- *Calculate the energy demand, e.g. by means of the Passive House Planning Package (PHPP) available from the Passivhaus Institut, Darmstadt.*
- *Negotiate the building project (pre-construction meetings).*
- *Apply for a housing subsidy.*

4. Final planning of the building structure (detailed design drawings)

- *Insulation of the building envelope: ideally U-values should be around 0.1W/(m²K). Minimum requirement: 0.15W/(m²K).*
- *Design thermal bridge free and airtight connection details.*
- *Choose windows that comply with passive house standard: optimize type of glazing, thermally insulated frames, glass area and sun protection.*

5. Final planning of ventilation and heating (detailed system drawings)

- *General rule: hire a specialist planner.*
- *Ventilation ducts: short, smooth-walled ducts. Air flow velocities below 3 m/s.*
- *Include measuring and adjusting devices.*
- *Take sound insulation and fire protection measures into account.*
- *Air vents: avoid air current short-circuiting.*

smoothly.

- *Consider the air throws of the air vents.*
- *Provide for overflow openings.*
- *Install a central ventilation unit, including a back-up unit (heater coils) in the heated area of the building envelope.*
- *Additional insulation of central and back-up unit may be necessary. Make sure to soundproof the devices. Heat recovery rate should be above 80 %. Airtight construction with less than 3 % recirculated air. Current efficiency: max. 0.4 Wh energy required per m^3 transported air.*
- *The ventilation system should be adjustable by the user.*
- *Provide for cooker hoods suitable for return air operation with grease filters made of metal.*
- *Optional: geothermal heat exchanger. Ensure air-tightness. Observe the necessary clearance between cold parts of the piping and the cellar wall resp. water pipe. Provide a bypass for summer operation.*

6. Final planning of the remaining utilities (detailed plumbing and electrical drawings)

- *Plumbing: Install short and well-insulated pipes for hot water in the building envelope. For cold water install short pipes insulated against condensation water.*
- *Use water-saving fittings as well as hot-water connections on washing machine and dishwasher. Short sewer pipes with only one downpipe.*
- *Sub-roof vents for line breathing (vent pipes).*
- *Plumbing and electrical installations: avoid penetration of the airtight building envelope – if not feasible, install adequate insulation.*
- *Use energy-saving household appliances.*

7. Call for tenders and awarding of contracts

- *Plan for quality assurance measures in the contracts.*
- *Set up a construction schedule.*

8. Assurance of quality by the construction supervision

- *Thermal bridge free construction: schedule on-site quality control inspections.*
- *Check of airtightness: airtight penetration of all pipes and ducts by proper sealing, plastering or taping. Electrical cables penetrating the building envelope must be sealed also between cable and conduit. Flush mounting of sockets in plaster and mortar.*
- *Check of thermal insulation for ventilation ducts and hot water pipes.*
- *Seal window connections with special adhesive tapes or plaster rail. Apply interior plaster from the rough floor up to the rough ceiling.*
- *n_{50} airtightness test: Have a Blower Door Test performed during the construction phase. Timing: as soon as the airtight envelope is complete but still accessible. This means: before finishing the interior work, but after completion of the electricians' work (in concert with the other trades), including identification of all leaks.*
- *Ventilation system: ensure easy accessibility for filter changes. Adjust the air flows in normal operation mode by measuring and balancing the supply and exhaust air volumes. Balance the supply and exhaust air distribution. Measure the system's electrical power consumption.*
- *Quality control check of all heating, plumbing and electrical systems.*

9. Final inspection and auditing

Energy efficiency is calculable.

Is it indeed possible to design extremely energy-efficient houses with simple planning tools? In the 1990s, it was still a widely held view that passive house planning could only be managed with the help of dynamic building simulation programs that were based on hourly performance and took the different uses of the rooms into account. Meanwhile, it has shown however that simplified calculation methods are sufficiently precise to dimension the heating system and predict the energy consumption of passive houses.

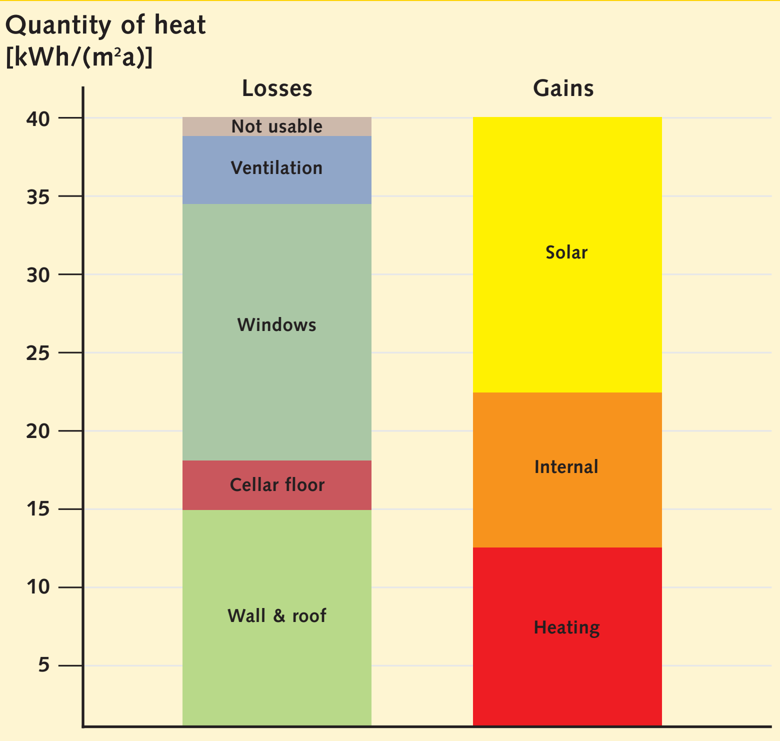
Very helpful: the Passive House Planning Package (PHPP)

Practical use of such an energy balancing procedure is made, for instance, in the Passive House Planning Package (PHPP). This is a spreadsheet-based design tool which can be used to calculate the complete energy balance of a building. To do so, it is on the one hand necessary to determine the building's heat losses caused by transmission and ventilation. On the other side of the balance, solar and internal heat gains need to be considered. The fact that these gains are not always achieved at times when they are needed is accounted for by setting them off against the losses. The difference between losses and useful gains eventually results in the building's demand for heating energy that must additionally be supplied.
In order to obtain correct results, it is of vital importance for the calculation to distinguish between significant and insignificant factors and to choose the proper frame conditions. This includes, for example, the thermal output of inhabitants and household appliances or the solar radiation available inside a house. For this purpose, the PHPP contains standard values which have proved successful in comparison with other measurements. Apart from establishing the room heat balance, the PHPP also deals with other project-specific issues that come up in the course of planning. Among others, these include the heatability via supply air, the energy demand for auxiliary power and household electricity, the energy needed for preparing domestic hot water and the room climate in summer.

The PHPP is available from the Passivhaus Institut in Darmstadt, Germany

(www.passiv.de)

Exemplary thermal balance of a passive house (based on one heating period)



Passive House Planning • ANNUAL SPACE HEATING REQUIREMENT

Climate:	Frankfurt (region 12)	**Interior Temperature:**	20.0	°C
Building:	End-of-Terrace Passive House Kranichstein	**Building Type/Use:**	Row House/Apartments	
Location:	Darmstadt-Kranichstein	**Treated Floor Area (TFA):**	156.0	m²
		Standard Occupancy:	4.0	pers. per m²

Building components	Temperature zone	Area m²		U-value W/(m²K)		Temp. faktor f_t		G_t kKh/a		kWh/a	Treated floor area
Exterior Wall – Ambient Air	A	184.3	•	0.138	•	1.00	•	76.4	=	1935	12.4
Exterior Wall – Ground	B		•		•	0.56	•		=		#VALUE!
Roof/Ceiling – Exterior Air	D	83.4	•	0.108	•	1.00	•	76.4	=	685	4.4
Floor Slab	B	80.9	•	0.131	•	0.56	•	76.4	=	454	2.9
	A		•		•	1.00	•		=		#VALUE!
	A		•		•	1.00	•		=		#VALUE!
	X		•		•	0.75	•		=		#VALUE!
Windows	A	43.5	•	0.777	•	1.00	•	76.4	=	2580	16.5
Exterior Door	A		•		•	1.00	•		=		#VALUE!
Exterior Thermal Bridge (length/m)	A	116.9	•	-0.030	•	1.00	•	76.4	=	-266	-1.7
Perimeter Thermal Bridge (length/m)	P		•		•	0.56	•		=		#VALUE!
Ground Thermal Bridges (length/m)	B	11.4	•	0.061	•	0.50	•	76.4	=	30	0.2
Total of all building envelope areas		392.1									kWh/(m²a)
Transmission Heat Losses Q_T									Total	**5417**	**34.7**

Ventilation system:

				A_{TFA} m²		Room Height m		m³
Effective air volume V_{RAX}				156.0	•	2.50	=	390.0
Actual Efficiency of Heat Recovery	n_{eff}	81 %						
Efficiency of Subsoil Heat Exchanger	n_{SHX}	33 %						

	$n_{V,\,system}$ 1/h		$ø_{HR}$		$n_{V,\,rest}$ 1/h		1/h
Energetically Effective Air Exchange n_V	0.300	(1	0.87	) +	0.019	=	0.058

	V_V m³		n_V 1/h		C_{air} Wh/(m³K)		G_t kKh/a		kWh/a	kWh/(m²a)
Ventilation Heat losses Q_L	390	•	0.058	•	0.33	•	76.4	=	568	3.6

		Q_T kWh/a		Q_V kWh/a		Reduction Factor Night/Weekend Saving		kWh/a	kWh/(m²a)
Total Heat Losses Q_L	(	5417	+	568	)	1.0	=	5985	38.4

Orientation of the Area	Reduction Factor see Windows		g-Value (perp. radiation)		Area m²		Global Radiation Heating Period kWh/(m²a)		kWh/a	
1. East	0.40	•	0.00	•	0.00	•	207	=	0	
2. South	0.44	•	0.50	•	30.42	•	352	=	2343	
3. West	0.41	•	0.50	•	2.00	•	210	=	85	
4. North	0.45	•	0.50	•	11.04	•	131	=	323	
5. Horizontal	0.40	•	0.00	•	0.00	•	318	=	0	kWh/(m²a)
Gross Solar Heat Gains Q_S								Total	**2752**	**17.6**

	kh/d		Heating Period d/a		Specific Power q_I W/m²		A_{TFA} m²		kWh/a	kWh/(m²a)
Internal Heat Sources Q_I	0.024	•	205	•	2.10	•	156.0	=	1608	10.3

			kWh/a	kWh/(m²a)
Free heat Q_F	$Q_S + Q_I$	=	4360	27.9
Ratio free heat vs. losses	Q_F / Q_L	=	0,73	
Utilization of heat gains n_G	$(1 - (Q_F / Q_L)^5) / (1 - (Q_F / Q_L)^6)$	=	93%	
			kWh/a	kWh/(m²a)
Heat Gains Q_G	$n_G \cdot Q_F$	=	4074	26.1
			kWh/a	kWh/(m²a)
Annual Heat Requirement Q_H	$Q_L - Q_G$	=	1910	12

	kWh/(m²a)		(yes/no)
Limit	15	Requirement met?	YES

The Realization.

Accelerated & controlled.

- A gain for every building style
- Airtightness from top to bottom: the building envelope
- Mistakes are avoidable
- The avoidance of thermal bridges is plannable
- Moisture protection and airtightness with ISOVER-VARIO
- The roof: good insulation is what matters most
- Optimum all-round thermal insulation
- Prone to thermal bridges: ceilings, walls, cellars
- The windows: triple glazing does a better job
- Making good use of the sun: solar power
- Good air, pleasant warmth: the Comfort Ventilation System
- Realization of balconies and conservatories

The Multi-Comfort Hou a gain for

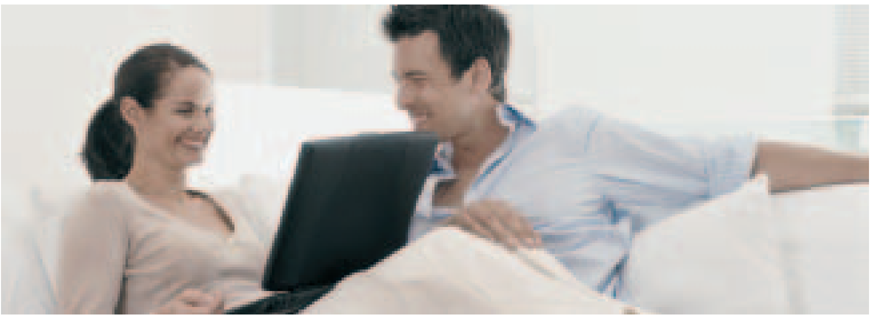
Whether massive, wood, glass or mixed construction – a passive house lends itself to any building style. Provided the individual components have been carefully installed without thermal bridges, a closed system results with attractive inner values. Thanks to high-quality insulation, the building envelope is airtight, offering protection from cold, heat and noise. The occupants enjoy greatest possible comfort – above all due to the small difference between air and surface temperature in both winter and summer months.

One-time perfect insulation – all-time pleasant temperature.

Continuous insulation from the roof down to the foundation does not only ease the burden on your wallet, but is also a sensible investment into your living comfort. Insulation materials made of natural fibres such as ISOVER mineral wool produce particularly good results. Just compare: To achieve the insulating effect of 1.5 to 2 cm insulation material, about 30 cm solid brick or 105 cm concrete would be required. Considering today's recommended insulation thickness of 30 cm or more, the impact on the building's statics would be too high – let alone the costs. Another important aspect is the excellent eco balance you can achieve when insulating your home with ISOVER mineral wool: less heating energy, lower CO_2 emissions and a longer service life ensure benefits – both for the individual and the community.

Passive House Disc Salzkammergut

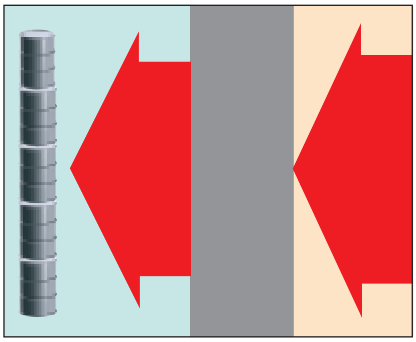
se –
every building style.

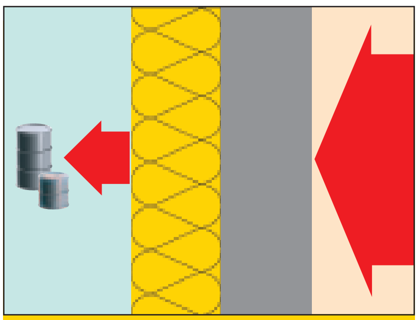


Keep warmth inside in winter and heat outside in summer.

Only when high-quality insulation materials have been installed can the passive use of sun energy produce the desired effect. The solar gains are kept inside the house instead of heating the outdoors. A cost-optimized solar thermal system is able to cover about 30-50 % of the entire low-temperature heating demand in an ISOVER Multi-Comfort House. Also the windows contribute to the positive eco balance. If they comply with the passive house standard, they give off more heat to the inside than to the outside. Thanks to triple glazing, thermally insulated frames and thermal bridge free installation, heat gains even in winter so high that they can largely compensate for the lost heat. However, to prevent the residents from sweating in summer, preventive measures need to be taken:

- Provide shading of east-, south- and west-facing windows
- Take structural measures to sun-screen south-facing windows, e.g. by roof overhangs.
- The room-enclosing areas should be capable of heat storage.
- Ensure efficient ventilation.





Good insulation helps you save a lot of money.

To the point.

The realization of ISOVER Multi-Comfort Houses makes high demands on the components used!

- *Thermal insulation: U-values of all components below 0.15 W/(m²K) – with detached one-family houses even below 0.10 W/(m²K) (recommended!)*
- *Freeness of thermal bridges*
- *Excellent airtightness proven by the Blower Door Test. Air change (n50) at 50 Pa pressure difference less than 0.6 1/h acc. to EN 13829.*
- *Glazing with Ug values below 0.8 W/(m²K), combined with a high total energy transmittance (g ≥ 0.5 acc. to EN 67507) so that net heat gains can also be achieved in winter.*
- *Window frames with U-values below 0.8 W/(m²K) acc. to EN 10077*
- *Highly efficient ventilation heat recovery (heat recovery 80 % acc. to PHI Certificate or based on DIBt measured values minus 12 %) combined with low electricity consumption (0.4 Wh/m³ transported air volume)*
- *Very low heat losses in the generation and distribution of domestic hot water*
- *Highly efficient use of household electricity*

Keeps airtight and warm: the building

The ISOVER Multi-Comfort House leaves nothing to chance.

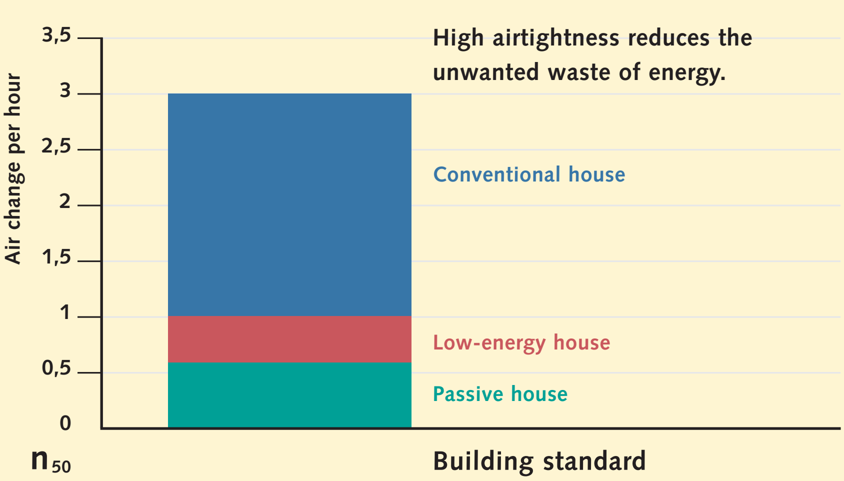
Only a controlled exchange of air makes sense. Otherwise, there will be heat loss, draught, ingress of moisture, superheating and the like. The continuous airtight shell, which envelopes the passive house from its roof down to the cellar floor, protects it against these undesired effects and allows energy-efficient and comfortable living. Needless to say that nobody needs to be afraid of suffocating: airtight and insulated walls do not breathe more or less than conventionally built walls. Moreover, the Comfort Ventilation System supplies you all the time with fresh air of best quality. If need be, the windows can of course be opened. In summer, window ventilation is a suitable way to keep a well-insulated house cool.

Lang Consulting

Breathing is done by the Comfort Ventilation System.

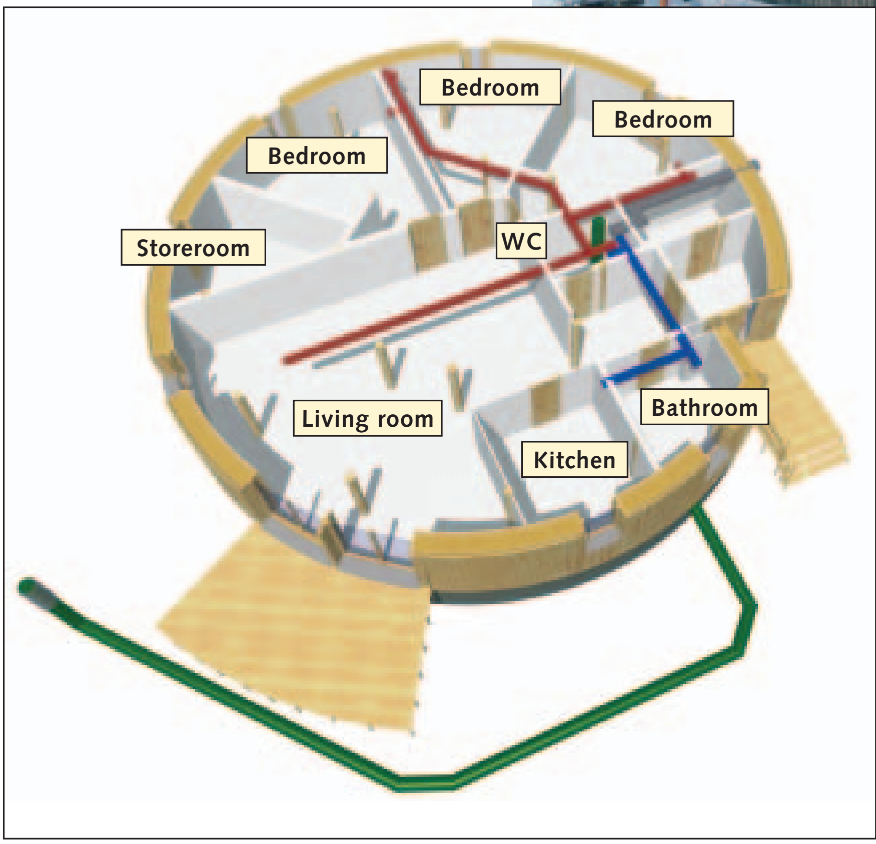
Controlled ventilation instead of an uncontrolled exchange of air: this is a demand not only made by the passive house standard. Comfort Ventilation Systems cater to this need. Operated by solar energy and equipped with a heat pump and an air-to-air heat exchanger, they ensure the permanent supply of fresh air in all rooms. At the same time, they control the energy-efficient distribution and also recovery of heat in the whole house. And in summer they additionally cool you with a soft breeze.

Modern demands to airtightness.



The nose of a passive house: air duct for fresh air supply.

envelope.



Lang Consulting

Passive House Disc Salzkammergut Architect's office DI Hermann Kaufmann, Schwarzach. Developer: Günter Lang, engineer.

Schematic drawing of a controlled ventilation system. Via a geothermal heat pump fresh air is drawn in and preheated (green). The used air in bathroom and kitchen is exhausted (blue). Its heat is transmitted to the incoming fresh air via an air-to-air-heat exchanger. The warm fresh air is then distributed in the sleeping and living rooms (red).

Seamlessly tight and insulated.

What is the recommended design of a continuous building envelope? In regions with cold winters, the airtight layer – which at the same time serves as a vapour barrier – is always installed on the warm side of the insulation layer. Leaky spots in the building envelope such as joints have extremely unpleasant consequences:

- increased heat losses
- uncontrolled air exchange
- poor sound insulation
- danger of structural damage caused by condensate, mould or corrosion.

Comfort Ventilation Systems with integrated heating and hot water supply are available today as compact units that hardly need more space than a fridge. (Ing. Lang Consulting)

Airtightness accepts no

This is where the building styles differ.

Whether solid, lightweight or wood construction – the selected building style requires different concepts for the planning and execution of the airtight barrier. It is therefore imperative at the planning stage to work out a detailed overall concept of airtightness, including all connections between structural components, wall junctions and punctures. For timber construction it is recommended to provide a separate installation layer on the room-facing side of the vapour barrier.

To the point.

These are the requirements to be met by the materials:

- *Airtight materials for the surface area, e.g. membranes, roofing felts, panels, plasters*
- *Carefully matched and compatible materials, especially sealing membranes and adhesives*
- *Moisture-, UV- and tear-resistant materials*
- *Vapour diffusion resistant materials (act as vapour barriers): in regions with cold winters, the airtight barrier is always installed on the warm side of the structure, i.e. facing the interior.*

ISOVER VARIO KM Duplex ensures airtightness in keeping with the highest passive house standard.

The flexible climatic membrane system adjusts itself to the seasons. In winter, humidity penetrating from inside is blocked. In summer, ISOVER VARIO KM Duplex allows the released water vapour to escape in all directions. This means:

- Ideal vapour barrier function against the ingress of moisture in roof and walls
- Maximum security for the building
- Excellent comfort of living.

compromise.

Good to know before starting work.

Nothing is more important for a passive house than the careful execution of its building envelope. For this reason, the chosen materials must in any case be employed under optimal conditions. This means in particular:

- Joints must only be sealed in dry weather.
- Substrate and joint flanks must be dry and free of dust.
- All junctions between adhesive tapes and porous materials must be pre-treated with a primer.
- For structural reasons, joint sealing tapes must also be able to prevent the penetration of water and moisture.
- Larger expansion joints can be sealed with VARIO KM FS (mineral wool joint tape).

The earlier the better: checking the airtightness.

The airtightness check is an essential constituent of the quality certificate for the ISOVER Multi-Comfort House. It is absolutely necessary to carry out this test before completion of the inner surface of the building envelope so that any faulty workmanship can be detected in good time and remedied at relatively low cost.

The Blower Door Test is used to detect any leakage in the building envelope. The smaller the measured value, the higher the airtightness of the building envelope. Passive houses require a value 0.6. This means: during the measurement, at most 60 % of the indoor air volume is allowed to escape through leaky spots within one hour. Experience has shown that values between 0.3 and 0.4 are attainable.

Only knowledge of troub

Planning and execution.

Apart from systematic leakage caused by poor planning, there is also the problem of faulty workmanship.

To the point.

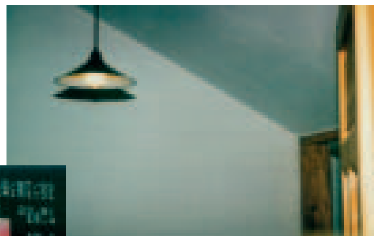
Typical leaks in the airtight barrier:

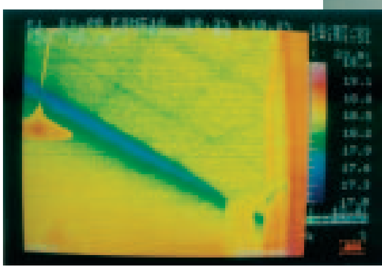
- *Interface external wall and foundation slab*
- *Interconnection of the external walls, e.g. element butts and corner joints*
- *Interface external wall and mezzanine floor*
- *Interface external wall and roof wall*
- *Cables and pipes penetrating the airtight barrier*
- *Windows and doors interrupting the airtight barrier*
- *Sockets*
- *Unplastered masonry also behind wall-mounted fittings*
- *Poorly adjusted house doors and windows*
- *Service openings for roller blinds*
- *Damage to the airtight barrier during the construction phase*

One example says more than 1000 words. Survey of frequent structural defects.

An important security factor is the quality of the bond. An airtight bond between two strips of a sealing membrane cannot be produced by riveting. The seam area must therefore be sealed with a suitable adhesive tape.

Carefully tape overlapping areas.



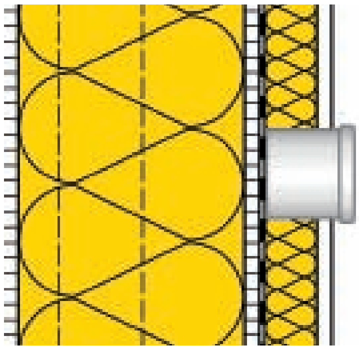


Source: Niedrig Energie Institut (Low-Energy Institute), Germany

The lack of airtightness between ceiling and wall results in clearly visible heat losses.

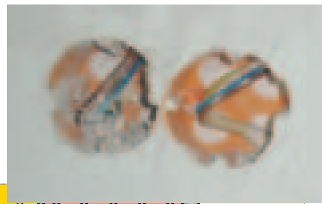
le sources can help avoid them.

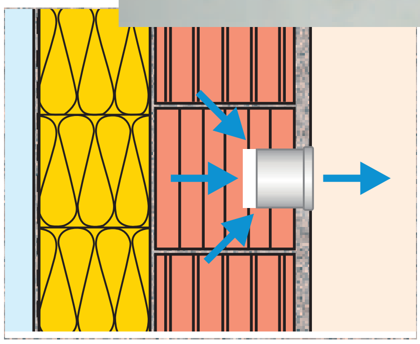
When penetrating the airtight layer, make sure to provide a leak-tight seal of the connections.



Sockets embedded deeply into a plaster bed prevent air flows in solidly built houses.

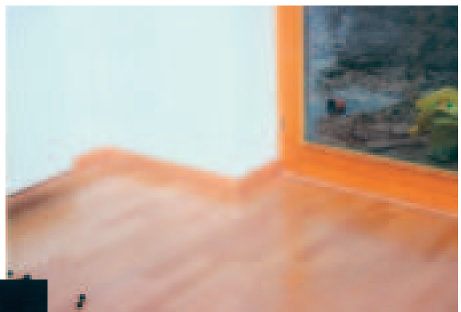
A sufficiently deep installation level helps prevent damage to the vapour barrier and airtight layer.

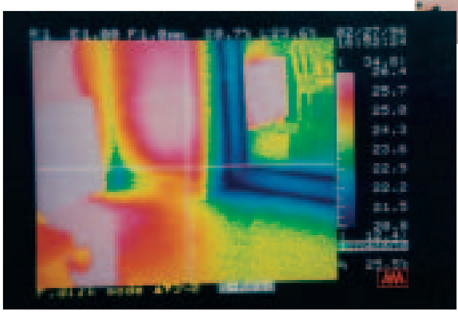




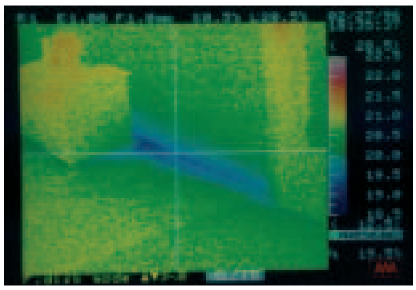
No matter whether solid or lightweight construction – wherever the airtight layer must be penetrated by pipes, electric cables or sockets, heat loss and water damage will result unless the penetrations have been expertly sealed.

Thermographic imaging is able to detect unwanted air flows caused by cellar doors and windows.





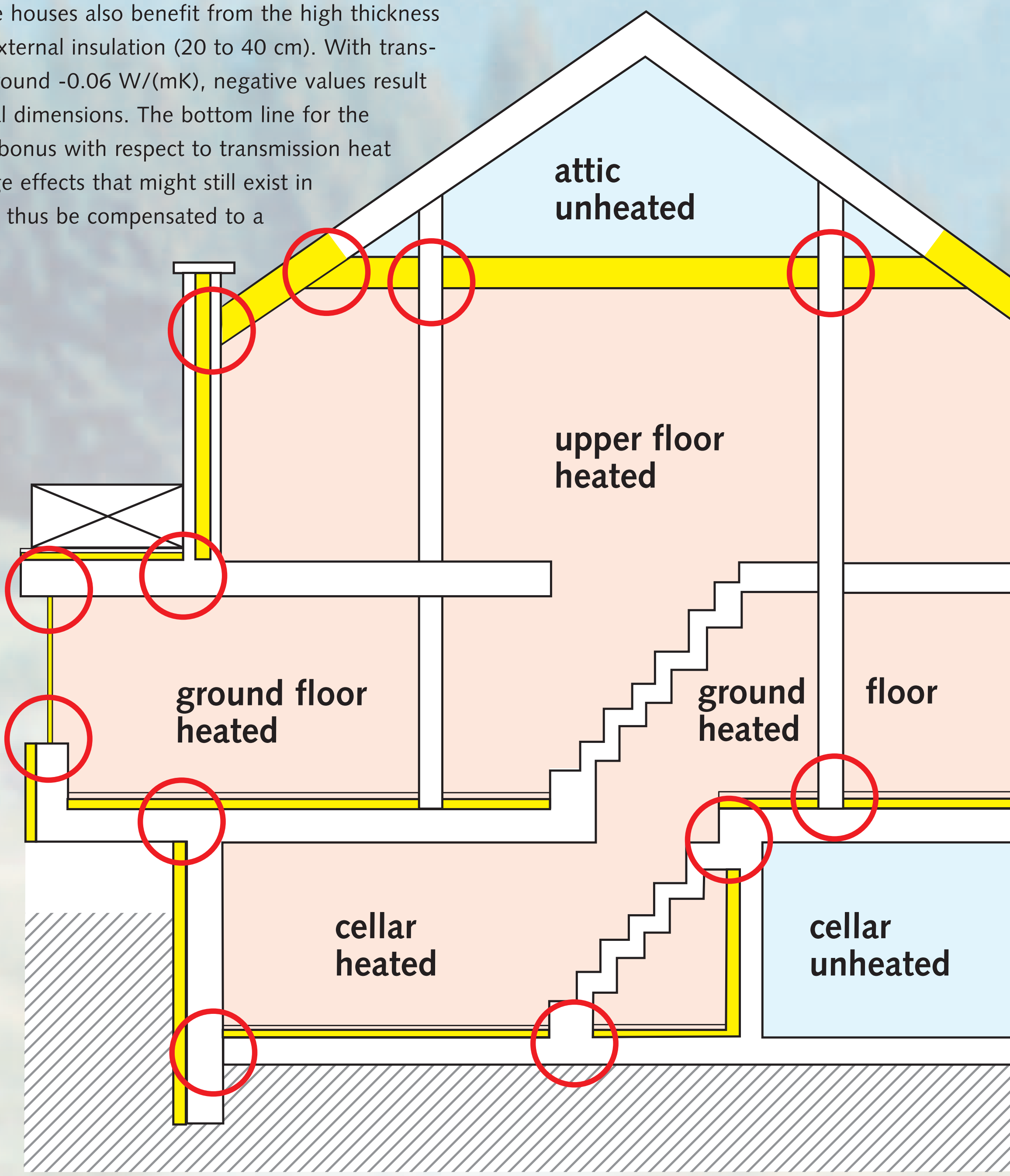
Source: Niedrig Energie Institut (Low-Energy Institute), Germany



Untight mortar joints are responsible for leaks in the area where the floor meets the wall.

Negative thermal bridge and plannable.

There is no doubt that thermal bridge effects must be avoided as largely as possible. In this respect, passive houses also benefit from the high thickness of materials that are used for external insulation (20 to 40 cm). With transmission heat loss coefficients around -0.06 W/(mK), negative values result based on the building's external dimensions. The bottom line for the passive house: a mathematical bonus with respect to transmission heat loss. Any positive thermal bridge effects that might still exist in other parts of the structure can thus be compensated to a large extent.

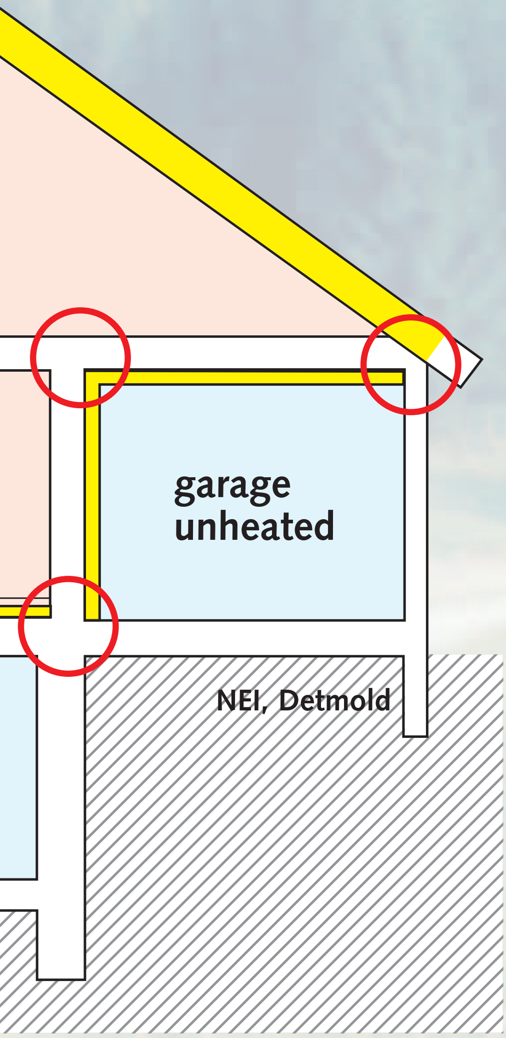


Source: Niedrig-Energie-Institut (Low Energy Institute), Detmold, Germany

effects are wanted –

Critical points: interruptions of the insulating shell.

A reliable method for detecting thermal bridges is to graphically capture the projected building. When studying floor plans, sectional drawings and detailed drawings, it becomes visible whether the exterior insulation shows any gaps. First, mark the actual position of the installed insulation layers yellow. Afterwards, check in which places the yellow line running around the building is interrupted. These are the weak points where potential thermal bridges occur. Next, it must be carefully considered if they are structurally avoidable. If not, solutions must be found so that they can at least be minimized. Every gap in the insulation layer is a thermal bridge which negatively affects the energy balance and can lead to structural damage.



To the point:
Geometric and structural thermal bridges.

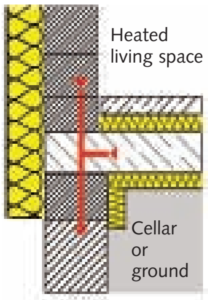
- *Geometric thermal bridges are negligible as long as the exterior insulation is sufficiently dimensioned and continuous.*
- *Structural thermal bridges must be avoided by all means or at least be minimized. This applies in particular to:*
- *Thermal bridges on sole plates and cellar floors*
- *Thermal bridges on stairs*
- *Thermal bridges on the upper edges of walls in the roof area*
- *Thermal bridges on cold-warm wall breakthroughs*
- *Thermal bridges on balconies, landings, projecting building components*
- *Thermal bridges on windows and roller shutter boxes*
- *Thermal bridges that repeatedly occur within a building component (rafters, lathwork, anchoring elements etc.) must be considered with respect to the U-value of the building component concerned. These structural details are referred to as inhomogeneous building components. Apart from causing high thermal loss, they can also result in structural damage. However: inhomogeneities in a brick wall behind a continuous insulation layer (e.g. a ceiling support) can be neglected if the insulation has been sufficiently dimensioned.*

The Realization.

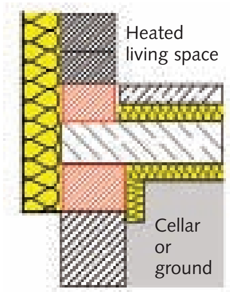
The comparison shows: There is always a good or even excellent solution to avoid thermal bridges.

Thermal bridges between cellar floors resp. sole plates with strip footing and external walls

With a single-leaf external wall and a cellar floor or sole plate insulated on its upper or under side

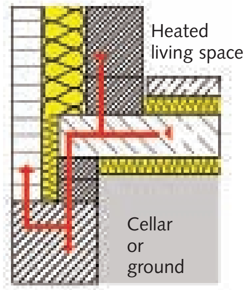


Insufficient if support of ceiling on cellar outer wall resp. strip footing and the support of warm internal wall ground floor has been installed without thermal separation using a material with lambda > approx. 0.12 W/mK.

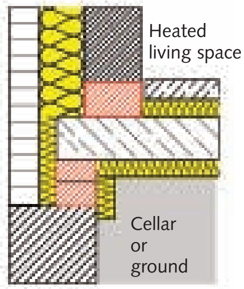


Good if both supports have been produced from a material with lambda < approx. 0.12 W/mK.

With an external cavity wall and a cellar floor or sole plate insulated both on its upper and under side

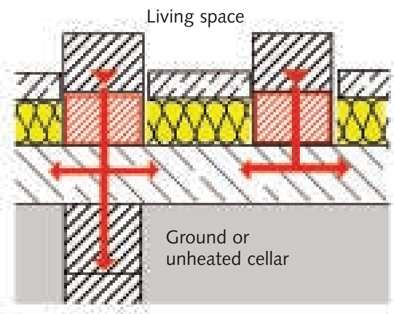


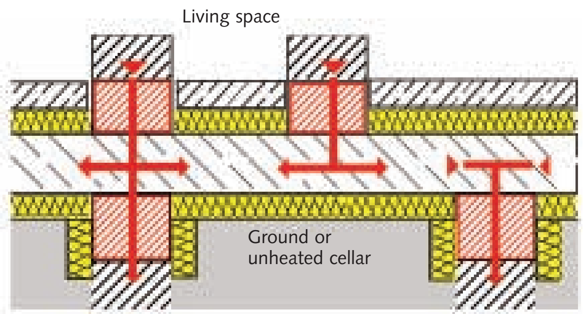
Insufficient if support of ceiling on cellar outer wall resp. strip footing and the support of warm internal wall ground floor has been installed without thermal separation using a material with lambda > approx. 0.12 W/mK.



Good if both supports have been produced from a material with lambda < approx. 0.12 W/mK.

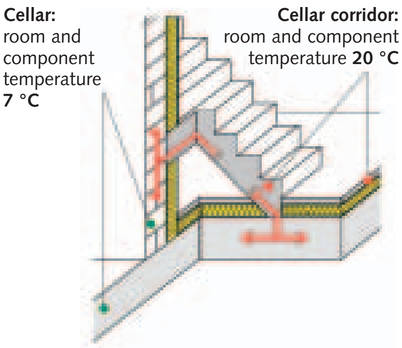
Thermal bridges between cellar floors or sole plates and internal walls



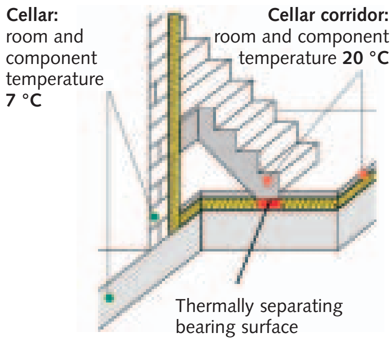


Here, the same applies as shown above for the external walls.

Thermal bridges between stair flights and thermally separating walls or sole plates



Insufficient:
Thermal bridges between the bearing surface of the "warm" stair flight and the "cold" sole plate (cold because of its upper side insulation) and between the "warm" lateral flank of the stairs and the "cold" cellar wall (cold because of its room-facing insulation).

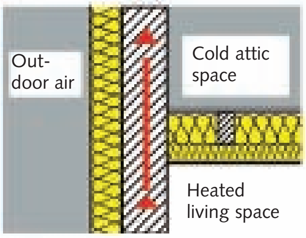


Good: Thermal separation between the bearing surface of the "warm" stair flight and the "cold" sole plate by using a foundation stone of low thermal conductivity and by installing continuous insulation to ensure complete separation of the stair flight from the cellar wall.

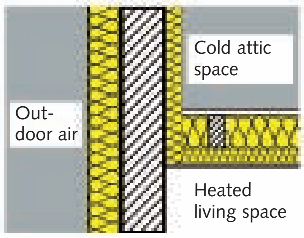
Source: Niedrig-Energie-Institut (Low Energy Institute), Detmold, Germany

Thermal bridges on vertical cold-warm wall breakthroughs

External walls

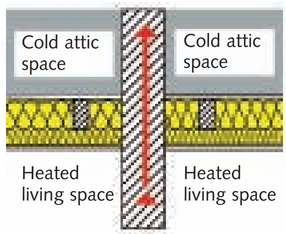


Insufficient: Thermal bridge caused by the external wall passing from a warm to a cold area when the brickwork consists of stones with lambda > 0.12 W/m*K.

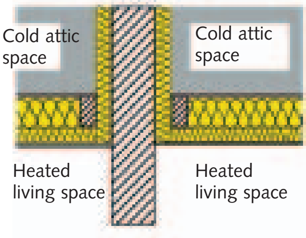


Good: Either interruption of a well heat-conducting vertical wall at the same height as the insulation level of the penetrating ceiling by installing a thermal separation layer using a material with lambda < 0.12 W/m*K (aerated concrete, foam glass, Puren etc.) or flank insulation to a height of approx. 60 cm on the inside of the external wall in the cock loft.

Internal walls

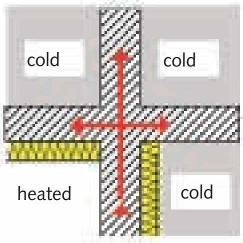


Insufficient: Thermal bridge caused by the external wall passing from a warm to a cold area when the brickwork consists of stone with lambda > 0.12 W/m*K.

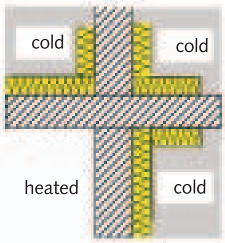


Good: Either interruption of a well heat-conducting vertical wall at the same height as the insulation level of the penetrating ceiling by installing a thermal separation layer using a material with lambda < 0.12 W/m*K (aerated concrete, foam glass, Puren etc.) or flank insulation to a height of approx. 60 cm on the inside of the external wall in the cock loft.

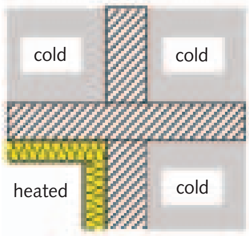
Thermal bridges on horizontal cold-warm wall breakthroughs



Unsatisfactory: The walls have been insulated partly on the warm and partly on the cold side. However, individual wall junctions pass right through.

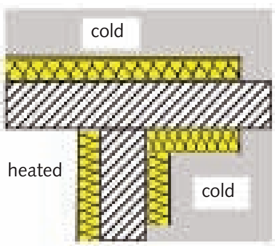


Satisfactory: All walls have been insulated on the cold side. Additionally, sufficient flank insulation has been installed on all wall junctions facing the cold side.

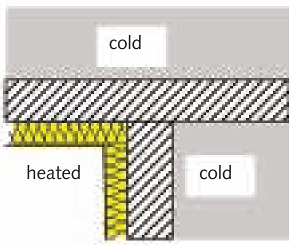


Excellent: The insulation layers interconnect without any interruption.

Thermal bridges on horizontal cold-warm wall junctions

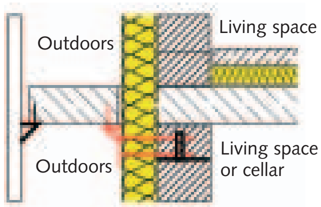


Satisfactory: Both walls have been insulated on different sides. In addition, sufficient flank insulation has been installed on the wall junction.

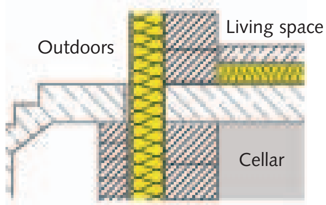


Excellent: Both walls have been insulated on the inside and the insulated areas directly adjoin each other.

Possible solutions to thermal bridging on balconies, landings and overhanging ceilings



Good: Only point support of balcony or landing slabs on small steel brackets and additional support by free-standing columns in front of the house. If the cross sections of the metal penetrating the thermal envelope are small, there will only be few thermal bridges.



Excellent: Completely separated construction with a separate support of the landing (see picture) or of the balcony. This is a truly thermal bridge free solution.

Dampproof and airtight the very last

A system that adapts to all seasons.

Whether winter or summer – seasonal changes do not play a role for ISOVER VARIO. This innovative membrane system for all wood-frame constructions quite flexibly adapts to different climatic conditions. In winter, ISOVER VARIO blocks the moisture diffusing inwards. In summer, the membrane allows the moisture to escape from the structure to the inside. In this way, damp structural components can more easily dry out in summer months. They are there, with every lightweight construction: the unavoidable sore spots where membranes interconnect, joints form, pipes and other installations penetrate the building envelope. Every leak in the otherwise highly insula-ted areas will result in avoidable heat losses and substantial ingress of moisture. With very costly consequences. But all this can most easily be prevented. With just a little effort – and the climatic membrane system ISOVER VARIO.

Fixing

Taping

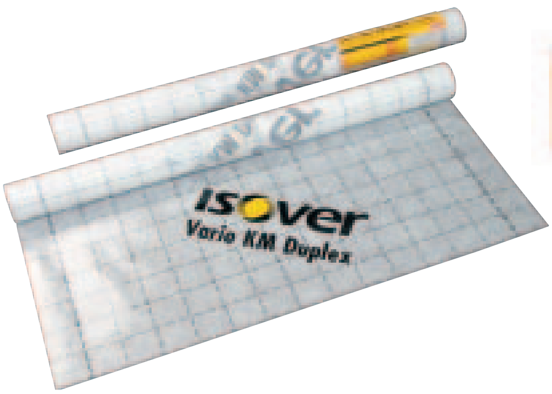
Sealing

isover
Multi-Comfort House

down to corner: ISOVER VARIO.

A perfect bond: climatic membrane, sealant and adhesive.

ISOVER VARIO system packages leave no gap or wish un(ful)filled. Besides high-performance protection against air and moisture, they offer good workability. Other benefits for the user include high quality, easy cutting to size and rapid bonding. This saves time, effort and money, and ensures long-term security. No matter whether you choose standard VARIO KM quality or premium VARIO KM Duplex with increased tear resistance.



To the point: ISOVER VARIO KM

- *Unique climatic membrane with variable resistance to diffusion*
- *Adapts to all seasons*
- *Vapour barrier function against ingress of moisture in roofs and walls*
- *Drying function that allows excess moisture to escape*
- *Proper installation ensures air-tightness at passive house level*
- *Greatly improves the living comfort*
- *Rapid workability*
- *Variable sd-value of 0.2 to 5 m*

To the point: ISOVER VARIO KM Duplex

- *Further development of VARIO KM*
- *Extremely high tear resistance*
- *Improved protective function*
- *Practical line marking for easy cutting to size and fewer off-cuts*
- *Easy installation without need for sagging*
- *Faster fixing thanks to a marked joint/overlap line*
- *Variable sd-value of 0.3 to 5 m*

The peak of energy effici

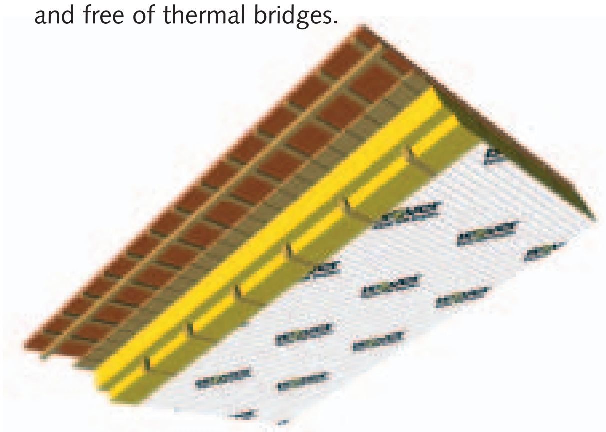
Roof structure is crucial, not roof shape.

Whether gable or ridge roof, hip, false hip, mansard or pent roof: the shape doesn't matter for an ISOVER Multi-Comfort House. However, this does not apply to the roof structure. The large surface area may cause substantial heat loss. In old buildings, about one third of the heating energy is lost to the atmosphere due to poorly insulated roof structures.

Passive house barn, Viernheim, Germany

First Class: the fully insulated, non-ventilated roof.

Good thermal insulation of the roof is economically viable. As most roofs are lightweight structures that leave a lot of space for insulation, high energy savings can be generated at low cost and effort. A highly efficient solution is the fully insulated, non-ventilated roof structure. The combination of intermediate and under-rafter insulation is a model example. This construction does not require ventilation, thus saving time and cost. And last but not least energy. Contrary to ventilated roofs, there is no uncontrolled air exchange via joints or gaps – and consequently no heat loss. To hamper the inward diffusion of moisture and speed up the drying process, the moisture-adaptive membrane ISOVER VARIO is used. It is installed on the room-facing side of the insulation layer. The single strips must overlap by about 10 cm and the seams be reliably bonded with VARIO adhesive tape. Joints between membrane and solid building components must be filled with VARIO sealant. Airtight sealing of conduits is achieved with adhesive tape VARIO KB3 or Powerflex. Before installing the interior cladding, the construction must be checked for tightness and any weak spots be eliminated. The result should be leakproof, airtight and free of thermal bridges.



ency.

100 % insulation: with ISOVER.

Whether winter cold or summer heat – with non-flammable insulation materials by ISOVER installed under the roof, every house is perfectly able to resist external influences. Protection against heat and moisture, sound and fire, and on top energy values typical of passive houses ensure that the residents can enjoy comfort of living. In every season!

Solar collectors, Christophorus Haus (passive house) in Stadl-Paura, Upper Austria

To the point:

This roof structure sets a good example for every building.

- *Roof cladding*
- *Roof battening*
- *Counterlathing*
- *Roof underlay*
- *Rafter system with mineral wool full rafter insulation*
- *Moisture-adaptive membrane, e.g. Difunorm VARIO*
- *Levelling battens / Installation layer insulated with mineral wool*
- *Interior cladding*

Good to know: protection against condensation water.

The insulation material must be installed free of joints and thermal bridges. On the inner side, an air-tight layer produced with Difunorm VARIO prevents the intrusion of moisture and protects from air infiltration.

Proper bonding is essential.

All overlaps in the surface area must be durably sealed with suitable adhesive tapes. Connections to penetrations must be sealed with collars and/or elastic adhesive tapes to ensure that they are air- and vapour-tight.

The Realization.

Connection outer wall (timber construction) to rafter roof

A. Roof (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard, 2-layered	0.0250	0.250	0.100
2. Glass wool under rafter insulation	0.0500	0.035	1.438
3. Climatic membrane Vario KM Duplex	–	–	–
4. Glass wool clamping felt	0.260	0.035	7.428
5. Roof boarding	0.024	0.130	0.185
6. Underlay, diffusible	–	–	–
7. Roofing, ventilated	–	–	–
Total sum of thermal resistances			9.151
Thermal surface resistances			0.140
U-value without wooden parts			U = 0.11 W/(m²K)
U-value with wooden parts			U = 0.13 W/(m²K)

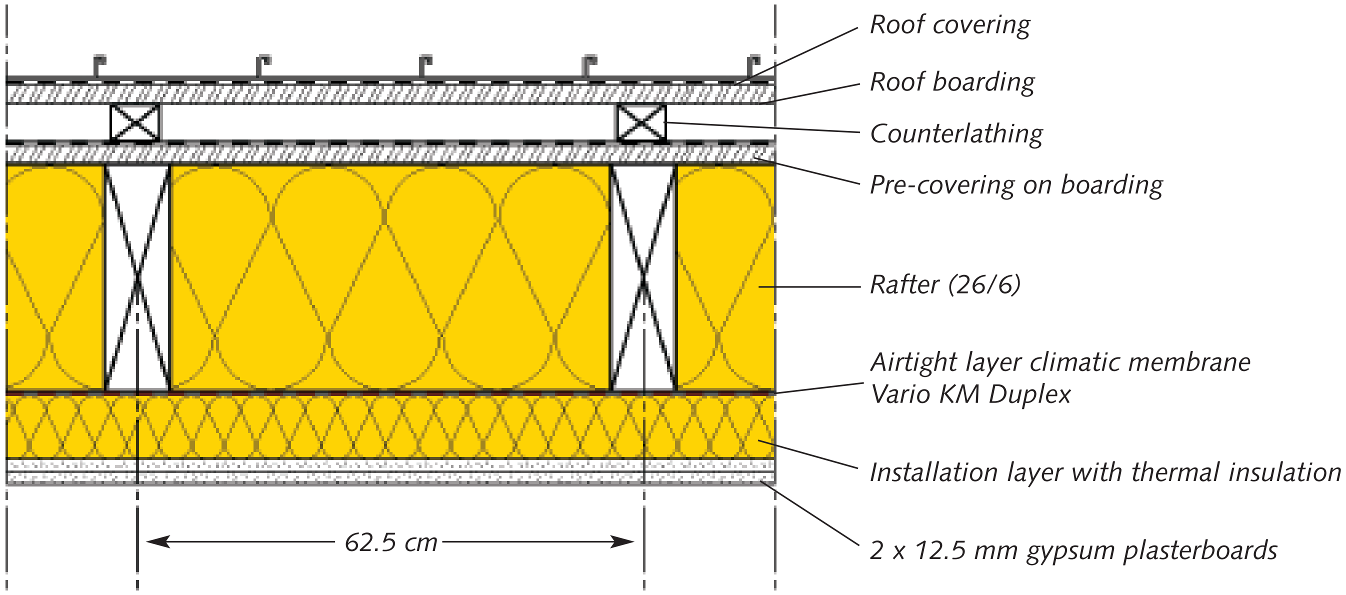
B. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Composite wood panel	0.015	0.240	0.062
3. Vario KM Duplex	–	–	–
4. Glass wool felt	0.320	0.035	9.143
5. Wood fibreboard, e.g. MDF	0.016	0.070	0.228
6. Ventilated cladding	–	–	–
Total sum of thermal resistances			9.493
Thermal surface resistances			0.170
U-value without wooden parts			U = 0.10 W/(m²K)
U-value with wooden parts			U = 0.11 W/(m²K)

ψ-value[1)] = -0.03 W/(mK); f-value[2)] = 0.952; minimal surface temperature ϑsi = 18.79 °C; at 20°C indoors and -5°C outdoors.

[1)] The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

[2)] The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

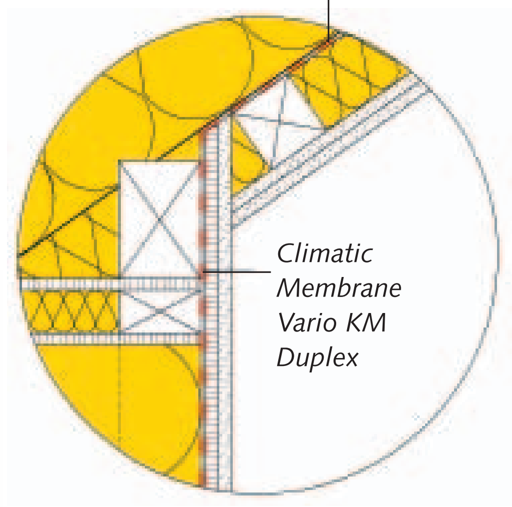


Double insulation for double effect.

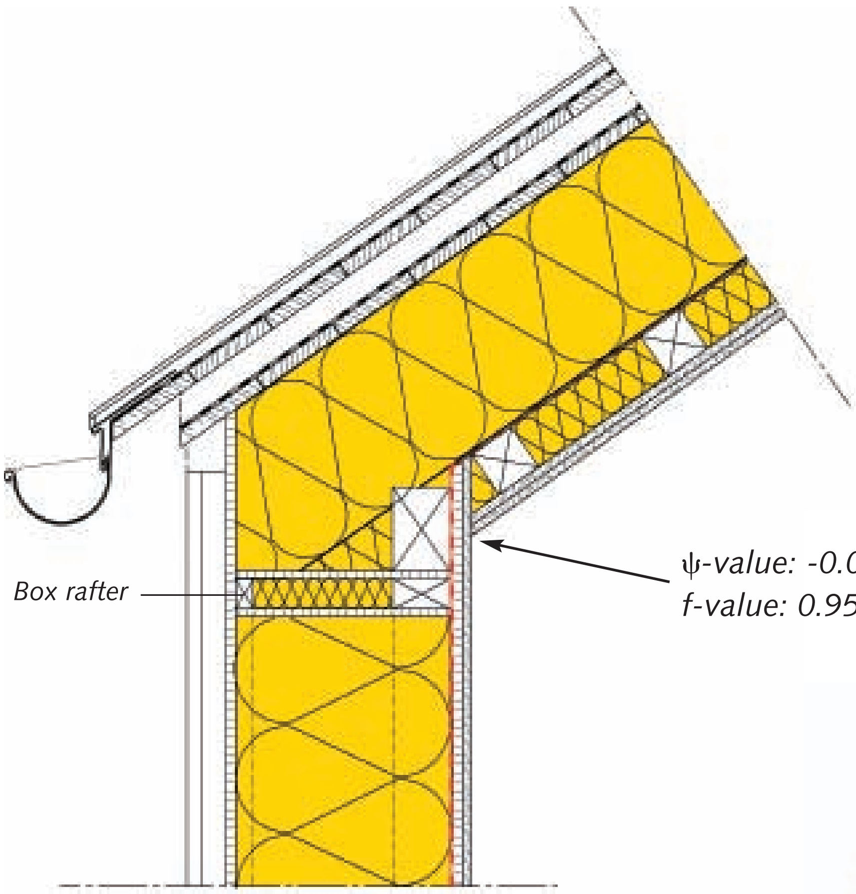
A reasonably priced variant that achieves a high level of thermal insulation. The reason: double thermal insulation of the roof. In addition to the non-ventilated intermediate rafter insulation, a heat-insulating layer is installed below the rafters in the installation layer. It protects the airtight layer against damage and reduces the thermal bridge effect of the rafters.

Roof:	Sound reduction index Rw = 52 dB
	Fire-resistance rating acc. to EN 13501-2, REI 60
Outer wall:	Sound reduction index Rw = 48 dB
	Fire-resistance rating acc. to EN 13501-2, REI 30

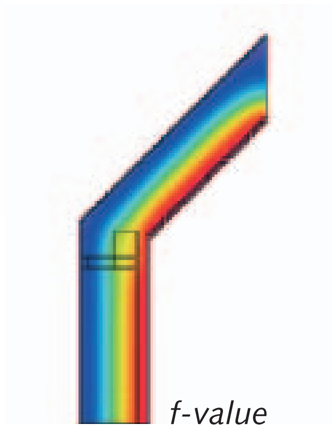
Climatic Membrane Vario KM Duplex overlapping and bonded with KB1



When laying the roof membrane, take it down before the eaves purlin and bond it with the wall membrane.



ψ-value: -0.03 W/(mK)
f-value: 0.952



Connection massive outer wall to rafter roof

A. Roof (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard, 2-layered	0.0250	0.250	0.100
2. Under-rafter insulation between the GB nailing lath	0.0500	0.035	1.428
3. Climatic membrane Vario KM Duplex	–	–	–
4. Glass wool clamping felt between the rafters	0.260	0.035	7.428
5. Roof boarding	0.024	0.130	0.185
6. Underlay, diffusible	–	–	–
7. Roof covering, ventilated	–	–	–
Total sum of thermal resistances			9.141
Thermal surface resistances			0.140
U-value without wooden parts			U = 0.11 W/(m²K)
U-value with wooden parts			U = 0.13 W/(m²K)

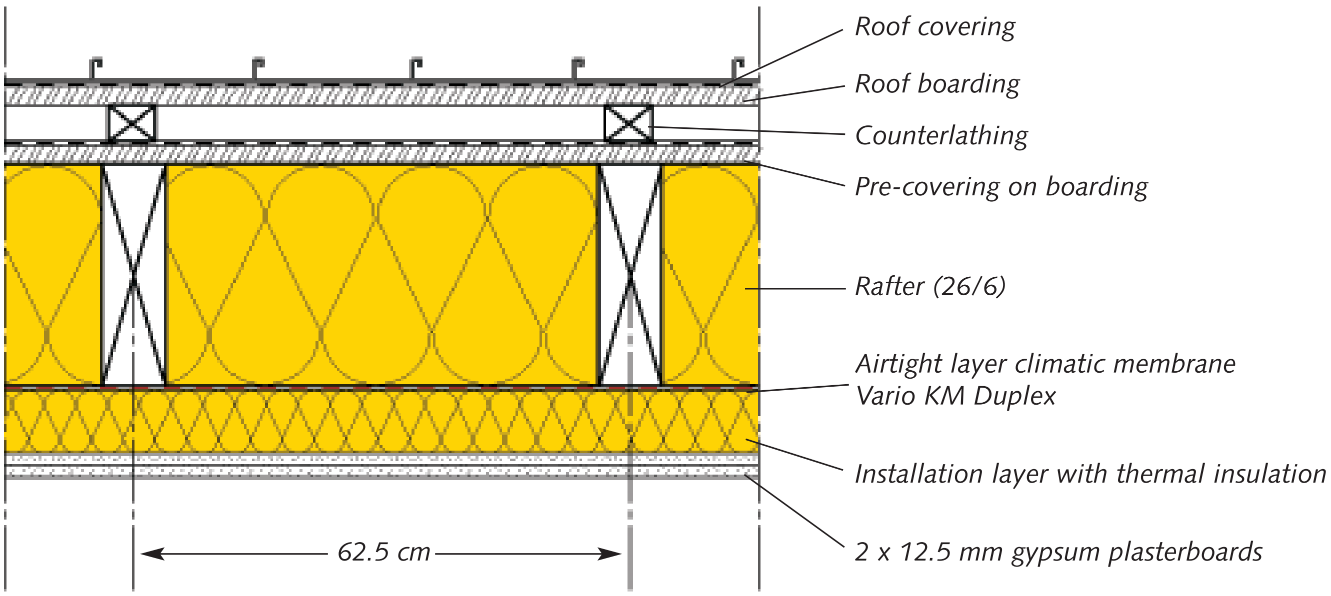
B. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Mineral wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.267
Thermal surface resistances			0.170
U-value of the construction			U = 0.120 W/(m²K)

ψ-value[1)] = -0,03 W/(mK); f-value[2)] = 0.944; minimal surface temperature ϑsi = 18.61 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

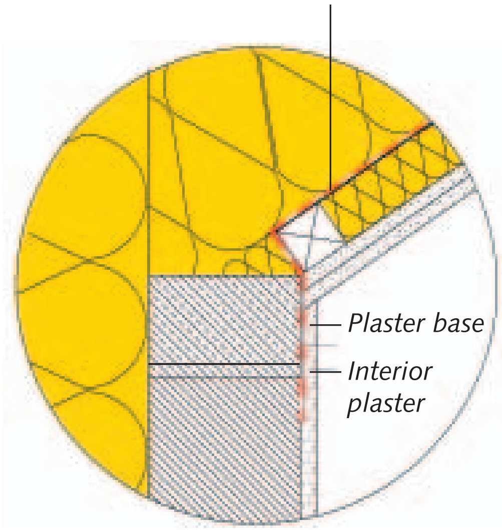
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

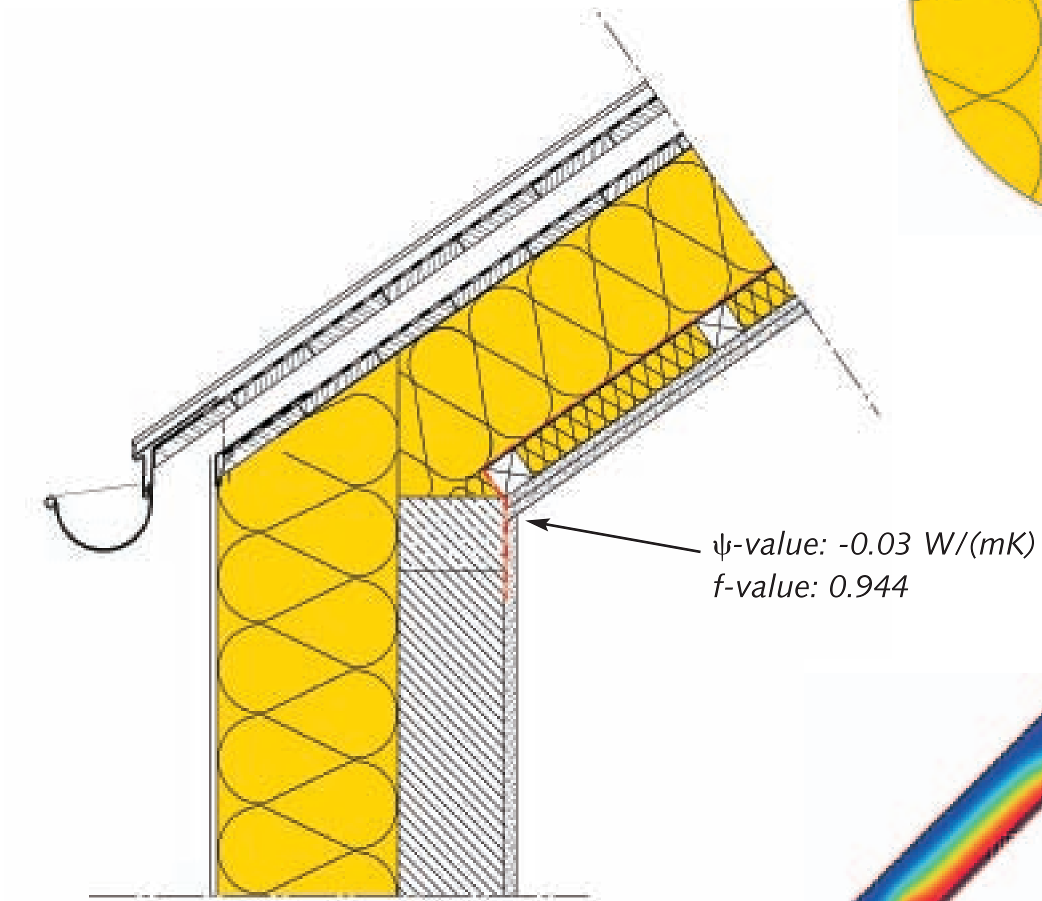


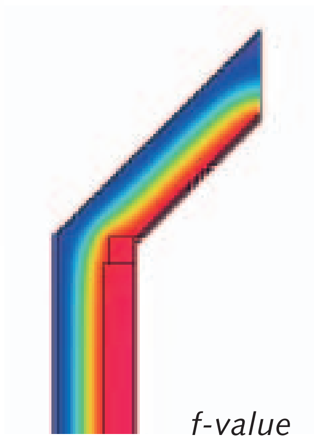
Double insulation for double effect.

A reasonably priced variant that achieves a high thermal insulation effect. The reason: double thermal insulation of the roof. In addition to the non-ventilated intermediate rafter insulation, an insulation layer is installed below the rafters in the installation layer. It protects the airtight layer against damage. An external wall insulated with a mineral wool External Thermal Insulation Composite System (ETICS) offers high acoustic and thermal insulation.

Roof:	Sound reduction index Rw = 52 dB
	Fire-resistance rating acc. to EN 13501-2, REI 60
Outer wall:	Sound reduction index Rw = 56 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90







The Realization.

Connection massive outer wall to rafter roof

A. Roof (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard, 2 x	0.0125	0.250	0.050
2. Air layer insulation	0.0500	–	0.150
3. Climatic membrane Vario KM Duplex	–	–	–
4. Glass wool clamping felt	0.280	0.035	8.000
5. Roof boarding	0.024	0.130	0.185
6. Underlay, diffusible	–	–	–
7. Roof covering, ventilated	–	–	–
Total sum of thermal resistances			8.385
Thermal surface resistances			0.140
U-value without wooden parts			U = 0.12 W/(m²K)
U-value with wooden parts			U = 0.13 W/(m²K)

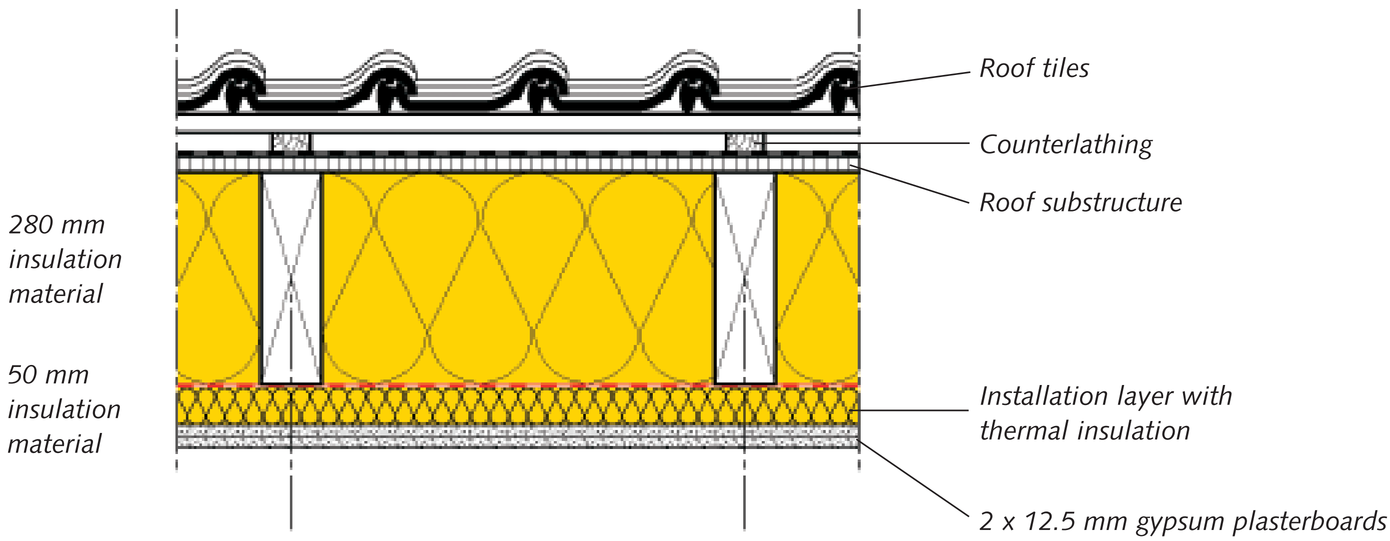
B. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Porous concrete	0.175	0.110	1.591
3. Glass wool core insulation board	0.200	0.035	5.714
4. Clinker 1800 wall facing	0.115	0.810	0.142
Total sum of thermal resistances			7.468
Thermal surface resistances			0.17
U-value of the construction			U = 0.13 W/(m²K)

ψ-value[1)] = -0,03 W/(mK); f-value[2)] = 0.944; minimal surface temperature ϑsi = 18.61 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

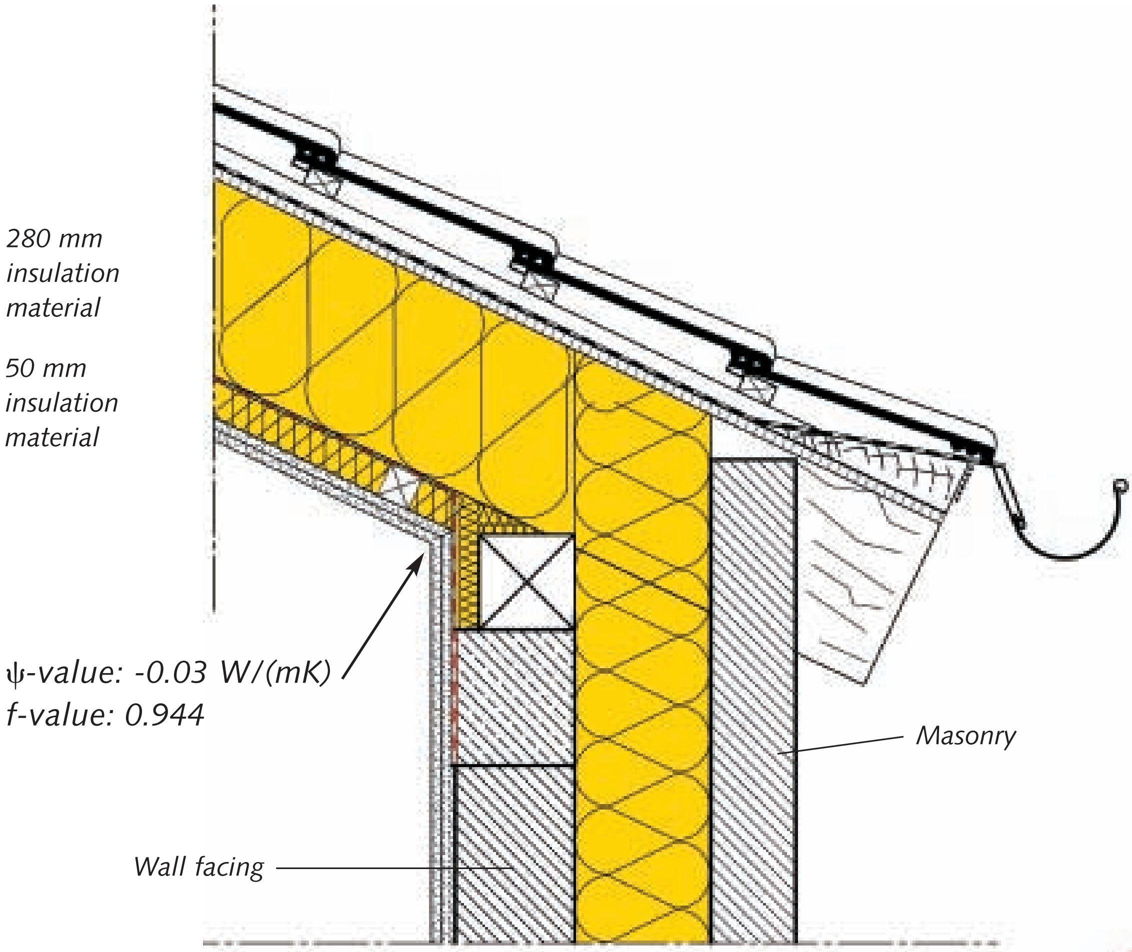
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

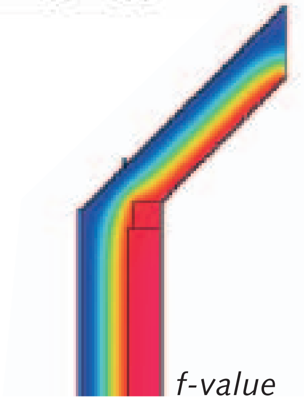


High acoustic, thermal and fire protection.

A reasonably priced variant that achieves a high thermal insulation effect. The reason: double thermal insulation of the roof. In addition to the non-ventilated intermediate rafter insulation, an insulation layer is installed below the rafters in the installation layer. It protects the airtight layer against damage. The external cavity wall with core insulation offers high acoustic, thermal and fire protection.

Roof:	Sound reduction index Rw = 52 dB
	Fire-resistance rating acc. to EN 13501-2, REI 60
Outer wall:	Sound reduction index Rw = 60 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90





Connection massive outer wall to above-rafter insulation

A. **Roof** (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Roof boarding	0.0240	0.130	0.185
2. Climatic membrane VARIO	–	–	–
3. Mineral wool above-rafter insulation with roof liner	0.280	0.035	8.000
4. Ventilation layer	–	–	–
8. Roof covering laid on boarding	–	–	–
Total sum of thermal resistances			8.185
Thermal surface resistances			0.140
U-value of the construction			U = 0.12 W/(m²K)

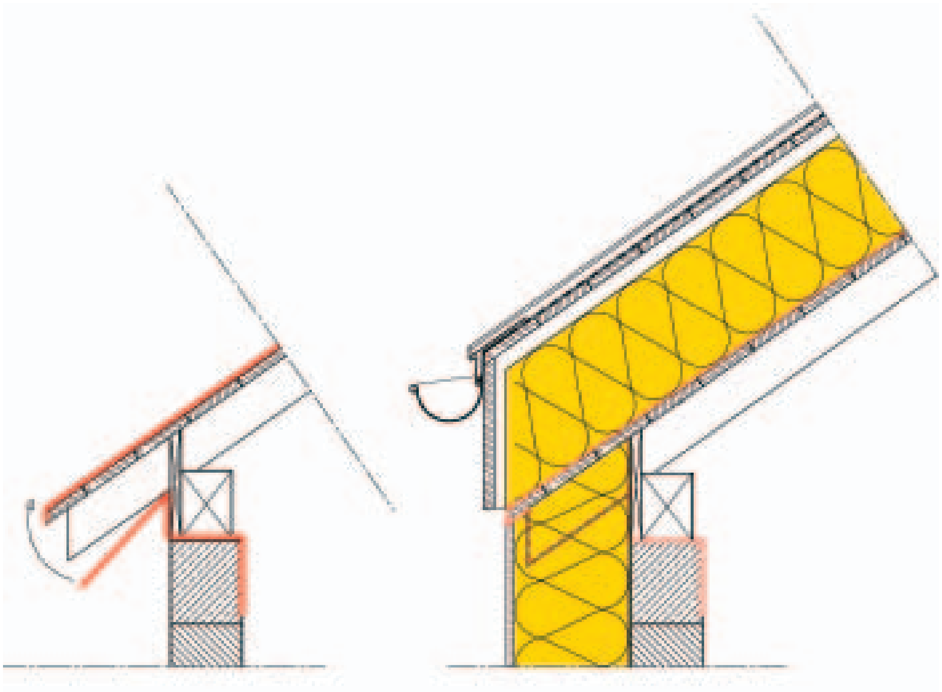
B. **Outer wall** (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Porous concrete	0.175	0.120	1.460
3. Mineral wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			9.506
Thermal surface resistances			0.170
U-value of the construction			U = 0.10 W/(m²K)

ψ-value[1)] = -0,04 W/(mK); f-value[2)] = 0.964; minimal surface temperature ϑsi = 19.11 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

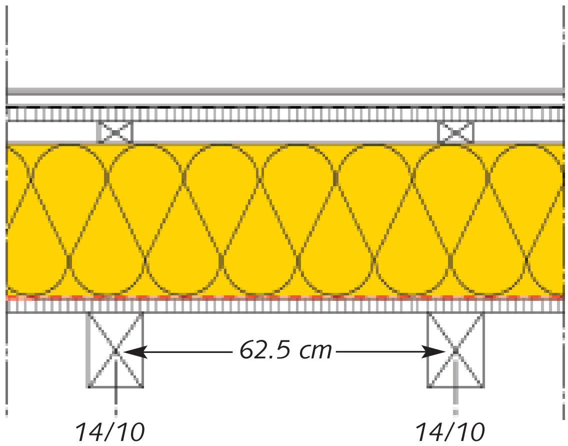
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

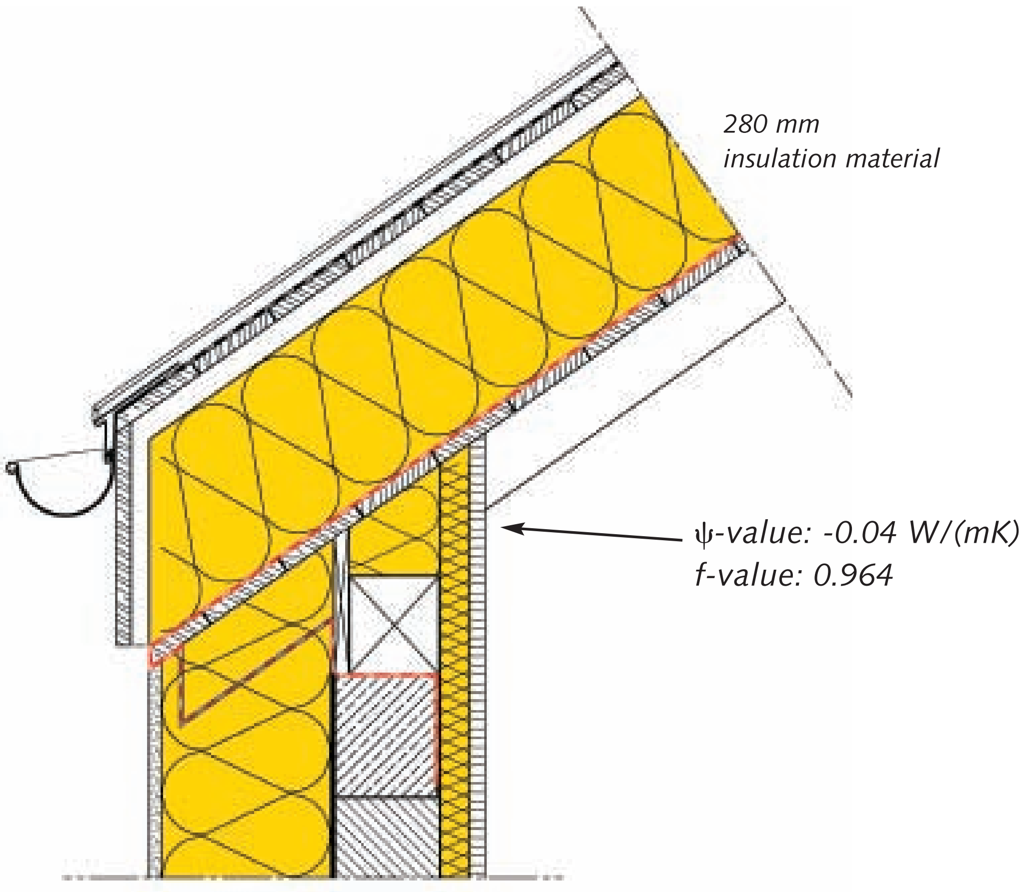


Slim construction offering good acoustic and thermal insulation.

The above-rafter insulation consists of a slim, continuous thermal insulation board with an integrated water-draining layer and offers excellent heat and sound protection. The boards are laid thermal bridge free above the rafters and ensure high comfort in summer.

Roof:	Sound reduction index Rw = 44 dB
	Fire-resistance rating acc. to EN 13501-2, REI 30
Outer wall:	Sound reduction index Rw = 56 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90





Connection massive outer wall to pitched roof construction with TJI joists

A. Roof (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.0125	0.250	0.050
2. Climatic membrane Vario KM Duplex	–	–	–
3. Oriented strand board 600	0.0150	0.130	0.115
4. Glass wool clamping felt	0.260	0.035	7.428
5. Oriented strand board 600	0.0150	0.130	0.115
6. Underlay	–	–	–
7. Roof covering, ventilated	–	–	–
Total sum of thermal resistances			7.708
Thermal surface resistances			0.140
U-value without wooden parts			U = 0.13 W/(m²K)
U-value with wooden parts			U = 0.14 W/(m²K)

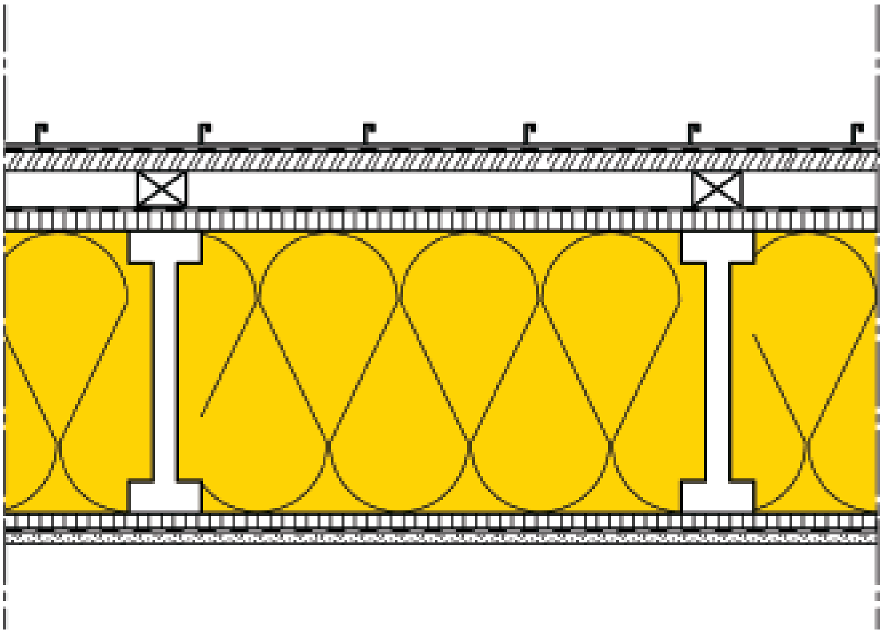
B. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Mineral wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.267
Thermal surface resistances			0.170
U-value of the construction			U = 0.120 W/(m²K)

ψ-value[1] = 0,025 W/(mK); f-value[2] = 0.942; minimal surface temperature ϑsi = 18.56 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

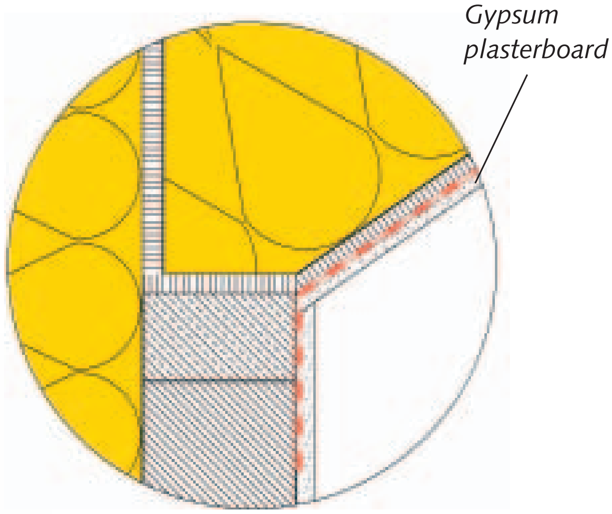
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

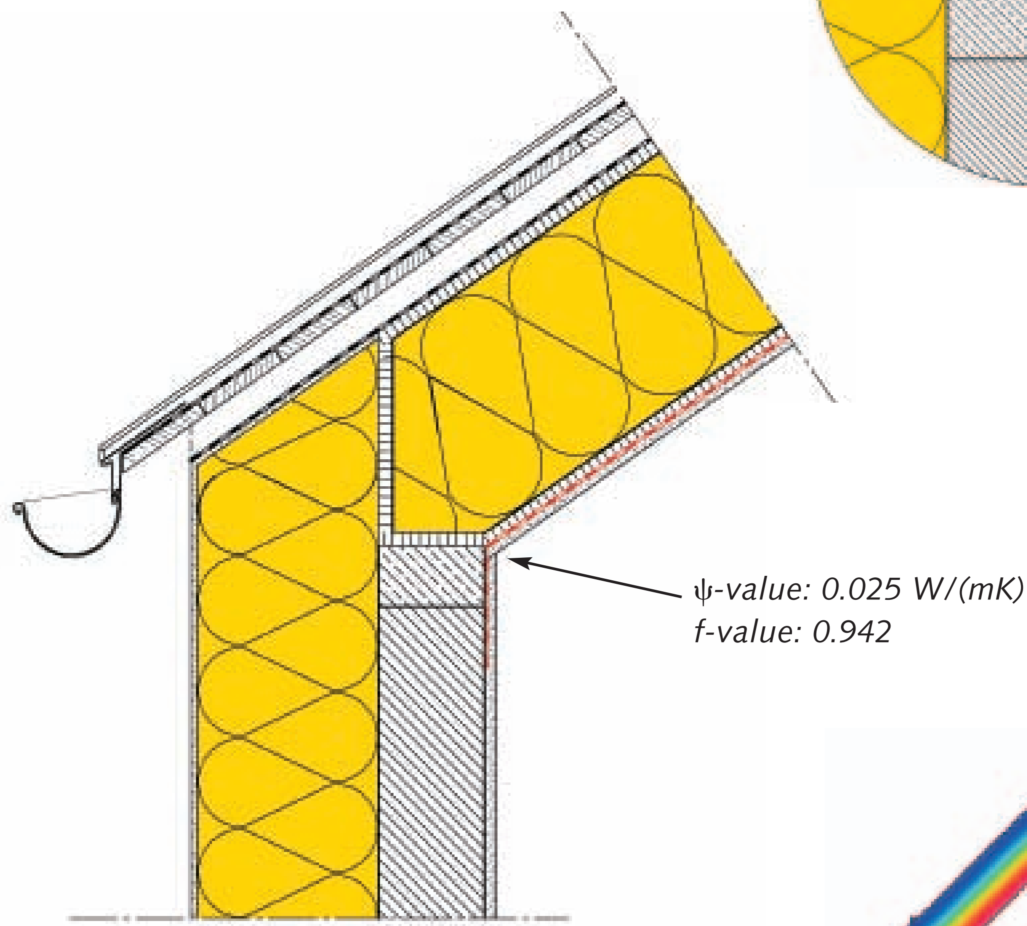


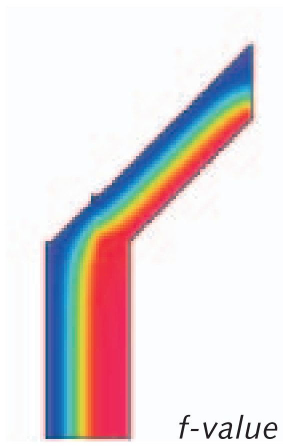
Cost benefit due to prefabrication.

TJI pitched roof construction with a diffusion-capable roofing underlay. A low-cost variant thanks to a high degree of prefabrication which at the same time reduces the number of thermal bridges by the use of TJI joists as supporting structure. The prefabrication of entire roof elements shortens the construction time.

Roof:	Sound reduction index Rw= 52 dB
	Fire-resistance rating acc. to EN 13501-2, REI 30
Outer wall:	Sound reduction index Rw = 56 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90







Connection massive outer wall to pitched roof construction, solid

A. Pitched roof, massive construction (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Roof concrete structure (coffin-type)	0.200	2.300	0.087
3. Glass wool board	0.280	0.035	8.000
4. Roof covering, ventilated	–	–	–
Total sum of thermal resistances			8.108
Thermal surface resistances			0.140
U-value without wooden parts			U = 0.13 W/(m²K)
U-value with wooden parts			U = 0.14 W/(m²K)

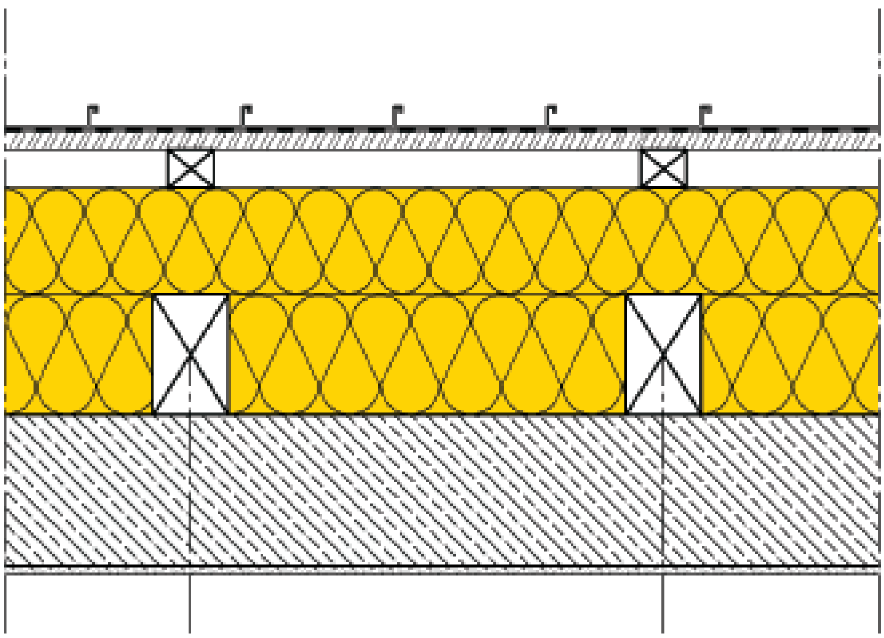
B. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Concrete	0.200	2.300	0.087
3. Mineral wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.133
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

ψ-value[1] = -0,03 W/(mK); f-value[2] = 0.946; minimal surface temperature ϑsi = 18.66 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

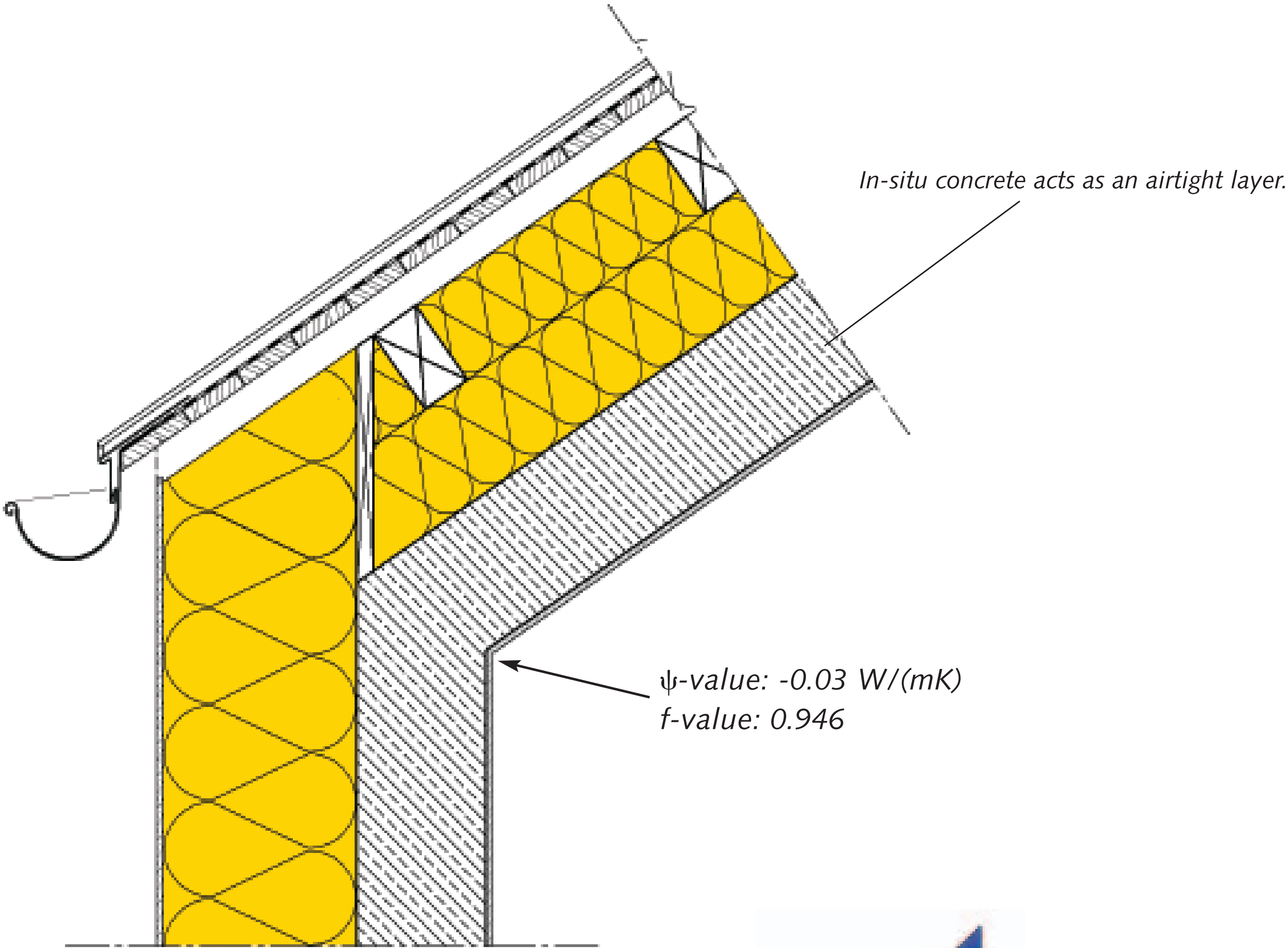
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

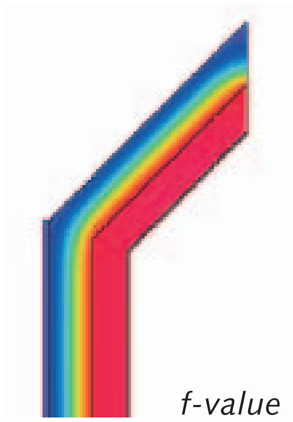


High thermal insulation and fire protection for multi-storey buildings.

A high-quality solution for the construction of multi-storey buildings. It combines a high level of thermal insulation with increased fire prevention At the same time, it offers enhanced sound insulation comfort.

Roof:	Sound reduction index Rw= 65 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90
Outer wall:	Sound reduction index Rw = 65 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90





Connection detail airtight layer rafter roof and wooden joist ceiling with the jamb wall

A. Roof (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.0125	0.250	0.050
2. Climatic membrane Vario KM Duplex	–	–	–
3. Composite wood panel	0.015	0.240	0.062
4. Glass wool under-rafter insulation	0.050	0.035	1.438
5. Composite wood panel	0.024	0.130	0.185
6. Glass wool clamping felt	0.260	0.035	7.428
7. Underlay, diffusible	–	–	–
8. Roof covering, ventilated	–	–	–
Total sum of thermal resistances			9.163
Thermal surface resistances			0.140
U-value of the construction in the compartments between rafters			U = 0.11 W/(m²K)
U-value of the construction with wooden parts			U = 0.12 W/(m²K)

B. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Pored brick 800	0.240	0.210	1.150
3. Mineral wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			9.196
Thermal surface resistances			0.170
U-value of the construction			U = 0.11 W/(m²K)

ψ-value[1)] = -0,03 W/(mK); f-value[2)] = 0.944; minimal surface temperature ϑsi = 18.61 °C; at 20°C indoors and -5°C outdoors.

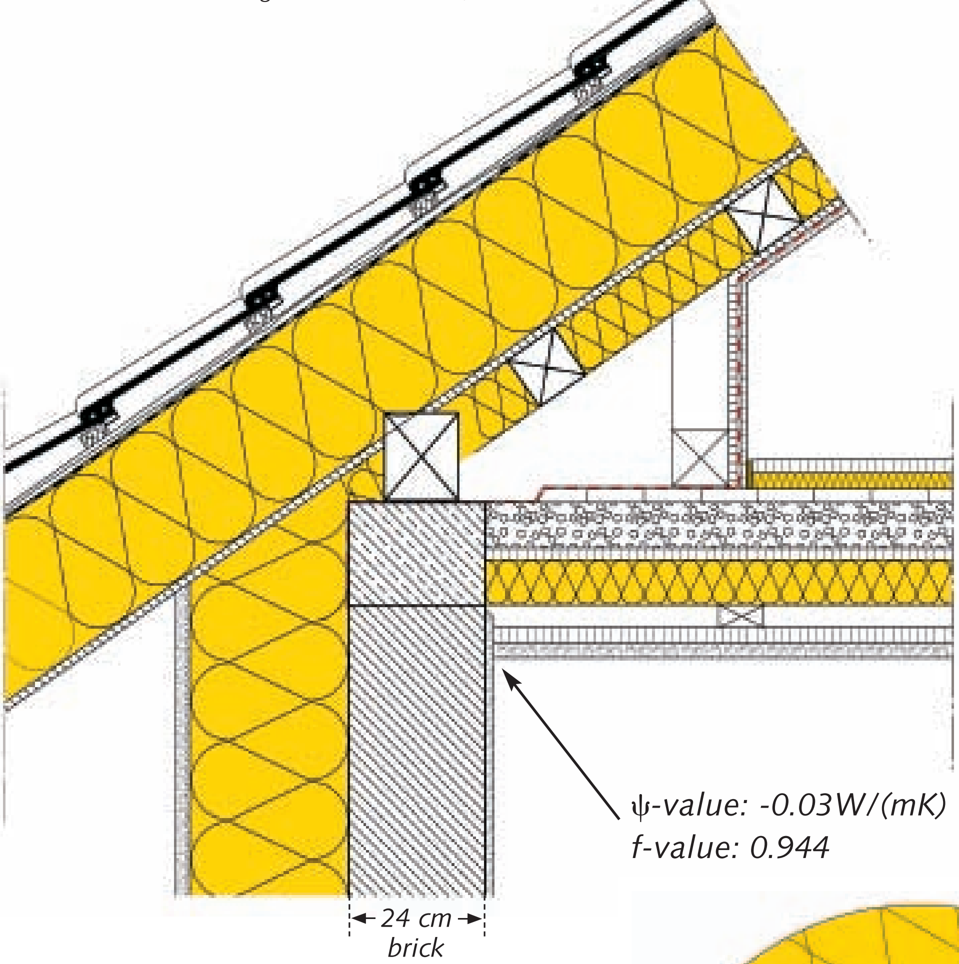
1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

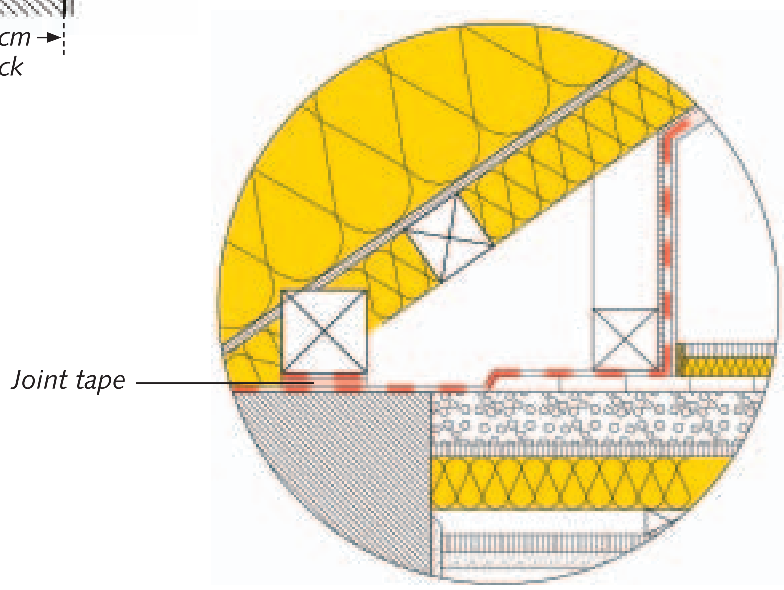
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Airtightness ensured.

The solution below shows how the airtight layer is designed when connecting a rafter roof to a massive wall in conjunction with a wooden joist floor as topmost floor slab.

Roof:	Sound reduction index Rw= 52 dB
	Fire-resistance rating acc. to EN 13501-2, REI 30
Outer wall:	Sound reduction index Rw = 48 dB
	Fire-resistance rating acc. to EN 13501-2, REI 60





Connection party wall to rafter roof

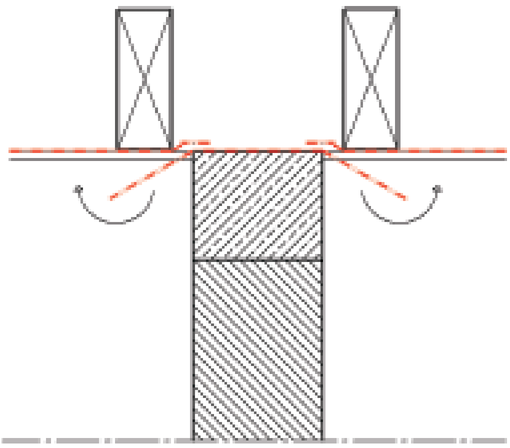
A. Roof (structure from the inside out)

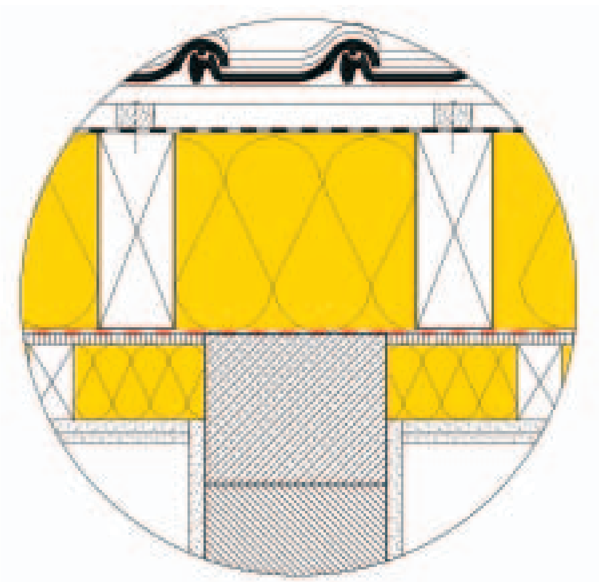
Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard, 2-layered	0.025	0.250	0.100
2. Glass wool under-rafter insulation	0.100	0.035	2.857
3. Composite wood panel 600	0.160	0.140	0.114
4. Glass wool clamping felt	0.240	0.035	6.857
5. Underlay	–	–	–
Total sum of thermal resistances			9.928
Thermal surface resistances			0.140
U-value without wooden parts			U = 0.10 W/(m²K)
U-value with wooden parts			U = 0.12 W/(m²K)

ψ-value[1] = 0,08 W/(mK); f-value[2] = 0.932; minimal surface temperature ϑsi = 18.3°C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

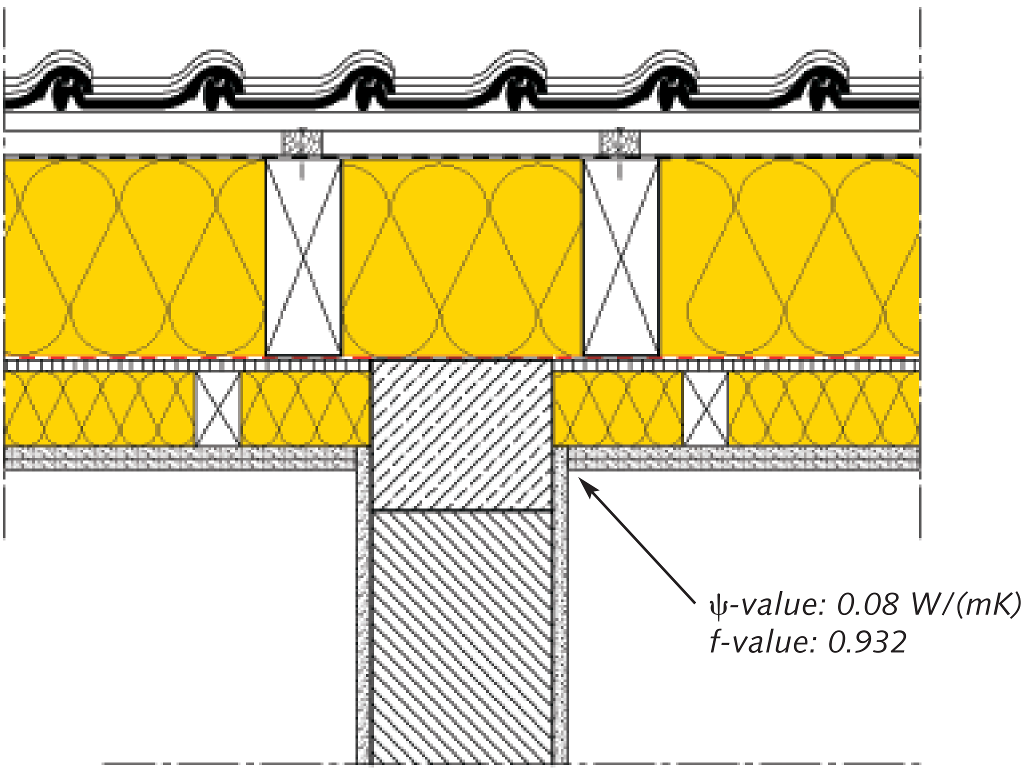


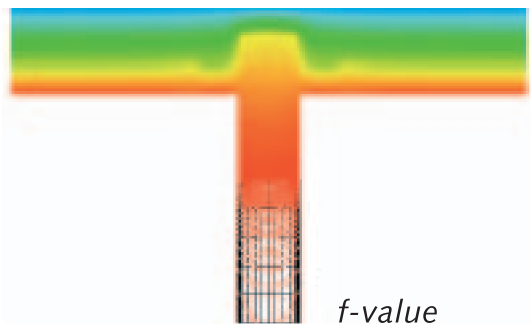


Thermal bridge optimization of the separating wall between flats.

The detail drawing below shows how it is possible to reduce the thermal bridge effect of party walls that have a connection to the roof area.

Roof: Sound reduction index Rw= 53 dB
Fire-resistance rating acc. to EN 13501-2, REI 30





Connection parapet to warm roof in massive construction

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Mineral wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.267
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

B. Parapet (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Roof covering made of sheet metal	–	–	–
2. Mineral wool insulation	0.180	0.035	5.143
3. Sand-lime wall 1600	0.175	0.790	0.221
4. Mineral wool plaster baseboard	0.280	0.035	8.000
5. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			13.389
Thermal surface resistances			0.170
U-value of the construction			U = 0.07 W/(m²K)

C. Flat roof (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Concrete 2300, 1 % reinforcement	0.140	2.300	0.221
3. Mineral wool roof insulation board	0.320	0.040	8.000
4. 2-layered roof insulation + gravel packing	–	–	–
Total sum of thermal resistances			8.242
Thermal surface resistances			0.140
U-value of the construction			U = 0.12 W/(m²K)

ψ-value[1] = 0,036 W/(mK); f-value[2] = 0.904; minimal surface temperature ϑsi = 17.6 °C; at 20°C indoors and -5°C outdoors.

[1] The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

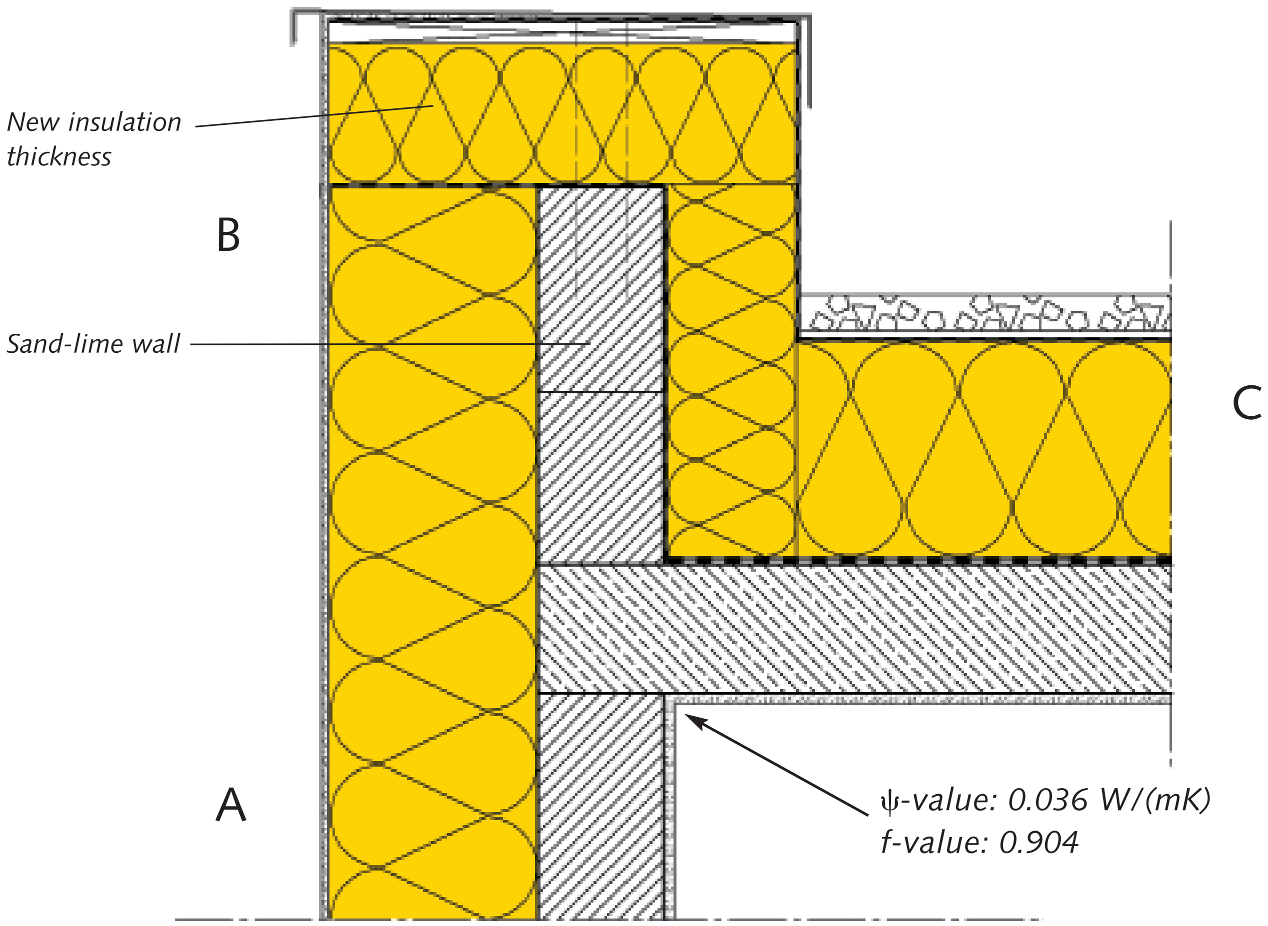
[2] The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

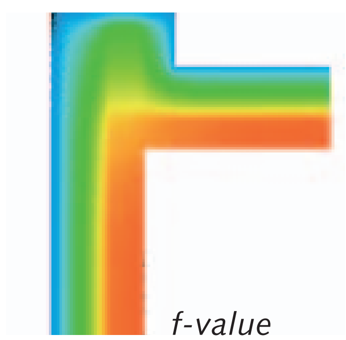
Thermal bridge optimized connection to parapet and flat roof.

The solution shown below is ideal for a compact building design with a flat roof as it clearly minimizes the cooling fin effect of the parapet.

Flat roof: Sound reduction index Rw= 57 dB
Fire-resistance rating acc. to EN 13501-2, REI 90

Outer wall: Sound reduction index Rw = 55 dB
Fire-resistance rating acc. to EN 13501-2, REI 90





The Realization.

Warm roof with parapet and curtain wall

A. **Outer wall** (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Glass wool facade insulation board	0.280	0.035	8.000
4. Ventilation layer	0.025	1.000	0.025
5. Cladding, ventilated	–	–	–
Total sum of thermal resistances			8.242
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

B. **Flat roof** (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Roof covering made of sheet metal	–	–	–
2. Mineral wool insulation	0.180	0.035	5.143
3. Sand-lime wall 1600	0.175	0.790	0.221
4. Mineral wool facade insulation board	0.280	0.035	8.000
5. Cladding	–	–	–
Total sum of thermal resistances			13.364
Thermal surface resistances			0.170
U-value of the construction			U = 0.07 W/(m²K)

C. **Flat roof** (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Concrete 2300, 1 % reinforcement	0.140	2.300	0.221
3. Mineral wool roof insulation board	0.320	0.040	8.000
4. 2-layered roof insulation + gravel packing	–	–	–
Total sum of thermal resistances			8.242
Heat transfer resistances			0.140
U-value of the construction			U = 0.12 W/(m²K)

ψ-value[1] = 0,036 W/(mK); f-value[2] = 0.904; minimal surface temperature ϑsi = 17.6 °C; at 20°C indoors and -5°C outdoors.

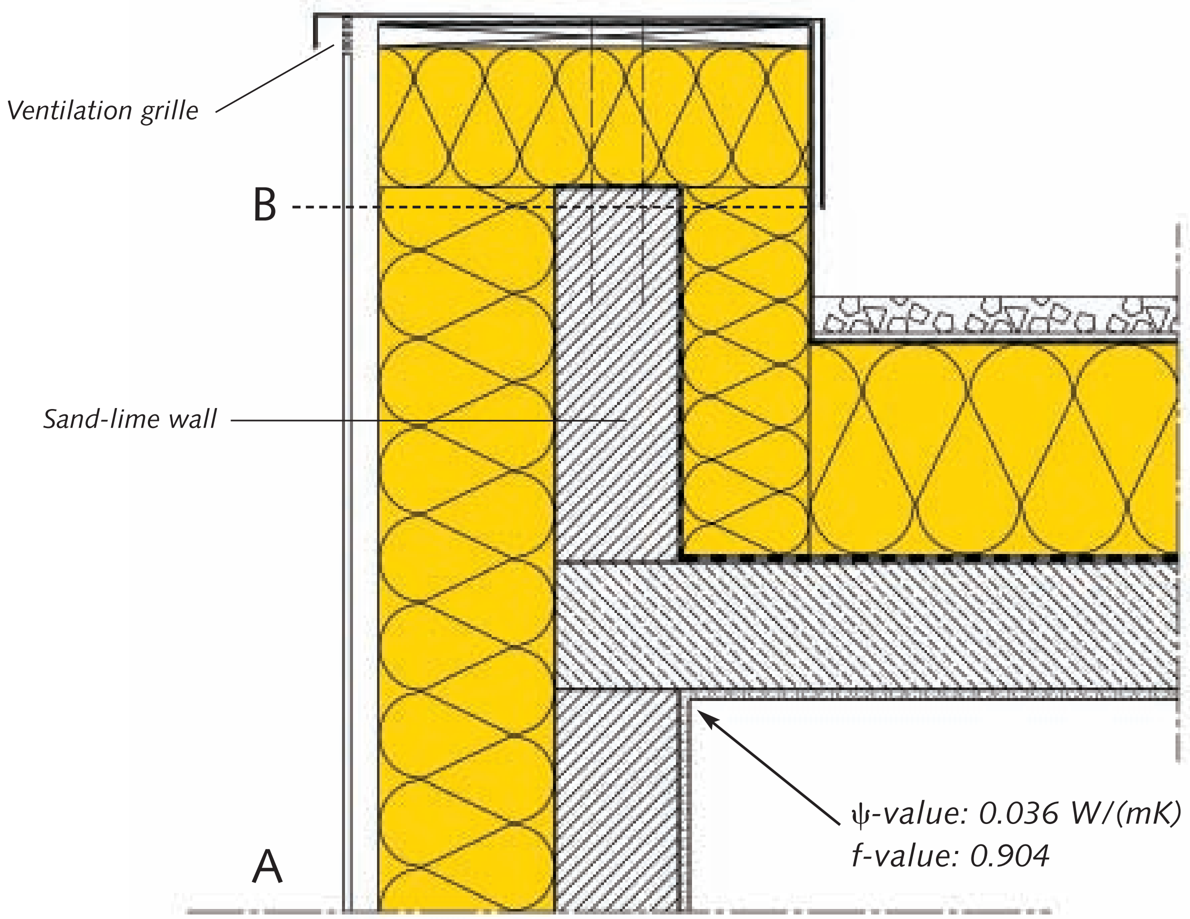
[1] The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

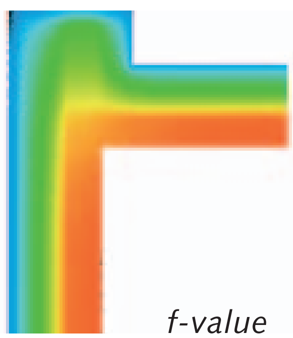
[2] The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Thermal bridge optimized connection to parapet and flat roof.

The solution shown below is ideal for a compact building design with a flat roof as it clearly minimizes the cooling fin effect of the parapet.

Flat roof:	Sound reduction index Rw= 57 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90
Outer wall:	Sound reduction index Rw = 56 dB
	Fire-resistance rating acc. to EN 13501-2, REI 90





The principle: optimal all-round

Each structural component has a crucial effect.

Whether roof, external wall or cellar – good thermal quality of the individual components is always the safest and most sustainable way to avoid heat loss. All opaque elements of the building envelope should be thermal insulated so well that their thermal transmittance (U-value) is less or equal 0.15 W/(m²K). In other words: for every degree temperature change and every square meter outer surface not more than max. 0.15 W heating energy must be lost. Usually, the major heat losers for most homes are edges and corners, connections and penetrations. It is therefore essential to ensure optimum insulation of these areas – as gapless as possible so that thermal bridges don't have the slightest chance.

To the point:

Recommended U-values for the building envelope.

External wall	U-value	≤	0.10 W/(m²K)
Roof/ceilings/floors	U-value	≤	0.10 W/(m²K)
Floor above cellar	U-value	≤	0.15 W/(m²K)
PHPP-value*)	Ψ	≤	0.01 W/(mK)

**) PHPP = Passive House Planning Package offered by the Passivhausinstitut in Darmstadt/Germany*

The facade: higher benefit from insulation than from masonry.

For economic reasons, the load-bearing masonry should only fulfil the static minimum requirements. Heat protection is primarily provided by thermal insulation. Facade and external walls can do more for a home than merely be its "visiting card": they can save a lot of energy if insulated well. And what is more: with a suitable orientation, the facade can be equipped with a system for producing renewable energy, e.g. a photovoltaic unit.

One external wall is not like the other.

This does not only apply to the visual but also to the technical design. Depending on the budget, intended use and desired form of the house, a matching design variant can be chosen. Here a brief overview:

- **The ventilated facade as universal solution.**

Here, we have a functional separation between a load-carrying, a heat- and sound-insulating and a water-draining layer, including an air gap between insulation and cladding. This separation optimally fulfils the physical demands made on the structure of an external wall. The ventilated facade lends itself to various designs. Whether wood, stone, glass, metal or ceramics: the facade can be clad with all weather-

thermal insulation.

Detached house Akazienweg, Bruck/Waasen, Austria
Planner: Plöderl.Architektur.Urbanismus.PAUAT Architekten

resistant materials. The load-bearing inner envelope makes it possible to install low-cost insulation materials (e.g. ISOVER mineral wool) and thus to achieve passive house standard.

- **Cavity walls: always with a heat-insulated cavity.**

This variant also assures good separation of the functions support, heat insulation and waterproofing. The use of hydrophobic core insulation made of glass wool provides durable, reliable as well as economical protection of the building.

- **External thermal insulation composite systems (ETICS): for jointless facade insulation.**

The advantages of systems based on mineral wool insulation boards are above all their non-flammability and the high diffusibility that promotes the rapid reverse drying of damp walls.

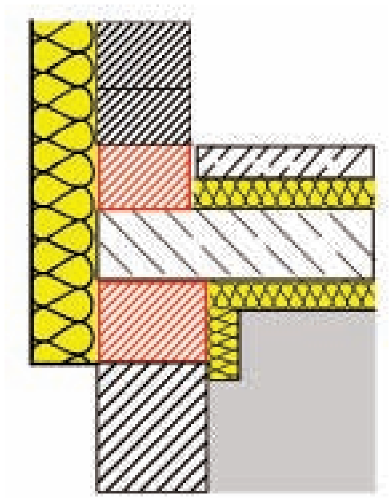
Timber construction
Good to know:
Compared to solid construction, timber construction offers the great advantage that a major part of the insulation can be fitted between the wooden frames and does not need to be additionally installed from outside. Consequence: lower wall thickness, higher degree of prefabrication, shorter construction times and lower building costs.

Filling the wood-frame construction tightly with ISOVER glass wool

The devil's in the detail: flaws in walls,

Junctions are the weakest spots.

Penetrations of the building envelope by utility pipes, windows and doors are unavoidable. For this reason, thermal bridges can never be fully excluded. It is therefore indispensable to reduce these energy wasters to a minimum. For: The higher the thermal insulation quality of the building, the stronger the proportionate effect of a structural weakness on the total heat loss.



For more security: decouple the foundation.

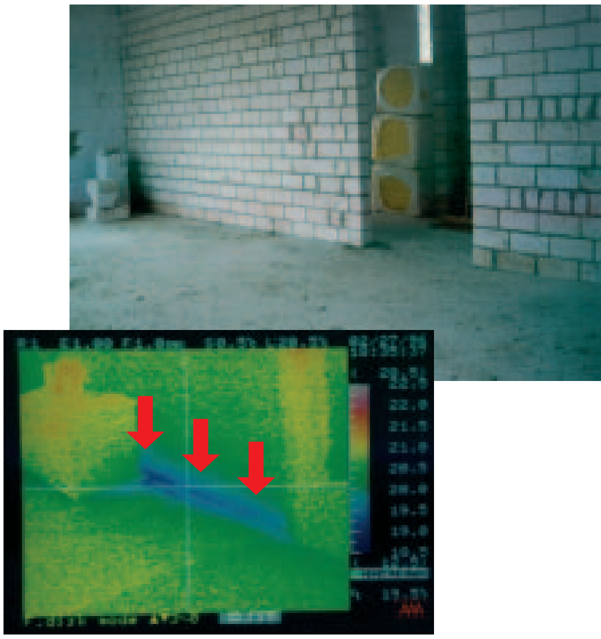
To prevent that heat is transmitted via the foundation or the ice wall, the foundation should be decoupled from the bottom slab. Even if the overlying insulation layer takes care of thermal insulation, greatest possible security can only be achieved by thermal separation.

Critical area: where the outer wall meets the cellar.

Especially with solidly built houses heat must be prevented from escaping through the brickwork or into the ground via highly heat-conductive concrete elements. Quite frequently, the cellar floor is insulated but the insulation layer interrupted in the area of the outer wall or of the foundations. This problem can be remedied by sufficient wall base insulation and should already be considered in the planning stage.

Likewise: partition wall meets insulated floor.

Where solid partition walls meet floors with room-side insulation, thermal separation by means of low heat-conducting building materials is necessary. The negative example on the right provides the proof: the job seems to have been executed with reasonable care and skill, but thermographic imaging clearly shows the thermal bridge. Refurbishment is done by additionally insulating the flanking building components.



Typical weak spot because a well heat-conducting inner wall of the ground floor rises directly from the cold cellar floor.
(Source: Niedrig Energie Institut Germany)

ceilings and cellars.

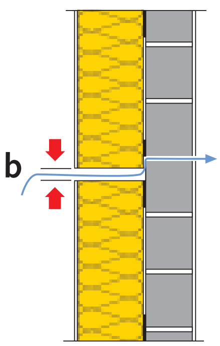
Cavities, insulation gaps and joints.

A closed, not too big cavity has only little energetic impact. By contrast, gaps and joints in the thermal insulation of a house cause considerable heat loss.

Their thermal bridge effect is so strong that they should best be filled with mineral wool. But don't use mortar as this would even reinforce the thermal bridge effect. Also watch out for communicating cavities: they can render an insulating layer nearly ineffective.

Joints are fatal.

Joints which are open on both sides have only little flow resistance. In a system that is otherwise completely closed, the heat loss multiplies many times over. It is therefore absolutely necessary to locate and completely eliminate them. Otherwise the building will be draughty and prone to structural damage.



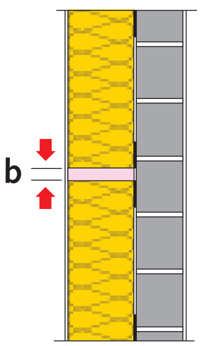
A joint is open on both sides and makes the house leaky.

No need to worry about closed cavities.

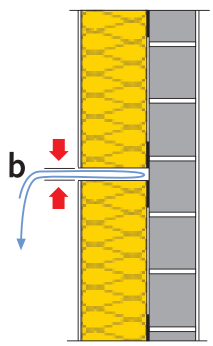
Cavities located in the insulation layer are always airtight although they are not insulated. With cavities below 5 mm width, this lack of insulation does not cause any problems. As long as the cavities are non-communicating, no remedial measures need to be taken. Not so with cavities of more than 5 mm width.

Insulation gaps ruin the energy balance.

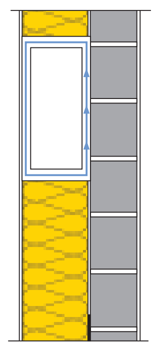
As gaps in the insulation are closed on only one side, they allow air flows on the other. This results in considerable heat loss. Thus a gap of 10 mm can reduce the insulating effect of a 300 mm thick composite thermal insulation system down to that of an insulation layer of just 90 mm thickness.



Cavities are airtight, but insulation is missing.



Insulation gaps are open on one side.



Communicating cavities considerably increase convection, thus being able to render the insulation nearly ineffective.

The Realization.

Connection outer wall (timber construction) to cellar floor above unheated cellar

A. Cellar base (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Concrete 2300	0.200	2.300	0.087
3. XPS insulation, 2-layered	0.240	0.039	6.154
4. Exterior plaster	0.025	1.000	0.036
Total sum of thermal resistances			6.298
Thermal surface resistances			0.170
U-value of the construction			U = 0.15 W/(m²K)

B. Outer wall, timber construction (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Mineral wool insulation	0.050	0.035	1.429
3. Composite wood panel	0.015	0.240	0.062
4. Glass wool felt	0.320	0.035	9.143
5. Wood fibreboard, e.g. MDF	0.016	0.070	0.228
6. Cladding, ventilated	–	–	–
Total sum of thermal resistances			10.922
Thermal surface resistances			0.170
U-value of the construction in the compartments between rafters			U = 0.09 W/(m²K)
U-value of the construction with wooden parts			U = 0.10 W/(m²K)

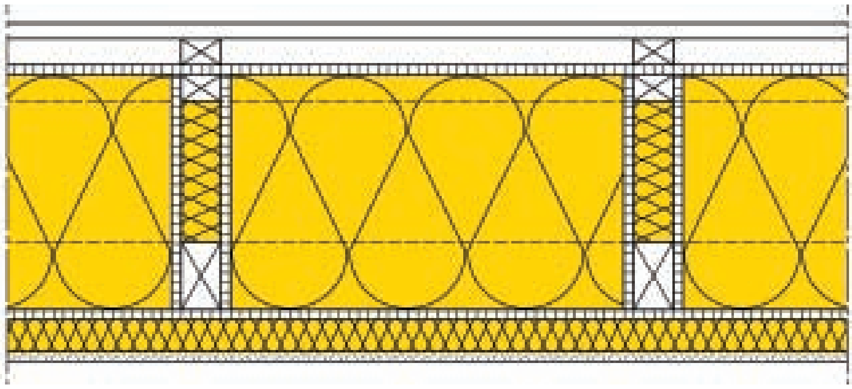
C. Cellar floor (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Cement screed	0.050	1.400	0.035
2. Mineral wool impact sound insulation	0.025	0.035	0.714
3. Composite wood panel	0.015	0.240	0.062
4. Mineral wool insulation	0.120	0.035	3.429
5. Concrete 2300, 1 % reinforcement	0.160	2..300	0.069
Total sum of thermal resistances			4.303
Thermal surface resistances			0.210
U-value of the construction			U = 0.22 W/(m²K)

ψ-value[1)] = -0.181 W/(mK); f-value[2)] = 0.940; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

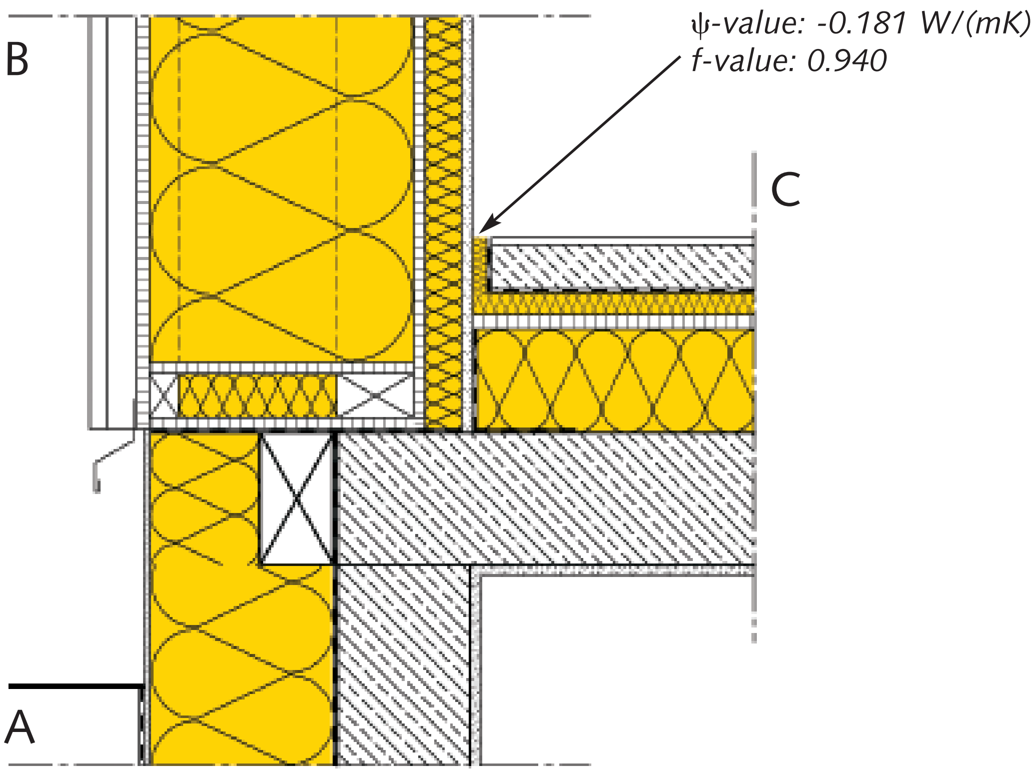
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

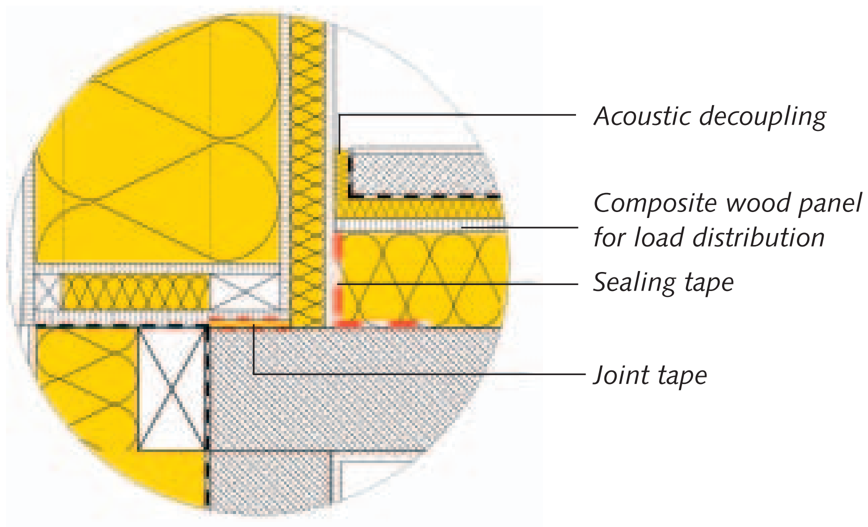


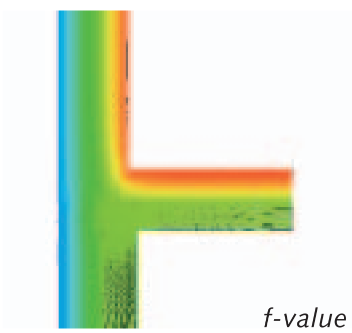
High thermal insulation and airtightness.

The solution shown below produces a thermal bridge optimized, airtight connection to a box rafter external wall with a ventilated cladding.

Outer wall: Sound reduction index Rw = 52 dB
Fire-resistance rating acc. to EN 13501-2, REI 30







f-value

Connection terrace door to cellar floor above unheated cellar

A. Cellar floor (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Cement screed	0.050	1.400	0.035
2. Mineral wool impact sound insulation	0.045	0.035	1.286
3. Concrete 2300, 1 % reinforcement	0.160	2.300	0.069
4. Mineral wool insulation	0.220	0.035	6.286
5. Plaster coat	0.015	0.700	0.021
Total sum of thermal resistances			7.697
Thermal surface resistances			0.210
U-value of the construction			U = 0.13 W/(m²K)

B. Cellar wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Concrete 2300, 1 % reinforcement	0.220	2.300	0.095
2. Moisture sealing	–	–	–
3. Perimeter insulation XPS	0.160	0.039	4.102
Total sum of thermal resistances			4.197
Thermal surface resistances			0.130
U-value of the construction			U = 0.23 W/(m²K)

Additional interior insulation of the floor connection d = 0.09 m , height = 0.50 m

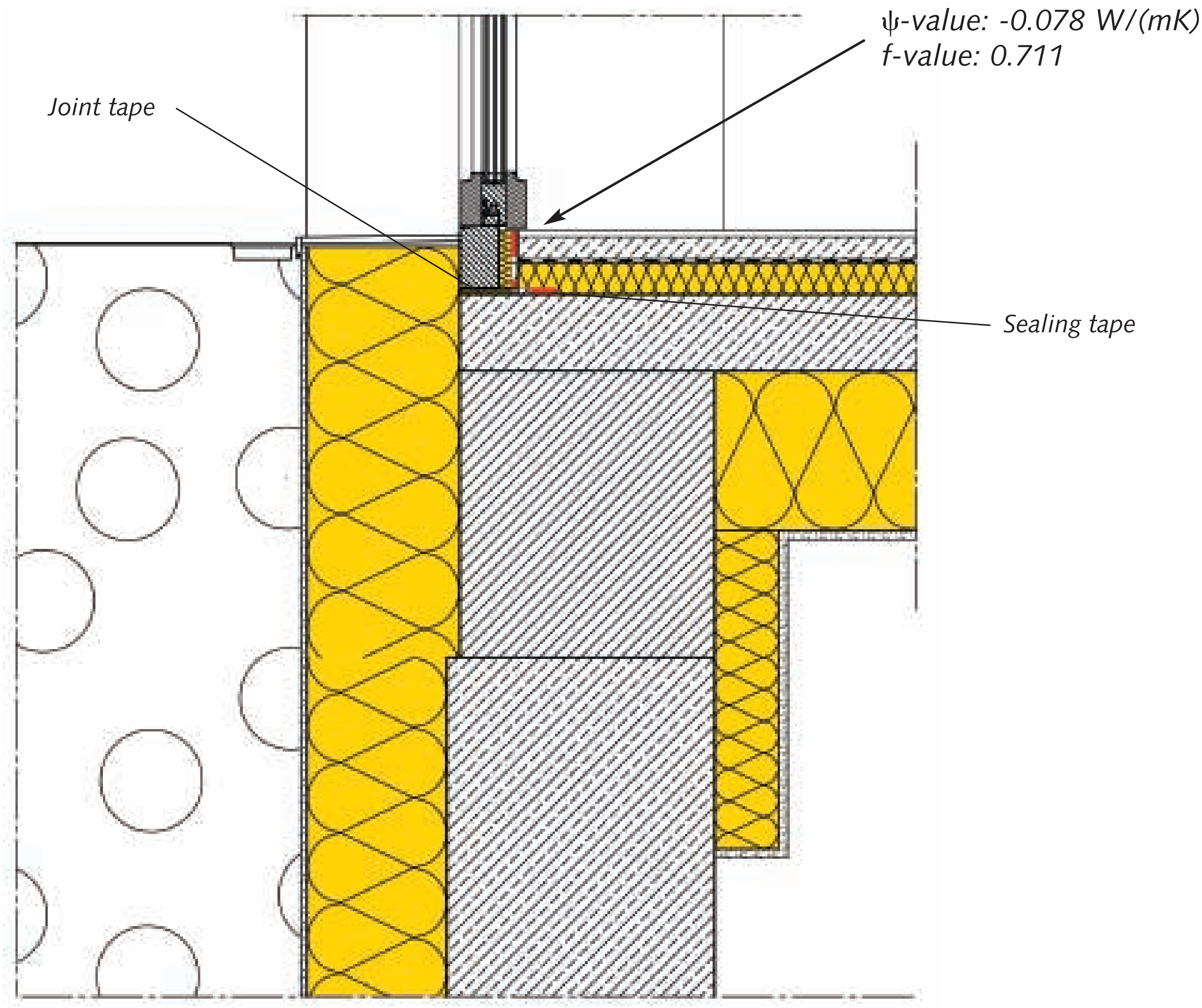
ψ-value[1)] = -0.078 W/(mK); f-value[2)] = 0.711

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Thermal bridge optimized terrace connection.

Thermal bridging can be reliably prevented when overlapping the window frame with thermally insulating materials and combining this with highly heat-insulating offset blocks and optimized insulation on the underside of the cellar floor.



The Realization.

Connection of outer wall (timber construction) to slab on the ground

A. Outer wall, timber construction (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Mineral wool insulation	0.050	0.035	1.429
3. Composite wood panel	0.015	0.240	0.062
4. Glass wool felt	0.320	0.035	9.143
5. Wood fibreboard, e.g. MDF	0.016	0.100	0.160
6. Cladding, ventilated	–	–	–
Total sum of thermal resistances			10.854
Thermal surface resistances			0.170
U-value without wooden parts			U = 0.09 W/(m²K)
U-value of the construction with wooden parts			U = 0.10 W/(m²K)

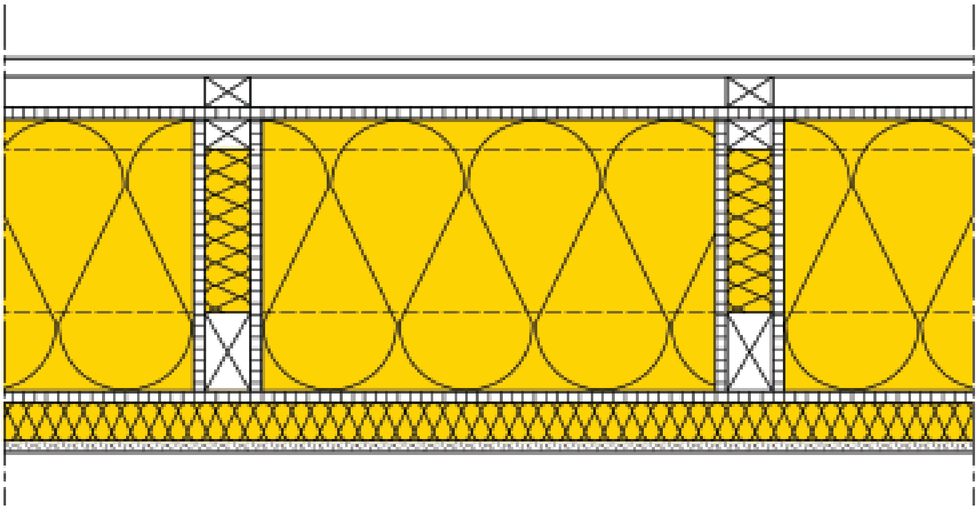
B. Base slab (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Cement screed	0.050	1.400	0.035
2. Mineral wool impact sound insulation	0.030	0.035	0.857
3. Moisture sealing	–	–	–
4. Concrete 2300, 1 % reinforcement	0.300	2.300	0.130
5. Separation layer	–	–	–
6. XPS insulation, 2-layered	0.240	0.039	6.153
7. Foundation course	–	–	–
Total sum of thermal resistances			7.175
Thermal surface resistances			0.210
U-value of the construction			U = 0.15 W/(m²K)

ψ-value[1] = -0.082 W/(mK); f-value[2] = 0.944; minimal surface temperature ϑsi = 18.6 °C; at 20°C indoors and -5°C outdoors.

[1] The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

[2] The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

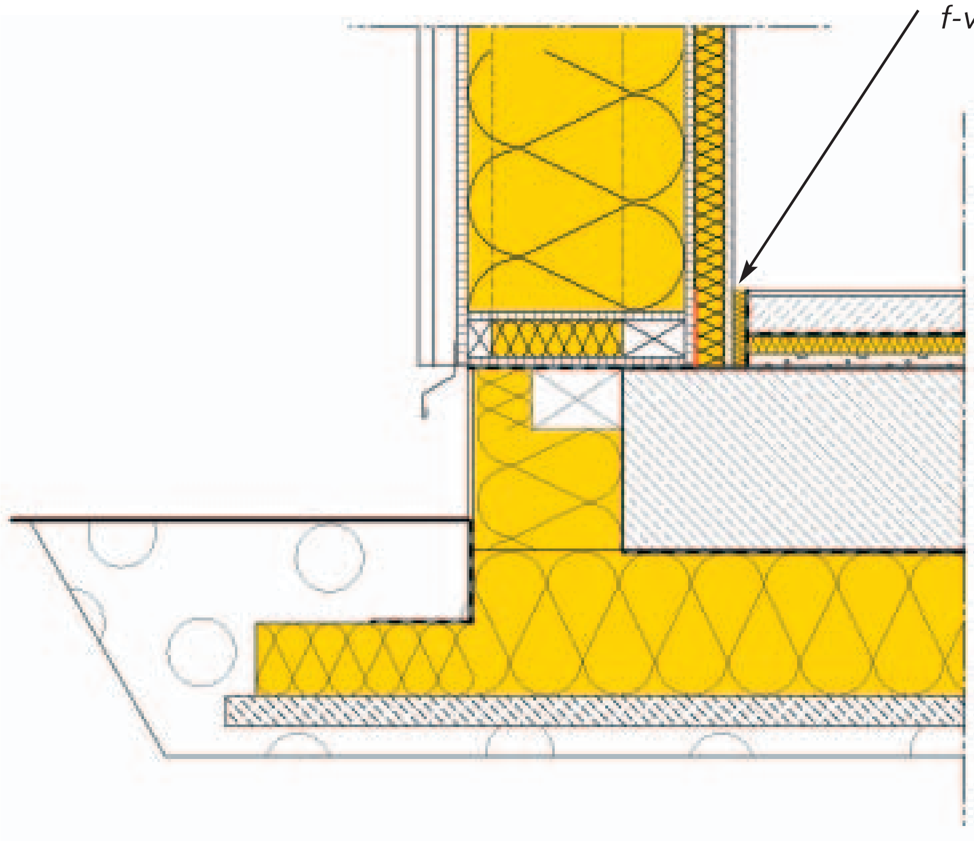


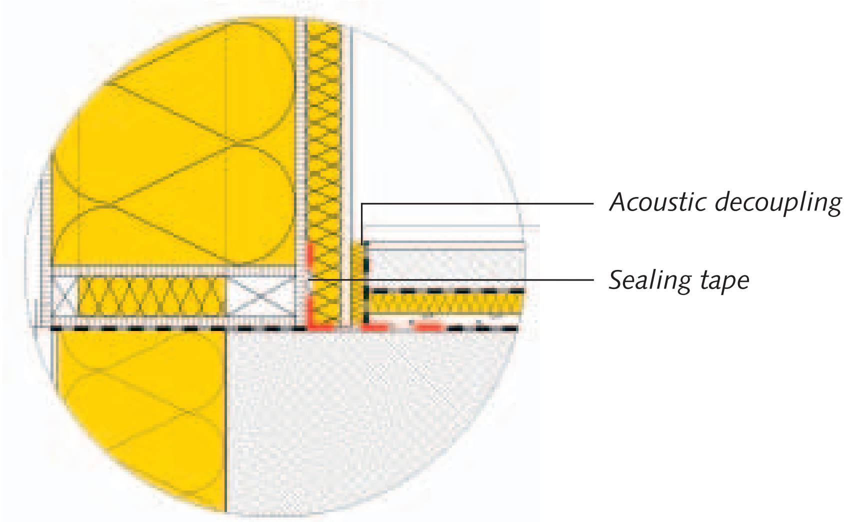
Connection of outer wall to slab on the ground.

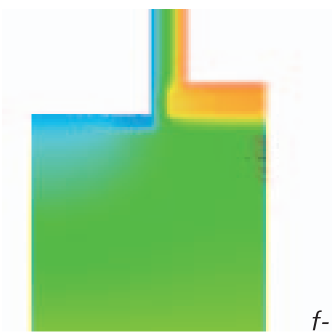
When connecting the ventilated outer wall with the base slab, the ice wall considerably contributes to reducing heat loss via the ground.

Outer wall: Sound reduction index Rw = 52 dB
Fire-resistance rating acc. to EN 13501-2, REI 30

ψ-value: -0.082 W/(mK)
f-value: 0.944







f-value

The Realization.

Outer wall (timber construction) with ETICS based on mineral wool to basement floor above unheated cellar

A. Cellar base (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Concrete 2300	0.200	2.300	0.087
3. XPS insulation, 2-layered	0.240	0.039	6.153
4. Exterior plaster	0.025	1.000	0.036
Total sum of thermal resistances			6.297
Thermal surface resistances			0.170
U-value of the construction			U = 0.15 W/(m²K)

B. Outer wall, timber construction (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Mineral wool insulation	0.050	0.035	1.429
3. Climatic membrane Vario KM	–	–	–
4. Composite wood panel	0.015	0.240	0.062
5. Glass wool felt	0.200	0.035	5.714
6. Wood fibreboard, e.g. MDF	0.016	0.100	0.168
7. Mineral wool plaster baseboard	0.140	0.035	4.000
8. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			11.458
Thermal surface resistances			0.170
U-value of the construction in the compartments between rafters			U = 0.08 W/(m²K)
U-value of the construction with wooden parts			U = 0.09 W/(m²K)

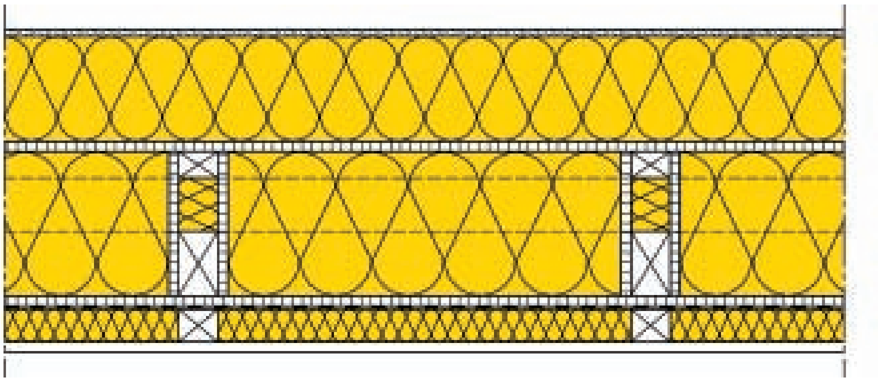
C. Cellar floor (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Wooden floor, frame-mounted	0.024	0.240	0.100
2. Glass wool between bolsters	0.040	0.035	1.143
3. Mineral wool insulation	0.200	0.035	5.714
4. Concrete 2300, 1 % reinforcement	0.160	2.300	0.069
Total sum of thermal resistances			7.026
Thermal surface resistances			0.21
U-value of the construction			U = 0.14 W/(m²K)

ψ-value[1)] = 0.033 W/(mK); f-value[2)] = 0.944; minimal surface temperature ϑsi = 18.6 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

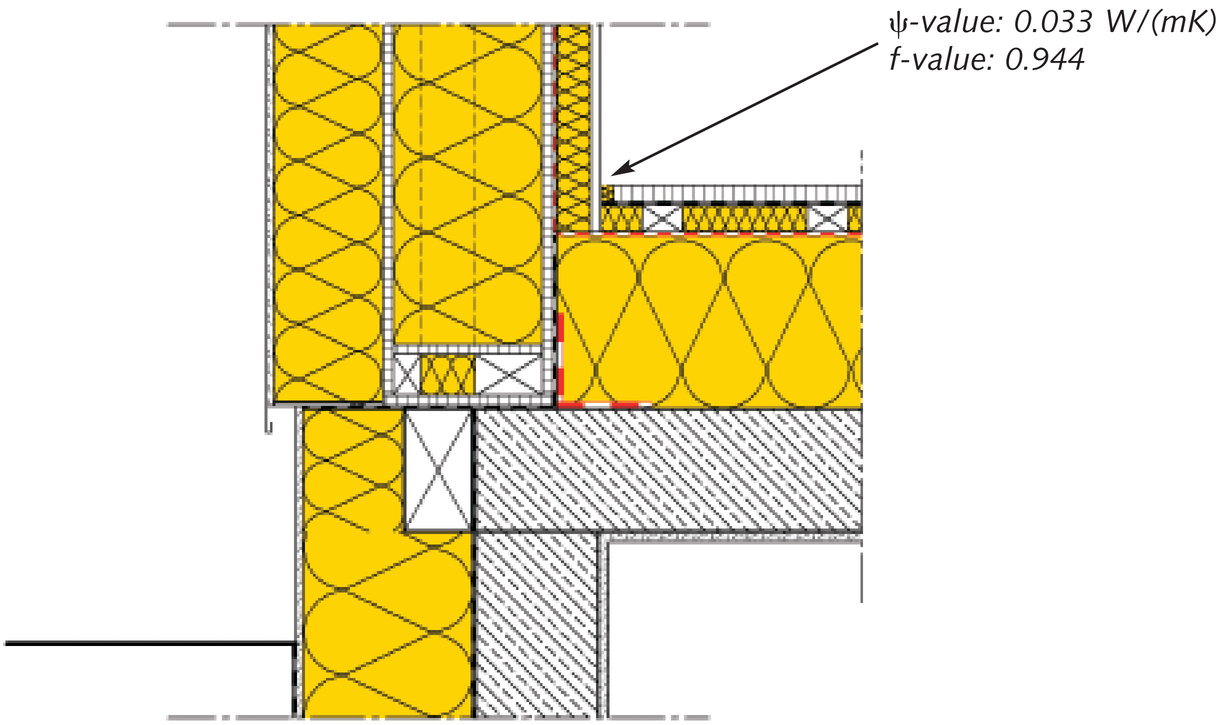
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

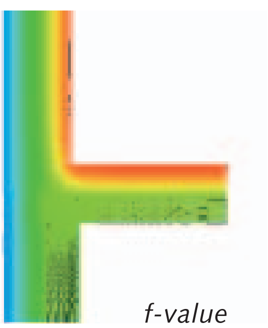


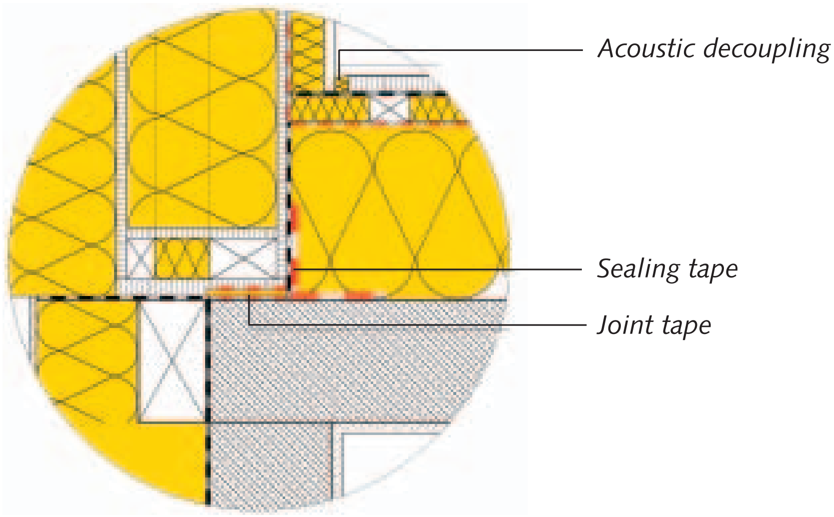
Thermal bridge free connection to the cellar floor.

The connection detail for an outer wall in timber construction – with externally installed mineral wool ETICS – has been optimized concerning thermal bridging. The wooden floor, which has been frame-mounted on the cellar floor, offers a particularly high-grade solution for heat and sound insulation combined with reliable air-tightness. The diffusion-capable external thermal insulation composite system based on mineral wool ensures the moisture balance of the wall construction.

Outer wall: Sound reduction index Rw = 51 dB
Fire-resistance rating acc. to EN 13501-2, REI 60







Ground floor with basement

A. Cellar base (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Concrete 2300	0.200	2.300	0.087
3. XPS insulation, 2-layered	0.240	0.039	6.153
4. Exterior plaster	0.025	1.000	0.036
Total sum of thermal resistances			6.297
Thermal surface resistances			0.170
U-value of the construction			U = 0.15 W/(m²K)

B. Outer wall, timber construction (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Mineral wool insulation	0.050	0.035	1.429
3. Climatic membrane Vario KM	–	–	–
4. Composite wood panel	0.015	0.240	0.062
5. Glass wool felt	0.200	0.035	5.714
6. Wood fibreboard, e.g. MDF	0.016	0.100	0.168
7. Mineral wool plaster baseboard	0.140	0.035	4.000
8. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			11.458
Thermal surface resistances			0.170
U-value of the construction in the compartments between rafters			U = 0.08 W/(m²K)
U-value of the construction with wooden parts			U = 0.09 W/(m²K)

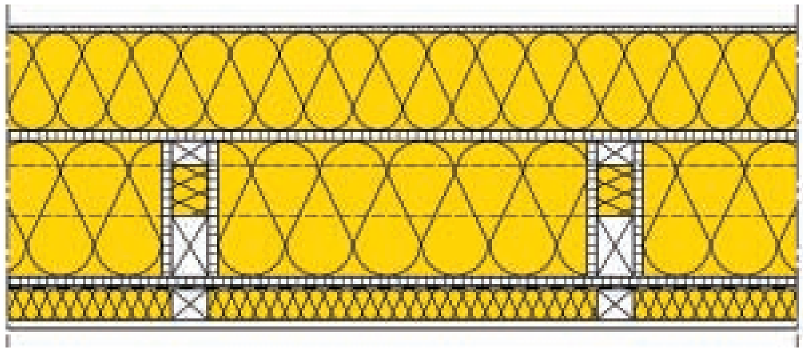
C. Cellar floor (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Cement screed	0.050	1.400	0.035
2. Mineral wool impact sound insulation	0.025	0.035	0.714
3. Composite wood panel	0.015	0.240	0.062
4. Mineral wool insulation	0.120	0.035	3.429
5. Concrete 2300, 1 % reinforcement	0.160	2.300	0.069
Total sum of thermal resistances			4.309
Thermal surface resistances			0.21
U-value of the construction			U = 0.22 W/(m²K)

ψ-value[1] = 0.033 W/(mK); f-value[2] = 0.944; minimal surface temperature ϑsi = 18.6 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

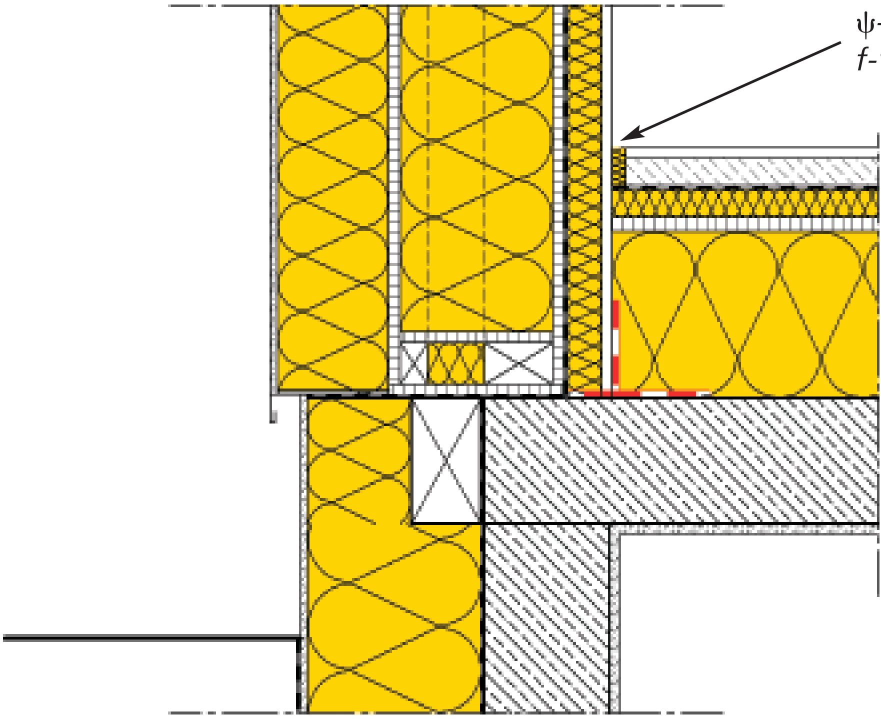
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

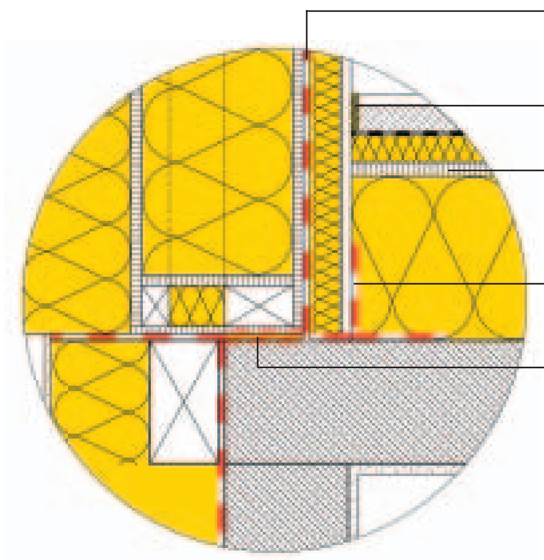


Safe. Airtight. High-grade.

The connection detail for an outer wall in timber construction – equipped with mineral wool based ETICS – has been optimized concerning thermal bridging. The floating cement screed installed on top of the cellar floor offers a particularly high-grade solution for heat and sound insulation combined with reliable airtightness. The diffusion-capable external thermal insulation composite system based on mineral wool ensures the moisture balance of the wall construction.

Outer wall: Sound reduction index Rw = 51 dB
Fire-resistance rating acc. to EN 13501-2, REI 60





The Realization.

Connection between massive outer wall insulated with mineral wool ETICS and slab on the ground with ice wall

A. Socle area outer wall (structure from the inside out)

Component layer	d in ml in W/(mK)	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.060
2. Sand-lime wall 1800	0.240	0.990	0.242
3. Moisture sealing	–	–	–
4. XPS insulation	0.080	0.037	2.162
5. XPS socle insulation	0.200	0.039	5.128
6. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			7.617
Thermal surface resistances			0.170
U-value of the construction			U = 0.13 W/(m²K)

B. Base slab (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Cement screed	0.050	1.400	0.035
2. Mineral wool impact sound insulation	0.030	0.035	0.857
3. Moisture sealing	–	–	–
4. Concrete 2300, 1 % reinforcement	0.300	2.300	0.130
5. Separation layer	–	–	–
6. XPS thermal insulation, 2-layered	0.240	0.038	6.316
7. Base course	–	–	–
Total sum of thermal resistances			7.338
Thermal surface resistances			0.210
U-value of the construction			U = 0.13 W/(m²K)

ψ-value[1)] = -0.109 W/(mK); f-value[2)] = 0.924; minimal surface temperature ϑsi = 18.1 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

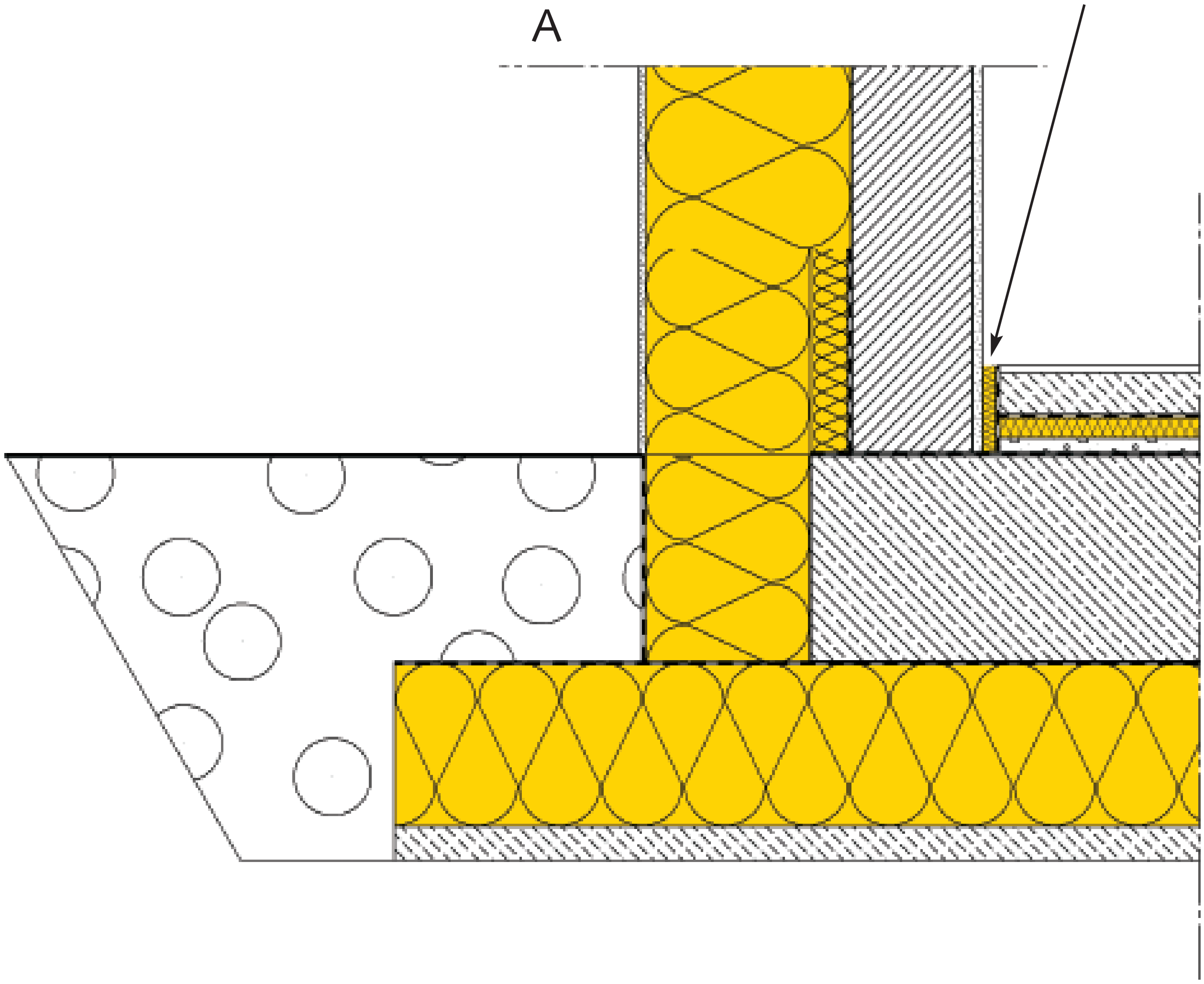
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

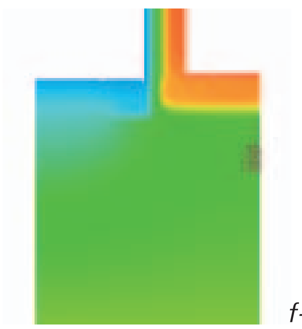
Thermal bridge optimized massive wall connection to slab on the ground.

When connecting the massive outer wall insulated with mineral wool ETICS to the base slab, the ice wall considerably contributes to reducing heat loss via the ground.

Outer wall: Sound reduction index Rw = 56 dB
Fire-resistance rating acc. to EN 13501-2, REI 90

ψ-value: -0.109 W/(mK)
f-value: 0.924





f-value

Spend the winter behind

Never below 17°C.

With triple glazing and thermally insulated frames the passive house window is well able to resist the cold. And more than that. The solar gains that can be achieved by south-facing passive house windows exceed the heat loss through the windows – even in the winter months of Central Europe. Thanks to state-of-the-art glass quality, the temperatures measured on the surface of the panes are always close to inside air temperature.

Passive house windows

Triple glazing	**approx. U_g 0.5-0.8 W/m²K**
Insulated window frames	**approx. U_f 0.7 W/m²K**
Thermal insulation total window	**$U_w < 0.8$ W/m²K**
Total energy transmittance (g-value)	**$g \geq 0.5$**

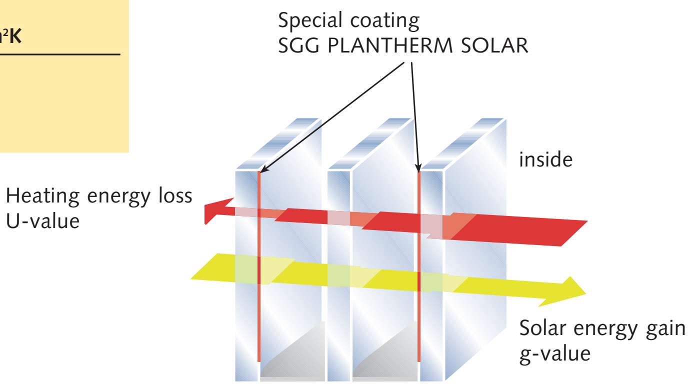
A gain for every room: properly positioned windows free of thermal bridges.

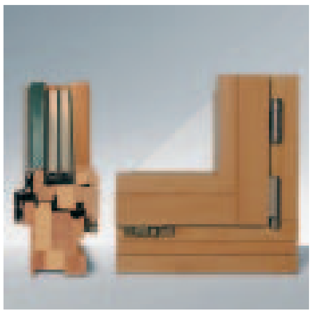
Under optimum installation conditions, passive house windows can contribute substantially to heating the building if positioned properly. Provided the following conditions are fulfilled:

- Install 80 % of the windows on the south side.
- Install the windows in the center of the insulated area.
- Cover the frame with an insulating wedge and install insulating layers below the windowsill.
- Provide an airtight seal of the perimeter joint between window frame and outer wall using environmentally friendly ISOVER VARIO FS1 or FS2 joint sealing strip and joint filler.

Good to know:

1. Due to the higher glass weight, triple glazing requires frames with a better insulation.
2. In general, large-area window glazing with a small vent is more favourable in terms of energy and cost.





Passivhaus Institut Darmstadt, Germany

Saint-Gobain glass CLIMATOP SOLAR consists of the extra-white Saint-Gobain float glass DIAMANT and the special Saint-Gobain glass coating PLANITHERM SOLAR. The triple glazing features excellent thermal insulation as well as a high g-value that normally can only be achieved with double glazing. This special relation of U_g - and g-value makes Saint-Gobain glass CLIMATOP SOLAR the perfect choice for realizing energy-efficient buildings.

passive house windows.

protection, for example a sufficiently dimensioned roof overhang, can provide better shading from outside. Additional temporary shading is advantageous. With east/west windows, by contrast, temporary shading is a must.

VARIO FS1 and FS2 joint sealing strip

Always warmly recommended: Saint-Gobain Glass.

Especially in the dark autumn and winter months, triple thermal insulation glazing by Saint-Gobain shows itself at its best. With optimally designed buildings, the limited amount of sun energy is utilized so efficiently that the solar gains from outside can largely compensate the heat losses through the windows. And if the sun doesn't shine, this is also no problem as the high-tech insulating glass is of extremely low heat emissivity. This means that the special pane structure reduces the amount of heat radiated from the building. The major part of this heat is reflected by the infrared layers and radiated back into the home's interior.

"Heat-free" in summer.

Especially on hot days, the ISOVER Multi-Comfort House remains pleasantly cool. If the windows face south, their triple thermal insulation glazing allows less sun warmth to enter the house than with conventional windows. While in winter the low sun shines into the house filling it with warmth, much less radiation hits the windows when the summer sun is high in the sky. Structural sun

The all-decisive U-value.

Modern double-glazed windows can achieve U-values in the range of 1.0 to 1.8 (W/m^2K) while the frames reach less favourable values of 1.5 to 2.0 (W/m^2K). The requirements to be met by passive house windows are much more rigorous: they need to achieve U-values of 0.7 to 0.8 (W/m^2K). This heat transition coefficient applies to the whole window though – and this includes the frame.

Window connection to lintel in timber construction

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Mineral wool insulation	0.050	0.035	1.429
3. Composite wood panel	0.015	0.240	0.062
4. Glass wool felt	0.320	0.035	9.143
5. Wood fibreboard, e.g. MDF	0.016	0.070	0.228
6. Cladding, ventilated	–	–	–
Total sum of thermal resistances			10.922
Thermal surface resistances			0.170
U-value of the construction			U = 0.09 W/(m²K)

ψ-value[1)] = 0.003 W/(mK); f-value[2)] = 0.864; minimal surface temperature ϑsi = 16.6 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Window connection to windowsill in timber construction

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Gypsum plasterboard	0.015	0.250	0.060
2. Mineral wool insulation	0.050	0.035	1.429
3. Composite wood panel	0.015	0.240	0.062
4. Glass wool felt	0.320	0.035	9.143
5. Wood fibreboard, e.g. MDF	0.016	0.070	0.228
6. Cladding, ventilated	–	–	–
Total sum of thermal resistances			10.922
Thermal surface resistances			0.170
U-value of the construction			U = 0.09 W/(m²K)

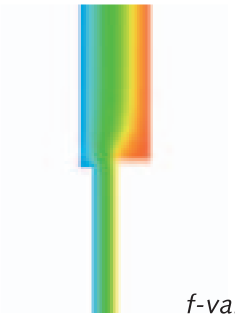
ψ-value[1)] = 0.01 W/(mK); f-value[2)] = 0.853; minimal surface temperature ϑsi = 16.3 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

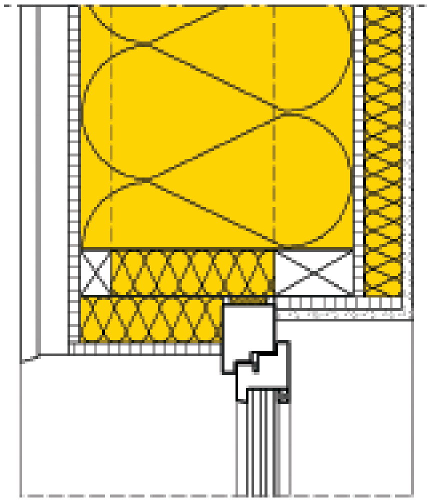
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

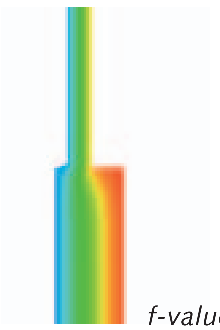
Thermal bridge reduction.

A reduction of thermal bridging can be achieved in the lintel area by insulating the window frame.
When connecting the windowsill, the positioning of the frame in the insulation layer helps to reduce thermal bridge loss in connection with the special window frame.



f-value





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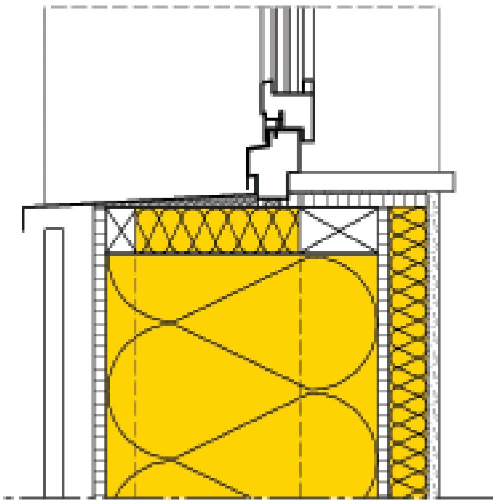


Window connection to lintel in massive construction

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Glass wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.267
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

ψ-value[1)] = 0.015 W/(mK); f-value[2)] = 0.910; minimal surface temperature ϑsi = 17.8 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Window connection to window sill in massive construction

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Glass wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.267
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

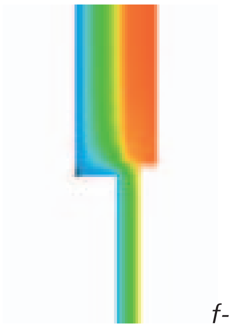
ψ-value[1)] = 0.034 W/(mK); f-value[2)] = 0.892; minimal surface temperature ϑsi = 17.6 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

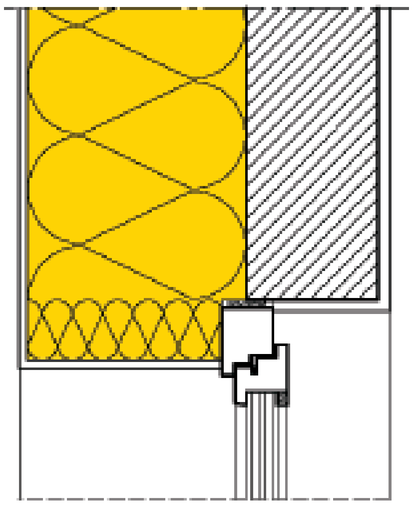
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

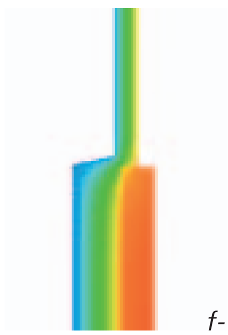
Thermal bridge reduction.

A reduction of thermal bridging can be achieved in the lintel area by insulating the window frame. When connecting the windowsill, the positioning of the frame in the insulation layer helps to reduce thermal bridge loss in connection with the special window frame.



f-value





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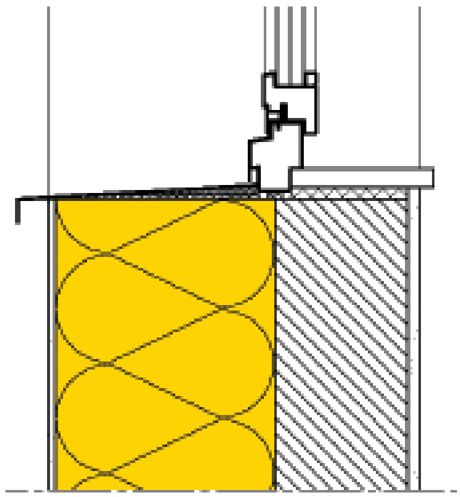


Spoilt and powered by th

The sun's energy potential is virtually inexhaustible: it is our most important energy supplier for the future. Day by day, the sun provides us with about eighty times the primary energy that is needed on earth. After deduction of the scattering loss to the atmosphere, an average of 1000 W per m^2 reach the earth's surface. This value is deemed to be the maximum possible irradiation on a cloudless day and at the same time serves as a base and reference value for all calculations.

Facade-integrated solar collectors, Pettenbach, Upper Austria

Window, facade and roof areas as power plants of passive living.

The highest solar gains for a building can still be generated with roof-mounted solar collectors. But also photovoltaic facades and window surfaces can considerably contribute to the positive energy balance of a passive home. Passive house adequate triple glazing allows solar radiation to enter the interior and take effect as passive heat gain. Roof areas are used for accommodating modern, highly efficient collectors. This is where the solar circuit in an ISOVER Multi-Comfort House starts. Sun collectors convert solar radiation into heat and transfer it to a carrier medium such as water, brine or air. Afterwards, the converted solar heat can be utilized for producing domestic hot water, but also for supporting the space heating.

Efficient all year round: the solar thermal system.

A cost-optimized system can cover about 40-60 % of the entire low-temperature heat demand in an ISOVER Multi-Comfort House. What does that mean in terms of domestic hot water supply? In summer, more than 90 % of the required hot water can be produced with solar energy. In the winter months and transitional periods, the supplied energy is always sufficient to preheat the domestic water.

To the point: Dimensioning of solar hot water systems.

Daily hot water demand (l)	Storage capacity (l)	Collector area*) Flat-plate collector SL (m^2)	Collector area*) Flat-plate collector SS (m^2)	Collector area*) Evacuated tube collector (m^2)
100-200	300	6-8	5-6	4-5
200-300	500	8-11	6-8	5-6
300-500	800	12-15	9-12	7-8

*) Depending on deviation from south orientation, ideal roof pitch and climatic influences. SL: solar varnish coating, SS: selective absorber coating

isover Multi-Comfort House

e sun.

Christophorus Haus, Stadl-Paura, Upper Austria

When using modern appliances with warm water supply instead of conventional washing machines and dishwashers, the available solar energy can, of course, be exploited even more efficiently. When dimensioning your home's solar system, you should always proceed from an average water consumption of 50 litres (45 °C) per person and day. The collector area required to cover this demand is normally between 1.2 m^2 and 1.5 m^2.

Solar heat storage pays off with large building projects.

For one- and two-family houses, partial space heating with solar energy based on hourly or daily storage of solar heat is of interest even today. But the complete heating of buildings via seasonal storage of solar energy, e.g. in heat buffers, is deemed economical only for large building projects – at least for the time being.

Efficient: solar systems for space heating.

The use of solar energy for indoor heating and for generating electricity is technically feasible and becoming more widespread. The economical and ecological benefits need to be assessed individually for each building though.

To the point:

Preconditions for a solar system to give its best.

- *A good collector does not guarantee a good solar system.*
- *All system components must be of high quality and perfectly matched.*
- *The angle of inclination for collectors to produce maximum energy is 45° on an annual average.*
- *In summer (April to September), an angle of 25° is ideal. In winter, modules with an angle of up to 70° or 90° produce the highest yield.*
- *South orientation of the modules is always recommendable although deviations up to 20° do not significantly reduce the yield.*
- *If possible, the solar system should be free of shading.*

Draught-free supply of fr

Healthy living – like in a health resort.

90 % of our breathing is done indoors.

Air is one of our most vital commodities, but modern man increasingly consumes it behind closed doors. These days, the population of Central Europe spends already as much as 90 % of their time indoors. Usually, indoor air quality is worse than outside the door. Above all, it contains too much humidity and is contaminated with pollutants, smells and the like. Remedial action is a steady exchange of air which fulfils the hygiene requirements for indoor air. Unfortunately, the air change rate cannot be dosed exactly by means of natural window ventilation. It strongly differs – depending on outdoor temperature, wind direction and individual airing habits. And just as bad: no possibility for heat recovery. Forced ventilation systems, by contrast, ensure a preselected, constant air change rate, recover heat from the exhaust air and take care of its distribution.

The Comfort Ventilation System controls heating and ventilation in one breath.

The ISOVER Multi-Comfort House doesn't need a boiler room. A compact ventilation unit the size of a fridge is totally sufficient to steadily supply all rooms with fresh air and heat while at the same time removing the consumed air. How does it work? The central unit comprises a heat exchanger, fans, filters and – if desired – air pre-heater, air cooler and air humidifier or dryer. Stale air from kitchen, bathroom and WC is removed via the exhaust air system. Before being routed outdoors, it gives off its heat in the heat exchanger, thus warming the incoming fresh air to near room temperature. Today, heat recovery rates of up to 90 % are possible.

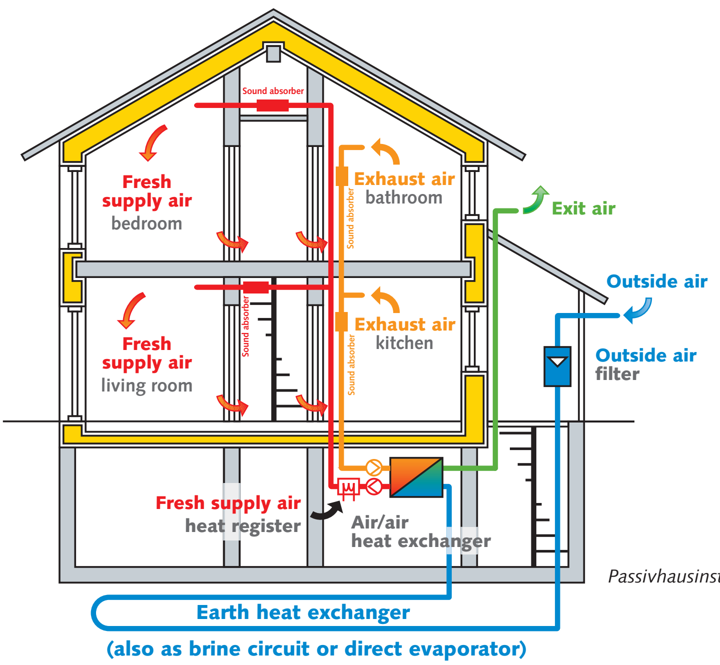
esh air.

Features of a passive house conforming ventilation system.

As it requires only little space, the ventilation unit can be accommodated in any storeroom or even in a cabinet.

- Performance: At a maximum air change rate of about 0.4 per hour required for hygienic reasons, the ventilation system can contribute via the fresh air max. 1.5 kW energy (when maintaining the max. supply air temperature of 51 °C) to a residential building of 140 m^2.
- Short wire lengths
- Pipe diameter – larger than 160 mm for main ducts, larger than 100 mm for branch ducts
- Acoustic insulation of the central unit and supply ducts by installing sound absorbers. A noise level of 20-25 dB(A) should not be exceeded for living space.
- Easy maintenance, e.g. when changing filters and cleaning the unit
- The system can be easily adapted to varying needs, e.g. switch off the incoming air fan when opening the windows, bypass for summer use.

In order to ensure the permanent exchange of air and heat even with closed doors, it is recommended that long-range nozzles are installed, preferably above the door frames.



Passivhausinstitut Darmstadt

Virtually soundless and economical.

Sound absorbers built into supply and exhaust air ducts ensure that the ventilation system of the passive home quietly does its job at a sound level of 25dB (A). And very economical at that: the combined ventilation/heating system is able to cover the entire demand for domestic hot water and space heating while consuming only 1500 to 3000 kWh per year. An average four-person household needs almost twice as much electricity – without heating.

To the point:

Comfortable advantages for man and building.

- *Healthy fresh air – free of dirt, pollen, aerosols etc.*
- *Low air humidity helps prevent the intrusion of moisture, mould formation and structural damage*
- *No bad smells as the controlled air flow does not allow stale air to mix with fresh air*
- *No draughts*
- *No temperature fluctuations*
- *No airing required*
- *Window ventilation – only if desired*
- *Highly efficient heat recovery*
- *Low electricity consumption*
- *Easy maintenance*

With a little effort and ex conservatory can be

Bracket-mounted or detached balconies are the simplest solution.

Where the air is good and no outside noise disturbs, balconies no doubt increase the quality of living. But if they are to be integrated as external elements into passive houses, they can in unfavourable circumstances considerably increase the heating demand. When connecting balconies, platforms, conservatories or other projecting elements to heated parts of the building, there is always the risk of a strong thermal bridge effect.

In the following cases, the heat loss is particularly high:

- if both building and balcony consist of a well heat-conducting material, e.g. concrete or steel
- if the structural connection has a large cross section because it needs to transmit static forces
- if both building components differ largely in temperature.

Christophorus Haus, Stadl-Paura
Correct solution: The balcony has been bracket-mounted in order to prevent thermal bridges.

pense also balcony and come part of your home.

View from the living room into the conservatory. Thanks to its passive house glazing, it is thermally separated from the passive house proper. Photo: Raimund Käser

With a built-in conservatory the living room doors need to remain shut.

The conservatory is located outside the warm building envelope and therefore needs to "function" separately. This means: Heat escaping from inside the building in winter months must be just as much avoided as summer heat flowing from the conservatory inside the house. For this purpose, the following measures are required:

- Separate the conservatory from the interior by installing glass doors fit for passive houses.
- Provide efficient thermal insulation of all adjoining walls.

It goes without saying that the conservatory must not be heated in the cold season nor cooled in the hot summer months, but airing must be possible.

To prevent this in the first place, balconies should be planned to be completely thermally separated. Bracket-mounted or detached solutions are attractive and don't cost a fortune. It's important though to consider both the balcony's positioning and its dimensions. One thing must be avoided by all means: shading of windows that contribute solar gains to the ISOVER Multi-Comfort House.

Photo: Niedrig Energie Institut (Low-Energy Institute), Detmold, Germany

The Realization.

Thermally separated, bracket-mounted balcony. Massive construction with plaster facade.

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Glass wool plaster baseboard	0.280	0.035	8.000
4. Exterior plaster	0.025	1.000	0.025
Total sum of thermal resistances			8.267
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

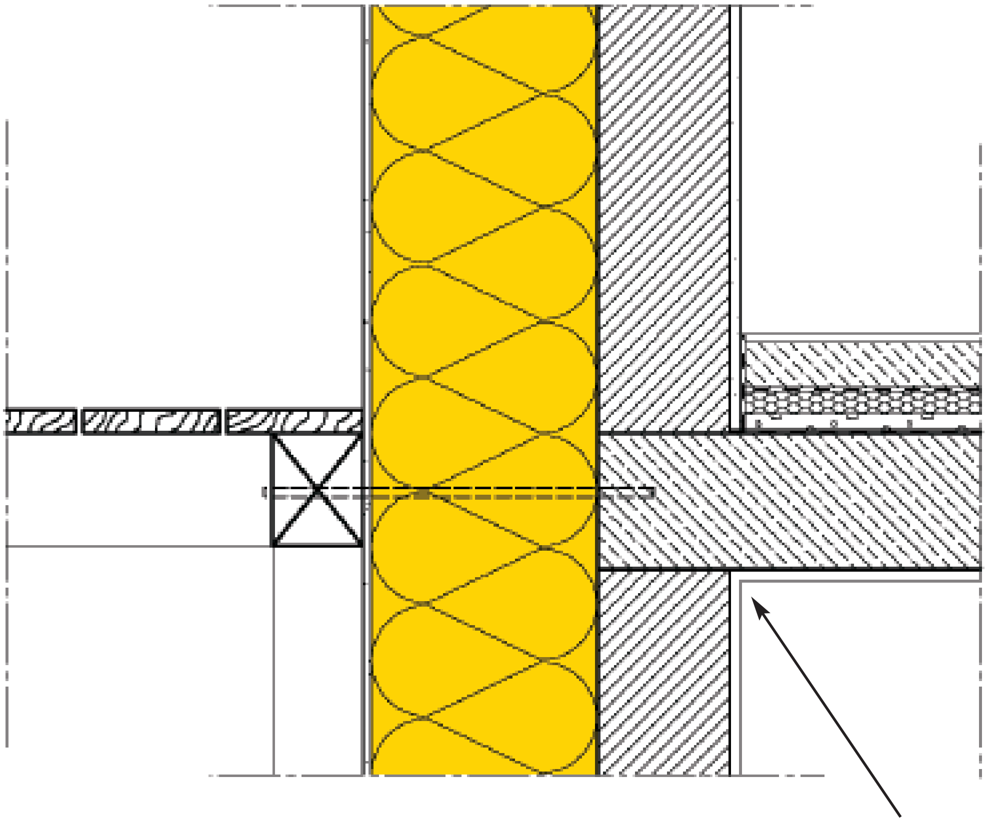
ψ-value[1)] = 0.00 W/(mK); f-value[2)] = 0.969; minimal surface temperature ϑsi = 19.2 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

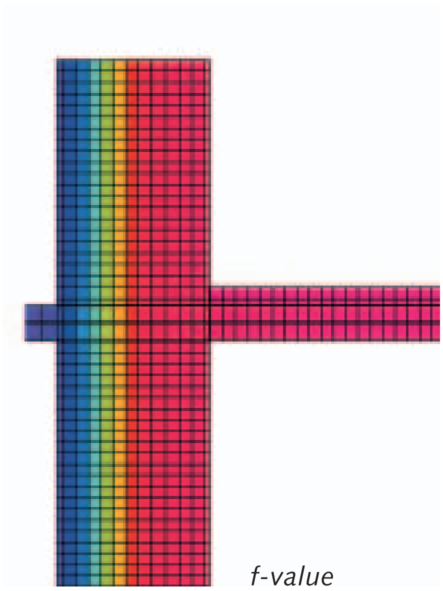
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Thermally separated balcony with optimized static safety.

Thermal bridge loss caused by detached balconies can be completely avoided in a Multi-Comfort House when the static safety has been optimized.



ψ-value: 0.00 W/(mK)
f-value: 0.969



f-value

The Realization.

Thermally separated, bracket-mounted balcony. Massive construction with ventilated facade.

A. Outer wall (structure from the inside out)

Component layer	d in m	λ in W/(mK)	R in m²K/W
1. Interior plaster	0.015	0.700	0.021
2. Sand-lime wall 1600	0.175	0.790	0.221
3. Mineral wool insulation	0.280	0.035	8.000
4. Cladding, ventilated	–	–	–
Total sum of thermal resistances			8.242
Thermal surface resistances			0.170
U-value of the construction			U = 0.12 W/(m²K)

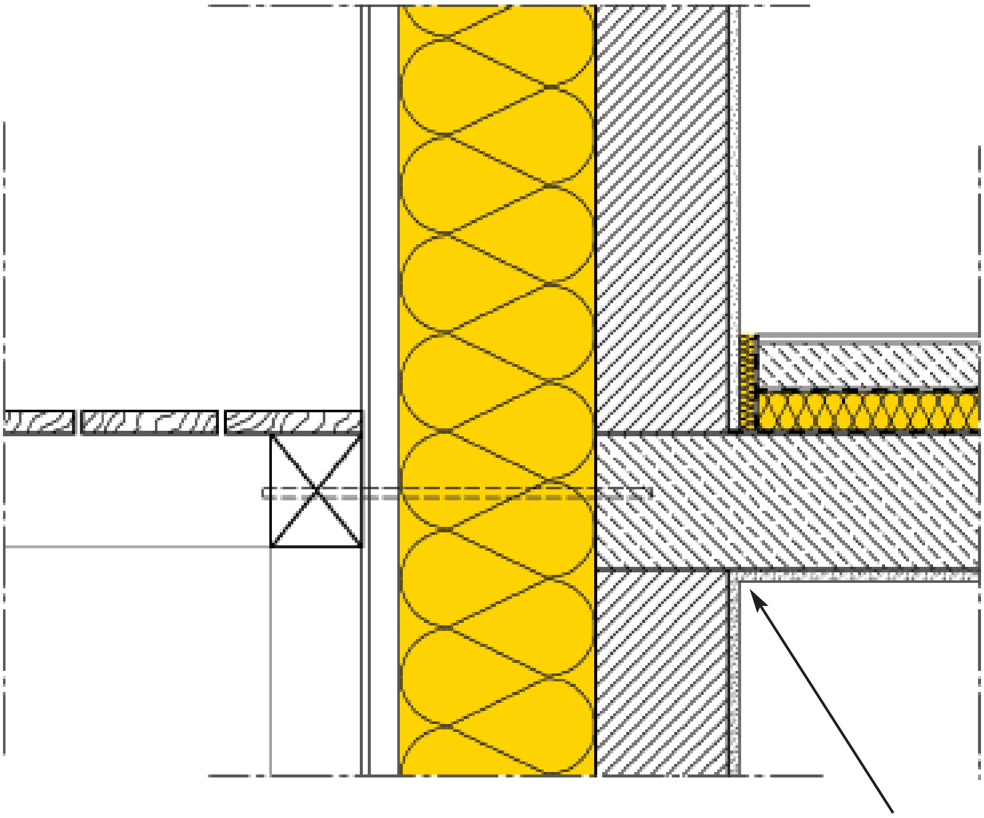
ψ-value[1)] = 0.00 W/(mK); f-value[2)] = 0.969; minimal surface temperature ϑsi = 19.2 °C; at 20°C indoors and -5°C outdoors.

1) The ψ-value describes the additional heat loss of a construction caused by thermal bridges. The values indicated above are based on the building's external dimensions. The psi values have been calculated in keeping with EN ISO 10211, based on the boundary conditions laid down in Supplement 2 of DIN 4108.

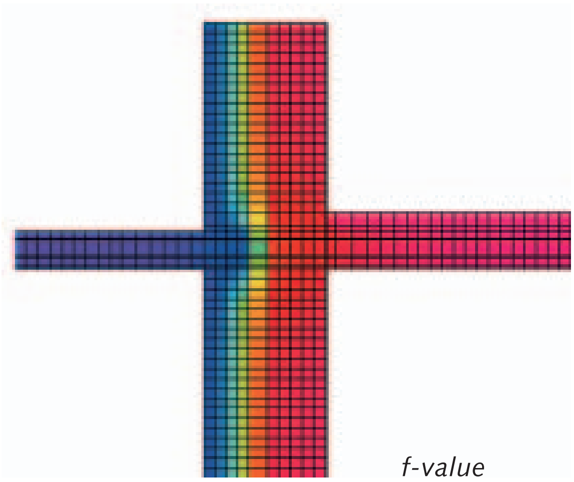
2) The f-value is a dimensionless temperature factor. It is a measure for the minimal surface temperature of a construction when the outdoor and indoor temperatures have been predefined. It describes the risk of condensation and mould formation.

Thermally separated balcony with optimized static safety.

Thermal bridge loss caused by detached balconies can be completely avoided in a Multi-Comfort House when the static safety has been optimized.



ψ-value: 0.00 W/(mK)
f-value: 0.969



Multi-Comfort House

The Possibilities.

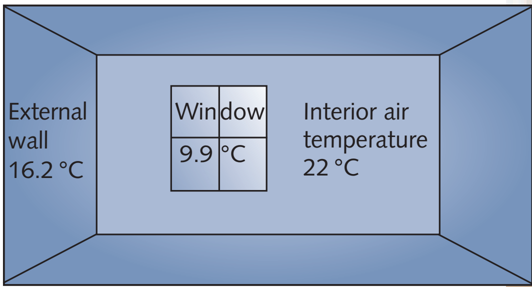
Worldwide & economical.

- Model examples can be found anywhere
- New buildings for private or commercial use
- Old house with a new shell
- Excellent climate – here and there

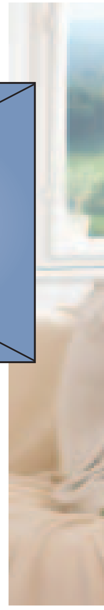
Whether new or historic.

Energy savings up to 90 % compared to conventional design make sense.

It is quite hard to find an argument against the passive house concept. After all, our whole climate is by now suffering from the impact of an increasingly high demand for energy. Bad air, climate change and scarcity of natural resources concern each and every one of us. In view of these developments, the comparatively little extra cost incurred for executing the passive house standard is not a valid counter-argument. You can rightfully speak of a "win-win situation" for all parties involved. The investors profit from excellent building quality and long-term increase in value, the residents from high living comfort and low operation and maintenance costs.



In buildings with poor thermal insulation, walls and windows are relatively cold. More often than not, this results in condensate, mould and structural damage.



A good image – in the private and public sphere.

Buildings that incorporate passive house technology are more than just pleasant to live in. They are also good places for working, learning and making money. This is because the increased comfort generated by good air, constant temperature control and less noise contributes to our well-being and promotes our ability to perform. The occupants are healthier, more focused and more productive. It doesn't come as a surprise that even a growing number of public institutions, authorities and companies build on the passive house standard – not least for material considerations: every new rise in energy prices increases the value of the building. Going easy on the building fabric by implementing the passive house standard assures a longer useful life and less repair work. Thanks to very low operating costs, passive houses are easier to rent out. And earn a high resale value.

Fresh air – always sufficient. Even in crowded classrooms. Thanks to a constant supply of fresh air via the comfort ventilation system.

Extreme situations take only little effect.

Even if the ISOVER Multi-Comfort House is not used for several weeks in the cold season and only

Architects: pos architekten (planning)
Treberspurg & Partner (site management)

ISOVER Multi-Comfort House

Private or industrial. North or south.

Simply feel well. Insulation and windows on passive house standard ensure warm surface temperatures all around.

ventilated to a limited degree, thus foregoing the use-related heat gains, the temperature hardly ever falls below 12° to 15°C. But then five tea lights (candles) are sufficient to snugly warm the children's room. In view of this, it's no wonder that the passive house standard is well able to resist both Alpine frost and Sicilian heat.

Best room climate and energetically self-sufficient – Alpine hut at 2150 m above sea level.

Such is life in the ISOVER Multi-Comfort House: Experiences that speak for themselves.

- No big seasonal temperature fluctuations: pleasantly warm in winter, pleasantly cool in summer.
- Always fresh air, no need for window ventilation.
- No bad or stale air – even after a 4-week holiday.
- Maintenance work is negligible. Replace the ventilation filters from time to time – that's about all.

To the point:

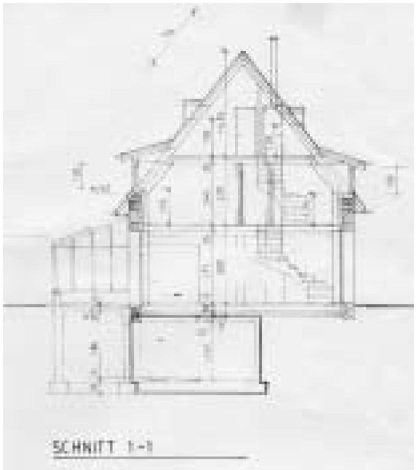
Good arguments for future-oriented passive house technology.

1. **Climate protection** – *Provided a good cost/benefit ratio, CO_2 savings of 90 % are possible compared to conventional buildings. Thermal insulation and energy efficiency are very gratifying fields of activity for the sake of our environment and economy.*
2. **Comfort & wellbeing** – *Insulation according to passive house standard ensures warm surface temperatures all around the inner side of the building envelope, uniform temperature distribution and thus excellent room climate and comfort.*
3. **Building protection** – *Good thermal insulation, reduction of thermal bridges, airtightness and forced ventilation prevent the development of severe structural damage.*
4. **Indoor air quality & healthy living** – *The ventilation system takes care of a healthy indoor climate by supplying a steady stream of fresh, filtered outdoor air. Pollutants are constantly removed. Window ventilation is not able to achieve a comparably high standard.*
5. **The building value** – *By using passive house components the building can retain its value for 40 years. There is no need for a renewed and costly renovation cycle after 15-20 years.*

Monument preservation a

Historical buildings can take a leaf out of this book: The tobacco barn in Viernheim reaches passive house standard. For a listed building this is unique up to now.

To refurbish a centuries-old building is never easy. But the tobacco barn, built around 1850, was a particularly challenging task. For one thing, the building fabric was severely damaged. For another, stringent conditions for monument preservation as well as the ambitious town-planning requirements of the "energy-saving town" Viernheim needed to be fulfilled. The actual task was to realize a comfortable residential building with an energy demand as low as that of a passive house.



The starting situation: not rosy at all.

The outer wall made of natural stone as well as the interior structure of the tobacco barn were highly salt-infested and damp after long years of agricultural use and could only be preserved at great expense. Due to war damage, the roof structure could not be restored, but was to be replaced as true to the original as possible. Indoors, the rooms were not allowed to be too high compliant with the town-planning requirements. The entire front courtyard had to be redone and all sewage, water and gas pipes as well as electricity and telephone lines had to be newly installed, including the installation of a rainwater cistern. Connecting the barn to its neighbouring buildings required demanding structural solutions. And the inner-city location causes undesirable shading.

Agricultural tobacco barn before refurbishment.

nd climate protection in constructive harmony.

The solution: innovative, individual, international.

It nearly goes without saying that with this ambitious project of converting a dilapidated tobacco barn into a comfortable passive house, it was not always possible to deploy "off-the-peg" construction solutions. Frequently, it was stand-alone developments, masterly workmanship and constant quality controls that produced the desired results. Just a few examples: As a screed substitute, a raised floor system was used, newly developed by ISOVER Austria and consisting of 32 mm chipboard with an additional 100 mm cavity fill made of facade insulation boards Kontur FSP 1-040. The interior insulation of the dormer cladding was done with the ROSATWIST system by ISOVER France. To achieve maximum tightness for the interfaces between wall construction and concrete members, joint sealing tubes developed by ISOVER in Sweden were used. The triple thermal insulation glazing Climatop V was contributed by SAINT-GOBAIN GLASS in Aachen. With the help of WUFI, a calculation program developed at the Fraunhofer Institute for Building Physics, the hygrothermal performance of the construction was successfully tested.

Reconstructed trussed gable. Stone slips were bonded on mineral wool infilling.

The new construction: concrete skeleton with front-mounted natural stone masonry.

After pulling down the almost 200-year-old natural stone walls of the tobacco barn – its stones being carefully cleaned and stored – the reconstruction into a fully functioning passive house could start in July 1997. Based on a ring footing equipped with 2 layers of thermal insulation (total insulation thickness 160 mm), a solid bottom slab was installed – totally free of thermal bridges. On top of that, it was possible to erect the static effective concrete skeleton construction. The natural stone walls were raised at a fixed distance to allow sufficient space for the subsequently installed interior thermal insulation. This was necessary for reasons of building physics: the natural stones had to be kept away from the interior construction due to their high moisture and salt content. Mineral wool was chosen as insulation material. Since it is not capillary active, it turned out to be the safest solution. Depending on certain structural details, total insulation thickness amounted to as much as 250 mm in some places.

To achieve a U-value ≤ 0.10 W/(m²K), a combination of between- and above-rafter insulation was chosen.

New elements – Roof, window, conservatory.

The roof was designed in consultation with the Monument Preservation Authority, in particular location, size and division of the

Metal rail construction using Difunorm Vario as vapour barrier and airtight layer. To ensure airtightness, electrical cables and wires are installed in the installation layer on the room-facing side which is likewise insulated with 60 mm glass wool. In some places, the insulation of the barn roof has a thickness of up to 440 mm.

The roof construction was insulated inside with 200 mm ISOVER glass wool between the rafters and the mounting system Rosatwist.

dormer windows. Based on this, it was possible to design the three floor levels, the window heights of the ground floor as well as the thermally separated conservatory facing the garden. In order to realize the passive house standard, the main focus was – besides sufficient and thermal bridge free insulation – on airtight execution. After a first check had detected an insufficient level of airtightness in the areas of roof, dormers and windows, improvements were made in due course to ensure optimum results. This extra work as well as the stand-alone developments and special constructions of roof, walls and windows considerably delayed the course of work. Nevertheless, this unique conversion process could be finalized after about two and a half years.

The result: energy-efficient living on 212 m².

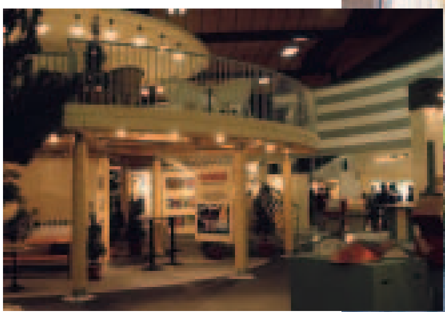
With a heating demand of 13.4 kWh per square meter and an annual heating demand of 2384 kWh according to DIN EN 832, the occupants of the former tobacco barn need not worry – despite the spaciousness – about rising energy costs and growing scarcity of resources: the total cost for heating, hot water and cooking amount to 350 EUR a year. Absolutely in keeping with the principles of the "energy-saving town" Viernheim. And in keeping with the Brundlandt Project of CO_2-reduced and sustainable living.

Building owners/Building physics: Stephanie und Raimund Käser, Viernheim
Architect: Dipl. Ing. Bernd Seiler, Seckenheim

Energy values

U-values	in W/(m²K)
Thermal insulation glazing incl. frame Wall areas	0.8 0.12-0.15
Barn roof (incl. wooden parts)	0.09
Floor	0.14

Minimum technology to yield max



ISOVER exhibition pavilion.
Architects: Haipl & Haumer

From an exhibition pavilion into a passive house: one-family "Passive house disc", Salzkammergut, 4661 Roitheim. Architect Kaufmann.

The project aim was to create a residential building that fulfils the criteria of ecologically sustainable construction. This meant that not only the energy needed for space heating, but also all emissions caused by construction, transportation and the consumption of natural resources had to be reduced by a factor of 10 compared to conventionally built houses. At the same time, the construction costs did not have to exceed those of comparable conventional buildings. Despite the savings, the project was meant to offer high living comfort and cosiness. And all this was to be achieved with minimal technical expense. No sooner said than done. In just under a year, the future-oriented project "Passive house disc" could be realized.

Barely visible but there:
30 m geothermal heat exchanger in 1.5 to 2 m depth.

imum energy savings.

Location – Use – Size

The single-storey, cellarless passive house is set on a level estate, free of shading. The design is very compact. Since the circulation areas were reduced to a minimum, the available floor area can almost completely be used as living space. At an outside diameter of 15 m, the one-family house offers net living space of 140 m².

A small bioalcohol burner helps on particularly cold days.

Recycled down to the last detail.

The bearing structure of this passive home – which, by the way, has received numerous awards – is based on a former ISOVER exhibition pavilion whose components were recycled for use in the new building. The old berth partitions, for example, serve as bookshelves today.

To the point: The energy concept.

- *Highly insulated building envelope*
- *Passive house windows*
- *Freedom from thermal bridges*
- *Airtightness*
- *Low-tech concept – the entire domestic HVAC system, including heat recovery and hot water generation, fits into a compact unit that can be accommodated in the toilet.*
- *Heat generation by means of a heat pump*
- *Pressure test n_{50} 0.41 1/h*

Building owner: Ing. Günter Lang
Architect: Hermann Kaufmann

Annual space heating requirement (HWB) acc. to PHPP:			**13.70 kWh/m²a**
Annual space heating requirement (HWB) acc. to Upper Austrian Energy Performance Certificate:			**11.00 kWh/m²a**
Heating load acc. to PHPP:			**11.40 W/m²**
Pressure test n_{50}:			**0.41 1/h**
U-values of structural components:			
External wall:	**0.10 W/m² K**	Roof:	**0.08 W/m² K**
Cellar ceiling/floor:	**0.12 W/m² K**	Glazing:	**0.70 W/m² K**
U_w total window area:	**0.78 W/m² K**	Acc. to:	**DIN EN ISO 10077**

The future: Refurbishment

Architectural and energetic upgrade: an unattractive bungalow turned into a showpiece. One-family house in Pettenbach, Upper Austria.

In many European countries, the number of newly built houses increases by no more than about 1%. Against this background, the energetic refurbishment of old buildings is becoming increasingly important. The house in Pettenbach was Austria's first refurbishment project that was executed according to passive house criteria. With a heating demand of 280 kWh/m²a, the dark, cramped bungalow from the 1960s was a typical representative of the category "energy waster". Today, it does not only meet the latest energy requirements (heating demand 14.8 kWh/m²a acc. to PHPP), but also got a major architectural facelift. The projecting wing of the unassuming building was clad with a horizontal larch-wood panelling while a smooth metal facade lends its character to the recessed part of the building. Generously sized windows – mostly of full room height – allow light to flood in and do not obstruct the outside view.

Annual heating costs for the entire house
Before refurbishment: EUR 2.700 per year
After refurbishment: EUR 200 per year

Building owner: the Schwarz family. Planner: Lang Consulting.

with passive house technology.

Fewer walls. Fewer thermal bridges. More comfort.

By breaking down some walls, it was possible to alleviate the problem of thermal bridges caused by the cellar walling. New layers of insulation installed in the cellar as well as a thermal envelope made of prefabricated hook-in wooden panels with integrated insulation provide seamless thermal insulation. A compact ventilation unit with highly efficient heat recovery assures the permanent supply of fresh air and a near-constant indoor temperature.

Planner: Lang Consulting
Building owner: Family Schwarz

To the point:

Exemplary new systems for sustainable conversion into a passive house.

- *Examination by laser scanning for precise surveying and CAD planning*
- *Prefabricated, storey-high wooden panels in passive house quality fixed with a special suspension system*
- *In the area of the cellar floor minimal floor structure with vacuum insulation*
- *Passive house compatible insulation to minimize thermal bridging caused by the masonry*
- *Earth heat collector along the sink hole for exploiting the waste heat, equipped with measuring probes*
- *Compact ventilation system with highly efficient heat recovery and heat pump*
- *Partial coverage of the electricity demand by facade-integrated photovoltaic panels (peak: 2.6 kW)*

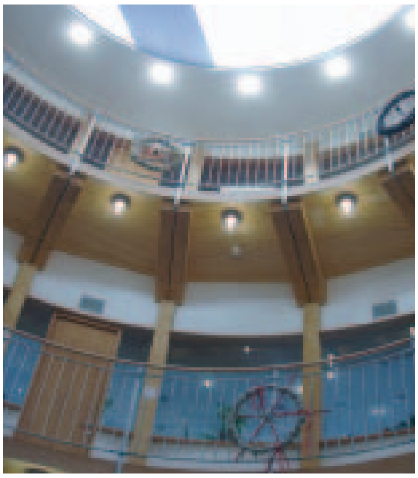
Energy coefficients

	Before refurbishment	After refurbishment
Heating demand	**280 kWh/m²a**	**14.8 kWh/m²a** acc. to PHPP
Heating load	**230 W/m²**	**12.1 W/m²** acc. to PHPP
Pressure test results (n50)	**5.10**	**0.50**

U-values of structural components:			
External wall:	**0.10 W/m² K**	Roof:	**0.09 W/m² K**
Cellar ceiling/floor:	**0.13 W/m² K**	Glazing:	**0.60 W/m² K**
U_w total window area:	**0.77 W/m² K**	Acc. to:	**PHI Certificate**

An ecological building th highest

The Christophorus House in Stadl-Paura, Austria, accommodates offices, a logistics center, seminar rooms, shopping facilities and most economical technology built to passive house standard.



Clever use of daylight in the offices which can be sun-protected with externally mounted shading devices.

After a most demanding planning phase and a construction period of about nine months, Austria's first three-storey timber building of passive house standard presents itself today with a top performance in many respects. For the developer, the Austrian non-profit organization MIVA (Mission Vehicle Association) and its central purchasing company BBM, the focus is on working for and with people. The building is used as an office, logistics and meeting center for collaborating with project partners from almost 100 different countries.

The Christophorus House is meant to be a place for international exchange and worldwide solidarity work. Years of experience with regard to energy and ecology – acquired in several BBM projects in Africa – have eventually led to this climate protection project.

The building structure: wooden, airtight and thermal bridge free.

By nature, the building material wood offers good thermal conductiv-

at meets the economical demands.

ity and facilitates thermal bridge free construction. Wood is therefore the preferred material for building passive houses. For the Christophorus House, wood was combined with high-quality insulation materials, resulting in a thermal bridge free construction of highest airtightness and excellent passive house values.

The energy supply: sustainable and cost-effective.

Eight Duplex geothermal probes of 100 m length are used to exploit the earth – both as a heat source and a heat sink – for this building. During the heating period, the heat pump supplies the building with additional warmth via the deep probes. In summer, the same system is used for cooling – with a minimum consumption of energy. Distribution of the cooling resp. heating medium in the house is done via 560 m² of heating/cooling ceilings and floor elements. An on-grid photovoltaic system with a peak output of 9.8 kW ensures that the power needed for the heat pump resp. for operating pumps and fans is largely supplied in a CO_2-neutral way.

The water concept: self-cleaning and economical.

The entire amount of greywater and rainwater is cleaned with the help of three biological sewage treatment plants and recycled as service water for flushing toilets, irrigating plants and washing cars. In this way, the consumption of potable water is reduced to a minimum. Nearly 70 % of the required hot water is generated by the thermal solar system.

Annual space heating requirement (HWB) acc. to PHPP:			**14.00 kWh/m²a**
Heating demand acc. to PHPP:			**14.00 W/m²**
Pressure test n_{50}:			**0.40 1/h**
U-values of structural components:			
External wall:	**0.11 W/m² K**	Roof:	**0.11 W/m² K**
Cellar ceiling/floor:	**0.13 W/m² K**	Glazing:	**0.70 W/m² K**
U_w total window:	**0.79 W/m² K**	Acc. to	**PHI Certificate**

The bottom line: exemplary.

Compared to a conventional office building, the Christophorus House realizes primary energy savings of approx. 275,000 kWh/a (average). Heating and cooling is largely done in a CO_2-neutral way. Yearly reduction: 75 tons of CO_2 compared with conventional construction. All this is achieved while providing a most comfortable indoor climate: about 40-50 % air humidity and temperatures of 21-23°C.

Planning: Dipl. Ing. Albert P. Böhm and Mag. Helmut Frohnwieser

Developer: BBM (Procurement Services of the MIVA). Contact: Franz X. Kumpfmüller

Live beautifully downtow

After passive house refurbishment of the residential complex Markartstraße in Linz/Austria, living comfort reached an all-time high.

Due to its location on a main thoroughfare and the resulting exposure to noise and pollutants, the 5-storey apartment house from the 1950s did not count among the town's top addresses until recently. Nonetheless, the tenants had to pay relatively high rental and ancillary costs. After a reconstruction phase of only 6 months, the situation looks quite different now: passive house standard achieved, comfort increased, energy costs reduced. New thermal envelope: 1st to 4th storey now meet the passive house standard, the ground floor complies with low-energy standard since cellar-facing insulation was only feasible to a limited extent. The following measures were taken to produce a new thermal envelope:

- Solar honeycomb facade elements bracket-mounted to the outer walls: the ventilation supply ducts for the individual rooms as well as the windows have already been built in.
- Triple-glazed windows with integrated sun protection.
- Closed loggia glazing instead of the existing open balconies and loggias, thus integrating them into the thermal envelope.
- Comfort ventilation system for controlled ventilation of single rooms.
- Hot water preparation by means of district heat instead of gas geysers.
- Insulation of cellar and attic.

Developers: GIWOG Gemeinnützige Industrie-Wohnungsaktiengesellschaft

Planners: ARCH+MORE ZT GmbH, DI Ingrid Domenig-Meisinger

n and save 90 % energy.

A constant level of fresh air, quiet and comfort.

Especially in an urban environment, the passive house standard ensures pleasant living conditions any time of the day. Since the comfort ventilation system continuously circulates fresh air in the rooms, window ventilation becomes superfluous, thus excluding street noise and pollutants. The tenants can draw a deep breath and enjoy the peace and quiet of their home. The new thermal insulation has equally beneficial effects. Pleasant indoor temperatures all year round improve personal wellbeing while reducing the heating demand by 90 %. The example of Markartstraße shows: passive house technology helps to save money despite rising energy costs! The realization of this project was made possible by government grants that had been earmarked for housing projects, including additional development

funds for energy-saving realization, as well as by a non-redeemable subsidy granted within the subprogram "House of Tomorrow". The latter is a cooperation between the Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT) and the Austrian Research Promotion Agency (FFG).

This project won the Austrian State Award for Architecture and Sustainability in 2006.

	Before refurbishment	After refurbishment
Heating energy demand	150 kWh/m²a	14 kWh/m²a
Monthly heating costs for a flat of 59 m²	EUR 40.80	EUR 4.13
Annual CO_2 emissions for the total building	160 tons	18 tons

Energy coefficients	Before refurbishment	After refurbishment
Heating energy demand	approx. 179.0 kWh/m²a	14.4 kWh/m²a acc. to PHPP
Heating load	approx. 118.0 W/m²	11.3 W/m² acc. to PHPP
Total heating energy demand	approx. 500,000 kWh/a	45,000 kWh/a
Heating energy savings	---	455,000 kWh/a
U-value external wall	approx. 1.2 W/m²K	0.08 W/m²K (with solar input)
U-value roof	approx. 0.9 W/m²K	0.09 W/m²K
U-value cellar floor	approx. 0.7 W/m²K	0.21 W/m²K
U-value window	approx. 3.0 W/m²K	0.86 W/m²K
Glass spacer	Aluminium	Thermix
Heated area	2,755.68 m²	3,106.11 m²
CO_2 emission/year	160,000 kg CO_2	14,000 kg CO_2

With annual heating energy savings of 455,000 kWh it is possible to save approx. 27,300 EUR, based on an estimated energy price of 0.06 EUR per kWh.

A passive house that sets

After passive house technology moved in, Austrian secondary school Klaus has become a place of human warmth.

In passive houses that are inhabited by many people, the "thermal contribution" of about 70 watts per person and hour is highly significant. Due to the airtight execution of the building envelope, the air change can be precisely controlled. By means of a heat exchanger, the ventilation heat loss can be limited to about 10 %. Since the number of persons in school and office buildings is normally higher, the heating demand is considerably lower than that of residential buildings. The requirements to lighting and cooling, however, are usually higher.

Average demand of fresh air: 30 m³/h per pupil and teacher.

To ensure best air quality and ideal room temperature in the Austrian secondary school Klaus, an earth-to-air heat exchanger was installed before the central ventilation unit with a volumetric flow rate of 35,000 m³/h. In winter, this pre-

heats the outside air before entering the building while pre-cooling it in summer.

a precedent.

Average heating energy demand: 15 kWh/m² heated floor space.

The secondary school Klaus thus meets the standards of passive construction – from the classrooms up to the administration wing.

Planners: Dietrich/Untertrifaller, architects
Building owners: Gemeinde Klaus Immobilienverwaltung GmbH

Annual heating energy demand (HWB) acc. to PHPP:			**14.5 kWh/m²a**
Pressure test n_{50}:			**0.60 1/h**
U-values of structural components:			
External wall:	**0.11 W/m² K**	Roof:	**0.11 W/m² K**
Cellar ceiling/floor:	**0.18 W/m² K**	Glazing:	**0.60 W/m² K**
U_w total window:	**0.76 W/m² K**	Acc. to	**EN 10077**

To the point: Benefits achieved for the secondary school Klaus.

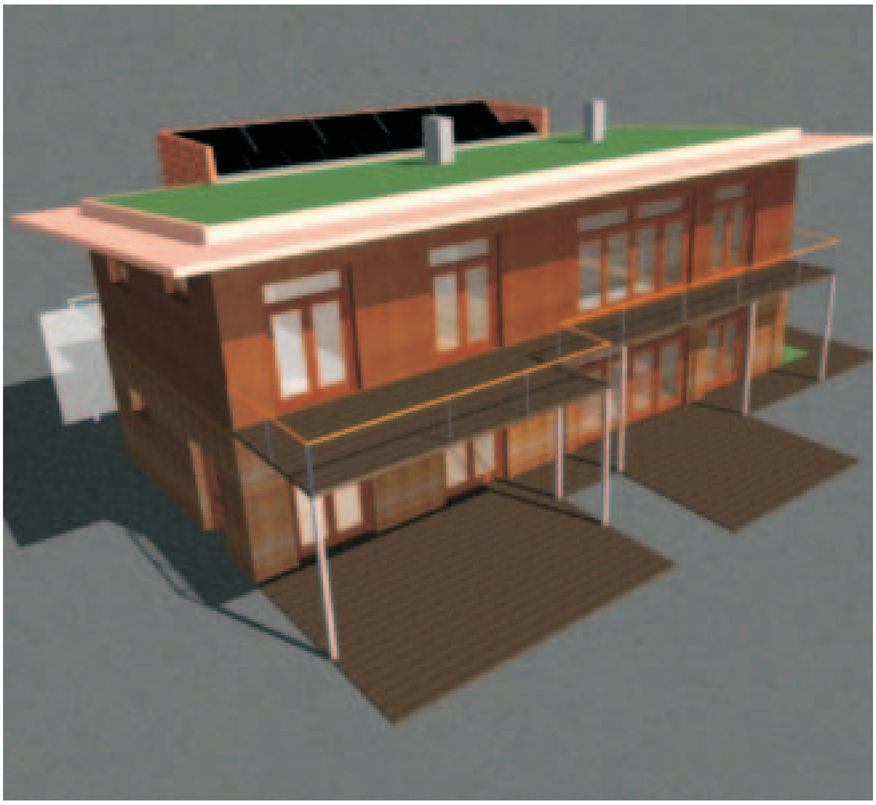
- *Continuous ventilation of the rooms with heat recovery via rotary heat exchangers. Result: strong reduction of the ventilation heat loss compared to conventional window ventilation*
- *Constant removal of CO_2 and smells to ensure high air quality and hygiene*
- *No noise disturbance caused by tilted or open windows*
- *Constant withdrawal of moisture to ensure human comfort and preserve the building fabric*
- *Use of solar energy*
- *Installation of shading devices in front of large window areas*
- *Pre-cooling in summer by earth-to-air heat exchanger without additional energy demand for cooling machines*
- *Water heating via solar collectors and storage in a well-insulated water reservoir.*

New life in a historic barn.

A traditional barn near Zagreb offered a very pleasant frame for energy optimization. Today, it's Croatia's first wooden passive house.

In most cases, it's not a question of age whether or not the passive house standard should move into a building. The extent of refurbishment largely depends on the form of the building. For instance, large-volume, compact buildings can often be equipped quite easily and inexpensively with all features that distinguish a passive house – regardless of the century they were built in. The building in Croatia is a good example. The detached barn – an unpretentious wooden building – lent itself to all kinds of architectural and energetic refurbishment measures. The building envelope could be equipped with a high level of thermal insulation at relatively little expense. Also the extra cost incurred for high-quality glazing did not have a big impact: compared to the useful area, the windows account for less than 15 %.

Historic barn beams in an ultramodern facade



The barn interior: simulation of the thermal insulation.

Modern comfort in a historic environment.

Preserve our cultural heritage, create comfortable living space for three generations under one roof, realize the passive house standard and secure the building's long useful life: all these demands were effortlessly fulfilled. Thanks to a location free from unwanted shade, ideal south orientation could be realized. The south-facing facade was generously opened up with large window areas, whereas the north-facing side was designed in a closed, compact style. The result: optimal solar gains. The traditional beams of the barn were retained as facade elements. Behind them, it was no problem to install highly efficient insulation. Solar and photovoltaic elements installed on the roof produce hot water and electricity. In addition, the roof was vegetated. Further important elements of the passive house standard were installed, including a comfort ventilation system and a heat pump. As a result, the historic character of the barn is preserved while state-of-the-art passive house technology ensures modern living comfort: heating energy demand below 15 kWh/m^{2}a.

Planner: Prof. Ljubomir Miščević, Dipl. Ing. Arch., University of Zagreb

The Ecological Import.

Exemplary & sustainable.

- Isover – From nature, for nature
- Rigips – Flexible and sustainable construction
- Weber – Mineral-based thermal insulation composite systems

From nature – for nature.

ISOVER
Multi-Comfort House

Energy-efficient living.

Optimum thermal insulation produces the highest energy savings. But it must also meet the highest demands in terms of workability, quality and in particular ecology. ISOVER has committed itself to fulfil all these criteria and develop the right products. ISOVER glass wool is primarily produced from waste glass. With a share of up to 80 %, this material now substitutes the main raw material quartz sand.

Production goes easy on our environment. The natural raw materials are extracted in small open-cast mines where regreening starts immediately after finishing the mining activities. Modern manufacturing methods assure that also the next production steps are environmentally sound.

With ISOVER mineral wool products on the safe side of insulation.

When production is based on a natural raw material, the finished product will also qualify as natural and eco-friendly. Benefits of ISOVER glass wool that speak for themselves:

- safe application and use
- not carcinogenic and not a hazard to health in compliance with Directive 97/69/EC of the European Commission
- free of propellants and pesticides
- chemically neutral
- excellent heat, sound and fire protection
- especially economical in high insulation thicknesses
- non-combustible
- free of flame-retardant, ground-water-polluting chemicals
- durable and rotproof
- capable of diffusion.

ULTIMATE, the new high-performance insulation material by ISOVER.

isover
Multi-Comfort House

Insulating with ISOVER.

ISOVER products – Exceptionally convenient handling.

ISOVER glass wool not only proves its worth in later energy savings, but as early as in the installation phase. Here, the material shows its strengths, also under economic aspects:

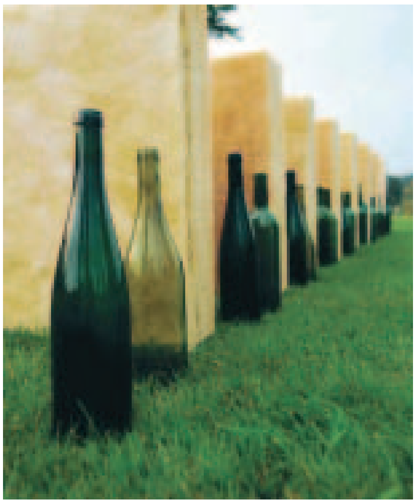
- up to 75 % storage and transport savings due to high compressibility
- easy workability
- dimensionally stable, high tensile strength
- no waste
- straight off the roll onto the wall
- versatile, reusable, recyclable
- easy disposal.

From old bottles to welln

What the industry and households discard as useless waste glass is turned by ISOVER into a valuable raw material. ISOVER glass wool consists by about 80 % of recycled waste glass. The other ingredients such as quartz sand, soda ash and limestone are virtually inexhaustible resources. This does not only sound but definitely is ecologically sustainable in many ways. Just a few examples may illustrate the point.

Each built-in ton of glass wool insulation felt helps us save 6 tons of CO_2 every year.

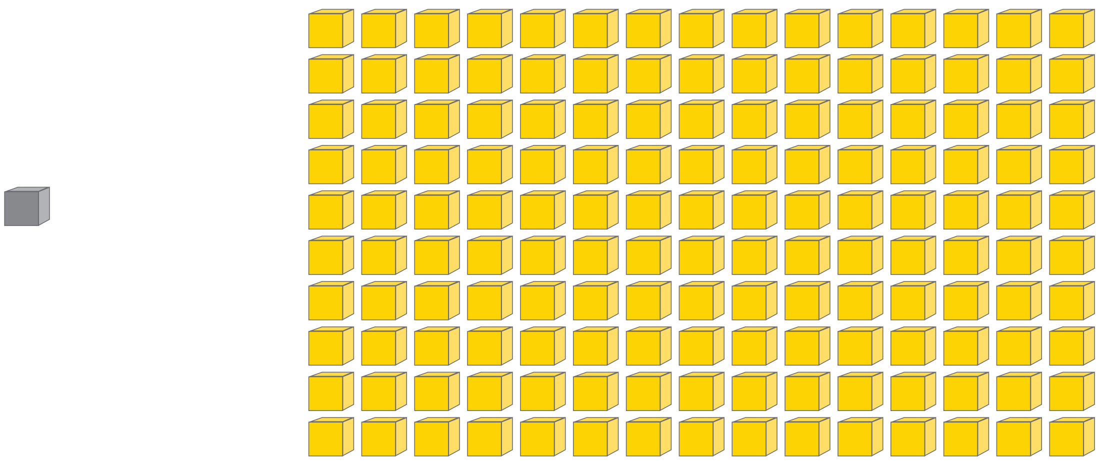
The use of glass wool does not only help us meet the Kyoto target but also realize energy-efficient living all around the globe. Just consider: The production of 1 ton of glass wool releases about 0.8 t of CO_2. The annual CO_2 saving that can be realized by building in glass wool amounts to as much as 6 tons. Assuming a useful life of 50 years, we can thus save up to 300 t of CO_2. And this is 375 times as much as the CO_2 emission caused by production.



ISOVER turns 1 m³ raw material into 150 m³ glass wool.

This is sufficient to completely insulate a large one-family house from top to bottom in keeping with the passive house standard.

1 m³ raw material **150 m³ glass wool**



ess climate with ISOVER glass wool.

Energy amortization

The production and transportation energy needed for glass wool already amortizes within a few days. The example below compares an upper floor slab made of reinforced concrete without thermal insulation with a reinforced concrete floor equipped with 35 cm (λ_D 0.04 W/mK) glass wool insulation (passive house level).

1 m³ upper floor slab		
Structure	**Heat transfer coefficient**	**Energy loss per square meter and year**
Reinforced concrete (20 cm) not insulated	**U-value = 3.6 W/m²K**	**360 kWh**
Reinforced concrete insulated with 35 cm glass wool	**U-value = 0.1 W/m²K**	**10 kWh**
Energy saving per m² and year (thanks to thermal insulation)		**350 kWh**

Compared to annual energy savings of 350 kWh/m², the energy needed for production, transportation and installation of the insulation material amounts to a mere 22 kWh. The energetic amortization time is less than 10 days.

Glass wool makes short work of application and amortization times.

When compressed into rolls, glass wool can be transported space-saving and quickly. With only little manual effort, it is installed directly from the roll onto the wall.

Glass wool offers further benefits as it is

- non-flammable
- not a hazard to health in compliance with Directive 97/69/EC
- free of propellants, pesticides, flame-retardant chemicals

Take responsibility: build safely with ISOVER.

Always on the safe side: preventive fire protection with non-flammable mineral wool insulation materials made by ISOVER – glass wool, stone wool and Ultimate. Optimum protection of roof, walls and floors.

www.isover.com

Flexible and at the same sustainable constru

The future of construction is increasingly determined by people's changing life situations. From one day to the next, nuclear or extended families change into "patchwork families". Flatshares shrink into single households, grow newly, only to disintegrate again and so on. These developments call for flats that can be adapted to the ever-changing needs of their occupants – with minimum resources and costs and the lowest possible impact on our environment. In order to provide space for these constant changes, the required planning and construction processes must break with traditional patterns. Here a couple of model approaches:

- Urban as well as rural space programs, site development and traffic areas, the increasingly dense infrastructure, the equipment of buildings adapt to the constantly changing forms of human coexistence.
- Structural masses are drastically reduced, thus generating material and energy savings – from the construction right up to the operation of a building.
- Operational costs of buildings are decreased by making use of passive and active energy systems.
- Structural components have multi-functional properties and and are integrated into the overall insulation of the building.
- In sustainable housing construction, the input side (resources, energy, materials, area etc.) is balanced against the output side (emissions, waste disposal).

With plasterboard systems by Saint-Gobain, every passive house is prepared for almost all eventualities.

Where a solid shell is integral part of a building's structure, rooms can be designed with light and dry gypsum building elements in a particularly economical, flexible and environmentally compatible way. For example the ISOVER Multi-Comfort House. Spot-precise and flexible – this is how the interior design can be realized. And should it later become necessary to adapt the interior to changing individual

time
ction? No problem at all!

All this can be done fast, clean and above all "dry" so that the residents can safely stay in their ISOVER Multi-Comfort House during the reconstruction work.

Light – strong – efficient.

When realizing building projects, Saint-Gobain system solutions based on gypsum turn out to be real lightweights. At a weight of only one fifth to one tenth of massive walls, living space can be generated in almost any building: without sacrificing living comfort or load-bearing strength.

In any case, lightweight elements relieve the building's static stress, triggering a chain reaction of advantages especially for multi-storey buildings. Material cost is reduced. Manufacturing and transport energy is saved. The slimmer construction generates up to 6 % extra space for living.

needs, this can be done fast and at low cost. Renovation is, of course, possible any time. Saint-Gobain plasterboard systems are the ideal solution when children's rooms need to be built in or removed again, for shifting doors, removing partitions and for many other rearrangements of room layout.

Gypsum-based innovative Best realized in the ISOV

Just like the ISOVER Multi-Comfort House, the gypsum-based system solutions offered by Saint-Gobain considerably contribute to reducing the consumption of resources and the emission of greenhouse gas. Thanks to their long service life, they save much more energy than needed for their production. And if finally the time for recycling should have come, the environmentally friendly plasterboards can even be returned to the production cycle or dumped in a non-polluting way.

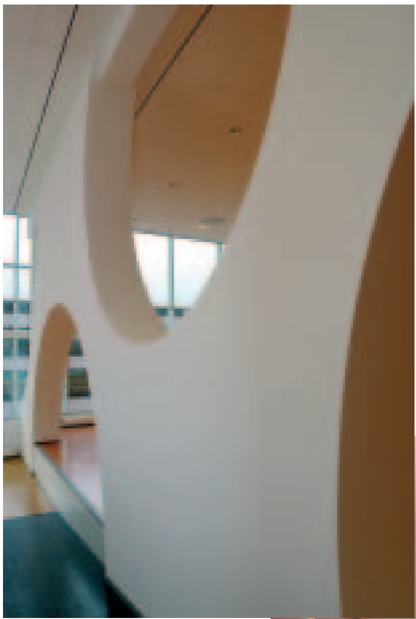
Healthy living guaranteed by nature.

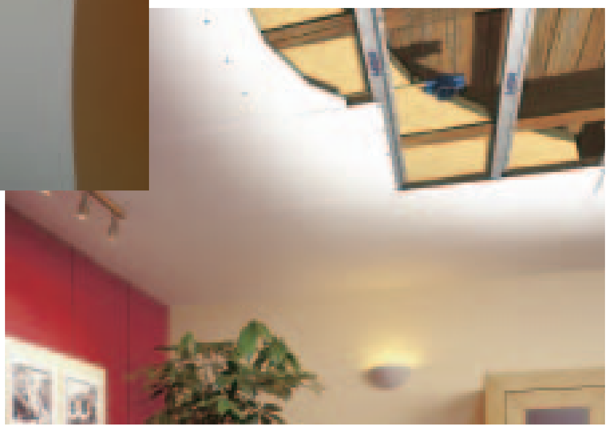
Being a natural building material, gypsum has proven its qualities for millenniums now – far more than any other material: it controls the level of air humidity, is fireproof, provides a comfortable climate and is flexible in use. Worldwide, thousands of buildings and millions of people benefit from these natural properties. On the one hand, gypsum is a material that ensures fast, clean, space-saving and inexpensive construction. On the other hand, it provides high-quality living space with a dry, healthy climate – even for people suffering from allergies.

Enjoy combined quality and design.

When using gypsum products and systems, every flat, every office building can be made to look identical. But that's not how it needs to be. With plasterboard systems by Saint-Gobain it is so easy to be creative – without any ifs or buts. With little effort and expense, curved walls or single round arches can be realized for example. Neither the completely cornerless flat nor stucco ceilings or avant-garde stairways need to remain unfulfillable dreams. And if you'd later like to

building concepts.
ER Multi-Comfort House.





create a walk-in wardrobe, this can be done fast and easily with Saint-Gobain plasterboards.

To the point:
Gypsum and its traditional advantages.

- *Humidity control: If the room humidity is too high, gypsum stores excessive moisture in its pores and releases it again to dry room air.*
- *Fire protection: If the worst comes to the worst, the fire-resistant properties of gypsum take full effect. Its natural water content of about 20 % acts like built-in extinguishing water and helps prevent the worst.*
- *Audibly quiet: Even in a cramped space, products made of gypsum provide acoustic quality that massive walls can only achieve with much thicker walls.*
- *Aesthetic, flexible, economical: Gypsum gives a maximum of creative freedom, allowing clever and individual structural solutions. Already the ancient pyramid builders appreciated these special qualities. Any structural indoor changes can be conveniently realized with plasterboards. Without drying times – and at a price that favourably compares both with respect to material and processing costs!*

Based on a versatile raw material, Saint-Gobain provides manifold system solutions.

Regardless of the structural requirements, Saint-Gobain offers gypsum products and systems that satisfy the highest demands: solutions that enhance the acoustic and thermal comfort and at the same time reduce energy bills. Perfect for every ISOVER Multi-Comfort House, fit for the present and the future.

www.bpbplaco.com
www.rigips.de
www.gyproc.com
www.bpb-na.com
www.rigips.com

Energetic, visual and fina
mineral-based thermal

In order to achieve the passive house standard, the outer wall must have a heat transition coefficient of U ≤ 0.15 W/m²K. Depending on the heat-insulating properties of the load-bearing outer walls and on the thermal conductivity of the insulation material used, it may be necessary to install an external thermal insulation system of up to 40 cm thickness. Modern external thermal insulation composite systems (ETICS) based on mineral raw materials combine best insulating properties with ease of handling. Compared to conventional insulation systems, the additional expense pays off after only a few years, thus enabling house owners to save a lot of money in the long run and go easy on our environment.

Good for the outdoor and good for the indoor climate.

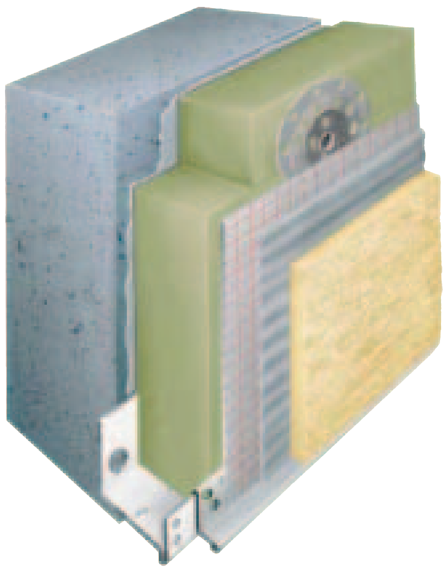
Especially the completely mineral-based insulation systems of Saint-Gobain Weber are ideally suited for passive homes. This is due to their "natural" origin as well as their high-quality composition. All com-ponents of the external thermal

ncial benefits: with insulation systems.

insulation system such as adhesive and reinforcing mortar, insulation material and finishing render are exclusively made of naturally occurring mineral raw materials. Finishing mortars as for example the mineral scratch render contain above all silica sand, calcium hydrate, white cement and crushed Jurassic limestone. This has numerous positive effects both for passive homes and their occupants – for instance best climate. Due to the natural, moisture-controlling properties, the masonry remains capable of diffusion despite the very high level of thermal insulation. As a result, the residents are able to enjoy a comfortable room climate while consuming only minimum amounts of energy. At the same time, they can rest assured that their homes enjoy long-term protection against fungi and algae. For the passive home this means an increase in value, for the residents higher quality of life.

Beautiful living with added safety.

No matter whether it's new buildings or old ones whose facades need to be refurbished to reach the passive house standard – the mineral-based thermal insulation composite systems of Saint-Gobain Weber always show their multifarious advantages. Not only can excellent thermal insulation be realized but also best sound and effective fire



protection – all in one go so to speak. And there's the aesthetic appeal on top of it. It is true that meanwhile numerous possibilities exist that allow an individual facade design. But it is also true that since the days of antiquity only mineral mortar has been able to stand the test of time – both technically and aesthetically. A fact which is also proved by the following comparison: While buildings with a non-mineral facade need to be renovated after an average of 8 years, the renovation interval for facades with mineral wool insulation and mineral scratch render is 30 years and longer!

To the point:

These benefits can be expected of mineral-based thermal insulation composite systems from Saint-Gobain Weber.

- *Perfect external and internal insulation*
- *Moisture control and capability of diffusion*
- *Maximum fire protection*
- *Optimum sound insulation*
- *Excellent resistance against the growth of fungi and algae*
- *Long service life*
- *Multitude of possible designs – even for old buildings*
- *Rapid and cost-saving workability*

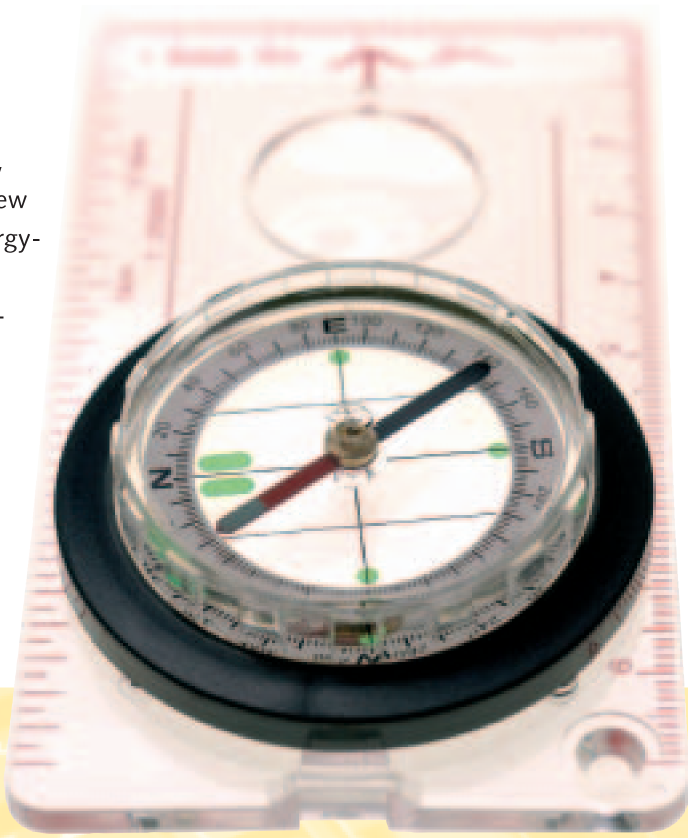
You want to learn more about the broad product range of Saint-Gobain Weber? For further information please refer to **www.weberbuildingsolutions.com**

The Service.

Well-founded & efficient.

- Addresses and contacts
- Selected literature

So just where can I find the ISOVER



Every year, thousands of people gain positive experience.

So far, more than 8,000 passive homes have been realized in Germany, well above 1,500 in Austria. And also all over Europe the number of new projects is constantly growing: there's no stopping the advance of energy-efficient construction. The future lies with the ISOVER Multi-Comfort House. In every location. For every purpose. And with best prospects – also for You!

Best addresses for best information.

In the meantime, there exists a wide network of communication, information and further training concerning the construction of passive homes. Many initiatives support the idea of energy-efficient building and living. Experienced engineers, architects, manufacturers, applicators and research institutes as well as satisfied building project clients pass on their knowhow and experience.

www.ig-passivhaus.de
www.ig-passivhaus.at
www.minergie.ch

Inform yourself on these websites about the advantages offered by passive houses, about quality criteria and available subsidies, about realized building projects and experiences made by the residents. Find suitable partners for your own projects and exchange your views with architects, engineers, scientists and housebuilders. Benefit from the latest news and information made available to you by regular press releases, circular e-mails and forum contributions.

ISOVER
Multi-Comfort House

Multi-Comfort House?

The higher the demand, the better the solutions.

Today, many passive house components are already part of the standard portfolio offered by the building industry and the trades. The passive house will soon become a reasonably priced standard solution. Under www.isover.com ISOVER offers you many constructive solutions to the problems of thermal and acoustic insulation.

www.passiv.de
Consultancy and Passive House Certification. The top address for all those who want to make sure their project is properly planned with the help of the Passive House Planning Package (PHPP) and is certified to fully comply with the Passive House standard.

www.ig-passivhaus.de
Information community for the passive house in Germany. Network for information, quality and further training.

www.passivhaus-info.de
Passive house service provider.

www.passivhaustagung.de
International Passive House Conference. Create a sustainable building culture based on the passive house concept.

www.passivhaus-institut.de
Welcome to the Passive House Institute. Research and development of high-efficiency energy systems.

www.passivhausprojekte.de
Realized passive house projects.

www.cepheus.de
Cost-efficient passive houses as European standards.

www.eversoftware.de
Energy Consultancy Center. Your partner for innovative energy consultancy.

www.blowerdoor.de
Systems for measuring airtightness.

www.optiwin.net
"Der Fensterpakt" – window systems for low-energy and passive houses.

www.passivhaus.de
Basic and comprehensive information on the passive house topic.

The Service.

www.nei-dt.de
Niedrig-Energie-Institut (Low-Energy Institute). Service provider for building consultancy and building research with the focus on energy-related construction issues.

www.sole-ewt.de
Brine geothermal heat exchanger for ventilation systems with highly efficient heat recovery.

www.passivehouse.org.nz
New Zealand Passive House.

www.igpassivhaus.ch
Information community for the passive house in Switzerland. Network for quality, information and further training.

www.pasivna-hisa.com
The first passive house in Slovenia.

www.minergie.ch
Minergie Switzerland. Higher quality of life, lower consumption of energy.

www.passiefhuis.nl
Passivhaus Holland. Passive House technology in the Netherlands.

www.passiefhuisplatform.be
Passive house projects in Belgium

www.pasivnidomy.cz
Passive House Center of the Czech Republic.

www.e-colab.org
Ecological Construction Laboratory.

www.passivhaus.org.uk
Passive House UK. Towards sustainable design.

www.europeanpassivehouses.org
Promotion of European Passive Houses.

www.energyagency.at
Austrian Energy Agency.

www.ig-passivhaus.at
Information community for the passive house in Austria. Network for information, quality and further training.

www.oekobaucluster.at
Green building cluster of Lower Austria. The central hub for the topics energy efficiency, living comfort, indoor air quality and old building renewal.

www.nachhaltigkeit.at
The Austrian strategy for sustainable development.

www.dataholz.com
Collection of data sheets providing information on building materials, timber constructions and building element connections.

www.energieinstitut.at
Energy Institute of Vorarlberg / Austria. Consultancy, education and research for the rational use of energy and renewable energy carriers.

www.energytech.at
The platform for innovative technologies in the areas of renewable energy sources and energy efficiency.

www.klimabuendnis.at
Climate alliance Austria.

www.passivhaustagung.at
International Passive House Conference.

www.drexel-weiss.at
Energy-efficient domestic engineering. Thought leaders in the energy turnaround.

www.lamaisonpassive.fr
The French homepage for passive houses.

Isover Multi-Comfort House

Selected Literature.

Books and brochures

Gestaltungsgrundlagen Passivhäuser
Dr. Wolfgang Feist
Building principles for houses where a special heating system is superfluous. A handbook for planners and architects.
Publishers: Das Beispiel GmbH

Luftdichte Projektierung von Passivhäusern
Passivhaus Institut / CEPHEUS
Planning principles and construction details for airtight connections with numerous pictures – example: passive house.

Grundlagen und Bau eines Passivhauses
Practice-oriented guide for developers and planners.
Publishers: Dieter Preziger, Ökobuch Verlag und Versand GmbH

Passivhäuser planen und bauen
Specialist book on basic principles, planning and construction details of passive houses.
Publishers: Carsten Grobe, Ökobuch Verlag und Versand GmbH

Niedrigenergie- und Passivhäuser
Published by Othmar Humm
The future-oriented technologies used in low-energy and passive house building styles, including realized building projects in solid and lightweight construction.
ISBN 3-992964-71-0

Das Passivhaus – Wohnen ohne Heizung
Anton Graf
Examples of passive houses from Germany, Austria and Switzerland.
Publishers: Georg D.W: Callwey 2000
ISBN 3-76674-1372-8

Cepheus – Wohnkomfort ohne Heizung
Helmut Krapmeier, Eckhart Drössler
Documentation of 9 Cepheus building projects.
Publishers: Springer Wien – New York

Das Passivhaus
Ing. Günter Lang, Mathias Lang
Basic planning, construction and calculation principles.
Publishers: Lang Consulting / Wien

Publikationen des Passivhaus-Instituts
Topic-related publications, conference proceedings, specialist journals and calculation software (PHPP Passive House Planning Package).
Supply source:
PASSIV HAUS INSTITUT
Rheinstraße 44/46
64283 Darmstadt
Phone 06151/82699-0
Fax 06151/82699-11
www.passiv.de

This brochure is meant as a quick guide to help you find useful information on the passive house design. The information given in the brochure is based on the current state of our knowledge and experience and was carefully compiled. Should any incorrect information be provided, a deliberate or grossly negligent fault from our side can be excluded. Nevertheless, we do not accept any liability for the topicality, correctness and completeness of this information since unintentional faults cannot be excluded and continuous updates not ensured.

The brochure contains the Internet addresses of other companies and third parties. These have been included to help you get a complete overview of the spectrum of information and services available. As the contents of these websites do not necessarily reflect our views or position, we must therefore exclude any liability.

ISOVER Multi-Comfort House

Energy-efficient living.

By using the innovative ISOVER insulating materials you simply ensure a better climate: in our environment as well as in your home. You reduce the consumption of energy while at the same time increasing your well-being and comfort. Can there be a more convincing argument?

Build on ISOVER. Show responsibility for our environment and for yourself!

ISOVER

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