The significance of thermal insulation

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The significance of thermal insulation

Introduction:

The energy renovation of existing buildings represents a key component of the “Energiewende” (energy revolution).
The building envelope and the system technology used within the building itself form a single unit. Prior to a building renovation project, these two aspects should thus in principle be analyzed together. Within this publication, however, together.
only the building shell is to be addressed, with a focus being placed on thermal insulation.
The authors provide their views on the most frequent objections, prejudices and misunderstandings in connection with structural thermal insulation and the use of insulating materials.

Why structural thermal insulation is necessary:

There are a number of key reasons to drastically reduce our consumption of fossil fuels. These include the need to limit the impact of the already apparent changes to our climate as well as the requirement to increase supply security by reducing dependency on imports from the world's crisis-prone regions. Dwindling supplies of fossil fuels and the resulting increase in energy prices are further factors that need to be taken into consideration. Around ٤٠٪ of energy consumption in Germany can be attributed to the building sector, predominantly for heating purposes. Sophisticated, cost-effective solutions are available on the market that provide a simple means for reducing energy consumption by a factor of four compared to renovated existing buildings. In the case of more ambitious refurbishments, consumption can even be reduced by a factor of ten. The structural thermal insulation required to reduce heating consumption plays a key role here.
Structural thermal insulation

is necessary in order to prevent building damage resulting from the formation of moisture on the inside of external building components (hydrothermal insulation), prevents the build-up of mold, which can be a contributing
factor in building damage and health risks (hygienic thermal insulation), guarantees sufficiently high surface temperatures on the inside of external building components during the winter, contributing to ensuring a feeling of comfort inside the building (comfort promoting thermal insulation); this allows for the same level of comfort to be achieved with lower room air temperatures and thus less energy consumption, reduces undesired heat input and thus the overheating of rooms during the height of summer (summer thermal insulation), ٢ contributes to reducing energy consumption in summer and winter (energy-saving thermal insulation), ٢ supports the preservation of resources and reduces the burden placed on the environment (environmentally-driven thermal insulation),
an support the durability of the building structure, contribute to the rectification of structural damage (sustainability-driven thermal insulation), facilitate a reduction in heating and cooling costs and ensure that the property's value remains stable (economically-driven thermal insulation, can be used to enhance the design of facades (design-driven

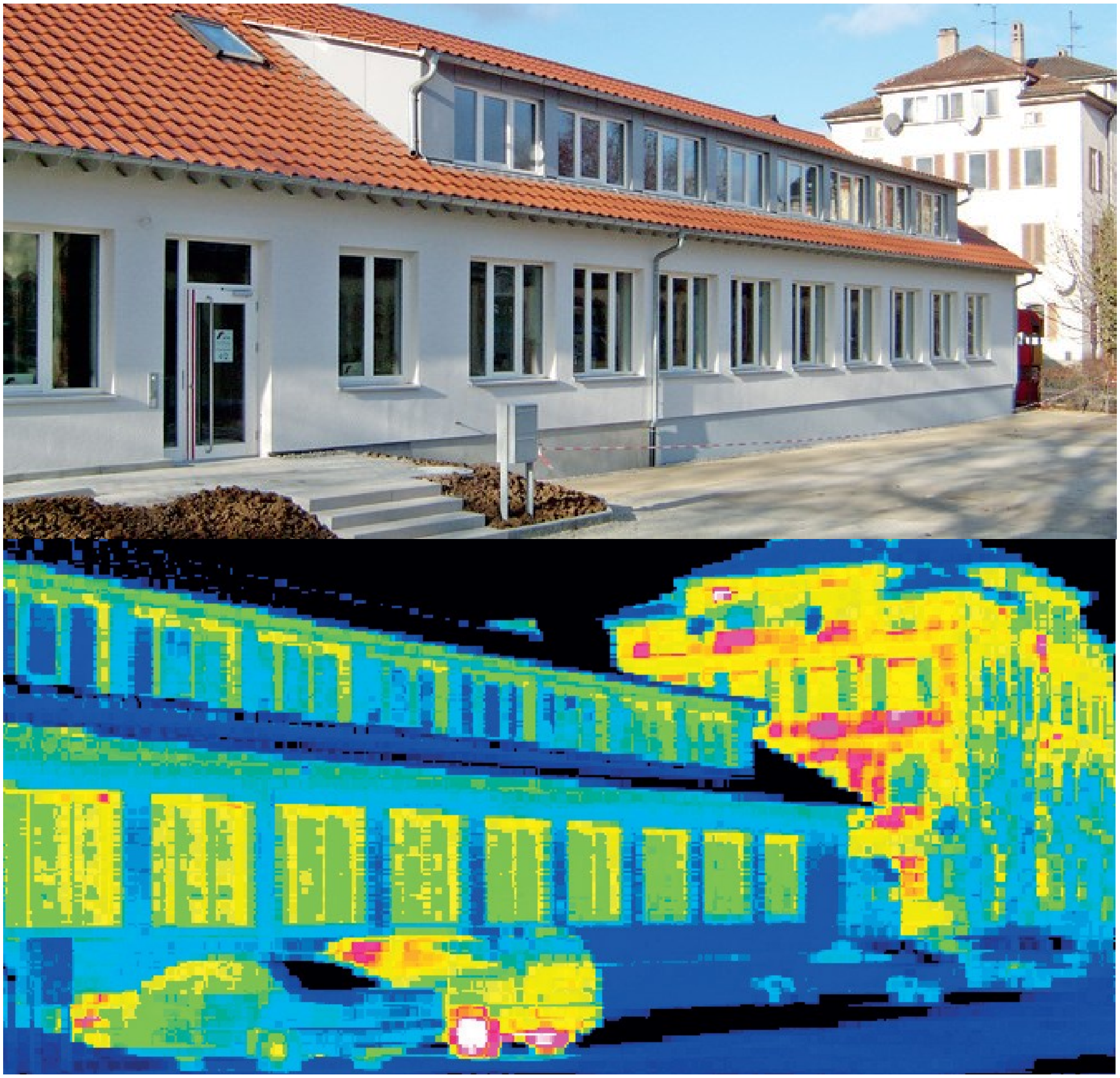
thermal insulation)
can be implemented economically – especially when combined with renovation measures that are required in any case

High-rise buildings in Sulaymany use Thermal Insulation

Valuable heat :

Over many centuries, "heat" was a valuable commodity. Back when wood and coal briquettes were used for heating, you would never find that all rooms were heated – this was even true in the case of wealthy households. Besides the kitchen, only the parlous at the most would also be heated with a tiled stove. Only in rare exceptional cases would other rooms enjoy heating. Attics and cellar rooms would generally be left unheated. During heating periods, the average room temperature
was around ١٥°C, meaning that for a long time warm clothing was also worn indoors.
The advancement of heating technology, greater demands in terms of comfort and the availability of cost-efficient energy sources later generally led to the full heating of all rooms. The first energy crisis during the mid-١٩٧٠s raised awareness in Germany about supply security and thus triggered a change of thinking in society. Compared to the building standard of the ١٩٦٠s, the legislator has reduced fossil fuel requirements for heating in new buildings by a factor of five, introducing
thermal insulation regulations and later energy-saving ordinances in several stages to this end. The requirement to further tighten these provisions under European law will lead to a further significant reduction in the energy consumption of new buildings. Across Europe, the political objective is to achieve "nearly zero energy buildings" from ٢٠٢٠, a
goal which in Germany is defined in the Energy Saving Ordinance as the “ultra-low-energy house" (Niedrigstenergiehaus).
In contrast however, the steady increase in levels of prosperity has meant that the living space per person has risen over the past ٦٠ years from between approximately ٨ and ١٢ m٢ to the current figure of around٤٥

m۲. There are also the heated and cooled areas used by the general public, including schools, libraries, nurseries, museums, theatres, restaurants and airports. Even in the area of residential construction, the use of cooling systems has been observed for many years. Savings made
thanks to the improved energy performance of buildings have thus



Thermography

been offset in part by the increasing living space and growing demands per capita.
One challenge is now to adjust existing buildings in line with modern requirements. In some cases, these were constructed under completely different premises with regard to usage and energy efficiency. Ultimately, however, the question must also be asked whether all rooms in a building always have to be heated to ۲۰°C or above or whether a deliberate limitation and acceptance of tolerance limits in terms of winter and summer room temperatures – alongside structural measures – could make an important contribution to saving energy, preserving resources and protecting the climate. Critically scrutinizing

demands in terms of comfort should thus – in addition to improving buildings themselves – represent a further approach to resolving this issue.
In summary, it can be said that heating energy is Germany's most significant energy consumption sector. Reducing the use of heating energy thus poses a challenging task for our generation, but one which can be tackled using a variety of approaches. If we do not succeed in achieving a turnaround in our consumption of heating energy, we will be unable to realize the desired energy revolution in our country.

Basics of building physics:

When looking at a building's energy balance, the losses and heat gains, on the one hand, and the energy to be provided, on the other, have to be compared. It should be noted here that energy-saving approaches – despite their high level of relevance – only account for part of the demands made as regards the thermal insulation of building components.
The overriding aspect here is undoubtedly healthy and damage-free construction.

Titanic Hotel Sulaymanya

Hydrothermal insulation:

Ensuring structures that remain damage-free over the long term and allow for healthy living represents a crucial building task. Here, thermal insulation performs the task, among others, of making sure that room-side surface temperatures do not fall below a critical level and thus that damage from condensation and the formation of mold can be avoided. Since the end of the ١٩٨٠s١, it has been known that for mold to grow, it is not necessary for condensation to form on building component surfaces. Instead, a relative humidity level of ٨٠٪ at such surfaces over a period of three to five days is sufficient to bring on this development. The relative humidity in a room in turn is greatly dependent on the local temperature of the air in the room itself. The higher the temperature, the lower the relative humidity. For this reason, the relative humidity in the middle of a room or close to interior walls is always considerably lower than in areas close to exterior walls, at the corners of exterior walls and even behind furniture positioned close to exterior walls. Thermal insulation ensures that the temperature of the internal surfaces of exterior building components does not fall so low that the cooling room air circulating close to them reaches a critically high level of humidity.

The thermal insulation in place thus now has to meet minimum requirements that are around twice as stringent as those that were common in the construction industry between the ١٩٥٠s and ١٩٧٠s.
lotion system during a renovation project, alternative measures must be drawn on in order to effectively prevent the formation of mold (e.g. by enhancing the continual ventilation of rooms). These generally entail higher heating costs – the poorer the thermal insulation, the greater the moisture-related minimum air change rate required. Generally speaking, a good thermal insulation reduces the risk of building damage as well as heating costs. It is thus also of high significance from a social perspective, as it combines the efforts made to improve public health and the required environmental initiatives in an exemplary manner.

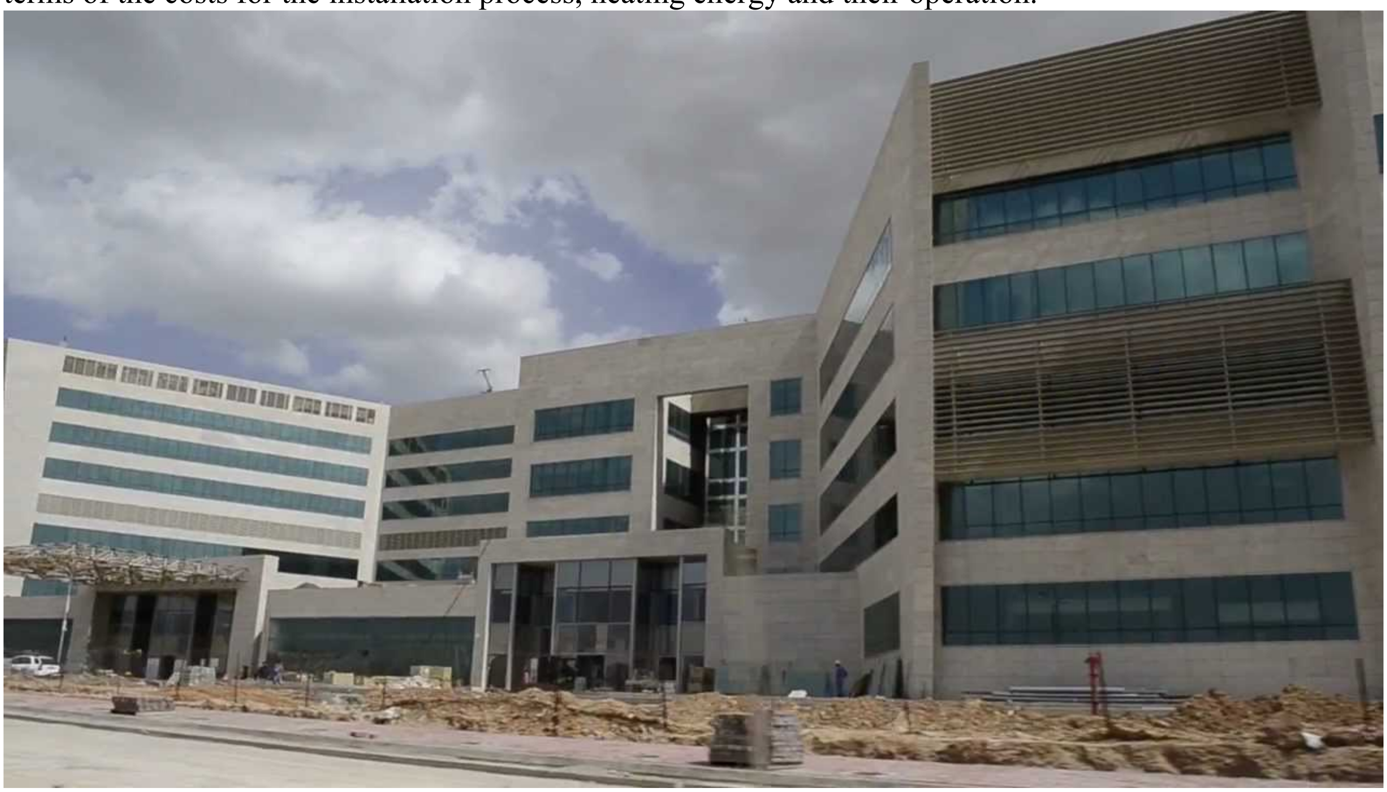
Energy-saving thermal insulation:

In the case of renovated old buildings, heat losses are dominated by the transfer of heat through building components – a process referred to as transmission. The better a component conducts heat, the greater the heat losses. The thermal quality of a building component is assessed with the help of the U-value. The U-value indicates the heat output required per m٢ of a component's surface in order to maintain a temperature difference of one kelvin between an interior space and its surroundings. Typical exterior walls found on old buildings have U-values of between ١.٤ and ١.٨ W/m^2K. At an outside temperature of approximately zero degrees, a heat output of approximately ٣٠ to ٤٠ W per square meter of external wall surface must thus be ensured to maintain an inside temperature of ٢٠°C. Modern, well-insulated exterior walls achieve U-values of between ٠.١ and ٠.٣ W/m^2K, meaning they lose five to ten times less energy via transmission than the existing building stock. Similar situations can also be observed for other building components such as ceilings and basement ceilings. For design reasons, however, objections are occasionally raised to excessive insulation thicknesses. An important objective of current research and development work is thus the creation of highly efficient, sustainable insulating materials and systems which also provide a considerable insulating effect even when smaller cross-sections are used. It must still be considered that the higher – and thus the poorer – the U-value of the building component ("cold radiation"), the lower the surface temperature on the inside in the winter. Conversely, high surface temperatures during the winter months lead to cosy living conditions.

Ventilation:

In order to remove harmful substances from the air inside buildings and, in particular, to eradicate moisture from interior spaces, it is necessary to regularly exchange the room air for fresh air. Rooms were traditionally ventilated by opening windows as well as via joints on windows and other building components. This process was also supported by the exchange of air through the fireplace. Nevertheless, Pettenkofer complained about the poor quality of the air in inside areas back in the ١٩th century. The investigations of the Berlin Health Insurance Fund (Berliner Ortskrankenkasse) performed in ١٩٠٥ reveal appalling images of moldy walls in houses from the Gründerzeit era[٢].
For many years already, it has been the generally accepted practice that a sufficiently air-tight building shell (referring especially to the wall and ceiling areas as well as all connections and penetrations) must be permanently ensured in order to avoid building damage and an excessive uncontrolled exchange of air[٣]. A significant air exchange dependent on the outside temperature and wind speed leads to considerable heat losses. Water vapor in the room air can also condensate in joint cross-sections.
Moisture in exterior building components can lead to building damage over the long term and must thus be avoided at all costs.

Contrary to the general expectation of many people, these leaks in building structures do not allow for a sufficient exchange of air – which is required for hygienic reasons. This is because weather conditions fluctuate greatly and the location of leaks is dependent on the building's specific design. It makes sense that the exchange of air has to be planned taking account of spatial and temporal conditions and that this exchange has to be ensured manually and/or technically. When performing renovations or constructing new buildings, the planner thus has to draw up or review a ventilation concept. This may still include the exchange of air through the opening of windows. Energy-efficient window ventilation entails exchanging used, moisture-laden room air for outside air via wide open windows. The process is to be conducted in as short a time
as possible while interrupting the heat supply to the greatest possible extent. This limits the losses to the energy content of the exchanged room air itself. With longer ventilation periods, the opening of windows leads to the cooling of building-component surfaces and thus to an increased risk of mold formation. Regular shock ventilation requires the presence and attentiveness of residents; with today's way of life, such ventilation can frequently not be implemented to a sufficient level. Hygrometers on the inside of external walls indicate to residents when the room humidity reaches critical values in excess of ٧٠ % during the winter. In the middle of a room or at interior walls, the level of humidity should not exceed ٦٠ %. Fan-supported ventilation systems, which ensure the necessary exchange of air regardless of the weather conditions and user activity, represent a better solution. Pure exhaust fans with air vent openings in the exterior walls of living and sleeping areas ensure the adequate removal of moisture provided by a sufficient exchange of air. Systems with supply and exhaust functions lead to ventilation heat losses being drastically reduced, especially in conjunction with highly efficient heat recovery.
All ventilation types differ in terms of the installation work, the degree of ventilation heat losses, the energy requirements for fans, the acoustic conditions and the achievable level of comfort as well as in terms of the costs for the installation process, heating energy and their operation.



Faruq Medical

Views on objections to the implementation of insulation measures:

Sufficient thermal insulation that is appropriate from a structural perspective has the primary task of ensuring healthy living and damage- free structures and is also part of a comprehensive energy concept. The topic of energy efficiency is frequently reduced to saving energy through the application of additional insulating layers. However, the condition of the existing structure, its usage, the building technology and the energy sources, among other factors, must also be incorporated within the framework of the energy concept. This requires developing a plan for addressing the specific situation – a task which depending on the size of the building and the complexity of its usage is assumed by
an architect or energy consultants. The topic of subsequently supplied thermal insulation is currently the subject of intensive debate. It is frequently looked at outside the context of a complex planning and building task and there are misunderstandings and misinterpretations. In the following sections, views are provided on the most frequent objections,
prejudices and misunderstandings in connection with structural thermal insulation٤ and the use of insulating materials. Focus is placed here on building renovation, but most statements apply in equal measure to new constructions.

Houses have to be able to breathe:

The common assumption that "houses have to breathe" originates from a measurement error made by Pettenkofer some ١٥٠ years ago. Pettenkofer presumably failed to seal off the fireplace when taking his measurements. As early as ١٩٢٨, Erwin Reich demonstrated in comprehensive experiments that a relevant exchange of air can take place through window and door joints as well as unplaster structural joints, but not through plastered walls.
As is the case with many assumptions, there is a kernel of truth in it. It is indeed true that a minimum rate of air change is required in every building in order to ensure that residents are supplied with sufficient fresh air and also that the moisture and harmful emissions they cause can be discharged. The poorer the quality of a building's thermal insulation,
the greater the necessary air exchange, as the room air in front of poorly insulated walls cools more significantly and thus can absorb less moisture. The exchange of air through homogeneous, joint less exterior building components does not take place to any considerable extent as part of any construction type, however. In renovated old buildings,
air is exchanged, as described above, not only by opening windows, but also in an uncontrolled manner through joints, with the process being supported by the chimney draught. For example, the roof area, which is traditionally not used as a living space in most cases, is rarely air tight and this is also true for the connection to the cellar.
Even without an air flow (convection), moisture is transported through many structural components by means of diffusion, even if these components are air tight. Nevertheless, there is not one commonly used construction method in Europe for which the transportation of water vapor in this way is sufficient to eradicate the moisture that forms in a flat. The volume of water vapor to be removed by means of ventilation must be up to ١٠٠ times greater than the volume removed via diffusion
Through exterior building components if damp and mold damage is to be avoided. The individual points at which building components "breathe" are their unsealed joints. Here, large quantities of moisture are "discharged" accordingly. This, however, also illustrates the danger of condensation collecting in unsealed structural joints. The transportation
Of water vapor through a building component must be planned in such a way that a permanent build-up of moisture inside the respective component can be excluded.
The interior surfaces of a building have an important buffer function:

Open-pored interior surfaces such as lime, clay and gypsum plaster as well as open-pored furnishings are able to absorb relatively large volumes of humidity in the short term, but are unable to discharge it outside. If the room humidity then falls, the water vapor that has accumulated here will once again slowly be released into the room air. This allows for spikes in humidity in the bathroom or kitchen to be cushioned and for phases in which the room air tends to be overly dry to be reduced. This, of course, only works where surfaces are not covered by tiles, vinyl wallpaper or impervious coatings that prevent the exchange of water vapor. This buffer function is restricted, however, to a few
Millimeters in depth below the surface. Such buffer effects should be avoided, however, at critical thermal bridges (e.g. poorly insulated window lintels), as this extends the periods during which there are high levels of humidity at the respective building component surface, supporting the formation of mold.
The idea of the "breathing wall" with regard to the exchange of air between inside and outside areas thus lacks any functional basis.
Problems emerge in existing buildings whenever structural or usage changes lead to a significant reduction in the exchange of air or a considerable drop in the surface temperatures of building components.

This means that thermal bridges should always be minimized during a renovation or conversion project and it must be examined how the required exchange of air will take place afterwards. This check has been required for some time by standards introduced under building law.

Thermal insulation leads to mold:

It should be noted that mold problems in flats have continued to account for a significant share of building damage over the course of recent decades. In the ١٩٩٦ and ٢٠٠٨ Building Damage Reports, ١٢.٧ % and ١٤ %, respectively, of building damage was attributed to mold problems. This affects new buildings, which in general are moved into much too quickly and not given sufficient time to dry, as well as renovated buildings and – to a very great extent – renovated existing
Buildings.

As stated previously, mold can occur wherever warm room air cools at building component surfaces, thus causing the relative humidity of the air to increase greatly; in extreme cases, this can even lead to the formation of condensation. The pH value and capillarity of a surface also impact the tendency for mold to form. Additional thermal insulation always leads to an increase in the room-side surface temperature of exterior building components and thus in principle reduces the risk of
mold. For the following reasons, however, mold problems can still emerge even with good thermal insulation:
In particular, points in the building shell at which the thermal insulation is interrupted or weakened (remaining thermal bridges) may now be the places with the lowest surface temperature. In particular when new windows are put in, condensation no longer forms first – as was the case previously – on the window panes. Critical situations as regards humidity can thus
no longer be immediately identified, meaning the required ventilation is not implemented. Such points can be outside corners as well as connections in the facade insulation to the cellar or a roof insulation system. Balcony panels, integrating garage
ceilings or letterbox installations are other possible problem areas.

Planning such details helps to identify structurally feasible and cost-efficient solutions. To this end, there are now a large number of tested and proven remedies.
In particular at thermal bridges in insulating layers on the warm side of building components (inside insulation), lower surface temperatures than those observed before the renovation can occur, leading to an increased level of risk. For this situation too, however, there are secure and proven constructions. Interior insulation must be planned in particular detail and applied in an expert manner, as it is less fault-tolerant than

external insulation:

The installation of new, better-sealed windows also leads to a reduced exchange of air through joints. Should heating and ventilation practices remain the same, this will result in significantly higher moisture

content in the room air compared to before the renovation. This difference can be offset by adjusting the ventilation methods via windows or using a mechanical system. Mold growth is avoided if a high level of relative humidity is also permanently prevented at unfavorable sections
of exterior building components (thermal bridges) through the use of sufficient heating and ventilation.
As people are unable to sense the level of relative humidity in their environment – in contrast to their ability to feel temperature changes – it is highly recommended to use a hygrometer during the winter months in order to monitor humidity levels.

Kurdistan Millennium Hotel & SPA

Thermal insulation becomes a fire hazard:

Many of the insulating materials frequently used – as well as other building materials – are manufactured so that they are at least classified as building material class B١ ("low flammability") by the building inspectorate. The permissibility of building materials of various building material classes is governed in the respective building regulations
(Regional building codes).
Of course – irrespective of the use of insulating materials – all fire protection regulations must be complied with in order to ensure that escape routes remain usable in the event of fire and that the spread of any blaze can be prevented: For example, barriers made of non-flammable materials must be installed above windows and doors or as a peripheral fire block, ensuring sufficiently long resistance to fire. High buildings may generally only be insulated using non-flammable materials.
Depending on the building and its usage type, it must therefore be evaluated carefully which material is suitable for which use.
It must be considered, however, that interior furnishings made from wood and plastics have a high fire load. Timber facade cladding, which is commonly used in practice and permitted for small buildings, must be assessed more critically as regards fire protection than the use of external thermal insulation composite systems with polystyrene. The high-profile reports on fire damage in connection with external thermal insulation composite systems usually relate to projects that were still in the construction phase, meaning that the systems had not yet achieved their final level of functional capacity.
Large permanent fire loads such as wooden sheds or rubbish containers must be avoided close to a facade, as must the storage of large volumes of flammable building materials or waste during the construction phase.

Insulating materials damage your health:

As is the case with all building materials, the potential health risks posed by insulating materials and how these can be countered must be examined. In the case of materials which emit particles, i.e. fibers or dust, it must be ensured that they are installed in a manner that seals them from the room air. For mineral fibers, regulations have been in place for a number of
years stating that no repairable fibers may be released.
Materials that may emit gaseous materials should wherever possible not be in contact with the room air. Renewable (ecological) insulating materials, as is also the case with synthetic insulating materials, are also often
Chemically treated in order to improve their flammability properties and to prevent pest infestations or decay. The type, volume and possible impact of additives of this kind must be taken into consideration when selecting the product. The publicly accessible and non-proprietary WECOBIS building material information system offers a source of information
in this regard.
If the right product is selected and the correct storage, application and usage conditions are in place, health impacts are not to be expected when the insulating materials are in their installed state. Compliance with occupational health and safety guidelines also ensures this is the case during the application stage.

The production of insulating materials consumes more energy than the materials save:

Those who oppose construction methods that incorporate a high degree of insulation argue that the production of the insulating materials uses more energy than the materials actually save during their service life in the building.
The non-renewable, i.e. fossil, primary energy requirements for the production of insulating materials (grey energy) differ considerably: While less than ١٠٠ kWh/m٣ is used for the production of materials requiring little processing such as wood shavings or cellulose fibers, up to ١,٣٠٠ kWh/m٣ is needed for the manufacture of foam glass, PU or XPS١٠.
When calculating the energy pay-back period for insulating materials, the expenditure for their production is compared to the saving of primary energy resulting from their insulating effect. The energy pay back is thus dependent on the original situation, insulation thickness, insulation type, heating method and energy source as well as the climate at
the respective location. As a rule, the energy payback period of insulating materials is less than two years. If appropriate insulating materials are selected, the energy amortization period can often be cut to less than ١٢ months. For the production of organic insulating materials such as cellulose insulation, hemp, etc., Less than ٥٠ kWh/m٣ is used up, meaning that the manufacturing expenditure is amortized in terms of energy in just a few months.

Thermal insulation results in big problems when it comes to disposal:

The fact that the disposal of composite structures can prove problematic should not actually be dismissed out of hand. The less bonding involved, the easier it is to remove insulated structures. Ventilated structures with detachable mechanical connections have an advantage relative to bonded composite structures.
When assessing the disposal issue, it also helps to look at the life-cycle balance: The energy expenditure during the production phase has already been taken into account. This is overcompensated several times over thanks to energy savings during the usage phase. The life-cycle balance is hardly affected by the disposal of the materials – as has been shown
by numerous studies. In the worst case scenario, disposal involves disposing of the entire system. Investigations on the removal process have been complied in a study by the Research Institute for Thermal Insulation (FIW)١٥. If the entire system is thermally recycled, the energy content stored in the building

material can be used. Procedures for the material recycling of insulating materials are at the development stage.

Insulated facades are coloured by algae and pose a health risk:

In buildings with high-quality thermal insulation, the final rendering is damp for far longer than is the case with insulated brickwork. In the case of exterior walls with poor thermal insulation, heat losses mean that the external surface is –permanently heated dry, while the high mass of the external wall means that even during the early hours of the morning on cool and clear days the dew-point temperature is only fallen below in rare cases. In contrast, with external thermal insulation composite systems, the top layer (plaster) often has a low mass with little heat storage capacity. In particular on clear nights, it thus cools more quickly owing to the radiation exchange with the cold outside space. This means that the moisture content of the external plaster on insulated facades is generally higher than on insulated brickwork, allowing for algae to grow more easily and thus leading to a green colorations of the surface. This, however, is a purely "cosmetic" problem and should not be put on the same level as noxious mold in internal areas.

In nature, algae growth is frequently observed if surfaces are damp for a long period – including on glass or metal surfaces and on trees.

In densely developed areas, this effect occurs far less frequently than in very leafy and spacious building spaces. Here, the relative humidity of the surrounding air is higher than in heavily populated inner-city areas due to the higher moisture turnover of the plant life.

The tendency of some plaster manufacturers to counter algae growth using pesticide and fungicide mixes in the paint should be evaluated critically. These poisonous substances are washed out as the paint layer is weathered and ultimately reach the earth and ground water. Eaves can be used to lessen the wetting of the facade, as this reduces the radiation exchange with the cold outside space and intrusions from driving rain. Heavy top layers (thick plaster) do not cool down as quickly at night and also reduce the frequency of instances in which the dew-point is fallen below. Pure lime plaster is alkaline and prevents the growth of algae. The level of alkalinity falls over the years, however, with the increasing accumulation of fine dust and dirt on the surface.

Some paint manufacturers have developed facade paints which include infrared-reflecting components, thus enabling them to limit the radiation exchange with the outside space. This leads to an increase in the surface temperature, but here too ageing effects are to be expected due to the accumulation of fine dust and impurities. The recently published idea of actively heating the final rendering dry contradicts the purpose of the insulation, however, and does thus not represent a meaningful contribution to solving the problem.

Bank building before and after the energy renovation and facade modernization

<u>Facade and roof greening can replace thermal insulation:</u>

Even if green facades have a great deal of charm, their energetic properties are only negligibly more favorable than those of a non-green facade; the thermal properties of insulated facades are fallen far short of. The vegetation merely serves to reduce the transfer of heat from the wall surface to the outside air. Thick layers of ivy also fail to create a standing air layer, as
even the smallest of air movements result in the complete ventilation of the plant layer. The vegetation does,
however, have a positive effect in the summer: It prevents the sun from shining directly on the facade and thus the wall from heating up, while the evaporation through the leaves leads to a significant cooling of the surrounding air.
Ideally, vegetation and insulation would be combined. In the case of ivy, however, there is the risk that the final rendering could be destroyed.
For this reason, insulated facades should be equipped with trellis and appropriate plants should be grown.
With roof greening too, the positive impact is generally restricted to the summer. Roof insulation, however, has a positive effect on the indoor climate both during the summer and winter months. The improvement achieved in the insulating effect via the substrate layer is minimal, especially as it is to be expected that the substrate layer will be fully penetrated
by moisture during the heating period. With some systems, it is allowed to take the drainage layer, which can comprise insulating materials, into account with regard to thermal insulation.

Thick walls in older houses already provide sufficient insulation:

In buildings with a wall thickness of ٦٠ cm or more, either solid bricks or quarry stones were traditionally applied. While these materials are very good at storing heat, they are also almost as good at transmitting it. Even with very thick historical wall structures, U-values of below ١ W/m٢K are the absolute exception. Their thermal insulation is thus insufficient
and as a rule – with today's conditions of use – requires improvement with a view to structural protection alone.
The high storage capacity merely slows down the warming and cooling processes. Here too, external thermal insulation can lead to a reductionin heat losses of ٨٠٪ to ٩٠٪. Storage mass is of benefit in terms of summer thermal insulation, allowing for heat generated in inside areas during the day to be stored and then discharged to the outside air during the night by means of overnight ventilation. For this day/night cycle, only around the first ١٠ cm on the room side are activated, however, and
exterior insulation does not hinder this effect.

Thermal insulation prevents solar radiation reaching the brickwork and thus reduces its contribution to saving energy:

One theory put forward by opponents of high quality insulation is that the solar radiation that falls on an insulated, solid exterior wall during the winter would contribute to covering heating requirements.
The Fraunhofer Institute for Building Physics (IPB) has led the scientific debate on this assumption for decades. Nevertheless, doubts are cast by relevant stakeholders at regular intervals. An additional simulation is also currently being conducted by Prof. Andreas Wagner at the Karlsruhe Institute of Technology (KIT). An insulated south-facing wall made from solid bricks with a thickness of ٣٦.٥ cm records a loss in heat (solar gains minus transmission heat losses)

of ١٠٢ kWh/m٢ during the period between March and October. If the wall is not exposed to solar input, the heat loss in the same period comes to ١٠٩ kWh/m٢. Solar input thus has a negligible effect in terms of reducing the loss of heat from the inside to the outside of the building. If a ١٥ cm insulating layer is added, the resulting heat loss is reduced to ١٤ kWh/m٢. Even if the solar input received by the wall is not taken into account, this figure still stands at ١٥ kWh/m٢. This once again illustrates that good façade insulation on traditional brickwork can also effectively reduce heat loss from south-facing walls (in this example by ٨٦٪). With optimal solar input, however, the observed insulated wall's heat loss is only reduced by almost ٧٪. It appears far more sensible to make active use of the solar gain on the insulated exterior wall, for example via photovoltaic systems or thermal solar collectors.

Thermal insulation is expensive and does not pay off:

Whether a measure "pays off" or not depends on, among other factors, the assumptions, boundary conditions and methods on the basis of which an economic efficiency calculation is performed. In principle, all measures which generate lower overall costs over their service life compared to a basic scenario can be deemed as economical. The values defined in technical regulations (DIN Standards, VDI Guidelines) are used for the service life. In practice, many building components even achieve considerably longer service lives. The basic variant is often the still un renovated building component. Here, it must be taken into account that many properties have already been partially renovated. Under certain circumstances, this reduces the saving potential to be achieved through the application of the insulation measures and thus impacts their cost effectiveness. The Energy Saving Ordinance (EnEV) takes this into consideration in the requirements it places on measures for existing buildings.

The annual costs of the different options, the cash/capital value, internal rate of return or possibly also an equivalent heating price represent appropriate benchmarks for assessing the cost effectiveness of additional insulation.

If the decision is taken to combine maintenance work and measures for improving a building's thermal insulation, a differentiation should be made between the costs for the renovation work that would need to be performed in any case and the additional expenditure for the solution aimed at improving energy efficiency. All of a building's components have a finite service life and have to be refurbished or exchanged on a periodic basis. The roof, facade and windows as well as the heating system and sanitary installations have to be restored or replaced regularly in order to preserve their functional capacity. If energy modernization measures are performed, additional expenses are incurred. These meas- ures can involve the application of insulating material or making improvements to the glazing quality of windows as well as the doubling up of rafters in order to accommodate greater insulation thicknesses. The full costs of the investment comprise the total of the "businesses-
usual costs" of a structurally necessary renovation project and the additional costs related to energy-efficiency measures. These full costs cannot always be paid back through the cost savings made thanks to improved thermal insulation. This expectation is also unrealistic, as the extent of the measure and the benefits it generates go far beyond energy savings. Buying a new fuel-efficient car will not allow you to amortise its purchase costs, but you may be able to amortise the additional
costs you paid compared to a standard model of the car. If only the additional costs are taken into account, however, it can be shown that, for example, the costs per saved kWh are already often smaller than those for their provision of consumption. The annual costs for interest and amortization – in due consideration of the lower heating costs – as a result of an insulation measure are thus smaller than the original heating and maintenance costs prior to the measures. Specific cost-efficiency
assessments must always be conducted on an individual basis.

When performing the calculations, appropriate assumptions for energy price developments should be applied, provided this is required by the chosen method. Each projection is of course uncertain, especially as the development of energy prices in the past has been very volatile.

It is therefore recommended to analyze options with different price-increase rates. With the very long usage periods of structural thermal insulation measures, the use of a plausible, average energy price during the respective measure's service life is recommended as an alternative to dynamic calculation methods in order to avoid exorbitant and unrealistic price estimates. The loan interest is generally used as the interest rate, provided the measure was funded using borrowed capital. Should the investor use equity capital, the interest rate currently paid on his or her other capital should be used. Assessments based on the possibly different perspectives of tenants and landlords are not looked at here. The policy objective is to promote energy renovation. The federal government, states and even a number of local authorities are therefore offering grants or subsidised loans for energy renovation projects.
The economic benefits of these promotion measures must be taken into account in connection with the specific case when calculating energy efficiency.
As a result, investments thus very often turn out to be economical if reinvestment cycles that were pending anyway are used for the energy improvement measures. The application of facade insulation to a building in excess of ٣٠ years old then proves to be especially economically beneficial if the exterior plaster has to be replaced or extensively repaired anyhow. This also applies to the insulation of roofs if bricks and flashings need to be replaced in any case.
Generalised statements regarding the cost efficiency must be viewed with a great deal of caution, however. For a well-founded statement to be provided, the expected investment costs of the specific project must always be compared with the realistically projected savings made on heating costs under the actual boundary conditions. Ultimately, when assessing the economic benefits, it must be considered that an energy renovation project increases the value of the respective property and also considerably increases levels of home comfort. The current Valuation Ordinance thus incorporates the quality of a building's energy performance in determining its value. Quality surcharges, which take account of a building's energy performance, are increasingly been included in the rent index.

Thermal insulation defaces buildings:

In addition to the technical and economic objections discussed above, the issue of design is also a topic that is subject to very emotional discussion.
A number of renowned media sources equate thermal insulation to the end of building culture. They believe that the supporters of thermal insulation want to see every timber framework and building from the Grunderzeit era disappear behind a faceless layer of insulating material. No party who is seriously interested in energy renovation can have this objective, however. Unfortunately, there are actually examples of buildings with facade insulation that are sufficiently dubious from a design perspective. Nevertheless, there are also a large number of insulated buildings that are far from design successes.
The issue of design is thus not primarily a question of whether thermal insulation is applied or not, but rather the use of creative architecture in handling the various materials. A large number of successful renovation projects demonstrate this.
Interior insulation can represent a very viable option for facades which should not be changed on the outside. As the line of argument in response to claim ٢ shows, the problems and risks associated with interior insulation have diminished significantly thanks to the introduction of capillary-active insulating materials which allow the wall to dry inwards.
Interior insulation must be planned carefully in order to minimize the thermal bridge effect of integrating walls and ceilings and to prevent mould problems in areas where thermal bridges remain.
The reveal depth should be taken into account when using thick, exterior insulating layers. To ensure appropriate insulation thicknesses, it is generally necessary to adjust the installation position of the windows.

They should not only be moved into the insulation layer for structural- physical reasons, but also for design reasons in order to ensure real- son able proportions. Folding shutters, rolling shutters and sliding shutters can be combined optimally with insulated facades and allow for solutions with an appealing design.
It must also be considered that inner-city buildings generally have one, or a maximum of two, designed facades. The facades facing neighboring buildings or the courtyard can almost always be insulated from the outside without any design limitations.

Conclusion:

Building is becoming increasingly complex. While a few years ago it was still enough for a craftsman to have mastered the manual skills of his trade, he must now also be familiar with issues such as domestic ventilation and thermal bridges. Architects in turn are required to deal with the subject of building physics and the opportunities and limitations of modern building materials much more than was the case in the past. All construction professionals require each other in order to produce good building work overall. Experienced and skilled building specialists will succeed in working together to design/renovate buildings in such a way that they allow their customers to enjoy comfortable, healthy living conditions with very low, socially acceptable follow-up costs over the long term. Integral planning is therefore the order of the day.
In selecting the insulating material, qualities such as pressure resistance, moisture resistance, heat storage capacity, acoustic properties, flammability, durability, long-term behavior, workability, energy expenditure during production and, of course, thermal conduction must be weighed up.
With an increasing level of insulation in building components, the airtight and thermal-bridge-minimizing planning of component connections and the interplay between different components become even more important. In order to avoid building damage, limit ventilation heat losses and not least for reasons relating to residential hygiene, a property-specific ventilation concept is also required for each renovation project. At least a basic exchange of air must be ensured – irrespective of the user – to provide the required moisture protection, taking account of modern lifestyle habits.
Historic structures must not be allowed to disappear under thick layers of insulation without a second thought. The design quality of our cities should not be negatively affected as a result of energy efficiency measures and instead, where possible, should be improved. There is a great deal of potential in many cases here. This is indeed leading to good construction work becoming more complex. Damage is possible if planners and those implementing the building project are unfamiliar with structural and physical interrelationships or do not take account of the interface to neighboring disciplines. Design aspects are also often neglected due to the selection of the "cheapest" solution, which discredits the overall objective.
There are multiple reports about "renovation disasters" which bear witness to the inability of those involved in the work on the respective property. There is also the fact that self-proclaimed specialists are loud voiced in stating half-truths, which put many people open to a renovation off going about the corresponding projects. However, correctly planned and implemented renovations lead to a considerable improvement in levels of home comfort, significantly reduced energy costs and ultimately an increase in the value of the respective property. The need for a minimum level of thermal insulation required in order to avoid mould and condensation and that allows for a minimum rate of air change is viewed as obvious. The poorer the thermal insulation, the greater the air exchange has to be in order to avoid damage. Thermal insulation thus pays off twice over. Furthermore, the improved thermal insulation of external building components increases the level of comfort in inside areas (prevention of "cold radiation"). There is a great deal of discussion about the cost effectiveness of structural thermal insulation. Here, it must be considered that the level of cost efficiency is also dependent on the energy price and its development in future. There is widespread consensus that energy prices will increase further in the medium term. Over the past ten years, heating costs in Germany have more than doubled – a

fact that is easily forgotten in the heated debate on energy prices. With a life expectancy for structural thermal insulation of ٤٠ years or more, a reasonable increase
in energy prices must be taken into account in all cost-efficiency assessments.
Ultimately, improved thermal insulation contributes to providing for the future and supply security. It leads to the preservation of resources and reduces undesirable environmental impacts.

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