EnerPHit

Renovating with Passive House components

SOLUTIONS FOR FAST, CHEAP AND RELIABLE DEEP RETROFITS

EnerPHit

Renovating with Passive House components

Passive House Institute

SOLUTIONS FOR FAST, CHEAP AND RELIABLE DEEP RETROFITS

The EU-project outPHit promotes deep retrofits which are cost-efficient and reliable, according to Passive House principles. On the basis of model projects and with the cooperation of many partners, outPHit opens up ways to implement deep energy retrofits. In the process, solutions with a one-stop-shop approach reduce the effort for planning, execution and quality assurance. www.outphit.eu

outPHit

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957175. The presented contents are the author's sole responsibility and do not necessarily reflect the views of the European Union. Neither the CINEA nor the European Commission are responsible for any use that may be made of the information contained therein.

CONTENTS

[1] Introduction 04

[2] EnerPHit Basics: It's all about the building physics 10

[3] EnerPHit: Renovation with Passive House principles 28

[4] Why EnerPHit: if you do it – do it right 34

[5] The classes classic, plus and premium 42

[6] Taking it step by step with EnerPHit 46

[7] Approaches 52

[8] A word on airtightness 58

[9] Monitoring – For proven success 64

[10] Built examples before and after 68

[11] Best-practice details 98

[12] Useful ressources 108

Imprint 110

| 1 |

INTRODUCTION

Our building stock is largely inefficient. With an estimated 95% of the buildings standing today likely still in use in 2050, deep renovation must be a priority.

A comprehensive approach to renovation

With more than three quarters of the buildings currently in use throughout the EU having been built over 20 years ago, the need for overall or partial renovation in the upcoming decades will be great. Such occasions are perfect opportunities to reduce energy consumption quite significantly by applying good building physics. Using components developed for Passive House new builds also allows for significant energy savings in existing buildings. EnerPHit is the name we give to the standard for renovations according to Passive House principles, using high performance, Passive House components and a fabric first approach.

There is a clear message from different scientific research institutions: a fabric first approach to renovation is what is needed, not simply increasing renovation rates and transitioning away from fossil fuels. Well done deep renovations offer a sound solution to the world-wide energy crisis. In fact, a future with renewables as the main energy source will depend on widespread adoption of extremely high performance – as delivered by the Passive House and EnerPHit standards.

Renewables alone do not have unlimited availability and require space. Extremely low energy buildings dampen peak loads, thus relieving our electricity grids and helping us to remain within our energy generation capacities. They also facilitate the transition to sustainable heating systems based on electric heat pumps, reducing heating loads and necessary flow temperatures as well as investment costs. Passive House buildings thus make electrification and a 100% renewable energy supply possible.

“The consequences of climate change can no longer be ignored. Given the importance of this task, in the Paris Agreement countries across the world have already pledged to limit global warming to well under 2°C and to aim for 1.5°C. In order to reach this goal, net emission of greenhouse gases must be rapidly and drastically reduced. With unchanged emissions, the remaining budget for the goal of 1.5°C would already be used up in the next 10 years – calculated from 2020 onwards.”

Emissions must drop to zero in 20 to 30 years.

Taken from the study “Towards a climate-compatible building stock” [PHI_2023]

If you do it, do it right!

If an entire building or just part of it is in need of renovation, taking advantage of the benefits that EnerPHit provides is worthwhile – even if rapid action is needed. Luckily, EnerPHit measures typically are both the simplest and the most cost-effective. Renovations to Passive House or EnerPHit standards reduce the energy costs to such an extent that they make users independent from energy price developments and energy suppliers, guaranteeing affordability into the future. Any added investment costs for high efficiency buildings will be repaid many times over in the form of lower energy bills, higher structural integrity and unrivalled levels of comfort. These high quality refurbishments both increase building value for owners while also raising otherwise vulnerable tenants out of energy poverty and are of course good for the climate – a win-win-win situation!

What it takes

A variety of ressources are available to help people embarking on an EnerPHit renovation.

- The **Passive House Planning Package** (PHPP) helps planners reliably reach high levels of performance from the design stage onwards. With this Excel based energy balance tool, planners can define and optimise each renovation step, taking a building's entire energy balance into consideration. The PHPP, developed in 1998 and constantly improved thereafter, ensures reliability right from the planning stage.
- Trained tradespeople are also of the essence; a **certified Passive House Tradesperson** knows why energy efficiency is necessary in existing buildings. Certified Passive House Designers and Certified Passive House Consultants are familiar with deep renovation and how it can be best optimised.
- If you are renovating in a step by step fashion, it is important to be sure that the measures taken today do not impede other renovation measures later down the road. The **EnerPHit retrofit plan** as part of the PHPP tool can help , because it precisely and transparently illustrates how each measure influences the final result.
  - For highest energy efficiency developed **Passive House components** are available for a rapid yet reliable implementation.
- EnerPHit renovations as well as the first step of a staged renovation can also be **certified** and thus quality-approved by an independent third party. Knowing your building meets the EnerPHit Standard and getting it certified as such means that sufficiently high temperatures in formerly cold corners can be ensured and mould can be avoided.
- To go one step further in quality assurance, **monitoring** allows you to really test that what was planned is what was delivered. Does the renovation achieve the very low predicted energy consumption? Is the interior air quality excellent? Are room temperatures comfortable year round according to individual needs? Simple monitoring is the safest way to find out.

Examples abound
An exponentially growing number of EnerPHit renovations shows that the standard is more than ready to be scaled up. In Greece, renovated single-family homes are reducing energy costs by 70%. In Austria, France, the Netherlands and Germany, fitting completely ready-made facades onsite is providing old buildings with fresh air ventilation systems, new high-performance windows and insulated, airtight walls. In Spain, thousands of Certified Passive House Tradespeople are renovating one large housing scheme after another in team work. Highlights from selected EnerPHit renovations across Europe give an insight into best-practice solutions.

In short: Deep renovations are the way to go. Following Passive House principles with EnerPHit will make them easier, faster and more reliable.

Enjoy the read!

"When it comes to buildings, Passive House and EnerPHit renovations offer the easiest path towards true climate protection."
Prof. Dr. Wolfgang Feist
Passive House Institute (PHI)

| 2 |

ENERPHIT BASICS

How can we achieve an impressive reduction in energy consumption while respecting the building physics in a renovation?

How can we get to a cost-effective, yet sustainable solution and improve the comfort in our buildings at the same time? Passive House is the sound answer.

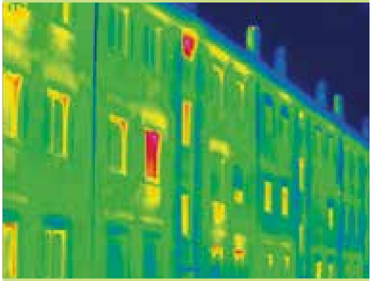


Photo: BEFORE
Tevesstraße, Frankfurt am Main, Germany
Photo © Fotostudio Michels, Darmstadt

Thermography © Passive House Institute

It's all about the building physics

The EnerPHit concept applies Passive House components in renovations when it is not feasible to reach Passive House in retrofits. Proven by EnerPHit renovations and certified by the Passive House Institute worldwide, this approach provides users with all the benefits of Passive House such as reliably low energy demand, high levels of comfort, consistently high indoor air quality, low running costs, mould-free living and increased building value. As the Passive House concept is based on physical principles, each building can and should be adapted to its particular climate. This is already foreseen in the Passive House criteria and design tool, the PHPP, making it easy to understand and follow.

The history behind the standard

The possibilities for the application of Passive House components in the modernisation of existing building stock was first systematically investigated 2003 in the 24th Research Group for Cost-effective Passive Houses, [AkkP-24], followed by an investigation of their use in renovations of historical buildings two years later [AkkP-32].

The challenges of carrying out individual renovation measures and ways to achieving an optimal final state, were addressed in [AkkP-39] "Step-by-step modernisation using Passive House Components".

After the successful realisation of a whole series of pilot projects such as Tevesstraße, Frankfurt, Germany, renovated in 2005 (see photo bottom right and more information: www.passivehouse-database.org/#d_1211) and Hoheloogstraße, Ludwigshafen, Germany, renovated in 2004 (www.passivehouse-database.org/#d_1450) the modernisation of existing buildings using Passive House components was finally ready for implementation on a large scale.

This brochure highlights built examples of recently renovated buildings across Europe. They all have a fast implementation in common, after a planning phase based on the EnerPHit methodology. What they also have in common is the use of the planning tool PHPP, to optimize and reduce costs and to perform as predicted. Monitoring results confirm key success factors (drastically reduced energy bills, comfort, etc.).

PHI's certification scheme offers the security to clients that the desired low energy consumption during the conceptual phase is matching the performance of the building in reality. The scientists at PHI partner with the public relations professionals to make available the range of solutions in a clear, practical way to home owners and architects, to the construction industry and to politicians.

"Passivhaus – it's not a brand, it's just physics."
Sarah Lewis, Passivhaus Trust, UK

Photo: AFTER (ID 1211)
Tevesstraße, Frankfurt am Main, Germany
Photo © Fotostudio Michels, Darmstadt

Thermography © Passive House Institute

“If you do it, do it right!”

This principle is taken very seriously in Passive House buildings and EnerPHit renovations, especially when it comes to insulation.
Quality insulation is a very affordable way to save energy.

The five Passive House principles

The five Passive House principles applied in EnerPHit renovations

There are five basic principles common to all Passive Houses and EnerPHit renovations around the world.

These, simply put, represent good building physics. Understanding and following them in new builds as well as in renovations is key to high performance and makes designing and refurbishing highly energy-efficient easy.

1. One continuous layer of thermal insulation

The principle of a continuous layer of thermal insulation wrapped around the building is the most powerful of all. For low-energy buildings in climates where the heating demand dominates, the entire **building envelope** has to be well insulated.

The building envelope consists of all the building elements that separate the inside from the outside. Like a skin, its main purpose is to provide for a comfortable internal climate and protect against the elements – regardless of the weather.

During cold periods, typically from mid-October to the end of April in cold, northern hemisphere climates, the temperature inside the building envelope is usually higher than it is outside. As a result, heat is lost through the envelope and, unless this heat is replaced, the inside of the building cools down, adjusting to the outdoor temperature. The inverse applies for hot climates or during hot periods, with excessive heat entering the building through its envelope. It thus makes sense to **restrict the heat flow** in any building irrespective of the climate – and this is where insulation comes in.

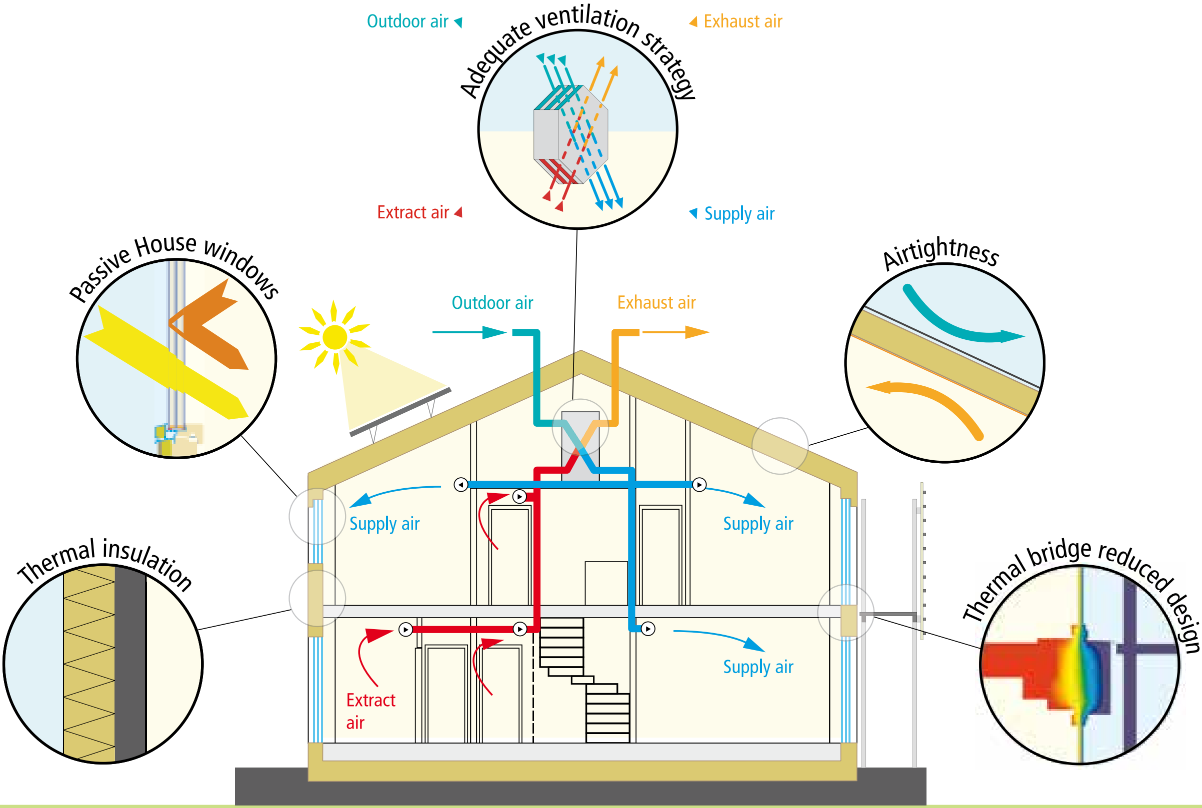


Figure:
The 5 Passive House principles known from new constructions apply to EnerPHit renovations as well.

Figure © Passive House Institute

How much is enough?
Assuming a common insulation material with a thermal conductivity of lambda = 0.035 W/(mK), about 14cm of wall insulation will be needed in Madrid, Spain, whereas a renovation in colder Innsbruck, Austria, would require approximately 24cm. And when it comes to insulation versus thermal mass, it is really the insulation that counts (for further reading, please visit Passipedia: insulation or storage). The EnerPHit standard is flexible though, allowing exemptions, for example, where it is not possible to insulate to ideally, and it is always possible to compensate with more insulation in the roof or better component qualities to still reach the EnerPHit or Passive House target.

It is, however, not only a matter of insulation thickness but also the correct installation. Any gaps in the insulation layer must be closed. Good examples from external wall and basement ceiling insulation can be achieved in various ways: If the insulation of a ceiling in a cold

Photo:
EnerPHit renovation standard achieved in Innsbruck, Austria (ID 4200) with 24cm insulation

Photo © Passive House Institute

basement is mounted with brackets, the still air layer between the insulation layer and the ceiling acts as insulation itself. The condition for this is that the air is kept still: the borders of the insulation layer have to be filled with insulation material so that there is no air connection between the basement air and the air layer between ceiling slab and insulation. Another solution is to glue the insulation to the ceiling. Often, it is recommended to use mechanical fixing in addition, using thermal-bridge-free dowels, see photo on the right.

For an external wall with an external insulation layer, the situation is more challenging: here, the wind hits the building and it is necessary that the insulation panels are installed according to state of the art. The point-bead method, in which the insulation wall panels are provided with a surrounding layer of mortar, prevents air from flowing behind the insulation boards. This ensures the air layers are still and allow the thermal insulation to develop its full effect.

Photo:
Basement ceiling insulation with dowels – additional mechanical fixing using dowels ensures the basement ceiling insulation is kept in place.

Photo © Passive House Institute

Photo:
EnerPHit renovation standard achieved with 14cm of mineral wool in Madrid, Spain (residential building, Calle Cartagena, ID 6898)

AFTER renovation
Photo © PAEE Construcción Passivhaus-ECCN

Photo: Monitoring by Passive House Institute. Deep renovation project in Giessen, Germany

Photo © Passive House Institute

Heat losses through external walls and roofs account for more than 70% of the total heat losses in existing buildings. Therefore, improving thermal insulation is the most effective way to save energy. At the same time it will help improve thermal comfort and prevent structural damage. Financial support such as low-interest loans, as currently available in a number of countries, reduces the initial investment for improved thermal insulation; yet, even without such incentives, the **investment will pay off in the long term**.

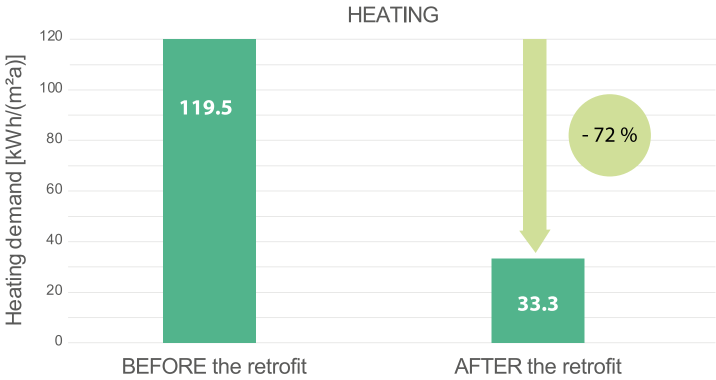


Figure above: With a measured heating consumption of 33.4 kWh/(m^{2}a), the refurbishment of the building in Giessen achieved a saving of more than 70 %. This represents a significant success of the measure and the potential of energy-efficient refurbishment of old buildings in general. Despite the success, consumption was found to be slightly higher than predicted. The causes were found to be individual longer periods of untypical winter window ventilation and the identified imbalances in the individual ventilation systems. Figure © Passive House Institute

U-values (thermal transmittance) of external walls, floor slabs and roof areas of Passive Houses range from 0.10 to 0.15 W/(m^{2}K) (for cool-temperate, e.g. Central European climate; these values may be slightly higher or lower depending on the climate). These values are not only benchmarks for all construction methods but also the most cost-effective values at today‘s energy prices.

Photo left: Certified EnerPHit Frankfurt, Germany (Tevesstrasse, ID 1211)
Photo © Passive House Institute

Thermal insulation must be installed correctly. These are good examples of external wall insulation without gaps between insulation panels.

The heat losses during cold periods are thus negligibly small, and the temperature of the interior surfaces is nearly the same as the air temperature, irrespective of the type of heating used. This leads to a very high level of comfort and reliable **prevention of building damage due to moisture build up**.

In warmer climates or during summer months, good insulation also provides **protection against heat**. Effective sunshades for the windows and sufficient ventilation are also essential to ensure a maximum level of comfort during hot periods.

Good insulation and airtight construction have proved to be extremely effective in Passive Houses. Another essential principle is "thermal bridge free design": the insulation is applied **without any "weak spots"** around the whole building so as to eliminate cold corners as well as excessive heat losses.

This method is another essential principle assuring a high level of quality and comfort in Passive Houses while preventing damages due to moisture build up.

Photo above: Madrid, Spain (Cartagena, ID 6898)

Photo © VAND Arquitectura, Anne Vogt

2. Thermal bridge free design
A thermal envelope without or reduced thermal bridges is an important yet cheap way of making a renovation more energy-efficient.
Heat makes its way from the heated space towards the outside. In doing so, it follows the path of least resistance.

A thermal bridge is a localised area of the building envelope where the heat flow is different (usually increased) in comparison with adjacent areas (if there is a difference in temperature between the inside and the outside).

There are two main effects of thermal bridges. First, lower interior surface temperatures and second, an increased heat loss. In the worst case thermal bridges can lead to moisture penetration in building components and mould growth.

Both effects of thermal bridges are avoided in Passive Houses and EnerPHit renovations: the interior surface temperatures are so high everywhere that critical levels of moisture cannot occur any longer – and the additional heat losses become insignificant. If the thermal bridge losses are smaller than a certain requirement (set at 0.01 W/(mK)), the detail even fulfills "thermal bridge free design". Thus, the thermal bridge or "psi" value can be ignored in the energy balance calculation.

If thermal bridge free design is implemented everywhere, the planners and construction manager don't have to **worry about cold and damp spots any more** – and less effort will have to be made for calculating the heat energy balance.

Thermal bridge free design leads to substantially improved details

and healthy living conditions; the durability of the construction is increased and **heating energy is saved**.
In the case of existing buildings and modernized building stock, thermal bridges typically have a negative effect due to remaining balconies and typical detailing at wall-basement junctions as well as external wall-roof connections. Experience has shown that this can result in an additional heat loss of up to 20%. Based on examples of different construction projects, this resulted in an increase in the annual heating demand of up to 14 kWh/(m^2a). Careful planning with regard to thermal bridges is recommended.

In constructions suitable for passive house or EnerPHit-design, thermal bridges with catastrophic consequences are generally avoided; the criteria and guidelines won't allow for such bad design in the recommended constructions. While there can still be thermal bridges with some remaining heat losses, massive temperature drops can always be avoided. A big part in avoiding catastrophic thermal bridges is the improved insulation level already for the regular components. This leads to a generally higher level of indoor surface temperatures to begin with, thus reducing the risk of mould growth from the start. Interior insulation, however, is a special case in which there are even more stringent rules "how to avoid thermal bridges of the catastrophic type". See **www.passipedia.org** for more information.

In the majority of renovations it is not possible to achieve a completely thermal-bridge-free design. However, checking all details at an early design stage and allowing the Passive House suitable components to do their work is key. Often, the thermal bridge effects can be reduced to such an extent that although a (sometimes high) heat loss remains, the detail is strongly improved and the interior surface temperatures have been augmented to a healthy, dry, mould-free level.

Often, not all materials and details used in old buildungs are known. In such renovations, it is necessary to demolish the old layers first. Once the detail can be accessed, measured and checked, the planning team needs to come up with a thermal-bridge-free or thermal-bridge-reduced design for it. It should not be left to the craftsperson to solve those details: it is a planning task. Certified details show best practice approaches and copying them is encouraged.

3. One undisturbed airtight envelope

Why is airtightness also important in retrofits? Indoor air has a higher water vapour content (absolute humidity) than outside air - if not dehumidified. In a cold climate, indoor air is cooled during flow inside-out (called exfiltration). The colder air cannot keep the high amount of water vapour – condensing will occur at a certain place within the construction. This may lead to serious damage. In hot and humid climates, the occupied rooms are going to be cooled, the airflow will be directed outside-in (called infiltration) and will cause the same moisture problem. The process described here is the main reason why external building structure has to be built airtight. For EnerPHit renovations a really good airtightness is required – the airflows discussed here will be negligible, which is one of the big advantages of the standard – without moisture problems, the components can last forever.

The key to making a building airtight is the principle of a “continuous, tight building envelope”. It should be possible to trace the whole building envelope with a pencil without any breaks in each sectional drawing. In the details it must be made clear how the airtight connection is realised. This makes it clear that **airtightness is primarily a planning task**. Craftspeople can only carry this out in an airtight manner if it has been thoroughly designed.

It is essential that only a single airtight layer is planned and implemented.

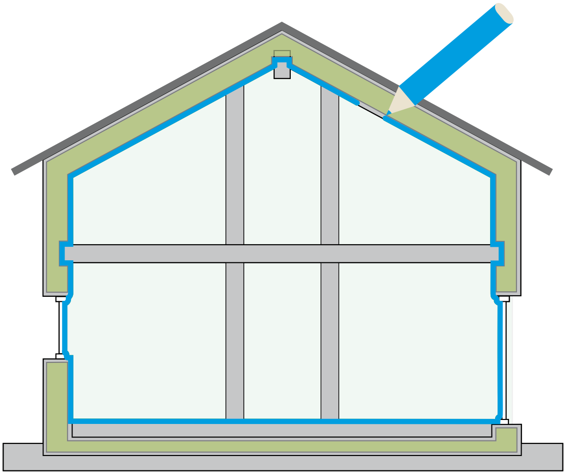


Figure: Pencil rule for planning and verifying the airtight layer in the cross-section of a building.

Figure © Passive House Institute

Two “nearly” airtight layers will serve no purpose – leakage will still take place! This can be visualized, for example, by a leakage in the entrance door of a house, where a leaking door in the lobby won’t remedy the problem, or two buckets, both with a hole in the bottom; if one is placed inside the other, this won’t stop the water from leaking out!

It is essential that the concept for airtightness is designed and applied long term. This is achieved by providing details where the airtight layer is clearly marked and by using appropriate building products.

Photos above:
Big frame – small frame width: Free heat gains in winter can be achieved by minimizing the frame widths.

Photos © Passive House Institute

4. Passive House windows

Windows are an essential factor in assuring pleasant indoor conditions. In cold climates, poorly insulated windows will cause relatively cold surfaces at the facade and will require active heating near the windows to compensate for cold air drops, draughts and "cold radiation" caused by the cold surfaces. Highly insulated windows, on the other hand, will make an active contribution to increasing the level of comfort. High performance windows, developed to meet the requirements of Passive Houses and thus used in EnerPHit renovations, are offered by an increasing number of manufacturers across the globe. A list of PHI Certified Passive House windows can be found on the Passive House component database.

Windows play an important role in the energy balance because they contribute with heat gains as well with heat losses. In a renovation, often the window size cannot be significantly changed. Then it is even more crucial to optimize the remaining factors. Passive House Designers maximise the glazing area to get more solar gains in winter by using thin frames for all 4 sides.

A Passive House window prevents energy loss, condensation and mould. In combination with a ventilation system, the Passive House window prevents mould. It is so well-insulated and airtight that there is no risk of condensation. Furthermore, the installation into the exterior wall or roof is airtight. With overlapping insulation over the fixed part of the frame, this weak point is addressed properly, increasing the interior surface temperatures in the corners.

In deep renovations Passive House windows should be installed in the first third of the insulation layer. The airtight window is connected with the airtightness layer of the wall.

Exterior shading devices, ideally moveable elements, ensure that the Passive Houses and EnerPHits stay comfortably cool in summer. For more extreme climates with very hot summers and very long periods of high temperatures, in addition to properly designed shading devices, an active cooling system is a must. The amount of overheating and strategies to reduce it as well as the size of the required cooling equipment can be easily assessed with the PHPP tool.

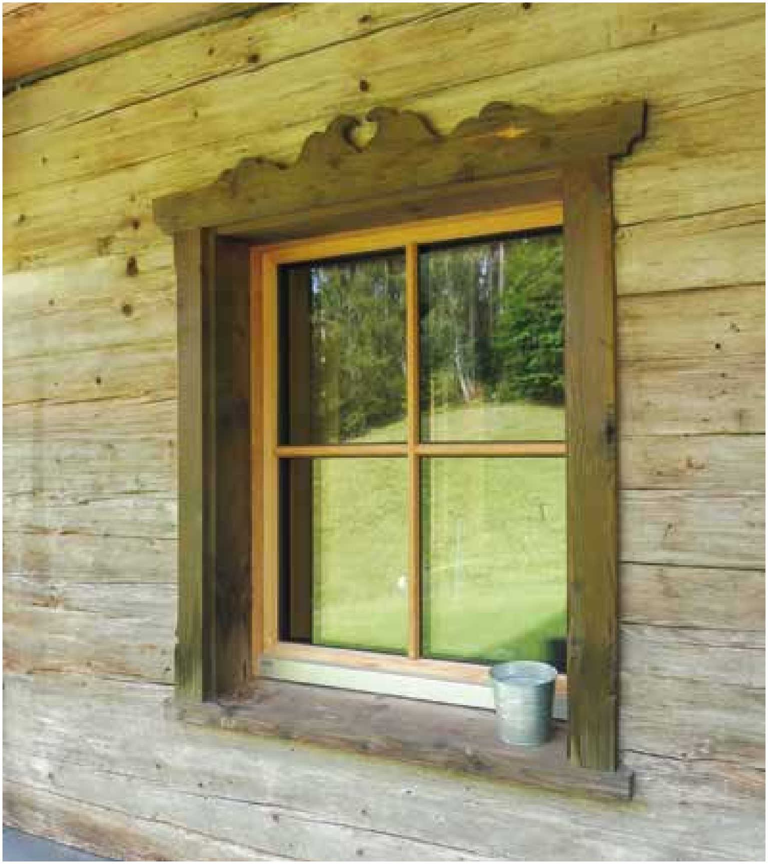


Photo above:
Aluminium Passive House window example

Photo © Passive House Institute

Photo on the left:
Farm house Neuhäusl, Austria
ID 5939

Photo © Passive House Institute

In the refurbishment realised in Giessen, Germany, which the Passive House Institute evaluated over two years with post-monitoring, a ventilation system with heat recovery was installed in each flat and in the staircores.

This shows the great influence of a heat recovery system on the heating requirement. In addition to the increase in comfort, this is also the reason why systems with heat recovery are preferable from a thermal point of view.

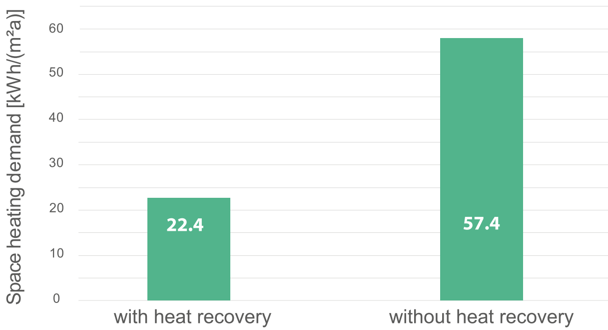
Hardly any other technical system has such a good ratio of energy used for fan power and frost protection to energy gained or saved. In this case, the power consumption of the ventilation units was measured at 3.7 kWh/(m^2a) for year-round operation. The seasonal performance factor (SPF) is therefore just under 10. If the ventilation units were only operated in winter, it would be well above 10.

Figure © Passive House Institute

5. Ventilation with heat recovery

The health and comfort of the inhabitants are the most important objectives of Passive House and EnerPHit design. Excellent indoor air quality is indispensable. But this can only be achieved if stale air is exchanged regularly with fresh outdoor air. This can definitely not be done by just opening windows twice a day. Ventilation via gaps in the thermal envelope is insufficient and „breathing walls“ do not exist, see also Chapter 8. Ventilation will work accurately only if stale air is removed constantly from the kitchen, bathrooms, and all other rooms with air pollution. Fresh air has to be supplied to the living room, children's room, sleeping rooms, and workrooms to substitute the removed air.

The system will supply exactly as much fresh air as is needed for comfort and for good indoor air quality; only outdoor air will be supplied – no recirculated air. This will lead to a high level of indoor air quality. The ventilation units are equipped with filters to provide clean, pollen-free and dust-free air while eliminating excess moisture and odours. In the winter, heat from the warm, stale air (extract air) is transferred to the cold, incoming, outdoor air, thus reducing heat losses considerably. In the summer, the system can work to a certain



extent in reverse, pre-cooling the fresh air that is supplied to the building. Depending on the efficiency of the heat exchanger, over 90% of the heat can be transferred, allowing the supply air to come in at nearly room temperature.

The basic principle of Passive House ventilation: humid, stale air is extracted from the kitchen and the bathrooms (extract air) while fresh air (supply air) flows into the living area. As a result, the hallways are automatically ventilated. As a general rule, the ventilation system should be designed to provide $30m^3$ of fresh air per person per hour. For a living space of $30m^2$ per person, this equates to a supply air volume of $1m^3/(m^2\,h)$. As a general rule, an average air flow of 0.3 1/h is reasonable.

The high-quality ventilation unit ensures that the supply and exhaust air ducts in the heat exchanger are leak proof, so that fresh and used air is never mixed. The high-quality ventilation unit saves much more energy through the prevention of heat losses than they use to run. The analysis of this shows 35 kWh/(m^2a) heat savings compared to 3.7 kWh/(m^2a) electricity consumption to run the ventilation system. (Source: Final report of Annex 71 "Monitoring and parameter simulation results of an apartment block renovation, Giessen, Germany"). More savings can be expected if the ventilation system with heat recovery is only switched on during heating season. This is possible if all bathrooms allow for window ventilation. If the ductwork is kept clean during the construction period, a filter exchange once a year will guarantee them staying clean during operation.

These five basic principles are valid for EnerPHit renovations all around the world!

However, the buildings look very different in each culture and location. They use preferably locally sourced materials and are adapted to their climate zone. Find out more in the following chapter!

Wrapping plastic foil around the ends of ducts during construction leads to clean ducts to transport fresh air. Manufacturers often provide lids to make quality work fast and easier.

Photo © Passive House Institute

| 3 |

ENERPHIT: RENOVATION WITH PASSIVE HOUSE PRINCIPLES

As we have learned Passive House buildings and EnerPHit renovations are the very expression of good building physics.

The two methods of the EnerPHit standard: building component method and demand method

Figure below:
EnerPHit u-value requirements for different climate zones and explanation what makes sense in Europe in general.

EnerPHit: Renovation with Passive House principles

Planning with energy efficiency in mind from the very beginning is a pillar of these standards. They are clearly defined standards resulting in incredibly comfortable, cost-effective, high performance buildings in Europe and beyond, for decades.

When it comes to renovations, it becomes even more important to select the right components for each individual situation as every building is unique. Fortunately though, Passive House principles and the laws of building physics are universal.

There are two ways to comply with the EnerPHit standard. You can choose the component method or the demand method:
The **building component method** defines energy-relevant criteria for individual building components (window, roof, ventilation system, etc.). The criteria were selected so that they lie within the range of (life cycle) cost-optimised solutions and correspond with the require-

Climatezone acc. to PHPP	Opaque building envelope towards				Windows (incl. entrance doors)					Ventilation	
	...ground	...outdoor air			Total			Glazing	Solar load		
	Thermal insulation	Exterior insulation	Interior insulation	Exterior paint	Max. thermal transmittance			Solar energy transmittance (g-value)	Max. spec. solar load during cooling period	Min. heat recovery efficiency	Min. moisture recovery efficiency
	Max. thermal transmittance (U-value)			Cool colours	($U_{D/W,installed}$)						
	[W/(m^{2}K)]			-	[W/(m^{2}K)]			-	[kWh/m^{2}a]	%	
Arctic	Calculation in PHPP using project-specific heating and cooling degree days for ground	0.09	0.25	-	0.45	0.50	0.60	Ug - g*0.7 ? 0	100	80%	
Cold		0.12	0.12	-	0.65	0.70	0.80	Ug - g*1.0 ? 0		80%	
Cool temperate		0.15	0.35	-	0.85	1.00	1.10	Ug - g*1.6 ? 0		75%	
Warm temperate		0.30	0.50	-	1.05	1.10	1.20	Ug - g*2.8 ? 1		75%	
Warm		0.50	0.75	-	1.25	1.30	1.40	-		-	
Hot		0,50	0.75	yes	1.25	1.30	1.40	-		-	60% (humid climate)
Very Hot		0.25	0.45	yes	1.05	1.10	1.20	-		-	60% (humid climate)

<table>
<tr><th rowspan="3">Climate zone acc. to PHPP</th><th>Heating</th><th>Cooling</th></tr>
<tr><td>Max. heating demand</td><td>Max. cooling + dehumification demand</td></tr>
<tr><td>[kWh/(m²a)]</td><td>[kWh/(m²a)]</td></tr>
<tr><td>Arctic</td><td>35</td><td rowspan="7">Corresponds with Passive House requirement</td></tr>
<tr><td>Cold</td><td>30</td></tr>
<tr><td>Cool temperate</td><td>25</td></tr>
<tr><td>Warm temperate</td><td>20</td></tr>
<tr><td>Warm</td><td>15</td></tr>
<tr><td>Hot</td><td>15</td></tr>
<tr><td>Very Hot</td><td>15</td></tr>
</table>

ments for Passive House suitable components. In this case there are no requirements for the heating or cooling demand.

The **demand method** is for buildings with favourable conditions, i.e. with few obstacles in the way of energy-relevant modernisation (due to the old building). The EnerPHit standard can then alternatively be achieved through compliance with requirements for the heating demand or the cooling and dehumidification demand.

The requirements for individual building components will not apply in that case, and the same level of freedom will apply for dimensioning of the individual thermal protection measures as in (new) Passive House constructions. Here, you can directly see if you even achieve 15 kWh/(m^{2}a) in your renovation and thus not only the EnerPHit but the Passive House standard.

The EnerPHit standard for renovations allows two methods for one goal! This is a relief for the design teams as they can apply the best fit to their individual projects.

Figure on the left:
According to this demand method table an EnerPHit renovation in the cool temperate climate of central Europe requires a maximum space heating demand of 25 kilowatthours per square meter and year.

Figures © Passive House Institute

In the case that only a part of the old house needs to be replaced, the EnerPHit method can be applied step-by-step, part by part, and the Passive House Institute provides a **certification scheme** for it, too.

What is more, the EnerPHit standard can be achieved in traditional way or by prefabrication without even the need to put a scaffolding.

When it comes to EnerPHit quality renovations, you can rely on the expertise of certified Passive House designers and consultants around the world. After generic calculations using the PHPP and with advanced progress in the planning process, designers choose product-specific values directly in the design tool. In PHPP users can select high-performance from a large number of Passive House-compatible components which are listed in the tool and published in the database of certified components.

Photo: AFTER retrofit Kohlweg, Innsbruck, Austria

© Rainer Pfluger, University of Innsbruck

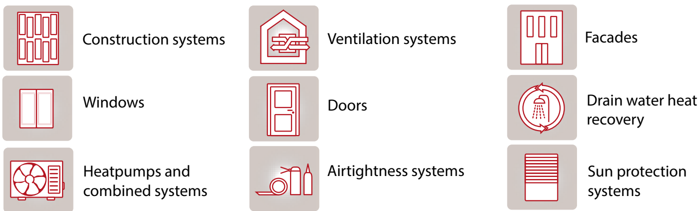
This ressource is based on demanding criteria guaranteeing optimal energy efficiency down to the last detail. All **component criteria documents** are published there aswell, in different language versions.

Other ingredients during the construction phase ensure the success of the EnerPHit retrofit: early coordination based on the planning with PHPP with all those involved in the construction, tracking of the calculation results and regular building site checks, such as the airtightness test during the construction phase.

The EnerPHit certificate proves that calculated savings are actually achieved in practice and a house plaque makes this sealed quality visible to everyone.

Component database

Discover energy-efficient components in our Component Database
The Passive House Institute enables easy comparison through total transparency in the testing procedures. The products certified by the Institute are regularly many times more energy efficient than typical components currently available on the market.



EnerPHit House plaque
Graphic © Passive House Institute

Graphic on the left: Database of the Passive House Institute with over 30 categories to choose certified components.

Graphic © Passive House Institute

| 4 |

WHY ENERPHIT:
IF YOU DO IT – DO IT RIGHT

Why is it so important to take care of energy efficiency and high quality when renovating a building?

Is EnerPHit really necessary for all renovations?

Photo:
Visiting the single-family home EnerPHit renovation in Arheilgen, Germany, at the Passive House Open Days in June 2024.

Photo © Passive House Institute

Why is it so important to take care of high quality when renovating a building? Is EnerPHit really necessary for all renovations? For sure, the first centimeters of insulation bring the biggest benefit and we should not exaggerate? The sun's energy is unlimited, isn't it? We could also wait until new technologies offer a way out of current problems? In the meantime, let's rely on bridging technologies based on fossil fuels. Why can we not just increase the renovation rate and we are done with climate protection and improved living conditions? There are many lower energy standards out there and they get funding, too. Surely this means that they also achieve climate protection and are less demanding/costly/faster to implement? And what about the others, should they not start before I take action?

We are sure you know these or similar questions around the application of high-performance standards such as EnerPHit. And we are happy to have the answers. Also have a look at the wealth of knowledge in our Passipedia ressource, where you can find many more questions and answers along with explanations based on realized EnerPHit renovations. Buildings modernised to the EnerPHit Standard offer optimal thermal comfort, fresh air at all times and protection from moisture and mould damage caused by condensation. In addition, a financial profit can also be expected because the measures as a whole save substantially more energy costs over the useful life than the amount invested for their implementation.

Some facts to answer the questions above: Sustainable energy supply is only possible with high energy efficiency and an increase in renewable energy. The potential for acceptable and economic use of renewable energies is limited. Biomass utilisation competes with food production for a growing population, while the use of hydropower frequently has a major impact on the landscape and ecosystems, and even wind power and photovoltaic systems compete with other uses due to the large space demand and negatively affect the appearance of the landscape and villages.

In cool and cold climates the energy demand is significantly increased in the winter due to the necessity for heating. At the same time, solar radiation is 7 times lower than in midsummer so that only a small amount of energy can be gained through photovoltaic and solar energy systems. The result is the so-called “winter gap” in which an above-average high energy demand stands opposite below-average energy production.

In order to be able to make enough renewable energy available, the surplus energy gained during the summer must be stored for the winter. This is possible e.g. by converting the solar energy into chemical energy which is stored in the form of a gas. However, the conversion of electricity into storable gas and reconversion into electricity later on is associated with losses, so that with seasonal storage, ca. 3 kWh of the original electricity is needed for 1 kWh of usable electricity in winter.

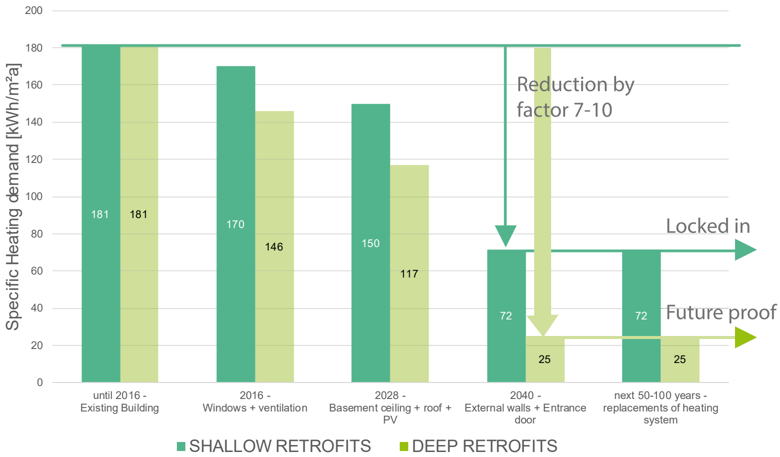


Figure: Not moderate, but deep renovations are future proof.

Figure © Passive House Institute

This is why so-called zero-energy buildings which only generate the same amount of energy as the total amount that is used annually are inadequate for a sustainable supply of energy in the future because this concept does not take into account the “winter gap”. It makes more sense to reduce the winter energy demand as far as possible so that a small amount of the valuable stored electricity and the biomass, which is only available to a limited extent, has to be used. This is achieved through modernisation using Passive House components which reduces the heating demand by up to 90% compared with existing building stock.

To achieve a sustainable standard of energy also in existing buildings, it is therefore expedient to combine highly efficient retrofits using Passive House components with the generation and use of renewable energy.

Public funding of measures must be directed towards overcoming dependency on fossil energy sources: Saving CO_2 as well as ensuring that climate neutrality can be achieved consistently with these forms of assistance. For this reason, systems that continue to rely on fossil energy sources as a “bridging technology” must not receive funding, and neither should incentives be provided for low quality retrofits such as those without improved ventilation, or such as those in which double glazing or uninsulated window frames are again used, etc..

Instead, special incentives should be set for highly energy efficient deep retrofits. A good example is the programme “Passive House in existing buildings“ by the state of Hesse in Germany, which provides funding for renovations with a space heating demand below 25 kWh/(m^2a).

Sustainable building stock will follow almost automatically from a programme which leads to the use of highly efficient components with competent planning and expert implementation.
Increasing renovation rate can help to a certain extent and should be raised from now 1.2% to a sustainable level of approx. 2%. A higher rate would economically be more costly than putting the efforts into high-efficiency standards.

So let's help the industry to quickly adapt their production of building components to energy efficient components. Good examples are available with the certified Passive House components – small and large companies have already successfully mastered this transition; it's not as hard as some people think. The Passive House Institute provides advice to companies in this matter. Passive House suitable components are documented in **www.componentdatabase.org**

The following will be important in the future:

- Consistent application of the coupling principle. If a component is to be renewed, the opportunity must always also be taken to improve efficiency to a sustainable level. Exceptions to the rule for conditional measures should be reduced.
- Furthermore, minimum legal requirements must be laid down regarding the quality of the building envelope, e.g. by specifying U-values or maximum values for transmission heat losses H'_T in the case of renovations in heating climates.
- A higher quality must be implemented – with each retrofit, regardless of the reason for it. Quality assurance similar to that for Passive House certification, supplemented with individual on-site visits/ appointments would be helpful here.
  Adequate CO_2 prices may have a supportive effect.

- The expansion of renewable energy must be continued and implemented. The high energy efficiency is the prerequisite for ensuring that the expansion of renewable energies is sufficient. Regardless of exactly how future developments proceed, highly efficient buildings will allow dead locks to be reliably avoided; they will be a “no-regrets” measure. Above all, they will facilitate the situation even when, in the course of restructuring, shortages in the supply of fossil energy occur e.g. due to political reasons!

- Apart from insulation a heat recovery ventilation and improved airtightness are recommended for reducing loads, particularly in winter. The minimisation of loads is important, especially with heat pumps, because investments are decreased due to this, and/or less expensive peak-load electricity is needed. In this way, substantial costs can be saved in especially critical periods in which a lot of heating is necessary but there is little sun and hardly any wind. Investments in network expansion can also be shouldered more easily as a result. Heat pumps should always be dimensioned so that they will still function efficiently in the heating load case.

- Suitable standards are needed for building efficiency. Assess-ment of CO_2 alone is unsuitable because CO_2 is a flexible goal and would lose all relevance as a benchmark when the energy supply becomes completely renewable. This is not appropriate because every form of energy provision implies an ecological cost (in the most favourable case this means additional land use). The efficiency of the building envelope as the most durable component should be evaluated separately; the specific heating energy demand is particularly suitable for this. The load/burden on the future rene wable energy system due to the building as a whole, including the heat supply, can be assessed easily on the basis of the PER system, for example.

In a consistent EnerPHit/Passive House scenario, it may be possible to halve the heating energy requirements of existing buildings within 20 to 30 years. Due to the coupling principle, this is exceptionally economical – for the most important measures even cheaper than today's heating energy from fossil energy sources.

Not only can implementing these measures save energy costs and decrease CO_2 emissions to almost zero, but it can also relieve the financial burden on households. In addition, in place of fossil energy from abroad, regional manpower can be deployed for carrying out construction measures. This will create jobs and increase domestic value creation. Furthermore, such an approach based on the EnerPHit principle will increase public sector revenues.

Climate protection is a global yet personal task. All our actions have an impact. Also continuing without taking action has an impact. We have some good news, though: Everybody can take positive action! Spread the word, share knowledge about best-practice examples, get fact-based answers to address doubts and use every opportunity to renovate to the EnerPHit standard.

Photo:
EnerPHit renovation in Laudenbach, Germany (ID 4664)

Photo © Cornelia Baumgärtner

| 5 |

THE CLASSES
CLASSIC, PLUS AND PREMIUM

The EnerPHit and Passive House classes classic, plus and premium are based on the Primary Energy Renewable, in short, PER system.

The EnerPHit plus and premium standards integrate renewable energies in addition to Passive House components.

Graphic/Seal © Passive House Institute

Fit for the future: Efficiency and Renewables

The underlying concept of the PER system is that electricity must be stored over different time periods (for example short-time storage from day to night, or seasonal-storage from summer to winter), which gives rise to losses and costs. The PER worksheet in the German PHPP shows the PER factors applicable in Germany. Every country has different boundary conditions and thus different PER factors.
In other words, Primary Energy Renewable (PER) is a measure of the expenditure for renewable energy which is needed for a specific energy application.

Renewable energy is mostly available in the form of electrical current, but not in the amount in which it is required. Only a part of the renewable energy electricity from solar, wind, or hydropower can be directly consumed. A part must be stored over a few days for example; this may be done utilizing batteries or pumped storage plants. These storage facilities have an efficiency of around 70%.

Besides this, it is necessary to store a part of the electricity generated in summer for use in winter. This is possible through the generation of hydrogen or methane from renewable electricity; however, the efficiency here is only 28%. Accordingly, an especially high amount of renewable primary energy must be generated for heating electricity in winter.

It is not sound to balance summer energy abundance with winter energy requirements without taking the (seasonal) storage losses into account. These introduce an additional factor greater than 1 by which the summer generation must exceed the winter demand. Further, the grid must absorb great quantities of energy in the summer and provide great quantities of energy and power in the winter.

Net zero energy alone is clearly insufficient.

Taken from report: “AdequateNetZeroRatingApproach“ [PHI_2022], available for download on the outPHit website and Passipedia.

The standards EnerPHit and Passive House require little seasonal storage due to their small heating energy demands.
You have to make an effort to achieve the EnerPHit plus and EnerPHit premium energy standards. **But it’s worth it!**

To explain plus and premium classes in a nutshell: If you have to renovate your roof, insulate it and put PV panels on it. The EnerPHit classes evaluate efficiency and renewables including storage losses together.

”Net zero energy“ alone does not reflect the effort required to provide energy and would lead to incorrect optimisation.

Source:
AdequateNetZeroRatingApproach report, PHI, 2022

Photo: Photovoltaic panels on insulated roof of EnerPHit plus certified retrofit in Greece (ID 5643)

Photo © Hellenic Passive House Institute HPHI

More about the PER system:
www.passipedia.org/basics/energy_and_ecology/primary_energy_renewable_PER

| 6 |

TAKING IT STEP BY STEP WITH ENERPHIT

Often, a more realistic approach is to do one step at a time.

It’s good to have a plan you can rely on!

The advantages of step-by-step renovations convince many building owners:

- The individual building components have a different useful life duration. In general, not all parts will need to be repaired or renewed when the building renovation is intended. With a step-by-step approach, owners can normally avoid unnecessary works on components that are still good in terms of appearance and function.
- With limited financial resources, it may be necessary to spread the investment costs for modernisation measures over a longer period of time.
- The extra costs for improving the level of thermal protection will often be moderate if energy saving measures are carried out at the same time as repair work which is necessary in any case. Thermal protection measures are therefore always particularly economical when the affected building component is currently in need of repair or renewal. This fact is taken into account optimally with a step-by-step renovation.

If Passive House components are used exclusively for modernising a building then impairment of comfort or mould growth can be ruled out with great certainty on account of the excellent level of thermal protection. Nevertheless, there is often some reason why building components cannot be retrofitted to achieve an optimal standard of thermal protection, e.g. due to historic building preservation requirements or simply because there is not enough space for thermal insulation. In addition, in the case of step-by-step renovation, it is not always possible to bring all building components up to an optimal standard right at the beginning.

In order to safeguard against mould growth and problems relating to comfort also in these cases, the criteria for Passive House buildings and EnerPHit retrofits include simplified minimum requirements for thermal protection which are considerably less stringent than the requirements for Passive House components. A pre-certification on the basis of an EnerPHit Retrofit Plan offers the client a confirmation that an independent professional has approved the first step of the renovation and at least 20% energy savings have been achieved.

ERP – The EnerPHit Retrofit Plan
Doing a staged retrofit, based on a plan.
As part of the PHPP energy balance tool users receive the ERP template and example files, complete with a 1-page cover showing each retrofit step along with its respective energy demand and generation of renewables, letter to the building owner, scheduler, summary of the measures, diagrams on expected energy costs and CO_2 emissions, and an overview on investment and maintenance costs.

A scheduler helps to highlight points of action and the right timing for quality controls such as carrying out an airtightness test.

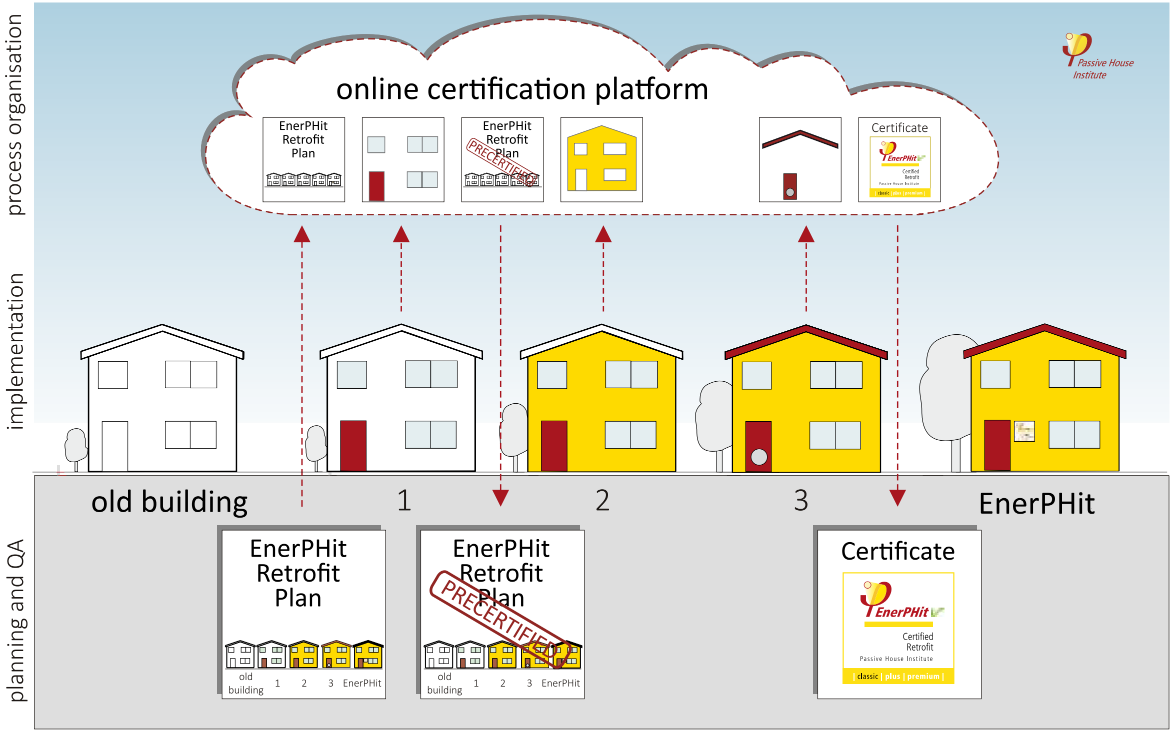


Figure: Schematic representation of the EnerPHit certification process for step-by-step retrofits

Figure © Passive House Institute

Did you know that: Individual apartments renovated to the EnerPHit unit standard can be certified, too.

EnerPHit
Certified Retrofit
Passive House Institute
| Unit |

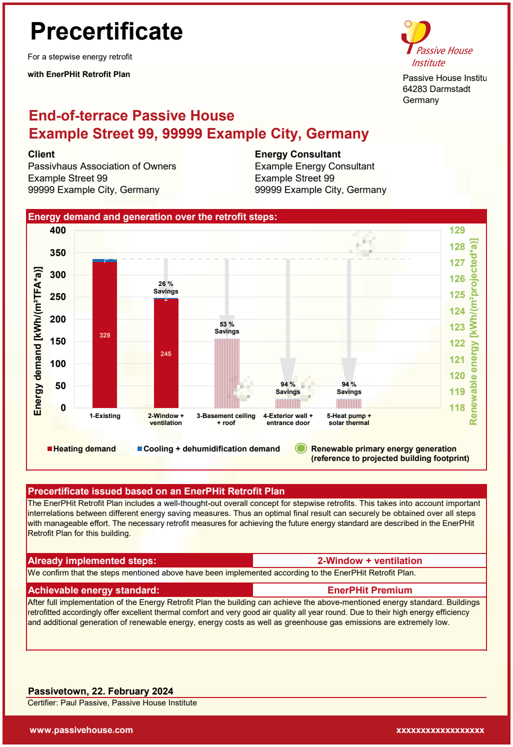
EnerPHit Unit: EnerPHit Unit is a special application of the EnerPHit building component method. Single retrofitted residential and commercial units in buildings with more than one unit can be certified with this option. For this, the unit under consideration must be completely retrofitted using Passive House components. The rest of the building won't be taken into account in the certification.

Image: Sample pre-certificate for step-by-step modernisation of a building to the EnerPHit standard

© Passive House Institute

Both the **highly efficient components** and the **planning method** using the PHPP are useful here. Which components have to be chosen depends on the local climate conditions. For a central European climate a highly thermally insulated building envelope, triple glazing, ventilation with heat recovery are key.

One thing is particularly important here: the principle of "if you do it, do it right": if a component of an old building is "touched" anyway,



Precertificate

For a stepwise energy retrofit

with EnerPHit Retrofit Plan

Passive House Institute

Passive House Institu
64283 Darmstadt
Germany

End-of-terrace Passive House
Example Street 99, 99999 Example City, Germany

Client
Passivhaus Association of Owners
Example Street 99
99999 Example City, Germany

Energy Consultant
Example Energy Consultant
Example Street 99
99999 Example City, Germany

Energy demand and generation over the retrofit steps:

Precertificate issued based on an EnerPHit Retrofit Plan

The EnerPHit Retrofit Plan includes a well-thought-out overall concept for stepwise retrofits. This takes into account important interrelations between different energy saving measures. Thus an optimal final result can securely be obtained over all steps with manageable effort. The necessary retrofit measures for achieving the future energy standard are described in the EnerPHit Retrofit Plan for this building.

Already implemented steps: 2-Window + ventilation

We confirm that the steps mentioned above have been implemented according to the EnerPHit Retrofit Plan.

Achievable energy standard: EnerPHit Premium

After full implementation of the Energy Retrofit Plan the building can achieve the above-mentioned energy standard. Buildings retrofitted accordingly offer excellent thermal comfort and very good air quality all year round. Due to their high energy efficiency and additional generation of renewable energy, energy costs as well as greenhouse gas emissions are extremely low.

Passivetown, 22. February 2024
Certifier: Paul Passive, Passive House Institute

www.passivehouse.com
xxxxxxxxxxxxxxxxxx

e.g. scaffolding is erected, a roof is repaired or a window is replaced, then it is very important that this is always done for the long-term and in a truly energy-efficient manner. It usually takes a very long time before such a component is "back on" again. The difference in cost between "refurbishment anyway" and a measure that ensures sustainability is regularly far lower than the costs incurred anyway.

Designers find complete information in the step-by-step handbook, an outcome of the EU project EuroPHit (this project funded by the European Union ran from 2013 to 2016).

Example: The building envelope
An existing building's shape or cubature is normally given and cannot be easily changed during refurbishment. However, it is sometimes possible to improve efficiency by reducing surface area and making the building shell generally more compact – for example, by integrating balconies or staircases into the thermal envelope. Insulating around an external staircase is the second best option but a pragmatic and valid approach. While it is not recommended for new buildings because the area to volume ratio is increased, in renovations this is often the easiest solution.

Even if the building's form cannot be improved during renovation, the application of insulation thicknesses typical of Passive Houses can not only reduce heating and cooling demands, but also greatly increase comfort.

The Criteria for Buildings describe the specific requirements defined for achieving each of the standards.

They are published by the Passive House Institute in German, English and Spanish.

| 7 |

APPROACHES

Achieving reliably high quality is often still a challenge but it doesn‘t have to. From conventional to serial renovation: Always with EnerPHit quality!

All photos: Prefabrication and automatisation are used in serial renovations.

Photos © ecoworks

There are many ways to EnerPHit renovations!
EnerPHit renovations can be conventional, prefabricated in parts or serial for a whole line of row houses, step-by-step, component by component, per apartment or for a whole building or even district, automated or traditional. They might be carried out in a do-it-yourself manner or by professionals, in streamlined team work or as a one stop shop. The different procedures all have their justification and show the versatility of the EnerPHit method.

In any approach **quality assurance** is included if you go for EnerPHit certification. EnerPHit renovated walls achieve very low u-values in the range of 0.10 W/(m²K) to 0.15 W/(m²K). They provide the right amount of insulation in order to increase interior surface temperatures to safe and comfortable levels.

The **serial EnerPHit renovation** provides the opportunity to digitalise the construction process even of complex building components and to deliver them to the construction site quality assured and prefabricated. With high-quality Passive House components it achieves sustainable solutions without "lock-in" effect: the full potential of Passive House components is used.

Thanks to the serial construction method with high degrees of prefabrication and quality-assured at planning stage via the EnerPHit design stage approval letter, effective and fast refurbishments can be realised. With Passive House quality properly installed the buildings deliver the high performance. Performance gaps known from other renovation concepts or significant rebound-effects do not occur with certified EnerPHit renovations.

Bringing all the experts together is integral for achieving a fast workflow and for ensuring the quality of the retrofit. This saves construction time and costs and is an important aspect for housing associations, as many buildings are retrofitted while residents remain in their homes. In turn, the residents can look forward to low running costs, as well as significantly improved comfort. Furthermore, with the installation of solar panels, the buildings will generate renewable energy. All this can be achieved within a few weeks.

One of the major advantages of this is that prefabricated components suitable for Passive Houses are already available!

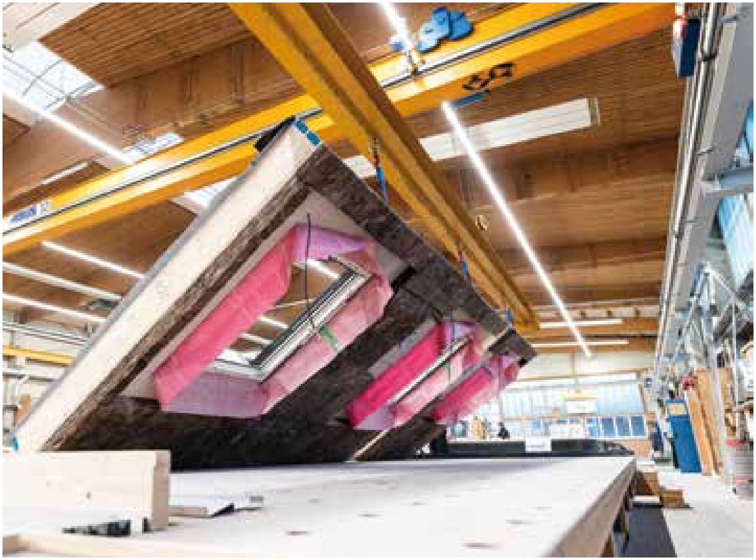


Photo above:
Balconies mounted with a crane

www.passivehouse-database.org
ID 7540

Photo ©
Zeller Kölmel Architekten

Good detailing in advance to resolve the connections smoothly on-site is key. And all involved must be in the know. It must be clear who is responsible for the seamless connection of both the airtight level and the insulation level. For EnerPHit certification, this must be documented.

Through the EU project outPHit (2020-2024) several EnerPHit serial renovations have been accompanied in different countries offering a so-called **one stop shop** for clients.

With prefabrication as little intervention inside the flats as possible is aimed for. Also, an attempt is made to limit the time frame of renovation measures so that the user is least disturbed. At the same

time the availability of Passive House components through better planning can be guaranteed.

PHI's certification programme where renovations are supported by **accredited Passive House certifiers**, and also via **component certifiers** for prefabricated component solutions, provides the necessary quality assurance from an independent body. It also helps to stick to the high quality standard agreed upon at design stage. The team knows what to do, how to achieve it and controls by independent third-party, the certifier, acknowledge the correct implementation. A certificate for the building owner and a plaque to attach to the building are handed-over after completion.

Photos:
Completed Passive House plus certified serial renovation in Schwalbacher Strasse, Cologne, Germany

www.passivehouse-database.org
ID 7540

Photos © dena | Jens Willebrand

| 8 |

A WORD ON AIRTIGHTNESS

It is essential that the concept for airtightness is designed and applied for the long term.

Why we need airtightness and its advantages was already explained in Chapter 2 where we saw the 5 Passive House principles. What is airtight and what is not as well as how to realise airtightness is the topic of this chapter.

Materials which are considered airtight in the long term are listed in the step-by-step EuroPHit handbook. The list shows a variety of durable solutions. Also rubbers, used to connect prefabricated facade elements on site, are airtight.

It is essential that the concept for airtightness is designed and applied for the long term.

Insulation materials are generally NOT airtight, therefore the airtight envelope must be designed and built separately. In timber constructions, mostly wooden composite boards with taped joints are used. In solid constructions continuous inside plastering is sufficient. This is because bricks are untight, but far from delivering the necessary air change. What makes masonry airtight is the interior plaster. Walls do not “breathe“, see more on the next pages.

To do so, there are three planning stages for airtightness:

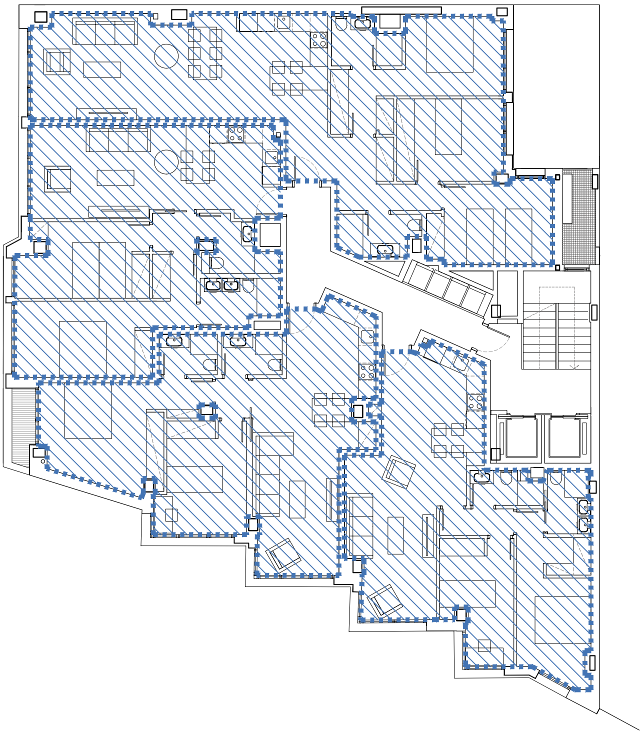
1. For each external building component, the component which will form the airtight layer should be specified (e.g. the OSB board or sheeting in a roof construction, the interior plaster for a brick wall, the concrete ceiling between the basement and the ground floor, etc.). The position of this airtight layer should be shown as a red line in the sectional drawing or floor plan. The heated space must be completely enclosed by the airtight layer.

2. As a second step, it must be specified how the ends of the airtight component layers will be permanently and airtightly joined. Attention: it is not enough to “connect” the window frame to the brick wall, for example, (because the wall level is not airtight!). Instead, the window frame must be permanently joined with the airtight layer of the external wall, which is usually the interior plaster in a solid construction, for example. In that case it would be suitable to use tape that can be plastered over, or a plastering strip.

3. Thirdly, any necessary penetrations must be planned: electric cables and pipelines which pass through the basement ceiling, power sockets (!) in external walls, etc.. Today suitable tried and

tested solutions and materials are available for this purpose. However, the principle of avoidance should be applied at first: it should be checked whether the penetration really is necessary. For example, feed throughs for downpipe ventilation can be avoided by the use of under-roof ventilators. It would also be better to concentrate all necessary penetrations in as few places as possible.

The "level of airtightness" can be determined by creating high and low pressure inside the building. This needs to be tested on site. An air pressure test is essential for EnerPHits and Passive Houses – it is part of the certification procedure.



Drawing:
Airtightness concept of Cartagena EnerPHit renovation, Madrid, Spain

Drawing © VAND arquitectura

False statements and questions like “Does a wall not need to breathe?” should be explained in order for correct appreciation and installation of an airtight envelope.

Walls do not “breathe“!

Word has spread about the necessity of airtightness for buildings. Airtightness leads to energy savings, the prevention of structural damage and improved sound insulation. A building airtightness requirement has been defined in Germany since 1952 (DIN 4108) and is not a special requirement meant only for Passive House buildings. Despite this, the misleading idea of walls that supposedly “breathe“ continues to persist.

The classic implementation of the required airtight layer in a solid construction is the continuous interior plaster layer. The idea that air exchange can take place through a wall build-up has already been refuted in 1928. Thus, for over 90 years, it has been clearly shown that buildings cannot be ventilated through walls.

The second incorrect idea relating to “breathing walls“ is that water vapour and harmful substances from the indoor space can be removed through the walls. It is true that water vapour diffuses through a wall build-up depending on the vapour diffusion co-efficient of the wall build-up.

However, even with a diffusion-open construction, the percentage of moisture that is removed in this way is **insignificant** compared to the amount of moisture which can be removed through normal ventilation techniques (a factor of more than 100).

Finally, there is the idea that the supposedly “breathing“ walls can regulate humidity. It is correct that the walls have the important task of buffering humidity of the indoor air.

The capacity to buffer the humidity and therefore improve the indoor climate is an important characteristic of appropriate surface materials, such as the interior plaster layer. Humidity buffering takes place in approximately the first 8 to 13 mm of the plaster layer. The rest of the wall build-up (e.g. airtight sheeting in the wall) does not have any significant effect on moisture regulation.

The notion that walls must “breathe” definitely belongs in the realm of myths. It is time that the focus is shifted to physical facts, in order to avoid defective construction and structural damage. The necessity for an airtight building envelope is beyond dispute. Airtightness is one of the essential foundations of energy-efficient and damage-free construction.

For more information, please take a look at the iPHA fact sheet “Airtightness – Walls do not breathe”, see:

www.passipedia.org/phi_publications#ipha_passive_house_fact_sheets

Quality assurance is essential: An airtightness test shows how airtight the building envelope is and leakage search is carried out in parallel to find out whether remaining penetrations are concentrated. Big holes will be detected and need to be sealed, so still having access to the airtightness layer during the test is recommended.

Airtightness test, Netherlands
Photo © Passiefbouwen

| 9 |

MONITORING – FOR PROVEN SUCCESS

Data-backed deep retrofits achieve further cost-savings.

Photos of typical devices for a minimal success monitoring

Photo above: Weather station

All photos © Hellenic Passive House Institute HPHI

Minimal monitoring results

Positive results in EnerPHit renovations can be demonstrated and verified with a minimal monitoring of the building over a two-year time period. During the first monitoring year, mistakes can be detected and resolved, leading to an even better performance.

Typically, minimal monitoring results include space heating, hot water and total energy consumption. In recent years, interior air quality and comfort are additional outcomes of such a performance test, measuring room temperatures as well as CO_2 and humidity levels. Ideally, two years should be measured. The first is used for data-supported adjustment of all systems, the second for quantitative evaluation. With this approach, the success of a renovation can be secured and verified.

Goals of EnerPHit Renovation Monitoring:

- Very low energy consumption
- Pleasant room temperatures
- Low CO_2 levels
- Adequate humidity levels

While in the past, monitoring meant high efforts and costs and the involvement of a team of specialists, nowadays it is quite easy and cheaper to install and supervise a monitoring system and analyse the results. Instead of manual monthly meter readings the data is transferred using a standard internet connection.

Quick monitoring guides are offered, for example on Passipedia and on the outPHit website.

Sometimes, the poor conditions before renovation are also measured to display the improvements more accurately. Otherwise, the before situation is calculated with standard boundary conditions in the energy balance tool PHPP or reconstructed from old energy bills. If a weather station can be installed on the roof (see photo from EnerPHit renovation in Madrid, Spain) you can record the actual weather conditions. Or else, this information is obtained from an external source such as the weather service. Then, this weather data is entered into the energy balance calculation, thus providing a very close representation of reality. The advantage of working with the PHPP tool is that the monitoring result can be quickly compared with the predicted energy consumption.

In the step-by-step handbook which was developed as part of the EU EuroPHit project, chapter "Minimal monitoring" describes the procedure for minimal monitoring and is also available on Passipedia.

The latest generation of monitoring devices is small and handy. Here you can see examples of typical monitoring equipment, installed in example renovation projects in the framework of the European project outPHit.

Photos:
Top right: IAQ (internal air quality) sensor
Below: Electricity meter
Top left:
The data acquisition unit, short DAU, is responsible for gathering all the data from every IAQ sensor and metering devices, like the electricity meters, heat meters (bottom left), etc.
Bottom right:
Domestic hot water meter

| 10 |

BUILT EXAMPLES BEFORE AND AFTER

This chapter features several examples of successful EnerPHit retrofits from across Europe. The examples illustrate various approaches including traditional, semi-prefabricated and serial renovation.

Complete EnerPHit renovation

www.passivehouse-database.com
ID 6898

01

Calle de Cartagena apartment complex renovation | Spain

Typology:	Apartment block
Location:	Madrid, Spain
Living area:	1465 m^2 (TFA according to PHPP)
Year of renovation:	2022

BEFORE renovation

Space heating demand:	unknown. The building was used as an office.
Space heating load:	unknown.

AFTER renovation

Space heating demand:	20 kWh/(m^2yr)
Space heating load:	11 W/m^2
Space cooling load:	7 W/m^2
Cooling demand:	6 kWh/(m^2yr) incl. dehumidification

Air tightness:	n_{50} = 1.0/h
Certification:	EnerPHit classic, warm climate zone

Architecture:	Díaz Rojo Arquitectos
Passive House Certifier:	VAND Arquitectura

EnerPHit Certified Retrofit
Passive House Institute
| classic | plus | premium |

AFTER renovation

Photo © PAEE Construcción Passivhaus-ECCN

BEFORE renovation

Photo © Diaz Rojo Arquitectos

The Cartagena residential building in Madrid, Spain, is a certified EnerPHit renovation. For this building, a traditional approach without prefabrication was taken and tenants moved out of the building before construction work began. The renovation design process was made possible by 3D-modelling with the designPH tool.

Complete EnerPHit renovation

www.passivehouse-database.com
ID 6898

01

EnerPHit Certified Retrofit Passive House Institute
| classic | plus | premium |

The original building dates to 1972 and was built using a traditional construction system: concrete floors and pillars, a double-leaf brick facade, a flat roof without insulation and double-glazed windows with anodized aluminium framing. The complex consisted of eight floors above ground for offices and two more below ground for parking, storage and building services. Two facades, located in the corner of the plot, are orientated to the north and west while the other two facades are party walls. A courtyard in the southeast corner provides light and ventilation for the common areas.
The team achieved the EnerPHit standard through the energy demand method. The building, post retrofit, now consists of six floors above ground for 22 apartments in total, with the ground floor for access, storage and building services and three further floors below ground for parking.

The complete renovation included the following measures:

- Building envelope insulation (including the facades, roof, floor, interior walls between apartments and staircase)
- Ventilated facade installation
- Windows, doors, and roller shutter replacement
- Airtightness improvement
- Installation of a ventilation system with heat recovery for each apartment
- Heating and cooling system renovation with one heat pump per apartment located in common areas
- Existing thermal bridges improvement
- Accessibility improvement
- Orientation improvement by means of removing the service staircase located next to the courtyard in order to allow several apartments to have a south-facing facade
- Photovoltaic system installation

AFTER renovation
All photos © PAEE Construcción Passivhaus-ECCN

Photo below: DURING renovation
Photo © VAND arquitectura

Complete EnerPHit renovation

www.passivehouse-database.com
ID 7452

02

Passive Social Plus renovation | Germany

Typology:	Apartment block
Location:	Darmstadt, Germany
Living area:	1662 m^2 (TFA according to PHPP)
Year of renovation:	2019

BEFORE renovation

Space heating demand:	unknown

AFTER renovation

Space heating demand:	16 kWh/(m^2yr)
Space heating load:	11 kWh/(m^2yr)
Air tightness:	$n_{50} = 0.51/h$

Climate zone:	cool-temperate climate zone

Architecture:	faktor10, dga architekten
Scientific evaluation:	Institut Wohnen und Umwelt IWU, Darmstadt, Germany

AFTER renovation
Photo right © Passive House Institute

BEFORE renovation
Photo left © faktor10

Photo below © IWU - Institut Wohnen und Umwelt GmbH

The client “Neue Wohnraumhilfe” managed to implement climate protection and social housing. Next to a new Passive House apartment complex (see ID 7454), a total of 22 apartments were renovated for people with difficulity accessing the housing market.
Passive House components were used throughout to follow the EnerPHit methodology.

The calculation with the energy and design tool PHPP proves that the renovation complies with the requirements of the EnerPHit classic standard. A monitoring was carried out and confirms the very low predicted energy consumption.

Complete EnerPHit renovation

www.passivehouse-database.com
ID 7452

02

The roof, basement ceiling and masonry walls are very well insulated and Passive House windows with triple glazing were installed. The thermal bridges were nearly completely eliminated, with a very low thermal bridge surcharge of only 0,018 W/(m^2*K). All apartments are heated via the old radiators with max. 48°C and have ventilation systems with heat recovery. Those are either installed in the wall, or, in small apartments, in the kitchen ceiling. The air volumes were reduced to ensure a silent operation yet always provide the flats with fresh air. All apartments have LED lighting and kitchens with energy-saving electrical appliances.

A grey water system reduces water consumption for flushing toilets and PV systems with battery storage provide electricity. Once the high space heating demand has been reduced, minimizing the hot water demand is the next in line. In multi-family buildings a lot of energy is lost distributing hot water. Planning short, highly-insulated ducts and reducing the water temperatures to 50°C are the solution. This optimization potential was used in the PassivhausSozialPlus renovation.

This combination of different measures leads to a significant energy reduction. And it translates into huge cost savings: The monthly energy bills are approx. 40% lower than those of comparable social housing flats in Darmstadt.

The monitoring results support the pledge to thorrowly commissioning by adjusting the "active" systems. In 2020 the building had a heating, DHW & electricity consumption of 64.9 kWh/(m^2yr), due to its "fabric first approach" and PV electricity production.

Since the renovation completion in 2019 the German subsidy standards for existing buildings have been extended. At the time of the implementation of PassivhausSozialPlus, the KfW Efficiency House 55 was the highest subsidy standard for existing buildings. Now Efficiency House 40 (with "EE" class to include renewable energies) has been added, so that a broader funding landscape for renovations is currently available in Germany. The PassivhausSozialPlus renovation could also have achieved this highest level.

Photos: Renovated building with blue balconies

Photos © Passive House Institute

Complete EnerPHit renovation

www.passivehouse-database.com
ID 4200

03

Technical faculty building | University of Innsbruck | Austria

Typology:	University building / Office
Location:	Campus Technik, Innsbruck, Austria
Living area:	8897 m^2 (TFA according to PHPP)
Year of renovation:	2014

BEFORE renovation

Space heating demand:	> 300 kWh/(m^{2}yr)

AFTER renovation

Space heating demand:	20 kWh/(m^{2}yr)
Space heating load:	24 kWh/(m^{2}yr)

Air tightness:	n_{50} = 1.0/h
Certification:	EnerPHit classic, cool-temperate climate zone

Architecture:	Generalplaner ATP Architekten
Passive House Certifier:	Passive House Institute

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

Photo: AFTER renovation

Photo © Passive House Institute

Photo: BEFORE renovation

Photo © Harald Konrad Malzer

The 9000m² office block built 1970 on the "Technik" Campus of the University of Innsbruck had a very high heating demand in winter and unbelievably hot temperatures inside in summer. Users had to bear above 30°C at their desks. The renovation design kept the reinforced concrete structure except for the external balcony consoles and a new ventilated facade with aluminium cladding with 24cm mineral wool was installed.

Difficult circumstances due to the close vicinity of the Innsbruck airport were overcome. Only on the North side a crane could be erected so the craftspeople slid the windows into their position using railings. Wooden structures de-couple them from the main building and thus avoid thermal bridge effects.

Complete EnerPHit renovation

www.passivehouse-database.com
ID 4200

03

The windows consist of 3 + 1 panes of glass. Night ventilation is possible using a clever window opening detail where the window tilts to the outside ensuring cool night air to enter at top, sides and bottom.

Glazed interior walls allowed savings because less artificial lighting was needed for the corridors, now operated automatically by light sensors. Interior office doors are equipped with overflow openings to allow the air to pass from one room to the next.

Architects from the neighbouring building “Faculty of Architects” claim the new facade looks like the typical Excel spreadsheet made by an engineer.

Involved engineers who work there and enjoy the comfortable in-door environment, reply: “It is like an Excel sheet: It works!”.

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

This anecdote illustrates the tension between good architecture and high energy efficiency. This is why many colleges and universities are already emphasising the importance of teaching the subject of Passive House from the outset when training architects and designers. After all, good architecture is more than just a beautiful facade. This example demonstrates how the additional structural effort ultimately required for this can be kept within very narrow limits.

The ventilation system with heat recovery provides always fresh air to the entire building. Temperatures stay all year round in the predicted range even without the need for active cooling. This was also experienced during the 27th International Passive House Conference in April 2024 held at the Technik Campus: While outdoor temperatures climbed to unusual 29 degrees, inside the renovated building it felt pleasantly cool.

The technical faculty building can thus act as a blueprint for similarly old concrete-structure buildings in need of renovation.

Photo: AFTER renovation

Photo © Passive House Institute

Complete EnerPHit renovation

www.passivehouse-database.com
ID 7049

04

Hybrid approach in non-residential building Ajena renovated to EnerPHit classic | France

Typology:	Training centre
Location:	Lons le Saunier, France
Living area:	280 m² (TFA according to PHPP)
Years of renovation:	2022/2023

BEFORE renovation

Space heating demand:	> 300 kWh/(m²yr)

AFTER renovation

Space heating demand:	19 kWh/(m²yr)

Air tightness:	n_{50} = 1.0/h
Certification:	EnerPHit classic, cool-temperate climate zone

Architecture:	Ahlem Paris, Lons le Saunier
Building services & physics:	Plan 9, Nancy
Passive House Certifier:	ProPassif, Paris, France

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

Photo: BEFORE renovation

Photo © R. Claret

Photo: AFTER renovation

Photo © Ahlem PARIS
Architecte D.P.L.G.

The original building was a 1960s concrete non-residential project on the outskirts of the city Lons le Saunier, near Lyon, France.
The building is used by AJENA, “Association Jurassienne d’Energies reNouvelAbles”, as a centre for training on retrofitting.

Complete EnerPHit renovation

www.passivehouse-database.com
ID 7049

04

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

Such a well renovated EnerPHit is a big plus, making obsolete its old fuel heating system and radiators and giving more sense to renewable energy production on top of the building. It serves now as a perfect showcase for comfortable and energy efficient renovation.

It is a semi-prefabricated global retrofit to EnerPHit classic level thanks prefabricated North wall and mounted on spot on the South wall. Windows are triple glazed and one comfort ventilation system with heat recovery serving the whole building.

The hybrid concept included internal insulation on the North facade while the South facade is insulated from the exterior. Bio-based

materials were used throughout the renovation phase where possible. A centrally placed wood pellet stove provides heat to the open-plan building.

On the southern slope PV panels were installed on the roof. Renovation started in summer 2022. The building was inaugurated in September 2023, revealing the EnerPHit plaque to the public because this building was certified achieving the EnerPHit classic standard.

Photo above:
The original radiators from 1960 were removed

Photo © Ajena, Lons le Saunier

AFTER renovation
Photo on the left

Photo © Ahlem PARIS Architecte D.P.L.G.

Complete Passive House renovation

www.passivehouse-database.com
ID 7540

05

Passive House plus serial renovation Schwalbacher Strasse | Germany

Typology:	Apartment block
Location:	Cologne, Germany
Living area:	1187 m^2 (TFA according to PHPP)
Year of renovation:	2022

BEFORE renovation

Heating, DHW & electricity consumption:	201 kWh/(m^2yr)

AFTER renovation

Space heating demand:	15 kWh/(m^2yr)
Space heating load:	11 kWh/(m^2yr)
Heating, DHW & electricity consumption:	39 kWh/(m^2yr) in 2023
PV electricity generation:	46 kWh/(m^2yr) in 2023
Air tightness:	n_{50} = 0.6/h
Certification:	Passive House Plus, cool-temperate climate zone
Architecture:	Zeller Kölmel Architekten
Passive House Certifier:	Passive House Institute

Certified
Passive House
Passive House Institute
| classic | **plus** | premium |

In consultation with dena (German Energy Agency) the Cologne housing association “Wohnungsgenossenschaft am Vorgebirgspark eG” (WGaV) commissioned Zeller Kölmel Architekten (ZKA) to convert an apartment block built in 1961 with 16 residential units into a ‘NetZero‘ building: the building should not consume more energy per year than it produces.

Photos: BEFORE and AFTER renovation

Photos © dena | Jens Willebrand

Complete Passive House renovation

www.passivehouse-database.com
ID 7540

05

Certified
Passive House
Passive House Institute
| classic | **plus** | premium |

The problematic winter/summer storage loss issue and little available renewable energy in winter times was overcome by persuing the Passive House standard, thus reducing the energy demand of this building to such extent it becomes possible to supply it by renewable energy sources.

Due to the very ambitious timeframe and the desire to minimise the impact on the tenants, prefabricated, highly thermally insulating facade and roof elements as well as facade-integrated ventilation with heat recovery were used. The result is impressive: The uninsulated old building was transformed into a highly energy-efficient refurbished building.

Careful planning by architects team Zeller Kölmel was key to the success. Certified Passive House designer Klaus Zeller and his team are realising Passive Houses since 2006 and know about the optimisation potential of compactness, window sizes, shading devices and high-performance components. As a result, this renovation even fulfils the Passive House plus standard.

Michael Kölmel presented this project at the research group meeting on cost-efficient Passive Houses no. 61 in October 2023, title "Serial refurbishment according to Passive House principles."

The serial renovation took place in 2022. Due to the layout there are internal bathrooms without the possibilty to open windows: So there is a need for ventilation which was met by installing a ventilation system with heat recovery. Very low heating energy consumption is possible following the five Passive House principles, first and foremost a well-insulated building envelope. Here, the walls consist of 60mm mineral wool insulation + 280mm cellulose insulation.

Serial renovation advantages:

- More projects in short time frame-> climate goals can be achieved
- Short installation and renovation times due to prefabrication of components. Here, the balconies were mounted with a crane.
- Reproducable high energy quality. The plan is to renovate a whole district in the near future.
- Low and short burden for the tenants. They typically can stay in their apartments during the complete renovation.
- Affordable energy costs (goal: rental price all-inclusive which means rent + low energy costs is not more than what tenants paid before, when they had to pay the rent + high energy costs). This was achieved and ensures people have planning security whilst enjoying the comfort of a renovated home.
- If Passive House or EnerPHit goal is persued, the proven and tested standards provide a reliable and sound basis for a renovation. The PHPP planning tool makes incorrect optimisations visible. In this case, the entire roof area was utilised in an exemplary manner for PV power generation and all energy requirements were reduced to the optimum.

Photos: AFTER renovation

Photos © dena | Jens Willebrand

Complete EnerPHit renovation

www.passivehouse-database.com
ID 6920

06

Two Family House Renovation, Papagos | Greece

Typology:	Detached house
Location:	Papagos, Athens, Greece
Living area:	150 m^2 (TFA according to PHPP)
Years of renovation:	2021-2022

BEFORE renovation

Space heating demand:	531 kWh/(m^2yr)
Cooling demand:	101.15 kWh/(m^2yr) (incl. dehumidification)
Air tightness:	8.0/h

AFTER renovation

Space heating demand:	35 kWh/(m^2yr)
Space heating load:	21 kWh/(m^2yr)
Space cooling demand:	18 kWh/(m^2yr) (incl. dehumidification)
Space cooling load:	15 W/m^2
Air tightness:	n_{50} = 0.8/h

Certification:	EnerPHit classic, warm climate zone
Architecture:	Ioannis Katopodis
Passive House Certifier:	Stefanos Pallantzas, Hellenic Passive House Institute

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

Following a streamlined approach, this renovated house located in Papagos, Athens, now has a final energy demand 15.2 times lower than its initial demand. The initial state of the house demanded urgent renovation.

An airtightness test carried out before the refurbishment revealed a draughty home.

Photos: BEFORE renovation

Photos © Aris Stavropoulos

The walls were plagued with mould and the temperature inside the house ranged from 18°C (max) during winter with the heating boiler on, to 30°C (min) during summer with the A/C working. The energy consumption of the house was high, at a cost of 3500 euros for heating oil and 1500 euros for electricity consumption of the A/C. The completely uninsulated house made of reinforced concrete slabs and brick walls stands on stilts and has several pillars that penetrate the building due to necessary antiseismic design. The house has old aluminium frame windows with single pane glazing.

The modernization proposal was defined by the energy upgrade of the house, which took place according to the EnerPHit criteria. The energy modelling using PHPP helped determine the necessary amendments to minimize the energy demand. Due to the geometry of buildings in Greece such as having many balconies or parapets, it is mostly not feasible to construct large prefabricated elements. Therefore the main focus was on a streamlined renovation approach including a very detailed design, which accelerates the work on-site,

Complete EnerPHit renovation

www.passivehouse-database.com
ID 6920

06

while minimizing the performance gap. It meant also using less materials due to precise calculations, fewer active systems needed. A continuous collaboration between all the engineers and technicians involved in the project was maintained. The design team conducted an implementation study and provided specialized workshops on-site for every tradesperson especially before the construction. This procedure made the total renovation cost less, also because fewer decisions had to be made on-site, resulting in less waste of time for everybody.

For example, the 3D ventilation design and the detailed step-by-step instructions for installing the whole system reduced the time required by up to 60% and the costs up to 40%.
After renovation the house consumes only a fraction of the energy it used to and this had led to significant cost savings on heating and cooling bills. Moreover, the improvements (insulation, air tightness and mechanical ventilation) have not only made the home more energy-efficient but also more comfortable and healthier to live in.

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

A noise-free internal environment and excellent air quality are crucial for the well-being of the occupants, and reducing dust and odors can further improve indoor air quality.
The renovation cost in total 80 000 euros. The area where the house is situated has many buildings of the same type that are in need of urgent energy renovation. This project serves as a promising pilot initiative in the area.

The steps taken to achieve this goal included:

- Continuous insulation throughout all the elements of the house
- Airtightness improvement
- Minimizing thermal bridges, which means taking care of the parts where the insulation needs to be interrupted
- Replacing the windows with high-quality thermal insulated PVC windows with triple pane glazing
- Installing airtightness tapes during the installation of windows in order to minimize air infiltration
- Installing mechanical ventilation with heat recovery to continously provide fresh and clean pre-conditioned air to the interior of the house

All photos: AFTER renovation

Photos © Maria Dimitriou

Complete EnerPHit renovation

www.passivehouse-database.com
ID 5939

07

Historic farmhouse “Neuhäusl” | Austria

Typology:	Detached house
Location:	Scheffau, Tyrol, Austria
Living area:	158 m^2 (TFA according to PHPP)
Year of renovation:	2017

BEFORE renovation

Space heating demand:	unknown. House was empty for two decades.

AFTER renovation

Space heating demand:	17 $kWh/(m^2yr)$
Space heating load:	15 $kWh/(m^2yr)$
Air tightness:	$n_{50} = 0.5/h$
Certification:	EnerPHit classic, cool-temperate climate zone

Architecture:	Hans Peter Gruber, Innsbruck
Passive House Certifier:	Passive House Institute

EnerPHit Certified Retrofit
Passive House Institute
| classic | plus | premium |

Photo on the left page:
BEFORE renovation

Photo © DI Hans Peter Gruber

Photos: AFTER renovation

Photos © Passive House Institute

The historic farmhouse "Neuhäusl" in the municipality Scheffau in Tyrol from the 18th century was renovated with great attention to detail and intelligent construction and building services solutions.

The architectural design and choice of materials are in an exciting dialogue with the existing building fabric. The example proves that upgrading the energy efficiency of historical buildings does not conflict with good design solutions while preserving important building culture.

Applying Passive House components meant combining innovation and tradition.

The project is a WINNER of the Tyrolean Renovation Award 2018.

Complete EnerPHit renovation

www.passivehouse-database.com
ID 5939

07

The external appearance of the old farmhouse has been preserved. As a result, the designer was forced to implement a consistent interior insulation, but this also brought the advantage of a targeted minimization of existing thermal bridges with it. The look from outside reminded the same even with new triple-glazed Passive House windows. The trick is a clever detail, see drawing on the bottom right, where the thick window frame is partially covered with the existing exterior cladding.

The former heating using a traditional "Kachelofen", a wood stove, was taken out because it was not needed anymore. In combination with an underfloor heating a compact unit including an air to water heat pump and a ventilation system with heat recovery provides the two apartments with energy and air. What is more, the sensation inside is as if the wood stove was still there.

EnerPHit
Certified Retrofit
Passive House Institute
| classic | plus | premium |

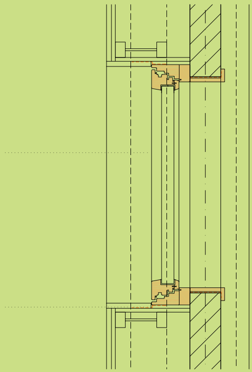
This is a result of the continous insulation layer which provides homogenous and pleasant temperatures. In combination with a draft-free environment due to the excelent airtightness, it feels cosy, like sitting right next to the former “Kachelofen”.

Fresh, filtered air adds to the comfortable sensation. Thanks to early consideration in the planning phase, it was possible to realise a very efficient duct network. A suspended ceiling was only required in the WC on each floor.

For more information and construction drawings, please see:
www.hiberatlas.com/en/hof-neuhaeusl--2-130.html

More typical projects
such as the Greek apartment block “Cholargos“ where the EnerPHit retrofit plan was made for the whole building and one apartment was renovated can be found in the section ‘Case Studies‘ on the outPHit website.
www.outphit.eu

Photos and drawing
© DI Hans Peter Gruber



| 11 |

BEST-PRACTICE DETAILS

How can we achieve reliable high quality details in renovations?

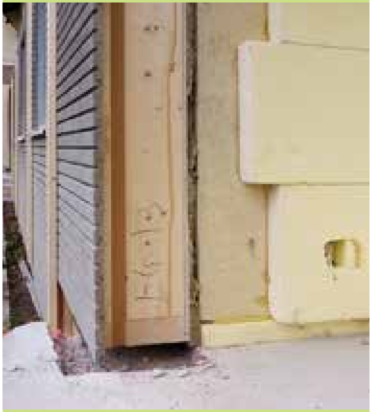
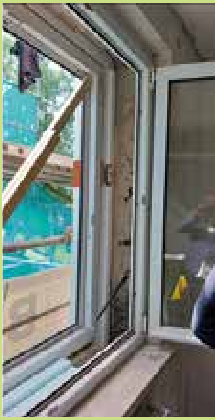


Photo above:
The external wall insulation (yellow) needs to be connected to the insulation of the prefabricated wall element. (Erlangen, Germany)

Photo © Passive House Institute

Photo below © Rainer Pfluger



Proper solutions for common details form part of successful EnerPHit renovations.

Streamlining and good coordination between the trades is of high importance. It must be clear who is responsible for the seamless connection of both the airtight level and the insulation level. In serial EnerPHit approaches you can call it a One Stop Shop because every-thing has to fit well together before the parts arrive on site.

Certified building systems make renovation easy.

Installing a ventilation system in a renovation project without the need for core drilling

A further innovation, which can be realised in combination with the window front wall installation and the duct routing in the insulation level, eliminates the need to drill core holes for the supply and exhaust air. This is because the air can be supplied and extracted behind the frame, i.e. between the frame and the existing wall.

For this purpose, the frame must be positioned further outwards so that a gap remains free between the frame and the existing masonry for the air duct. This technique is shown in the installation example on the left, using a window pre-wall installation made of pressure-resistant EPS insulation material (Compacfoam). These construction site photos show the oval ducts made of spiral ducting, which are routed on the wall surface under the insulation up to the window.

This type of air routing can be used both when using centralised units and for the supply and extract air distribution on the facade of a flat unit. This eliminates the need for any pipework within the residential unit and, as already mentioned, the need for core drilling.

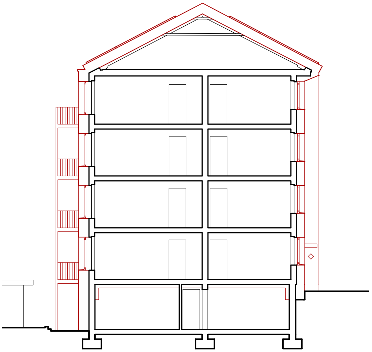
This is an invaluable advantage, especially when it comes to avoiding disturbance to residents.
More of those clever details can be found in the book Research group no. 61 Serial energetic renovation with Passive House principles.

Fast & easy: One Stop Shops deliver all-in-one renovation solutions!

Rendering and photo: Two systems certified by the Passive House Institute

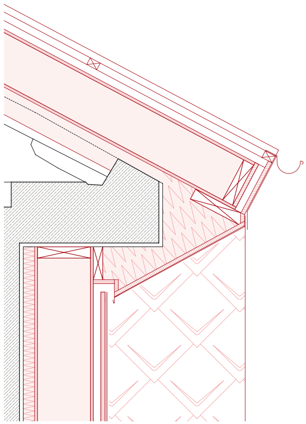
smartshell reno
© www.passivhausfenster.com

and ecococon (www.ecococon.eu)
Photo © ecococon



Drawings:
Section and eaves detail
Schwalbacher Strasse 24-26,
Cologne, Germany

Drawings ©
Zeller Kölmel Architekten



Best-practice details

The components and their connections are thought through in advance by the design team. The decisions made in the planning phase are crucial to achieving cost-effective solutions. The good news: it has been done before and the lessons-learnt are available to all (please see chapter ressources at the end of this brochure). In this chapter we will show and explain construction details of EnerPHit renovations. All have the following in common:

The details work in terms of building physics: Also known as u-value the thermal transmittance after renovation is significantly lower than before. In a cool-temperature climate, the final u-value of a wall should be below 0.10-0.15 W/(m^{2}K), the final u-value of a window as low as possible. Typical window values are below 0.85 W/(m^{2}K) for an installed window of size 1.2m x 1.5m. Avoided by all means should be so-called “medium qualities”. They cost little less than high quality, but create a lock-in effect: The performance will not be as good as it could be, but it will never again be cost-effective to update to a higher quality during the long lifespan of the component.

The consistent user feedback is positive: the high comfort due to higher interior surface temperature, constantly fresh air, absence of drafts and building damage, quiet homes due to airtight and insulated homes is appreciated by old and young tenants.

The details work in terms of logistics on the building site: The job of the architect and planning team is to ensure that theoretical knowledge is put into practice at the right time on site. Integral planning is key and good communication right from the start is necessary to get there. Experienced Passive House designers bring all parties involved in the renovation process to the table at a very early design stage.

The details work as part of the whole house to achieve outstanding results: The PHPP calculation defines the final outcome of each individual project. Before but more importantly after renovation calculation results for heating and cooling demand, airtightness and primary energy demand are numbers that are influenced by design and execution of each detail. Moreover, these numbers can be checked, even monitored.

The short answer is easy: If you apply Passive House components you are on the right path. You can rely on the scientifically proven details, use the right, easy-to-use tools provided and get an independent check by a third-party. Example: an airtight, well-insulated and quality-assured wall will perform during its entire lifetime in the expected way. This is good for the environment, good for the tenants, good for the house owners and their wallet.

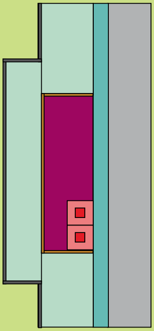
Some details are highlighted in this brochure. Many more can be found in **www.passipedia.org** and in the project documentations on **www.passivehouse-database.org**

"It's fantastic here after the renovation."
"Saving energy works really well."
Sascha Will
Tenant of Tevesstrasse EnerPhit renovation in Frankfurt, Germany.

Sascha Will is absolutely delighted. In his previous flat, which was also smaller, he had paid almost six times as much in service charges compared to Tevesstrasse.

Tevesstrasse EnerPHit renovation, Frankfurt, Germany

Photo © Passive House Institute



Drawing:
Schematic wall construction, Erlangen, Germany

© Passive House Institute

Photo bottom left: Backpacker, Erlangen, Germany

Exterior wall with external insulation and backpacker including ventilation unit and ducts.
A so-called backpacker line for two storeys has been mounted. You can see the ventilation units which will supply the individual flats with fresh air, as well as the sealing to achieve a continuous airtight layer.

All photos © Passive House Institute

The old building is being given a new facade piece by piece:
It is important that all connections are well planned in advance. For example, accompanying insulation is required when newly insulated, warm surfaces come into contact with cold surfaces. This is the case with the upper connection of the external wall insulation.

A grille is essential at the bottom to protect against rodents. As there is a cold basement behind it, expanded metal can be used for this.
In the new facade, the mechanical systems can be located. In Erlangen, the construction company installed so-called "backpackers" made of PU foam to ensure that the backpackers are thermally well separated insulated building envelope.

To further optimise such a backpacker you can use wood instead of steel, a double-pipe system and a minimum of 200mm insulation around it.

New windows and roller shutters should be installed without thermal bridges. The need to accommodate insulation in the reveal and in the shutter box is a challenge that many planners successfully tackle. These details can be solved properly. A case for serial refurbishment: Prefabricated elements are now also available for this. The new window sits perfectly in the first third of the external wall insulation.

In this example, there was already an 8cm thick thermal insulation composite system from the 1990s. To level out any unevenness, 4cm of mineral wool was first applied before the new, insulated facade element was installed, see photo below.

Photo left page, bottom right:
Manually insulated loggias

All photos ©
Passive House Institute

"The existing building stock plays a key role in the achievement of climate objectives."

Taken from the study "Towards a climate-compatible building stock" [PHI_2023], Passive House Institute

The thermal break between inside and outside at the terrace access door is achieved with a cellular concrete block. The airtightness layer is formed by tapes and gypsum plaster connecting the airtight door frame to the airtight concrete slab.

16.4 degrees in the corner is the lowest internal surface temperature according to the thermal bridge calculation and corresponding fRSi calculation*. Horizontal interior insulation has been required to raise the lowest temperature well above the critical mould growth temperature of 12 degrees.

** Thermal bridges cause additional heat losses on one hand and on the other they cause low interior surface temperatures. Accordingly, to characterize the effect of thermal bridges, two different, independent parameters are needed.*

Measures for increasing the energy efficiency of buildings using the Passive House and EnerPHit quality standards are most appropriate for reliably achieving climate goals as well as for supply security for containing costs. The expertise, experience, suitable products and procedures for this are already available. What counts now is good and comprehensible communication, competence/capacity of the trades, widespread acceptance and, where necessary, the right incentives – and especially the avoidance of false incentives. We will provide suggestions for optimisation of these measures in the short term. Mitigation of the social impact of rising energy costs has already been considered in the coalition agreement. Such measures must aim for a reduction in the energy demand instead of further subsidising energy consumption.

Nevertheless, this scenario will not run by itself: it requires boundary conditions that must be actively created.

1. Communication: there are many examples of building retrofits to a sustainable level of efficiency. Let's make these better known/ let's raise awareness of these!
   Information initiatives are needed for this; the project documentation available in the Passive House database/portal
   www.passivehouse-database.org
   and the international Passive House Open Days are a good basis for this. The focus now is on existing building stock!
2. Implementation to a high standard ("if you do it, do it properly") and – even when rapid action is needed – without impeding further subsequent measures. Capacity of the trades is necessary for this, and (easily communicated) basic training on the topic of "Why is energy efficiency necessary in existing building stock, and how this can be achieved effectively and sustainably?"
3. Advanced training: Let us impart the know-how for energy efficient retrofits. The courses offered by the PHI are a good basis for this:
   https://cms.passivehouse.com/en/training/courses/

Check out latest Passive House trainings here:

"To summarise, it can therefore be said that suitable and proven solutions in EnerPHit quality are available for all facade and ventilation problems: thermal insulation, window connections, solar shading and ventilation with heat recovery."

Rainer Pfluger, University of Innsbruck, Austria

(Source Research Group 61 "Seriel energetic renovation with Passive House principles")

Passipedia
The ever-expanding knowledge database on energy efficient building and Passive House, comprising over two decades of research. Articles relating to step-by-step energy refurbishments and deep retrofits are also found here.
www.passipedia.org

OutPHit website
www.outphit.eu

Passive House Institute
An independent research institute that has played an especially crucial role in the development of the Passive House concepts – the only internationally recognized, performance-based energy standard in construction.
www.passivehouse.com

iPHA – the International Passive House Association
A global network for Passive House knowledge working to promote the Passive House Standard and connect international stakeholders. Join us!
www.passivehouse-international.org

Passive House Database
www.passivehouse-database.org
Component Award
www.passivehouse.com (awards)
Component Database
database.passivehouse.com

outPHit project lead:

www. passivehouse.com

outPHit partners:

www.passivehouse-international.org

www.climatealliance.org

www.eneffect.bg

www.ecoworks.tech

www.vandarquitectura.info

www.uibk.ac.at/en

www.eipak.org

www.passiefbouwen.nl

www.propassif.fr

www.neueheimat.tirol

IMPRINT

Passive House Institute

Publisher
Passive House Institute GmbH
Rheinstraße 44/46
64283 Darmstadt | Germany
mail@passiv.de
www.passivehouse.com
www.outphit.eu

Design and execution
Marlies Blücher | Passive House Institute
Cover Design
Francesca Rover | Passive House Institute

Editorial
Susanne Theumer | Passive House Institute
Teams of Climate Alliance and
Passive House Institute

Graphics and picture credits
All photos not otherwise marked:
© Passive House Institute

© Passive House Institute, 2024

Photo cover: © Passive House Institute

Thanks to all persons who contributed to this brochure with drawings, details and knowledge sharing!

Scope of content/Disclaimer
This publication mainly deals with the energy-relevant aspects of building modernisation, but it does not claim to cover all other aspects that are important for planning and realising a building retrofit project. The construction details shown here are meant as basic representations of the principles and cannot be applied on a one-to-one basis in other contexts. The focus of the content is on solutions for the cool, temperate climate (e.g. of Central Europe). Instructions for other climates are also given in some places.

The contents of this publication have been compiled with the greatest care and to the best of our knowledge and belief. However, no liability can be accepted for any deficiencies with regard to the content or for printing errors. With reference to the use of the information given here, the responsibility for checking the legal requirements, standards, or regulations lies with the user. Any liability for the accuracy and completeness of the contents and data, and in particular for any damage or consequences arising from the use of the provided information is therefore excluded.

We hereby explicitly address all gender identities even if the generic masculine is used for reasons of better readability and easier comprehension.

With support from the EU:

outPHit

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957175.
The presented contents are the author's sole responsibility and do not necessarily reflect the views of the European Union. Neither the CINEA nor the European Commission are responsible for any use that may be made of the information contained therein.

outPHit

Find out more: